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Updated for Silverlight 4

Silverlight Recipes

A Problem-Solution Approach

Core concepts and real-world techniques for Silverlight developers

SECOND EDITION

Jit Ghosh and Rob Cameron

Apress®

Silverlight Recipes:

A Problem-Solution Approach

SSecond Edition

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For Sumona, my wife, the love of my life and the source of all my inspiration; and Pixie, the greatest kid on this planet, and the best daughter one could ever have. You are the lights of my life.

—Jit

To my beautiful and loving wife, Ally, and daughters Amanda and Anna, who bring so much joy to my life.

—Rob

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From Jit: I would also like to thank my family, especially my wonderful wife Sumona for being the force behind everything I have ever achieved and for making me believe in myself; and my beautiful daughter Pixie for being patient when Daddy could not make time and for never forgetting the daily dose of hugs and kisses. And lastly, a huge thanks to Rob Cameron for agreeing to work with me on this book, for sharing his insight on authoring, and for his technical acumen—without Rob, this book would have remained a dream.

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Introduction

Silverlight Tools for Visual Studio 2010, Visual Studio 2010, and Microsoft Expression Blend 4 give you the power to design innovative and powerful Silverlight 4 user interfaces. They give you access to cutting-edge graphics, animation, rich controls, and data binding in the powerful XML Application Markup Language (XAML) declarative language. For application logic, you can continue to use all the usual Visual Studio 2010 features such as debugging and access to your favorite development language, like C# or VB, and dynamic languages such as IronPython, IronRuby, and Managed JScript. What is truly amazing is that the breadth of the .NET Framework for Silverlight including functionality such as multithreading, generics, LINQ, and extension methods, is included in such a diminutively sized browser plug-in.

While rich Internet application (RIA) development tools have been around for a while, Silverlight 4 makes RIA development real for traditional developers letting them use their favorite tools and programming languages to create fabulous user experiences.

Who This Book Is For

If you are an existing Silverlight developer, this book will provide details on what's new in Silverlight 4. If you are a web application developer looking for ways to create rich, interactive, and immersive browser-hosted applications using Microsoft Silverlight and .NET, then this book will give you the information you need on the core concepts and techniques fundamental to Silverlight-based development. Even if you did not have Silverlight in mind, the book will help you see the possibilities and understand what you can (and in some cases can't) achieve with the technology.

Having an understanding of the .NET Framework will help, but if you are an experienced developer new to the .NET Framework, you will still be able to learn Silverlight 4 using this book because much of the development is in the XAML markup language as well as in code.

■ **Note** You still may want to grab a programming in C# text such as Christian Gross's *Beginning C# 2008: From Novice to Professional, Second Edition* (Apress, 2008) if you are not confident with C#.

If you are a Windows Presentation Foundation (WPF) developer, this book will help you understand how to work with Silverlight, which uses the same markup language but is a subset of WPF functionality packaged in a cross-browser and cross-platform plug-in.

The example code in this book is written in C#. However, much of the development is in the XAML, not in C#, so if you are a VB.NET developer, the markup is almost exactly the same. For the examples that do include C# code in the code-behind, the code translates pretty easily, as the .NET Framework for Silverlight is language agnostic.

If you are a developer in need of learning a particular technique, this book is for you as it is task driven in Apress's recipe format. Each major facet of Silverlight 2 development is presented with a description of the topic in the form of a problem statement, a "How It Works" section, and a section that walks through the recipe sample code.

How This Book Is Structured

This book consists of chapters that focus on individual topic areas of Silverlight. Each chapter attempts to address core concepts and techniques as individual recipes in that topic area. Chapters 1, 2, and 3 are primarily intended to help you grasp the fundamental concepts of Silverlight, including a quick tour of the developer tools, the Silverlight programming model, and XAML-based UI development. Many of these concepts are critical to understanding the later chapters, so we advise you to start the book by reading these chapters first. Chapters 4 through 8 address the topics of data binding, control customization, and development; browser integration; networking and web services; and out-of browser Silverlight applications. Chapter 9 provides a detailed overview of WCF Ria Services. Chapter 10 covers how to integrate rich media and Chapter 11 covers how to integrate smooth streaming for rich adaptive streaming support.

Prerequisites

You will need a version of Visual Studio 2008, with Service Pack 1 of Visual Studio 2008 applied. You will also need to install Silverlight 2 Tools for Visual Studio 2008 Service Pack 1. You can use any version of Visual Studio 2008, and you can download the free version of Visual Studio 2008 Express edition here:

`http://www.microsoft.com/express/vcsharp/Default.aspx`

You can get the Silverlight tools from `http://silverlight.net/GetStarted/`, and you can download a trial version of Expression Blend 2 from `http://www.microsoft.com/Expression`. If you are an MSDN Subscriber, you can also download it from subscriber downloads. You will also need to apply Service Pack 1 to Expression Blend 2.

Some of the recipes in this book use a SQL Server Express 2008 database. You can download SQL Server Express 2008 for free from `http://www.microsoft.com/express/sql/`. For some of the recipes in Chapter 8, you may need a video encoder. You can download a trial version of Microsoft Expression Encoder from `http://www.microsoft.com/Expression`.

Downloading the Code

The code is available in zip file format in the Source Code/Download section of the Apress web site. Please review the `readme.txt` for setup instructions.

Contacting the Authors

To reach the authors, please go to their blogs and click the Email link to send them an email.

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CHAPTER 1

A Quick Tour of Silverlight 4 Development

This is a recipes book, which means it is prescriptive, targeting specific scenarios that developers are likely to encounter. You don't have to read the chapters in order, though we did put some thought into chapter organization for readers who want to proceed that way. The Silverlight product team has been on a tear, shipping the fourth version in about two years, adding amazing new features sure to please developers and designers alike with each new version. Still, some developers and designers may be relatively new to Silverlight, and if you're among those folks, this chapter may be essential to help you get started. Otherwise, it's likely to be a helpful review. The recipe format follows this outline:

- *Title*: Description of the recipe
- *Problem*: The challenge that the recipe solves
- *Solution*: A short description of the approach
- *How It Works*: Detailed explanation of the approach
- *The Code*: An implementation of the described approach to solve the problem

The first sections of this chapter will provide a quick overview of Silverlight. Given the fast pace of the shipped product updates, we chose not to remove the background on Silverlight 2 when the .NET Framework for Silverlight was introduced or the Silverlight 3 highlights in order to provide context.

Getting Up to Speed with Silverlight

Silverlight is Microsoft's cross-browser, cross-platform, and cross-device plug-in for delivering the next generation of .NET Framework–based rich interactive applications for the Web. Silverlight runs on Windows in Internet Explorer 6 or higher, Mozilla Firefox, and Chrome build 1251 and higher. Silverlight also runs on the Apple Mac in both Safari and Firefox, as well as on Linux in Firefox as part of the Moonlight project (`www.mono-project.com/Moonlight`), a collaboration project between Novell and Microsoft to bring Silverlight to Linux.

Figure 1-1 shows a Silverlight application running in Firefox.

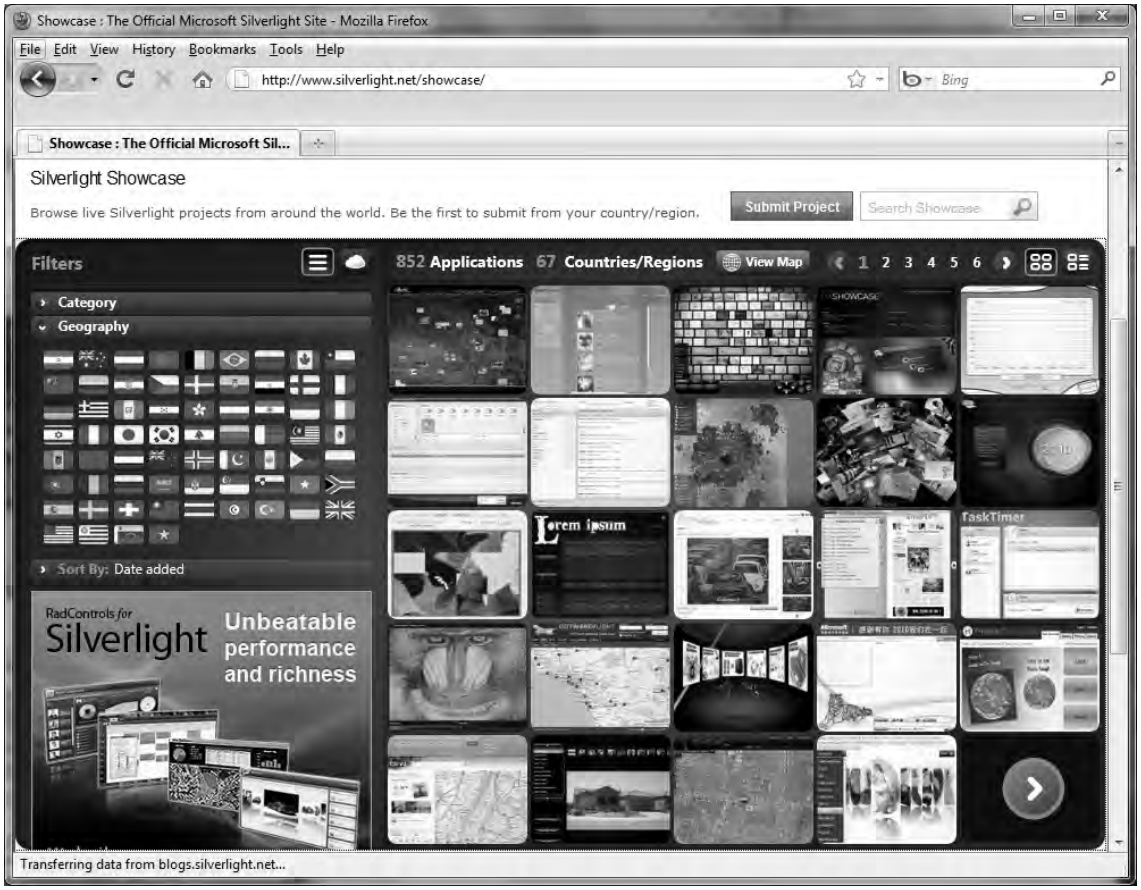

Figure 1-1. *Firefox running a Silverlight application*

Because Silverlight is a browser plug-in, the user is prompted to install the plug-in if it is not already present, which is the same behavior as similar technologies like Adobe Flash. Once the plug-in is installed (a 5MB file that takes about ten seconds on most Internet connections), Silverlight content can be downloaded and run.

Because Silverlight is client-side technology, Silverlight applications can be hosted on any backend system, just as any other web-based content such as HTML pages and JavaScript can be hosted from a Windows server, a Linux server, or any other web-serving technology.

Starting with Silverlight 2, you may be asking, "Did Microsoft port the .NET Framework to additional platforms?" The answer is both "yes" and "no." The full desktop and server versions of the .NET Framework runtime have not been ported to other platforms. However, the product team did encapsulate a tiny common language runtime (CLR) into the plug-in that is cross-browser as well as cross-platform (and even cross-device, with the announcement of Silverlight for Windows Phone and Silverlight for Nokia s60 devices).

What makes Silverlight so compelling is that much of the power and programmability of the .NET Framework is available within this relatively small 4.7-MB plug-in on Windows. Here is a summary of some your favorite .NET Framework namespaces available in Silverlight 2 and later:

- System
- System.Collections
- System.Collections.Generic
- System.Diagnostics
- System.Globalization
- System.IO
- System.Linq
- System.NET
- System.Reflection
- System.Runtime
- System.Security
- System.ServiceModel
- System.Text
- System.Windows
- System.XML

As you can see, Silverlight 2 packed a powerful .NET Framework base class library that continues to be available through Silverlight 4. Next, we highlight the enhancements added in Silverlight 3 followed by the enhancements added in Silverlight 4, which is the latest version covered in this edition.

Silverlight 3 Highlights

Silverlight 3, which was released in July of 2009, built on top of Silverlight 2 by introducing more than 50 new features, including support for running Silverlight applications out of the browser, dramatic video performance and quality improvements, and features that improve developer productivity. Some of the highlights include:

- Major media enhancements like H.264 video support
- Out-of-browser support, which allows web applications to run offline
- Significant graphics improvements including perspective 3-D graphics support and graphics processing unit (GPU) acceleration
- Improved developer and designer tools including a full editable and interactive designer for Silverlight that will be available in Visual Studio 2010 when it ships. You can still develop Silverlight 3 in Visual Studio 2008.

The next couple of sections provide more details on the areas of enhancement.

Major Media Enhancements

Media support was dramatically enhanced in Silverlight 3, including improved streaming capabilities in the Internet Information Services (IIS) Media Services extension called Smooth Streaming with support for live and on-demand true HD (720p or better) playback. Smooth Streaming dynamically detects and seamlessly switches the video quality media based on local bandwidth and CPU conditions. Silverlight 3 also includes true HD playback when viewing content in full-screen mode utilizing GPU acceleration at 720p+.

Silverlight 1 and 2 provided support for VC-1 and the WMA formats. Silverlight 3 added native support for MPEG-4 based H.264/Advanced Audio Coding (AAC) audio, enabling content distributors to deliver HD content to all supported platforms. In addition, Silverlight 3 added a new raw AV pipeline that can be extended to provide support for a wide variety of third-party codecs. This allows audio and video content to be decoded outside of the runtime environment.

Silverlight 3 includes built-in support for Digital Rights Management (DRM) powered by PlayReady Content Protection enabling in-browser DRM using Advanced Encryption Standard (AES) or Windows Media DRM.

Enhanced User Experience Rendering Capabilities

The product team enhanced programmability for rich user experiences in Silverlight 3 and later by including new perspective 3-D graphics, animation features, hardware-accelerated effects, and text improvements.

With bitmap caching, Silverlight 3 greatly improved rendering performance by allowing users to cache vector content, text, and controls into bitmaps. This allows background content that needs to scale but does not change internally to be cached for better performance. Silverlight 3 also added a Bitmap API that allows developers to write pixels to a bitmap object in order to perform tasks such as editing scanned documents or photos and creating special effects for cached bitmaps from elements displayed on the screen.

With support for perspective 3-D graphics, developers are no longer limited to simulated 3-D in a 2-D plane. You can now rotate or scale live content in space without having to author additional code.

Shaders are computer programs that execute on the GPU. Shaders have been an important part of game development for years. Windows Presentation Foundation (WPF) added support for Pixel Shader effects in .NET Framework 3.5 SP1. Shader support was added in Silverlight 3 and allows developers to incorporate amazing effects with relatively little effort.

Improved animation effects in Silverlight 3 helped to make animation more natural in appearance. Examples are spring and bounce, but you can also provide you own mathematical function to describe animation. Silverlight 3 also added much more efficient support for font rendering and text animation, as well as support for taking advantage of local fonts.

Support for application themes and control skinning were also incorporated in Silverlight 3. Styles can be applied applicationwide and can build on each other or be combined; you also have the ability to dynamically change styles at runtime. Controls can be more easily skinned and maintained outside of an application for easy sharing of style templates across applications.

Rich Internet Applications and Line-of-Business Enhancements

Silverlight 3 added an amazing range of new controls packaged with full source code, which in itself is a huge learning resource. Silverlight 3 included over 60 fully skinnable, customizable, and ready-to-use controls in the following categories:

- Charting and media
- Layout containers such as `DockPanel` and `Viewbox`
- A dialog to easily write files for offline support
- Support for multipage applications with built-in navigation
- New controls like `AutoCompleteBox`, `TreeView`, `DataForm`, and `DataPager`

The controls come with seven professionally designed themes available at the Expression Gallery at `gallery.expression.microsoft.com/en-us/`. The controls also ship with full source code for review and modification.

One of the most important additions to Silverlight for line-of-business (LOB) applications is the WCF RIA Services platform that provides a solid base for building *n*-tier data applications.

■ **Note** WCF RIA Services, formerly known as WCF RIA Services, has undergone tremendous changes since the initial CTP that shipped with Silverlight 3. This edition of the book is updated to work with the latest version of WCF RIA Services that targets Silverlight 4. While WCF RIA Services shipped as a beta for Silverlight 3 at PDC 2009, this version will not be carried forward to product release.

WCF RIA Services Data Support Improvements

Beyond additional controls, Silverlight 3 improved data support with the ability to bind data between elements without having to write additional code. As an example of element databinding, the zoom level for the new Bing Maps Silverlight Control can databind directly to the `value` property of a `Slider` control without writing any C# code.

The `DataForm` control can databind to a record or object and automatically create nested controls databound to individual fields of a database record or object properties. For two-way datasources, the `DataForm` can provide automatically generated edit support.

Silverlight 3 also added support for data validation that will automatically catch incorrect values and warn the application user with the built-in validation controls.

Browser Support

Silverlight 3 improved browser support with the navigation application model that allows bookmarking of XAML pages within a Silverlight 3 or later application. Pages are created individually by inheriting from `System.Windows.Controls.Page`, instead of `UserControl`, but are hosted within a `UserControl` element.

Silverlight 3 also made great strides in search engine optimization (SEO) challenges by utilizing business objects on the server combined with ASP.NET and site maps to automatically mirror database-driven RIA content into HTML that is easily indexed by Internet search engines.

Out-of-Browser Capabilities

The out-of-browser experience introduced in Silverlight 3 lets end users add Silverlight 3 applications to their local desktop without having to download an additional runtime or browser plug-in; the application can even be accessed when the user is not connected to the Internet. Internet connectivity is automatically detected, and applications can react intelligently to cache a user's data until the Internet connection is restored.

Out-of-browser support includes the ability to add a link to the application on the desktop or Start menu, enabling one-click access. Because offline Silverlight 3 applications are stored in the browser's local isolated cache and run within a sandbox, additional user privileges are not required to run the application.

Application maintenance is easy with the automatic update functionality built into the out-of-browser Silverlight support. When a user launches an out-of-browser Silverlight application, Silverlight automatically checks for new versions on the server and will update automatically if an update is found.

We've just touched on many of the improvements offered by Silverlight 3. For a full feature list comparison through Silverlight 4, please go to `silverlight.net/GetStarted/overview.aspx`.

Silverlight 4

Introduced as a beta at the Microsoft Professional Developers Conference in November 2009, just a few short months after the release of Silverlight 3, Silverlight 4 adds many new features in the following areas:

- Enhancements focused on business applications
- Improved developer tools support
- Enhancements focused on interactive user experiences
- Enhancements focused on the out-of-browser programming model

The next couple of sections provide details on the above four major areas of enhancement.

Business Application Development

Business application development is highly driven by control user elements. Silverlight 4 adds RichTextbox with support for hyperlinks, imaging, and editing as well as a new Masked textbox for complex field validation. The DataGrid includes sortable/resizable columns as well as the ability to copy/paste rows.

Business applications also tend to be highly data driven. WCF RIA Services provides a platform to build n-tier applications that include transactions, data paging, etc., as well as enterprise class networking and data access to server-side resources. In addition, databinding support gets better through support for data grouping/editing as well as inline string formatting within bindings.

Another major enhancement for building business applications is the Managed Extensability Framework (MEF) that provides a platform based on well known best practices for building large composible applications.

Other improvements that can enhance business applications are:

- Support for printing with the ability to specify exactly what part of the UI should be printed to hardcopy reports.
- A full set of forms controls with over 60 customizable and styleable controls.

- Support for 30 new languages including bi-directional text, right-to-left support, and support for complex scripts such as Arabic, Hebrew, and Thai.

Developer Tools

New in Visual Studio 2010 is a fully editable design surface that supports drag & drop data-binding and automatically bound controls with datasource selection. The editor includes full IntelliSense for XAML as well as the C# and VB languages. Also, project support for Silverlight 3 is no longer an add-on but instead is built in to Visual Studio 2010. You will need to install the Silverlight 4 Tools for Visual Studio 2010 for Silverlight 4 support.

Visual Studio 2010 also includes an improved property grid with custom editors for values like Grid Column and Row definitions, color Brushes, etc. The property grid also includes the ability to select a style from a drop-down menu that is populated with styles that were previously created in Expression Blend.

There are other editor enhancements such as the right-click Reset Layout command that allows the developer to reset All, Size, Alignment, or Margin properties to their default values.

Expression Blend 4 continues to evolve as a great tool for creating user experiences in conjunction with Visual Studio 2010.

Interactive User Experiences

Just take a look at the Silverlight.net showcase for examples of great user experiences available in Silverlight The examples run the gamut from media scenarios with HD video and Smooth Streaming to powerfully interactive LOB applications.

One of the most important enhancements in Silverlight 4 is that applications load faster and can run up to 200% quicker than the equivalent Silverlight 3 applications. You can realize these impressive improvements gains by simply upgrading to Silverlight 4. Here is a quick hit list of other user experience enhancements:

- New FluidUI Behaviors to quickly make applications more interactive
- Webcam and microphone support
- Local recording of audio and video
- Support for text copy/paste and drag-and-drop
- Support for mouse wheel scrolling
- Right-click menu support
- Multi-touch support enabling gesture and touch interactions
- Support for Multicast networking for more efficient / better performing Enterprise streaming

A feature not related to user experience but certainly of interest to content providers is support for content protection with H.264 media via PlayReady DRM. This includes Output protection so that protected content can only be viewed via a secure video connection.

Out-of-Browser Programming Model

Silverlight 3 introduced the ability to run Silverlight applications out-of-the-browser (OOB) on the desktop. Silverlight 4 builds on this base by adding additional support for sandboxed and trusted applications. Sandboxed applications are similar to OOB in Silverlight 3 with the standard cosent UI and access restrictions. Trusted applications introduced Silverlight 4 have a modified consent UI and can access native code on the machine directly.

The following features are available to Silverlight sandboxed applications:

- Host HTML content directly within an OOB application.
- Support "toast" notifications to communicate status to the user
- Support for offline DRM with PlayReady technology
- Control over OOB UI including window settings such as start position, size, and chrome

The following additional features are available in Silverlight trusted OOB applications:

- Read and write files to user specific folders such as MyDocuments, MyMusic, and MyVideos folder.
- Launch other desktop applications, such as loading a document in Word
- Enable COM automation so that a Silverlight OOB application can access system capabilities
- Allow cross-domain access without a security policy file
- Enhanced keyboard support in fullscreen mode

Silverlight and Visual Studio 2010

Outside of Expression Blend, tooling support has not been very rich in prior versions of Silverlight and Visual Studio. Starting with Visual Studio 2010, Silverlight becomes a first class citizen with support for both Silverlight 3 and Silverlight 4, including a full drag-and-drop visual designer, a fully functional Properties toolwindow, and a new Document Outline toolwindow as shown in Figure 1-2.

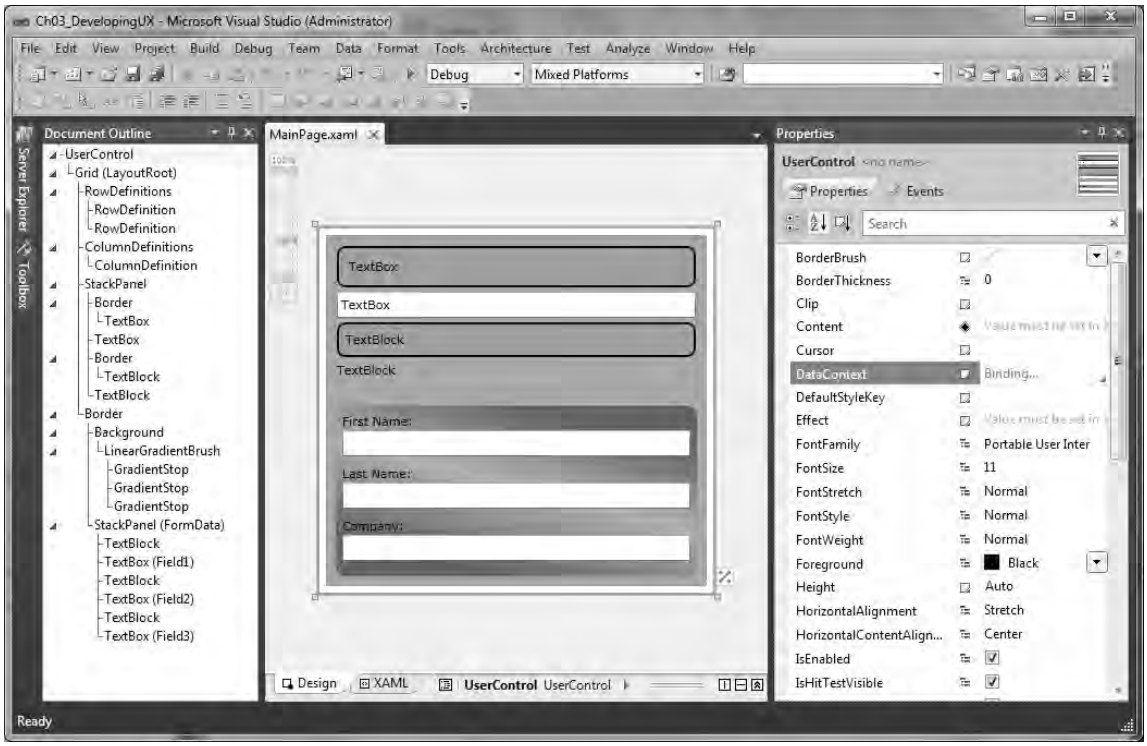

Figure 1-2. *Visual Studio 2010 Silverlight Tools Support*

The Document Outline view of the XAML shows a hierarchical Tree to help developers quickly find the desired control. Within the Visual Studio 2010 visual designer, you can right-click on the design surface to bring up a context menu that allows you to view the XAML as a tree in the Document Outline toolwindow. The context menu also has handy commands like Reset Layout that allow you to remove configured sizes, alignments, and margins if a set of controls are not laying out the way you want.

Visual Studio 2010Expression Blend 4Visual Studio 2010Expression Blend 4.

1-1. Setting Up the Silverlight 4 Environment

Problem

You need to set up a Silverlight 4 development and designer environment.

Solution

Uninstall any previous versions of Silverlight pre-release tools, runtimes, or tools that are installed. Install a version of Visual Studio 2010, Silverlight 4 Tools and SDK (which includes WCF RIA Services), the Silverlight toolkit, and Expression Blend 4 following the latest installation guidance at Silverlight.net.

How It Works

The steps listed at `Silverlight.net/GetStarted` cover the details, but the first step is to install a version of Visual Studio 2010.

■ **Note** Silverlight 4 is supported on Visual Studio 2010 Express.

At `Silverlight.net/GetStarted`, you can obtain Silverlight Tools for Visual Studio 2010, which includes the runtime (if not already installed), the project templates, debugging support, the SDK, and documentation files.

Install the Silverlight Tools to enable development of Silverlight 4 in Visual Studio 2010. The installation will want you to close any conflicting applications such as Internet Explorer; otherwise, a reboot may be required.

At the same URL, another tool is available called Deep Zoom Composer. This tool allows developers to prepare images for use with the Deep Zoom feature in Silverlight. Deep Zoom allows users to explore collections of super-high-resolution imagery, from a 2- or 3-megapixel shot from a digital camera to gigapixel scans of museum pieces, all without waiting for huge file downloads. The simple zooming interface allows users to explore entire collections down to specific details in extreme close-up, all with fantastic performance and smooth transitions. A great implementation of the Deep Zoom is the Hard Rock Café web site, where users can get up close to their huge collection of memorabilia (`memorabilia.hardrock.com`).

The next step is to install Expression Blend 4. This is an important tool in the application creation arsenal that is part of the Expression Studio product line. It provides a powerful graphic editing environment for designing user experiences. It also is the best tool to use for creating animations in Silverlight.

If you are a Microsoft Developer Network (MSDN) Premium subscriber, you can obtain Expression Blend from MSDN downloads. If you are not an MSDN Premier subscriber, you can download a trial version at `www.microsoft.com/expression/try-it/Default.aspx`. Even as a developer, you will want to have Expression Blend 4 installed along with Visual Studio 2010. If developers keep their source code in Microsoft Team Foundation Server, the designer will be able to check out and check in code directly with Expression Blend 4, which includes support for accessing source code control directly.

1-2. Installing Additional Silverlight-Related Services and Controls

Problem

You want to be able to take advantage of the additional services and controls available to Silverlight 4 developers such as WCF RIA Services, the Silverlight Toolkit, and the Bing Maps Silverlight Control.

Solution

Download and install the Silverlight 4 Toolkit, WCF RIA Services, and the Bing Maps Silverlight control.

How It Works

The Silverlight Toolkit is a collection of Silverlight controls, components, and utilities available separately from the normal Silverlight release cycle. The toolkit adds new functionality for designers and developers. It includes full source code, unit tests, samples and documentation for many new controls covering charting, styling, layout, and user input. It also provides an opportunity for the community to provide feedback. The Silverlight 4 Toolkit can be obtained at `www.codeplex.com/Silverlight`.

WCF RIA Services is a framework that provides a pattern for creating middle-tier and client-side classes to provide access to data. It takes a model-driven approach that starts with an updated ADO.NET Entity Framework model available in .NET Framework 4. A domain service is created based on the Entity Framework model that allows the developer to add custom operations and logic to interact with the model. WCF RIA Services then generates client-side access code that combines with custom controls to allow you to easily create data-driven applications in Silverlight 4. Download the Microsoft WCF RIA Services at .robcamer-PUT LINK HERE WHEN AVAILABLEs

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■ **Note** Please check Microsoft's site often for important product updates.

The Bing Maps Silverlight control is a native Silverlight control that provides very smooth panning and zooming functionality. It supports all the things you would expect from a Bing Maps control, such as street view, aerial view, layers, icons, and overlays, providing a powerful way to display geospatially referenced data within the Silverlight rich presentation framework. The Bing Maps Silverlight control can be downloaded (after registering)at `www.microsoft.com/downloads/details.aspx?`

`displaylang=en&FamilyID=beb29d27-6f0c-494f-b028-1e0e3187e830`

1-3. Understanding the Structure of a Silverlight Solution

Problem

You need to understand the structure of a Silverlight 4 solution and projects.

Solution

Create a new Silverlight 4 application in Visual Studio, and then review the solution and project files.

How It Works

Once the Silverlight 4 Tools are installed and help is configured, open Visual Studio 2010, choose File ➤ New Project, and click the Silverlight folder to see the available project templates. Six templates are available: Silverlight Class Library, Silverlight Application, Silverlight Business Application, Silverlight Navigation Application, WCF RIA Services Class Library, and Silverlight Unit Test Application (as shown in Figure 1-3).

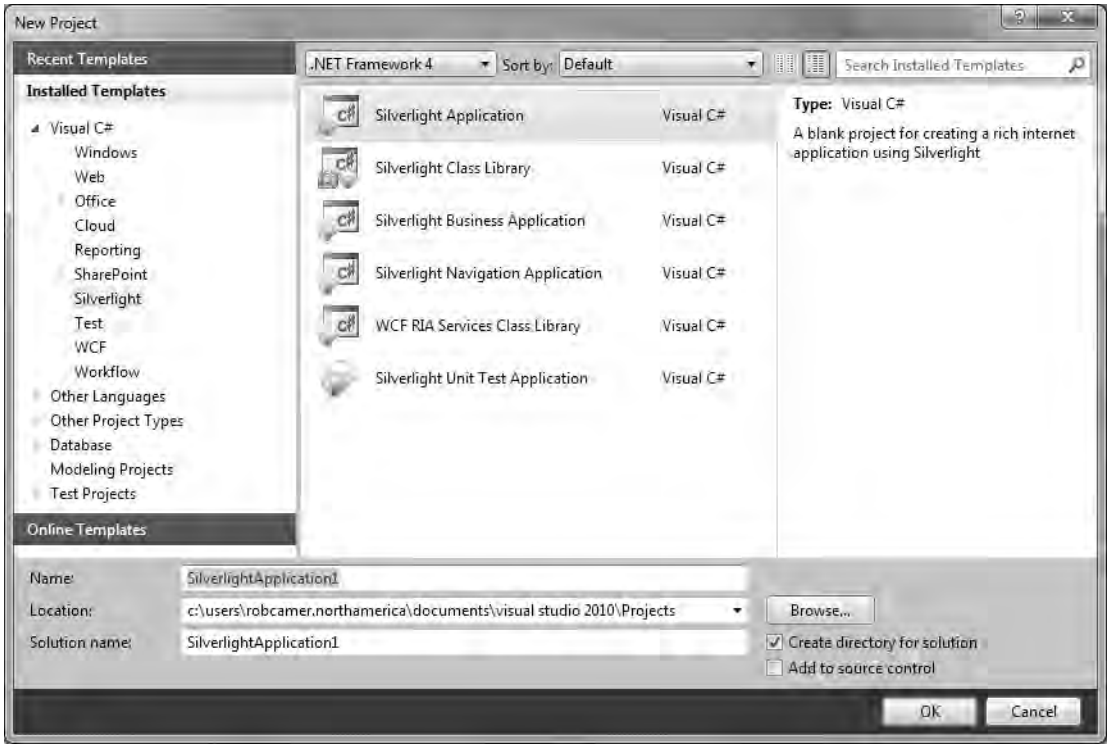

Figure 1-3. *Available Silverlight 4 Projects in Visual Studio 2010*

The Silverlight Class Library project template generates a class library project that you can use to separate Silverlight 4 application assets into additional assemblies that can be shared by multiple applications.

The Silverlight Application project template is what developers start with to create a basic Silverlight application, which begins with up to two projects: one containing the Silverlight application project and another optional project containing web pages to host the Silverlight application for testing.

You can also create a Silverlight application that has just the Silverlight application without a separate web project. In this case, Visual Studio will dynamically create a test page for the control. We recommend starting out with an actual web project, so you can see how to host Silverlight applications in web pages, but we cover both options in this recipe.

You can also add Silverlight applications to an existing Visual Studio solution. The project wizard will ask you whether you want to add test pages to the existing web project (if there is one), which makes it easy to add new applications to an existing Visual Studio web solution. If there isn't an existing web project in the Visual Studio solution, the project wizard will prompt you to create one.

The third project template available in Silverlight 4 is called Silverlight Business Application. When you select this template, it will automatically create a new web application as well as a new Silverlight application. This is one of the more complex starter projects targeting LOB application developers. It covers WCF RIA Services support, including authentication and user registration. WCF RIA Services developers build n-tier Silverlight applications. This is a great project template to start with when building LOB applications as covered in Chapter 9.

The fourth project template available in Silverlight 4 is called Silverlight Navigation Application. When you create a new application with this template, it starts out with the same options as when creating a regular Silverlight Application and includes up to two projects as well. The difference is that the new Silverlight Navigation Application supports views to allow easy navigation between application forms. This template also provides support for the browser Back and Forward buttons, as well as support for bookmarking individual application views in browser favorites. We'll cover this new application model in more detail in Chapter 6.

The fifth project template available in Silverlight 4 is WCF RIA Services Class Library. This allows you to separate WCF RIA Services into separate class libraries that can be shared. We cover WCF RIA Services in Chapter 9.

The sixth project template available in Silverlight 4 is the Silverlight Unit Test Application project template. Unit testing is an important tool in writing high quality code and this template provides a starter project to help you add unit testing to your Silverlight 4 application. We cover unit testing in Chapter 2.

The Code

When you create a new Silverlight application project, type a name, select the project location, and then click OK. The New Silverlight Application dialog appears (see in Figure 1-4).

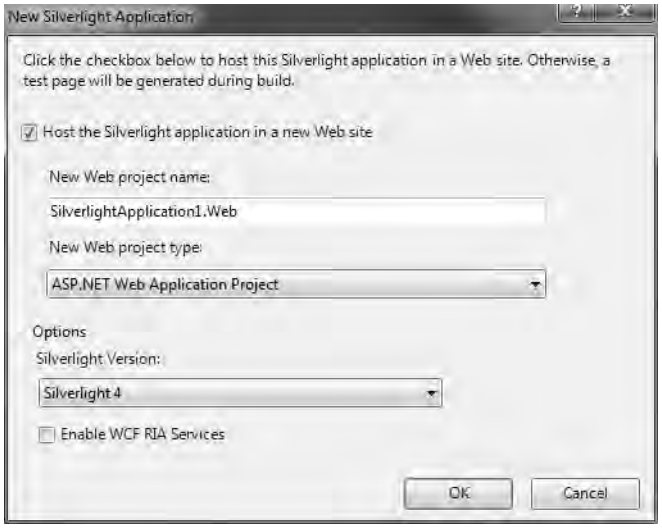

Figure 1-4. *The New Silverlight Application dialog*

Notice in Visual Studio you have the option to choose which version of Silverlight (either Silverlight 3 or Silverlight 4) you want to use for a project. You can also choose the web project type, which can be an ASP.NET Web Application Project, ASP.NET Web Site, or ASP.NET MVC Web Project. The first two options are pretty familiar to developers already. The new ASP.NET MVC Web Project introduced in .NET Framework 4 adds a new programming model for ASP.NET web applications based on the popular Model View Controller pattern. For more information please refer to "Introducing .NET 4.0: with Visual Studio 2010" published by Apress.

The default option is to add a new web application to the solution for hosting the control. This option creates a web project for you with two pages, an ASPX page and an HTML page, that are both automatically configured to host the Silverlight application.

When you opt for adding the web site, Silverlight defaults to a web project type of ASP.NET Web Application Project. If you instead select ASP.NET Web Site, you get a simple file-based web project. We prefer to stick with either the ASP.NET Web Application Project or the ASP.NET MVC Project because they allow more project configuration options such as specifying a static port for the web site. This is handy when you're creating web services and want to keep the port number consistent. You can choose the name for the test web site as well. Also, the web site properties include a Silverlight Applications tab that links the Silverlight project to the web site, copying the output to the default `ClientBin` folder, but you can customize the location in the web site.

After the project is created, if you go into the web site's properties dialog and click the Silverlight Applications tab, you will see the Change button, which allows you to specify that you would like to use configuration specific folders. This option lets you specify if you want to copy the `.xap` file to a configuration-specific (debug, release, or custom configuration) subfolder of the build's target folder (`ClientBin`) or simply copy the chosen build configuration (debug or release) into `ClientBin` directly.

The output of a Silverlight application is a XAP file. It contains the assemblies, manifest, and other output files that are loaded by the Silverlight 4 plug-in to execute the application. The XAP file is actually just a ZIP file renamed with the `.xap` extension, so you can crack one open to see what is inside by simply changing the extension to `.zip`.

If you uncheck the "Host the Silverlight application in a new Web site" option in the New Silverlight Application dialog, a web project is not created. This option results in a solution with a single project containing the Silverlight control. When you run the application, an HTML page is automatically generated that hosts the application. Our preference is to create a separate web application project and not use the dynamically generated HTML test page option, but it is good to have options.

Once you've chosen the Silverlight Application option to have a separate project-based web site in the file system and you've updated the name for the web site project, click OK to create the initial solution. Figure 1-5 shows the initial project layout in Solution Explorer.

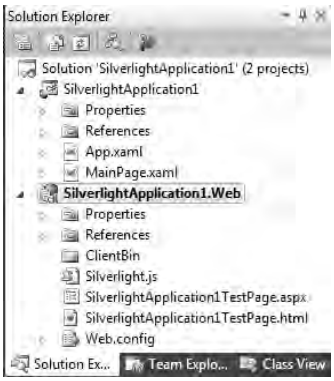

Figure 1-5. *The Silverlight 4 initial project layout*

The Silverlight application project consists of two files: `App.xaml` and `MainPage.xaml`. There are also corresponding code-behind files: `App.xaml.cs` and `MainPage.xaml.cs`. The class in the `App.xaml` file serves as the start-up object for the Silverlight application. We created a Silverlight application project named "1.3 Understanding the Structure of a Silverlight Solution" that is based on the same application template. Listings 1-1 and 1-2 show the initial `App.xaml` file and its code-behind, `App.xaml.cs`, respectively.

Listing 1-1. *Recipe 1-3's App.xaml File*

```
<Application xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
             xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
             x:Class="Ch01_IntroToSilverlight.Recipe1_3.App"
             >
    <Application.Resources>

    </Application.Resources>
</Application>
```

Listing 1-2. *Recipe 1-3's Initial App.xaml.cs Class File*

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Net;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Documents;
using System.Windows.Input;
using System.Windows.Media;
using System.Windows.Media.Animation;
using System.Windows.Shapes;
namespace Ch01_IntroToSilverlight.Recipe1_3
{
  public partial class App : Application
  {

    public App()
    {
      this.Startup += this.Application_Startup;
      this.Exit += this.Application_Exit;
      this.UnhandledException += this.Application_UnhandledException;

      InitializeComponent();
    }

    private void Application_Startup(object sender, StartupEventArgs e)
    {
```

```
      this.RootVisual = new MainPage();
    }

    private void Application_Exit(object sender, EventArgs e)
    {

    }
private void Application_UnhandledException(object sender,
ApplicationUnhandledExceptionEventArgs e)
    {
      // If the app is running outside of the debugger then report the exception using
      // the browser's exception mechanism. On IE this will display it a yellow alert
      // icon in the status bar and Firefox will display a script error.
      if (!System.Diagnostics.Debugger.IsAttached)
      {

        // NOTE: This will allow the application to continue running after an exception has
been thrown
        // but not handled.
        // For production applications this error handling should be replaced with something
that will
        // report the error to the website and stop the application.
        e.Handled = true;
        Deployment.Current.Dispatcher.BeginInvoke(delegate { ReportErrorToDOM(e); });
      }
    }

    private void ReportErrorToDOM(ApplicationUnhandledExceptionEventArgs e)
    {
      try
      {
        string errorMsg = e.ExceptionObject.Message + e.ExceptionObject.StackTrace;
        errorMsg = errorMsg.Replace('"', '\'').Replace("\r\n", @"\n");

        System.Windows.Browser.HtmlPage.Window.Eval("throw new Error(\"Unhandled Error in
Silverlight Application " + errorMsg + "\");");
      }
      catch (Exception)
      {
      }
    }
  }
}
```

Both files contain partial classes for the `Ch01_IntroToSilverlight.Recipe1_3.App` class that inherits from the `System.Windows.Application` class. Notice at the top of `App.xaml` in the `<Application>` element two namespaces are declared that are required for Silverlight 4 development. Also, in the `<Application>` element tag is an `x:Class` attribute linking the `App.xaml` markup file to the `App.xaml.cs` code-behind file with the related partial class. The `App.xaml` file is a good place to store applicationwide resources such as styles and templates, which we cover in Chapters 4 and 5.

The `App.xaml.cs` class file implements methods of the `Application` class, such as the constructor where events are wired up and `InitializeComponent()` is called to process the XAML markup. The `App_Startup` event sets the visual root to the `Page` class defined in `MainPage.xaml` and `MainPage.xaml.cs`. `Application_Exit` is implemented as a placeholder for the developer to add logic needed to handle the exit process. Finally, `Application_UnhandledException` is implemented to provide a basic top-level exception handler event. In Silverlight 4, it is somewhat enhanced with this line of code in `Application_UnhandledException` method:

```
Deployment.Current.Dispatcher.
BeginInvoke(delegate { ReportErrorToDOM(e); });
```

It calls the method ReportErrorToDOM to display an error message in the browser but allows the application to continue running, which is helpful during development.

All of the UI and execution logic for the Silverlight 4 application exists in the `MainPage` class XAML and code-behind class file. Listings 1-3 and 1-4 show the `MainMainPage.xaml` file and its code-behind, `MainMainPage.xaml.cs`.

There is a lot of code in these listings that we do cover in detail here, since this is an introductory chapter, but we wanted to demonstrate more than a simple "Hello World" application when you run the application. Most of the code was generated by Expression Blend 4 to produce the animation, which we cover in detail in Chapter 3. We also provide an overview of Expression Blend 4 in the next recipe.

Listing 1-3. *Recipe 1-3's MainMainPage.xaml File*

```
<UserControl x:Class="Ch01_IntroToSilverlight.Recipe1_3.MainPage"
    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"
    mc:Ignorable="d"
    d:DesignHeight="300" d:DesignWidth="400">
  <Grid x:Name="LayoutRoot" Background="White">
    <TextBlock Text="Hello from Silverlight 4!!!" />
  </Grid>
</UserControl>
```

Listing 1-4. *Recipe 1-3's Main MainPage.xaml.cs Class File*

```
using System.Windows.Controls;

namespace Ch01_IntroToSilverlight.Recipe1_3
{
  public partial class MainPage : UserControl
  {
    public MainPage()
```

```
    {
      InitializeComponent();
    }
  }
}
```

Both files contain partial classes for the `Ch01_IntroToSilverlight.Recipe1_3.MainPage` class that inherits from the `System.Windows.Controls.UserControl` class. At the top of `MainMainPage.xaml` in the `<UserControl>` element, notice that two namespaces are declared; these are required for Silverlight 4 development. Also in the `<UserControl>` element tag is an `x:Class` attribute linking the `MainMainPage.xaml` markup file to the `MainMainPage.xaml.cs` code-behind file with the related partial class. The `MainMainPage.xaml` file is a good place to store resources that apply to an entire page, such as styles and templates, which we cover in Chapter 2.

The project settings for the Silverlight 4 application have a Silverlight tab, as shown in Figure 1-6.

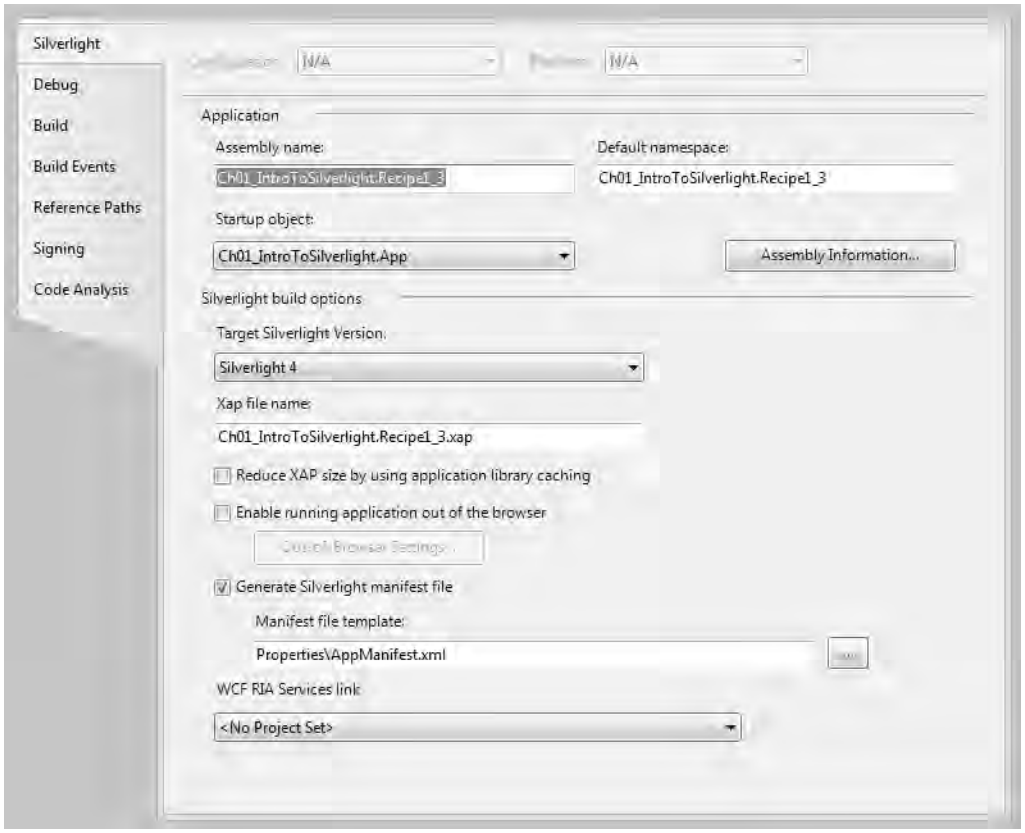

Figure 1-6. *The Silverlight 4 application settings tab in the Silverlight project settings*

In addition to the properties typically available for a .NET application are the XAP file name and an option that lets you specify whether you want to generate a Silverlight manifest file. Silverlight 3 introduced two additional settings:

- *Reduce XAP size by using application library caching*: Caches framework assemblies on the client in order to improve performance
- *Enable running application out of browser*: Enables out-of-browser capabilities, which is covered in detail in Chapter 7

In Visual Studio 2010 you can also choose the target Silverlight version via the property shown in Figure 1-6.

The other project in the solution is the `TestWeb` web project. The web project consists of two pages per Silverlight application. One file is an ASPX page, and the other is an HTML page. So the corresponding files for the Silverlight application we just covered are `Recipe1.3TestPage.aspx` and `Recipe1.3TestPage.html`. Both pages instantiate the Silverlight application using an `<object>` tag. Here is an example of the HTML markup from the HTML page:

```
<object data="data:application/x-silverlight-2,"
  type="application/x-silverlight-2"
  width="100%" height="100%">
  <param name="source"
   value="ClientBin/ Ch01_IntroToSilverlight.Recipe1_3.xap" />
  <param name="onError" value="onSilverlightError" />
  <param name="background" value="white" />
  <param name="minRuntimeVersion" value="4.0.50303.0" />
  <param name="autoUpgrade" value="true" />
  <a href="http://go.microsoft.com/fwlink/?LinkID=149156&v
    =4.0.50113.0" style="text-decoration: none">
    <img src="http://go.microsoft.com/fwlink/?LinkId=161376"
     alt="Get Microsoft Silverlight"
      style="border-style: none" />
  </a>
</object>
<iframe id="_sl_historyFrame" style="visibility: hidden;

 height: 0px; width: 0px; border: 0px"></iframe>
```

The `<object>` tag references the XAP file as well as some client-side JavaScript events, such as `onSilverlightError` as parameters on the OJBJECT tag. Also notice the `iframe` named `_sl_historyFrame`. This `iframe` is required to provide support for integration with browser navigation bookmarking and deep linking, which we cover in Chapter 6.

Figure 1-7 shows the project settings for the `TestWeb` web project. The tab shown in Figure 1-7 lists the Silverlight projects available in the solution, where the XAP file should be copied to (the `ClientBin` folder), as well as whether there should be configuration-specific folders under the `ClientBin` folder for debug or release versions of the Silverlight application.

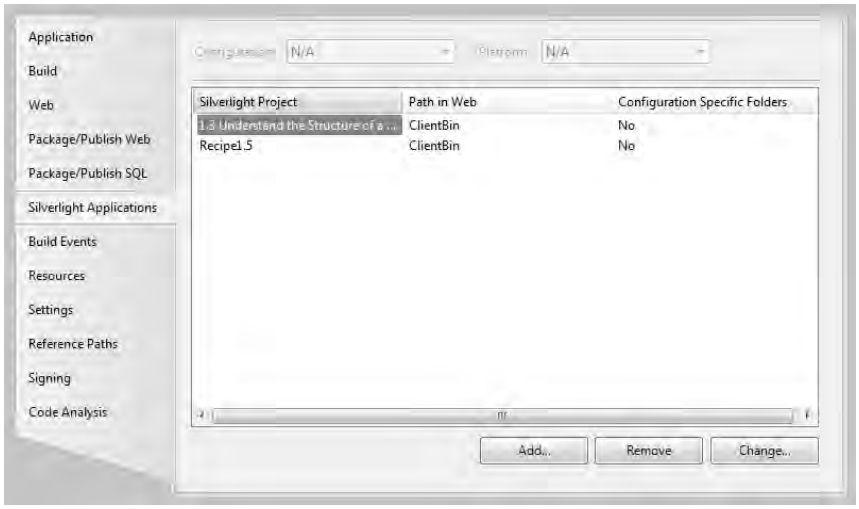

Figure 1-7. *The Silverlight Applications tab in the web project settings*

Notice also in Figure 1-7 the Add, Remove, and Change buttons. The Add button allows you to easily add a Silverlight application to a web project. Let's say you have an existing ASP.NET application, and you now want to add to a Silverlight application. Open the project settings for the web project, and click the Add button to display the Add Silverlight Application dialog shown in Figure 1-8.

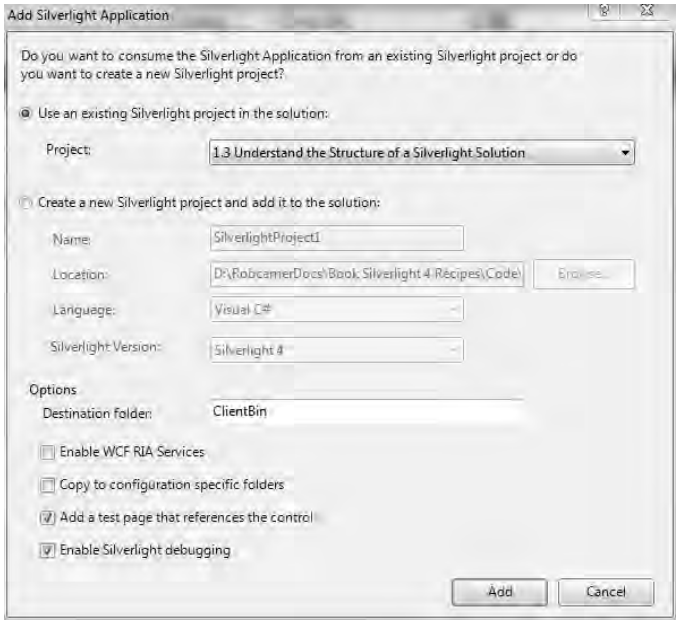

Figure 1-8. *The Add Silverlight 4 Application dialog*

You have the option to create a new Silverlight 4 project or add an existing project from the prepopulated Project combo box, as well as options to configure related settings, such as specifying the destination folder, including configuration-specific folders, adding test pages, and enabling Silverlight debugging.

When you click the Change button on the Silverlight Applications tab, a dialog displays with the message shown in Figure 1-9.

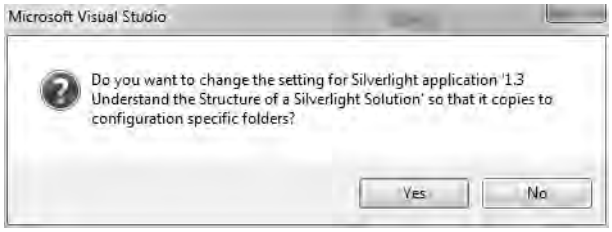

Figure 1-9. *Clicking the Change button allows you to switch to using configuration-specific folders for debug/release versions.*

This dialog allows you to switch to using configuration files for debug, release, or custom configuration versions. When you click the Remove button on the Silverlight Applications tab, you'll see the dialog shown in Figure 1-10.

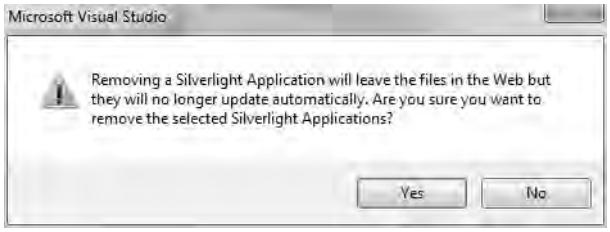

Figure 1-10. *Clicking the Remove button opens this dialog, which lets you remove a Silverlight application from a web project.*

1-4. Understanding the Developer/Designer Workflow

Problem

You need to understand the developer and designer workflow for creating Silverlight applications.

Solution

Learn the capabilities of the Visual Studio 2010 and Expression Blend 4 environments. Depending on the type of application, determine whether a dedicated UI designer is required for the project or whether the developer will handle the UI development and the coding. If the application requires a dedicated designer due to UI requirements, introduce the designer to Expression Blend 4.

How It Works

With any application development effort, many roles—such as project manager, architect, developer, tester, and designer—are involved. Depending on the target application, the role of the designer can greatly vary in the amount of effort required. For an intranet LOB application, the designer may not have much more of a role other than letting developers know where the required corporate application standard resources, such as Cascading Style Sheets (CSS) and images, are located. In a public-facing rich media application, a designer may be heavily involved from conception of the application all the way through development and user experience testing.

For Silverlight, the same generalizations apply. You can build powerful desktop-like applications within Silverlight that may not require a dedicated designer. Or, you can build a Rich Internet Application that requires dedicated designer skills from start to finish.

The Tools

Silverlight developers do not have to become full-fledged designers. Developers and designers can work independently in an integrated environment with full source code control access from both Visual Studio 2010 and Expression Blend 4. However, from a practical standpoint, developers may want to become familiar with Expression Blend 4.

As we mentioned above, Visual Studio 2010 includes a full-featured designer surface Visual Studio 2010 with first-class IntelliSense support for editing XAML. Expression Blend 4 is a great tool for designing Silverlight 4 UIs, especially when the application includes animations

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■ **Note** You can open a solution in Expression Blend 4 from within Visual Studio by right-clicking any `.xaml` file and selecting Open in Expression Blend from the context menu.

Expression Blend 4 provides rich designer support that includes drag-and-drop control editing, visual creation of animation timelines, and a rich properties window. Expression Blend 4 includes full IntelliSense when editing markup.

Figure 1-11 shows the beginnings of a Silverlight application in Expression Blend 4.

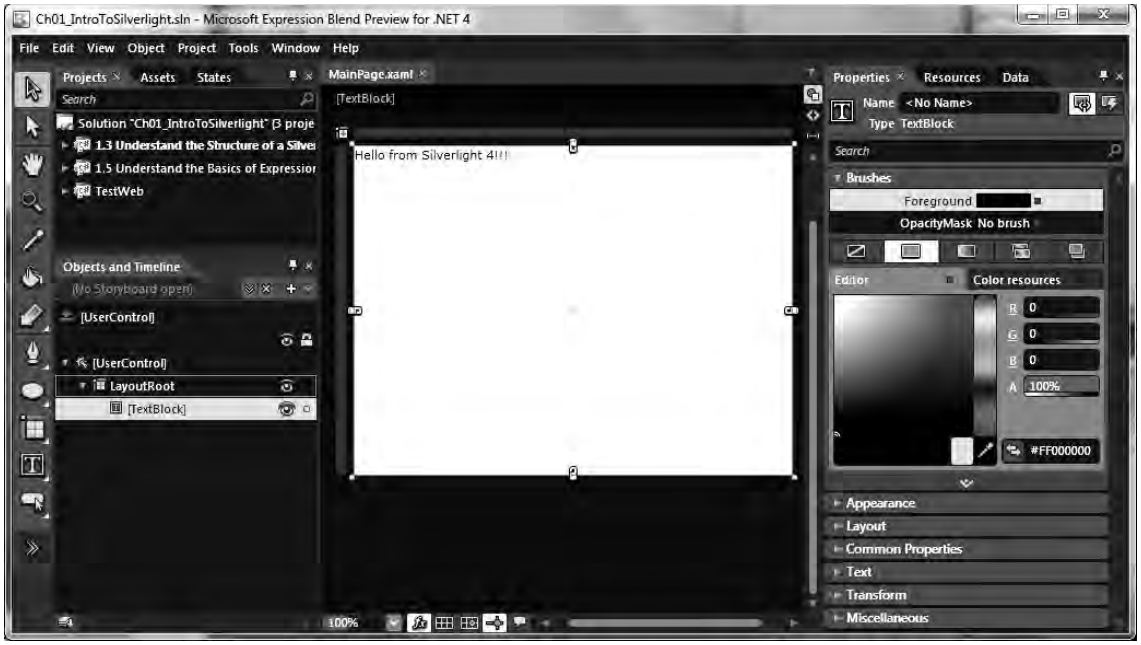


Figure 1-11. *A Silverlight 4 application in Expression Blend 4*

Expression Blend 4 includes a rich design surface. Also, the Properties window on the right side of the screenshot provides full access to an element's properties. As in Visual Studio 2010, there is a XAML tab that is available on the top right side of the Artboard by clicking the button with the caption "< >" that lets you view the underlying markup in Expression Blend 4 with full IntelliSense support.

The Process

After the above review in this recipe, the developer/designer workflow should start to take shape in your mind. UI development is primarily done in Expression Blend 4 and coding in Visual Studio. Both Expression Blend 4 and Visual Studio 2010 can create the initial Silverlight 4 project, but the UI design will most likely start out in wireframe diagrams realized in Adobe Creative Suite or Expression Design and then be exported to XAML. There are a few third-party converters available that will export from Adobe tools to XAML:

- `www.mikeswanson.com/XAMLExport/`
- `www.infragistics.com/design/Fireworks_XAML_Exporter.aspx`

Expression Blend 4 also has two new menu items under File that will import from Adobe Photoshop or Illustrator.

Figure 1-12 provides a visual representation of this iterative development and design process.

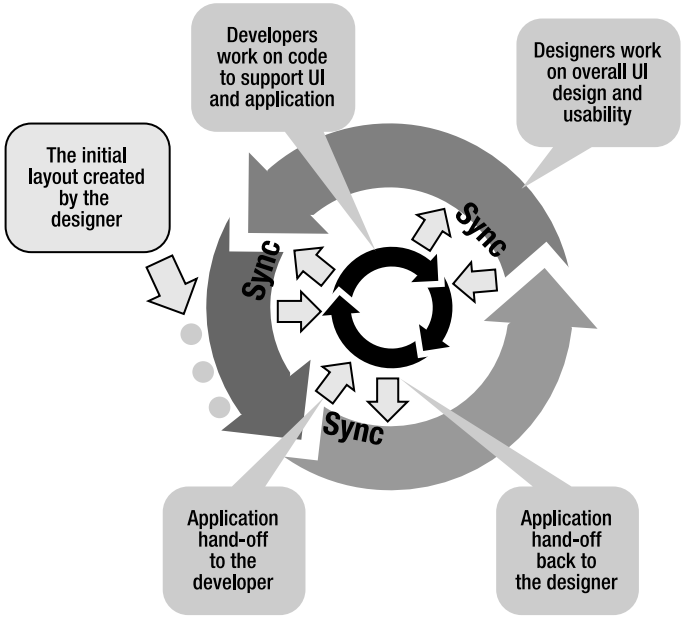


Figure 1-12. *The developer/designer workflow*

For a highly interactive, rich UI, the designer may want to perform the initial layout of the application, as shown in Figure 1-12, by developing the initial UI concepts. Unlike when building mock-ups in an image-editing tool, what is great about Silverlight 4 and Expression Blend 4 is that the mock-up of a visually compelling UI can become the foundation of the actual UI. As Figure 1-12 shows, designers can focus on UI design and usability in the outer loop, while the developers in the inner loop focus on writing the code behind the UI and the rest of the application. Periodic synchronization points allow the application to be fully integrated between the developer and designer workflows with minimal overhead because of the common underlying markup.

■ **Note** Expression Blend 4 also includes SketchFlow, which allows designers and developers to build rich and dynamic prototypes very quickly.

As an alternative to starting the development process, a developer can start to build the basic UI with Visual Studio 2010 and then hand off the UI to a designer, who then refines the application's layout, adding animation and control templates. This workflow would make sense if you are migrating an existing .NET application to Silverlight: the developer must first get the code working within the Silverlight programming model, make adjustments, and lay out a basic UI.

Developers can also open a Silverlight application in Expression Blend 4 from Visual Studio 2010 by right-clicking the `any .xaml` file and selecting Open in the context menu. Doing so opens the entire solution in Expression Blend 4.

The synchronization illustrated in Figure 1-12 occurs either manually by sharing folders or via source-code integration available in both Visual Studio and in Expression Blend 4. With Expression Blend 2, designers had to use the stand-alone Team Foundation Server client to check files in and out of source code control. Now with Expression Blend 3 or later, designers are even more integrated into the design/development process.

A point to emphasize is that, unlike with other technologies, the output from the rich design tool, XAML, is what actually is compiled into the application. For comparison purposes, in Windows Forms development, a designer cannot create a rich, highly visual control in the technology used by the developer directly. Instead, the designer might use a drawing tool such as Adobe Photoshop or Microsoft PowerPoint to create a mock-up. The developer starts from scratch using separate tools and technology and attempts to create a custom control that renders like the mock-up. This creates a developer/designer disconnect, or lag, between design changes and coding implementation because the designer and developer work in separate toolsets.

XAML technology enables you to use a wide range of tools since it is well-formed XML. The fact that XAML can be compiled directly permits the developer to take the output from the design team and directly utilize it in the application, completely removing the lag between the designer and the developer.

1-5. Understanding the Basics of Expression Blend 4

Problem

You need to understand how to create a UI in Expression Blend 4.

Solution

Learn the basics of the Expression Blend 4 environment.

How It Works

As mentioned previously, Expression Blend 4 is a visual design tool that generates XAML. It is a powerful tool that is worthy of a book dedicated to completely understanding its environment. While this book is not exclusively about Expression Blend 4, we will cover the basics of the environment to help communicate steps when performing tasks visually.

We create a simple application that animates changing a square to circle below in the code section. We use it here to help us explain Expression Blend 4 functionality.

Visual Studio developers may find Expression Blend 4 to be a dramatic departure from what they are familiar with in Visual Studio. However, developers will want to know how to work in Expression Blend 4 for maximum productivity.

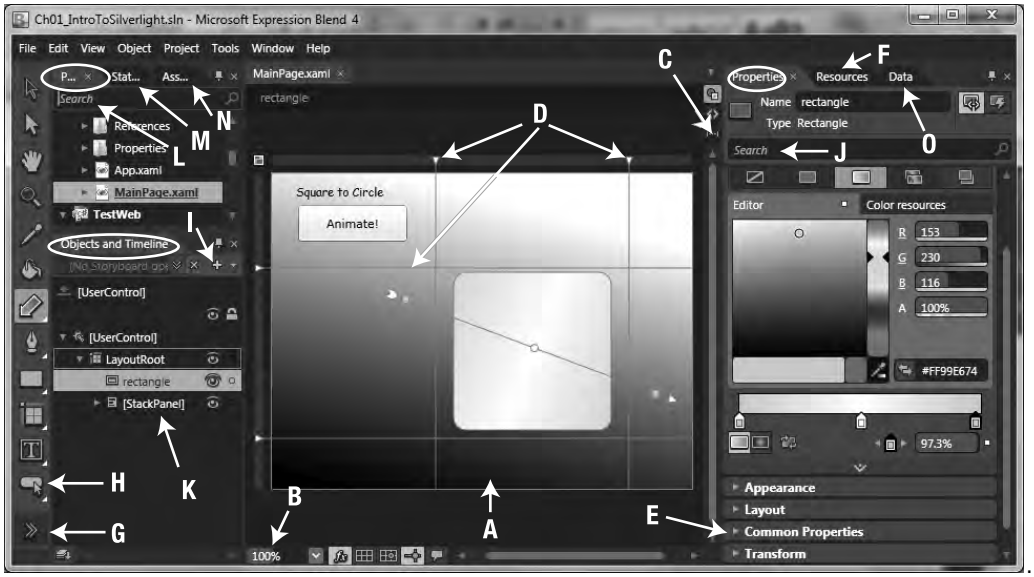


Figure 1-13. *Navigating Expression Blend 4*

Figure 1-13 shows Expression Blend 4 with a simple project opened in order to provide an overview of the tool's major features. The project is a simple animation: when the button is clicked, an animation is kicked off that turns the square into a circle and then back into a square again. Table 1-1 provides a quick description of the annotated points.

Table 1-1. *Expression Blend 4 Features*

Annotation	Description
A	This is the designer surface, also known as the Artboard, which supports drag-and-drop editing.
B	Use this to zoom in or out of the designer surface as needed. Zoom out to see the entire application, or zoom in close to perform precise visual editing.
C	Tabs allow you to switch between the design surface, the XAML markup, or split view to see both the design surface and XAML.
D	These represent grid lines for laying out controls in the UI. When you move the mouse over the edge of the Grid control, the UI provides a visual cue that you can add a grid line.
E	This is the Properties window; here, several sections are collapsed so that they fit in the view.

Table 1-1. *Continued*

Annotation	Description
F	The Resources window lists available resources such as styles and templates. We cover these resources throughout this book, particularly in Chapters 2, 4, and 5.
G	Clicking this chevron brings up the Asset Library, where you can search for a control if you are not sure what the icon is or whether it is visible. The Asset Library is similar to the Visual Studio toolbar area where controls are listed.
H	The little arrow in the lower-right corner under some of the controls shown in the Asset Library is a visual cue that related controls are available for quick access. Clicking and holding the arrow brings up a small window listing the related controls. Click a control and it becomes the visual control for that section of the Asset Library.
I	Clicking this button creates a new `Storyboard` object. You use storyboards to design animations. We talk more about storyboards later in this chapter.
J	This is the extremely useful Search text box. Type a property name, and Expression Blend 4 will search the list of properties available for the control and bring the property into view for easy access. Be sure to clear the Search text box when you've finished. Otherwise, it can be confusing when you switch objects and the filter entered in the Search text box does not apply, resulting in a blank properties window.
K	The XAML visual tree is listed in this area of Expression Blend 4. The yellow frame around the LayoutRoot control indicates that the LayoutRoot control is the active element. This means that double-clicking a control in the Asset Library will insert that control as a child to the LayoutRoot control. Double-clicking another control, such as the StackPanel, would make that one the active element and the insertion point for child controls dragged on the visual design surface.
L	New in Expression Blend 4, this extremely useful Search text box allows you to find project files quickly.
M	The Visual State Manager has an improved user interface in Expression Blend 4. More states for controls are displayed with a warning indicator when a property has been changed in more than one state group.
N	New in Expression Blend 4, the Assets tab provides fast access to project, controls, styles, behaviors, and effects assets in a nicely organized list.
O	New in Expression Blend 4, the Data tab provides designers with the ability to create either a sample or live data source that makes it easier to design a data binding UI.

The Code

At first glance, Expression Blend 4 looks a lot like Visual Studio with a Projects tab (circled in Figure 1-13) that lists the solution, project, and files as in Visual Studio (see Figure 1-14).

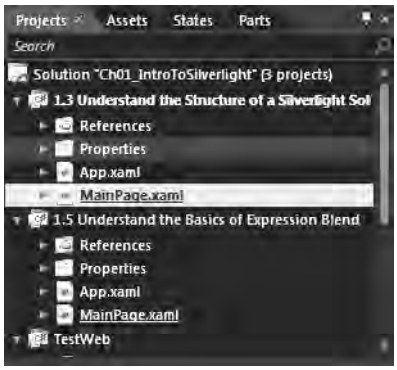


Figure 1-14. *Expression Blend 4's Projects tab*

In Figure 1-13, the letter I points to a button that lets you create a new `Storyboard` object. When you click that button, you are prompted to provide a name or key for the storyboard in the Create Storyboard Resource dialog. Click OK to put Expression Blend 4 into time line recording mode, which is shown in Figure 1-15.

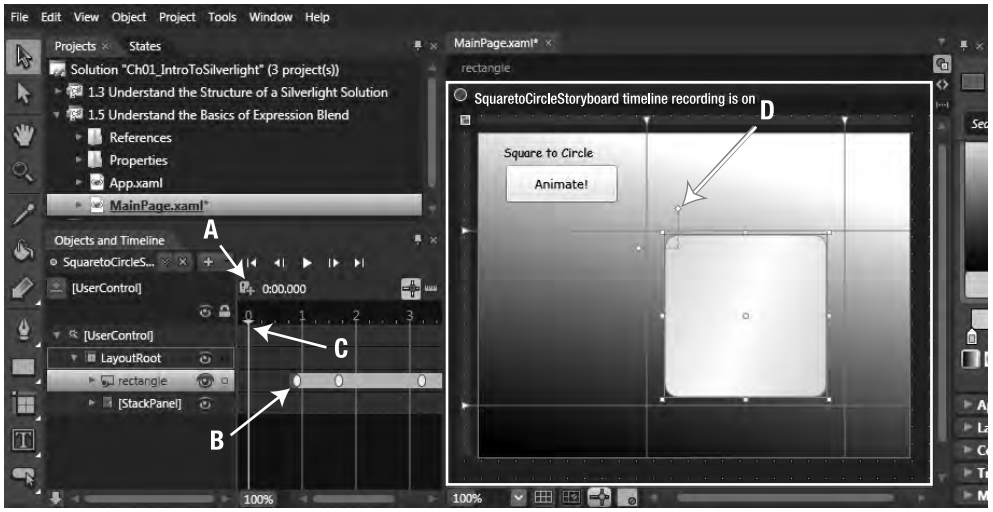


Figure 1-15. *Expression Blend 4 with time line recording on*

When Expression Blend 4 is in time line recording mode, you can visually create animations. We are now going to create an animation that has four keyframes. We animate a `Rectangle` object in the shape of a square that will transition from a square appearance to a circle appearance between the first and second keyframes. The animation will keep the circle appearance between the second and third keyframes and finally transition from the circle appearance to a square appearance between the third and fourth keyframes.

To create this animation, click the Record Keyframe button labeled letter A in Figure 1-15. This creates a keyframe wherever the yellow vertical line in the time line is located. The letter B in Figure 1-15 points to the keyframe we create at the start time of 0 seconds on the time line. We then drag the yellow vertical time line pointed to by the letter C to 1 second. Clicking the Record Keyframe button creates a keyframe at that point in the time line where the yellow vertical line sits, as shown in Figure 1-16.

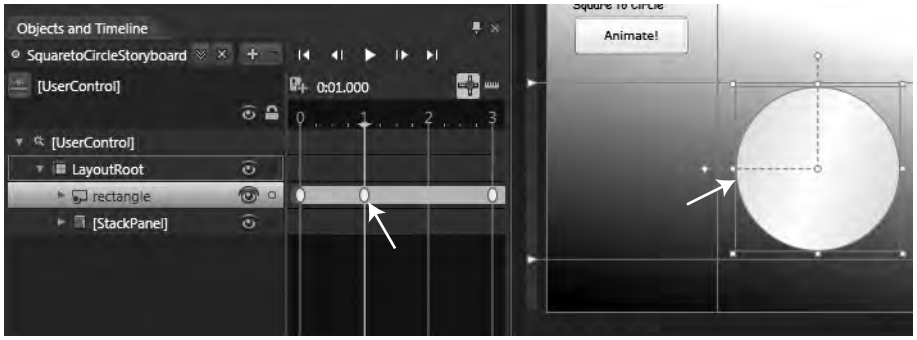


Figure 1-16. *Adding a keyframe to create an animation*

We then adjust the square to make it look like a circle by dragging the handles pointed to in Figure 1-15 with the letter D to create the circle shown in Figure 1-16 at time of 1 second. This results in an animation transitioning from a square to a circle over a period of 1 second. We want the circle appearance to last for 2 seconds more, so we copy the keyframe at 1 second and paste it at a time of 3 seconds on the time line. This results in the appearance not changing from 1 second to 3 seconds; the shape remains a circle.

We now want the animation to transition back to a square. At a time of 4 seconds on the time line, we add a copy of the original keyframe at 0 seconds, which is a square. This results in an animation that transitions back to the square appearance between a time of 3 and 4 seconds on the time line.

A great technique to adopt when you need an animation to go back to its original look is the use of copy and paste. Notice in Figure 1-16 that there are three keyframes shown for the `Rectangle` object in the visual tree. The first keyframe is set at 0 seconds to represent the initial state. At 1 second, a keyframe is created, as shown in Figure 1-16, with the shape now looking like a circle. When this animation runs, the square will smoothly transition into a circle.

The third keyframe shown in Figure 1-16 is a copy of the second Keyframe, so that from 1 second to 3 seconds on the time line, the circle shape is maintained. To copy a `Keyframe`, simply right-click it, and select Copy from the context menu. When you paste the object, the paste location for the keyframe is wherever the yellow vertical line is located along the time line. So, to paste a copy at 3 seconds, move the yellow vertical time line to 3 seconds and press Ctrl+V to paste (a right-click context menu is not available).

For the fourth `Keyframe (not shown in the figure)`, copy the first `Keyframe` as before, move the yellow timeline to 4 seconds, and then press Ctrl+V to paste. Click the DVD player-like play button at the top of the timeline window to test the animation and fine-tune as desired. We cover animations in more detail in Chapter 3, but we wanted to provide an introduction here as part of learning Expression Blend 4.

The last step is to add code that kicks off the storyboard to `MainMainPage.xaml.cs`. To do this, switch to the same solution opened in Visual Studio 2010. We add a Button to the UX to kick off the animation. Locate the `Button` XAML, and type a space inside the first part of the `<Button>` element tag to invoke IntelliSense, as shown in Figure 1-17.

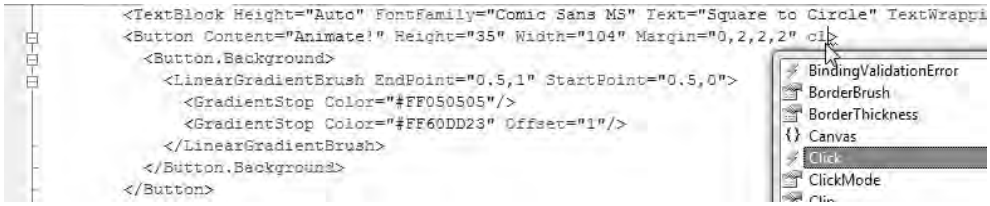


Figure 1-17. *Adding an event in Visual Studio 2010*

It takes one line of code to launch the animation when the button is clicked:

```
SquaretoCircleStoryboard.Begin();
```

Listings 1-5 and 1-6 show the `MainMainPage.xaml` and `MainMainPage.xaml.cs` files, respectively. The storyboard XAML markup is automatically added after doing the work in Expression Blend 4.

Listing 1-5. *Recipe 1-5's MainPage.xaml File*

```
<UserControl x:Class="Ch01_IntroToSilverlight.Recipe1_5.MainPage"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    d:DesignWidth="400" d:DesignHeight="300" xmlns:d=
"http://schemas.microsoft.com/expression/blend/2008" xmlns:mc=
"http://schemas.openxmlformats.org/markup-compatibility/2006"
mc:Ignorable="d">
  <UserControl.Resources>
    <Storyboard x:Name="SquaretoCircleStoryboard">
      <DoubleAnimationUsingKeyframes BeginTime="00:00:00"
        Storyboard.TargetName="rectangle"
        Storyboard.TargetProperty="(Rectangle.RadiusX)">
        <SplineDoubleKeyFrame KeyTime="00:00:00" Value="12"/>
        <SplineDoubleKeyFrame KeyTime="00:00:01" Value="75"/>
        <SplineDoubleKeyFrame KeyTime="00:00:03" Value="75"/>
        <SplineDoubleKeyFrame KeyTime="00:00:04" Value="12"/>
      </DoubleAnimationUsingKeyframes>
      <DoubleAnimationUsingKeyframes BeginTime="00:00:00"
        Storyboard.TargetName="rectangle"
        Storyboard.TargetProperty="(Rectangle.RadiusY)">
        <SplineDoubleKeyFrame KeyTime="00:00:00" Value="12"/>
        <SplineDoubleKeyFrame KeyTime="00:00:01" Value="75"/>
        <SplineDoubleKeyFrame KeyTime="00:00:03" Value="75"/>
        <SplineDoubleKeyFrame KeyTime="00:00:04" Value="12"/>
      </DoubleAnimationUsingKeyframes>
    </Storyboard>
  </UserControl.Resources>
<Grid x:Name="LayoutRoot">
    <Grid.Background>
```

```
      <LinearGradientBrush EndPoint="0.810999989509583,0.18299999833107"
        StartPoint="0.630999982357025,1.15100002288818">
        <GradientStop Color="#FF000000"/>
        <GradientStop Color="#FFFFFFFF" Offset="1"/>
      </LinearGradientBrush>
    </Grid.Background>
    <Grid.RowDefinitions>
      <RowDefinition Height="0.3*"/>
      <RowDefinition Height="0.54*"/>
      <RowDefinition Height="0.16*"/>
    </Grid.RowDefinitions>
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.39*"/>
      <ColumnDefinition Width="0.461*"/>
      <ColumnDefinition Width="0.149*"/>
    </Grid.ColumnDefinitions>
    <Rectangle  Margin="17.2000007629395,4,17.2000007629395,8" Height="150"
      Width="150" Grid.Column="1" Grid.Row="1" RadiusX="12" RadiusY="12"
               x:Name="rectangle">
      <Rectangle.Fill>
        <LinearGradientBrush EndPoint="1.32400000095367,0.783999979496002"
          StartPoint="-0.310999989509583,0.172000005841255">
          <GradientStop Color="#FF99E674" Offset="0.004"/>
          <GradientStop Color="#FFFFFFFF" Offset="0.504"/>
          <GradientStop Color="#FF99E674" Offset="0.97299998998641968"/>
        </LinearGradientBrush>
      </Rectangle.Fill>
    </Rectangle>
    <StackPanel Margin="8,8,8,8" Grid.Column="0" Grid.Row="0">
      <TextBlock Height="Auto" FontFamily="Comic Sans MS" Text="Square to Circle"
        TextWrapping="Wrap" Width="150" Margin="15,2,2,2"/>
      <Button Content="Animate!" Height="35" Width="104" Margin="0,2,2,2"
        Click="Button_Click">
        <Button.Background>
          <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
            <GradientStop Color="#FF050505"/>
            <GradientStop Color="#FF60DD23" Offset="1"/>
          </LinearGradientBrush>
        </Button.Background>
      </Button>
    </StackPanel>

  </Grid>

</UserControl>
```

Listing 1-6. *Recipe 1-5's MainPage.xaml.cs File*

```
using System.Windows;
using System.Windows.Controls;

namespace Ch01_IntroToSilverlight.Recipe1_5
{
  public partial class MainPage : UserControl
  {
    public Page()
    {
      InitializeComponent();
    }

    private void Button_Click(object sender, RoutedEventArgs e)
    {
      SquaretoCircleStoryboard.Begin();
    }
  }

}
```

This recipe covers the basics to help you get started. We will cover Expression Blend 4 extensively in Chapter 3. For the most up-to-date information, visit this site for self-study tutorials, starter kits, training videos, virtual labs, and webcasts: `expression.microsoft.com/en-us/cc136522.aspx`.

1-6. Accessing Source Control

Problem

You need to understand how a non–Visual Studio user such as a designer can access a Silverlight 4 project from Team Foundation Server (TFS), Microsoft's Application Lifecycle Management (ALM) and source code control solution.

Solution

Use the new source code support built into Expression Blend 4. Otherwise, use the stand-alone Team Foundation Client Windows application or the TFS Web Access client to connect to TFS and check in and out source code.

How It Works

Given the highly iterative nature that Silverlight development can entail, designers will most likely access the application source code more frequently than before when designers generally simply provided an image and didn't interact with source directly throughout the development timeline. Therefore, it is important that source code integrity be maintained no matter who is working on the application.

Designers will generally spend their time in Expression Blend 4 designing and building Silverlight 4 applications. For most real Silverlight applications, developers will want to store source code within Team Foundation Server (TFS) or another source code application.

Most, if not all, source code control applications have stand-alone clients that do not require Visual Studio to access source code. Designers can use the stand-alone client access tools appropriate for their environments, and they should work with their development team counterparts to obtain the appropriate client for their systems.

If the source code is stored in TFS, designers should use the integrated source code control support available in Expression Blend 4. To enable source code control in Expression Blend 4, download the Microsoft Visual Studio Team System 210 Team Explorer by searching the Microsoft downloads web site. The download is an ISO so you will have to first burn it to a CD or mount the ISO virtually using a third-party utility. Next, install Visual Studio 2010.

After installing the updates, contact your administrator for the project's TFS to obtain the correct permissions. Once you have permissions, such as the Contributor role, you will be able to add or modify files. Use Team Explorer to create a workspace on your computer. The workspace is a local folder that is mapped to the source code repository. For information on how to download a solution or project to your computer, see `msdn.microsoft.com/en-us/library/ms181385.aspx`.

When you open the solution in Expression Blend 4, additional source code control menu items will be enabled when you right-click on the Solution, Project, and individual files that will allow you to check items in and out of source code control. If you are not familiar with how source code control works, please go to Help ➤ User Guide in Expression Blend and type **`source control`** in the index for more information.

1-7. Running Silverlight 4 on a Mac

Problem

You need to run Silverlight 4 on a Mac.

Solution

On your Mac, navigate to a web site running Silverlight 4 to automatically download the plug-in, or download it at `go.microsoft.com/fwlink/?LinkID=149156&v=4.0.40624.0`.

How It Works

Silverlight is a cross-platform, cross-browser plug-in designed to automatically install when the web browser accesses a site running Silverlight. Note that Silverlight 4 works on Intel-based Mac systems, not the PowerPC.

1-8. Running Silverlight on Linux

Problem

You need to run Silverlight applications on a Linux system.

Solution

Download the Moonlight plug-in from `www.mono-project.com/Moonlight`. To access the Moonlight Getting Started page at the Mono project, go to `www.monoproject.com/Moonlight#Getting_Started`.

How It Works

In partnership with Microsoft, Novell is providing an implementation of Silverlight for Linux called Moonlight. The Moonlight 2 beta is available for the major Linux distributions, with support for Firefox, Konqueror, and Opera browsers.

The goal of the implementation is to allow Moonlight to run any Silverlight application without having to recompile that application. To view screenshots of Moonlight running existing Silverlight demonstrations, go to `www.mono-project.com/Screenshots`.

CHAPTER 2

Application Design and Programming Model

The Mechanics of Silverlight Applications

Silverlight is a UI or presentation layer programming model for rich interactive client-side user interaction. Silverlight also includes strong distributed application hooks coupled with rich data binding to facilitate a solid application architecture that will be familiar to traditional .NET or Java developers. This means that the same overall design principles that architects and developers live by today for web or n-tier applications can apply to Silverlight-based applications as well. Silverlight provides excellent support for calling services, whether those services are based on Simple Object Access Protocol (SOAP), Representational State Transfer (REST), plain old XML (POX), or JavaScript Object Notation (JSON).

Note Please refer to Chapter 1 for information on how to set up the environment and create a Silverlight 4 project. Chapter 7 covers networking and web services in detail. In Chapter 9, we cover WCF services in detail.

The Silverlight platform consists of three major components: the presentation framework, the .NET Framework for Silverlight, and the installer/updater. The presentation framework contains a rich set of XAML UI controls, media playback support, and digital rights management, as well as support for user input, data binding, and presentation features like vector graphics, animation, and layout.

The .NET Framework for Silverlight is a subset of the full .NET Framework that contains a powerful set of components and libraries. Silverlight continues to inch closer to WPF in terms of feature alignment with Silverlight 4. The .NET Framework for Silverlight includes extensible UI controls and powerful networking capabilities, as well as base class libraries and the common language runtime (CLR). Some parts of the .NET Framework for Silverlight are deployed as part of the runtime encapsulated within the cross-platform browser plug-in. Other parts, such as some UI controls, LINQ to XML, and so forth, are packaged with your application and downloaded to the browser as a separate assembly as part of the `.xap` container.

■ **Note** Take a moment to browse the topic "Silverlight Reference by Namespace" in the Silverlight SDK help file. You will see that the .NET Framework for Silverlight contains a rich subset of the full version of the .NET Framework, including support for generics, collections, diagnostics, reflection, cryptography, and LINQ, just to name a few components.

We provided detailed highlights in Chapter 1, but to quickly review, Silverlight 3 introduced more than 50 new features, including support for running Silverlight applications out of the browser, dramatic video performance and quality improvements, and features that improve developer productivity in the following areas:

- Media
- User experience rendering capabilities
- Rich Internet Applications (RIAs)
- Data support
- Browser support
- Out-of-browser capabilities

While Silverlight 3 introduced many new controls and capabilities, Silverlight 4 introduces major feature enhancements in the following areas:

- Business Application Development – printing, Rich Text Control, RIA Services, improved commanding, support and new error handling interfaces to name a few enhancements
- Rich User Experiences – Fluid UI states, implicit styles, webcam and microphone support, offline PlayReady DRM support, and right mouse click support
- Sandboxed Application Enhancements – Out-of-Browser (OOB) Windowing updates, `WebBrowser` control, HTMLBrush, and notifications support
- Trusted Applications – New OOB model with elevated trust allowing native integration, file system access, cross-domain network access, and full keyboard access in full screen mode
- Tooling Support – Visual Studio 2010 adds full designer and property tool window support to Silverlight 3 and 4 applications.

The other major component of the Silverlight platform is the runtime installation and update control that simplifies the process of installing the plug-in for first-time users of your application. The Silverlight runtime plug-in control provides low-impact, automatic updates to the plug-in as they become available.

While not based on Silverlight 4, Microsoft introduced Windows Phone 7 and its Silverlight and XNA programming model at MIX 10. The Silverlight programming is based on Silverlight 3 but several Silverlight 4 features such as the `WebBrowser` control and offline PlayReady DRM support were brought forward to the platform.

In this chapter, we will focus on the Silverlight application programming model in the .NET Framework. We'll cover topics like custom components, concurrency, resource management, and persistence, all of which facilitate integration into the overall application architecture.

2-1. Leverage and Locate Controls and Classes

Problem

You want to add a custom class and a custom control to your application and access both the class and the control in the XAML, which is the markup similar to the ASPX page in ASP.NET. You also want to know how to dynamically find a control so that you can modify its properties.

Solution

To add a class, add a clr-namespace to the `<UserControl>` element in your Silverlight application via the xmlns attribute to make the custom class available to the Silverlight application. To add a control, first add a project reference to the assembly containing the custom control and then add a clr-namespace in a similar manner. To dynamically locate a control at runtime, use the `FrameworkElement.FindName` method.

How It Works

Most of the time, applications consist of more than one class and custom control. You can add a class to project by right-clicking a Silverlight project and selecting Add a Class. Classes can also be brought in through a separate project or assembly just as you would in any other .NET application by adding a reference to the assembly. To make the class or control available in XAML, you add an xmlns attribute to the root UserControl. Note that you add a `using` statement if the class is in a different namespace and you want to access the class in code.

Generally, in Silverlight applications much of the code is written in XAML, which is an XML markup language, so it takes an additional step to make the class or control available within the XAML markup. This step involves adding an `xmlns` namespace import statement to the `<UserControl>` element.

Add a Custom Control

To make a custom control available, the steps are similar to making a class available. You'll use a custom control from a separate solution titled `SimpleControl` that creates a simple control consisting of a `TextBlock` that displays the text `Full Name:` in front of the value set for the `FullName` property on the control. We don't go into detail on how to create the `SimpleControl` here because we describe how to create custom controls in Chapter 5.

Find a Control

Finding a control at runtime is often a necessary task. The abstract base class for controls in Silverlight is the `DependencyObject` class that represents objects participating in the Silverlight dependency property system. `UIElement` inherits from `DependencyObject` and represents objects that have visual appearance and that can perform basic input. `FrameworkElement` inherits from `UIElement` and provides common APIs for elements to participate in Silverlight layout, as well as APIs related to data binding, the object tree, and object lifetime.

One of the available members on `FrameworkElement` is `FindName`, which takes a string that contains the name of a control and returns either an object reference or `null`. The `FindName` method provides a convenient way of locating a control within the XAML visual tree without having to walk through the object tree.

In order for a control to be found, it must have its `Name` property set in code or via the `x:Name` property in XAML. XAML is hierarchical by nature, since it is an XML tree where there is a root element that contains child elements. After the XAML processor creates the object tree from markup, the `x:Name` attribute provides a reference to markup elements that is accessible in the codebehind file, such as in event handler code.

Names must be unique within an XAML namescope. The XAML `<UserControl>`, by default defined in `MainPage.xaml` as the `MainPage` class, is the most common namescope and is referred to as the root XAML namescope. Calling APIs that dynamically load XAML can define additional namescopes as well. Refer to Recipes 2-4 and 2-5 to learn more about how to dynamically load XAML.

When XAML is added dynamically to the visual tree, the tree remains unified, but a new namescope will be created at the point where the dynamic XAML is attached. Templates and resources define their own namescopes independently of the containing page where the style or template is applied.

The reason for the detailed discussion regarding namescope is because `FindName` works within the constraint of namescopes. If you call `FindName` from the `MainPage` level to get a named object in the root XAML namescope, the call will succeed as usual. However, if you call `FindName` from the `MainPage` level, the method will not find the objects in the new discrete XAML namescope created by `Load` or within templates or resources. To find an element with `FindName` within newly created namescope, retain a reference to an object or `UIElement` within the namescope, and call `FindName` from the element that is within the new namescope in the XAML visual tree.

Since `FindName` is part of the visual control base class `FrameworkElement`, it is accessible in all visual controls and can be called just about anywhere. What is convenient about `FindName` is that if the XAML element has child elements, they are all searched recursively for the requested named element. `FindName` will search the current XAML namescope in both the up (parent) and down (children) direction within the visual object tree defined in XAML.

In this recipe, you will work with a class named `Organization` that you will add to the Silverlight application. The `Organization` class is just a fictitious class example with a few example data items. The `Organization` class is in the same `Ch02_ProgrammingModel.Recipe2_1` namespace as the `MainPage.xaml.cs` file so you can access the `Organization` class directly without having to add a `using` statement. If the `Organization` class was in a separate assembly with a different namespace, you would need to add a reference to the other assembly and a `using` statement as you normally would to access a class within an application.

At the top of `MainPage.xaml`, you will notice namespace declarations within the `<UserControl>` element:

```
xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
```

The first statement imports the presentation framework namespace as the default namespace. The second declaration maps an additional XAML namespace, mapping it to the `x:` prefix. To access the `Organization` class within `MainPage.xaml`, you need to add an additional namespace declaration with a unique prefix by typing `xmlns:data=` in the `<UserControl>` tag. You use the prefix `data` because you want to data bind to the `People` collection in the `Organization` class. You can pick any prefix you want, but it helps to use something that makes sense for the application. Figure 2-1 shows the support in Visual Studio 2010 that lets you easily import the `Ch02_ProgrammingModel.Recipe2_1` namespace.

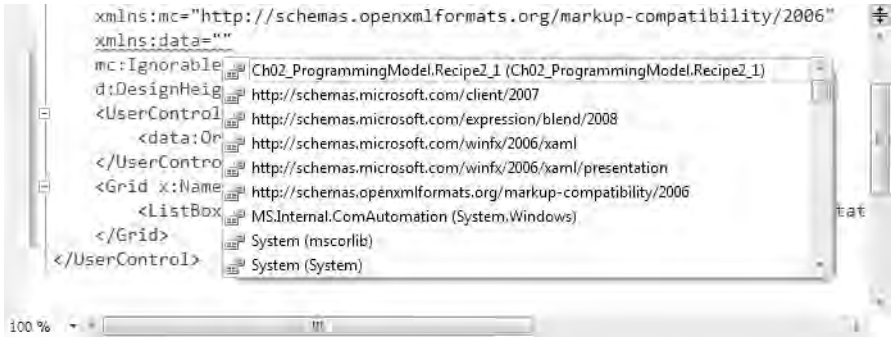


Figure 2-1. *The Visual Studio 2010 namespace import IntelliSense window*

Selecting the first line in the pop-up IntelliSense window imports the correct namespace that allows you to access the `Organization` class within the Silverlight XAML markup, resulting in this namespace statement:

```
xmlns:data="clr-namespace:Ch02_ProgrammingModel.Recipe2_1"
```

You add a `ListBox` control to the XAML to help test your ability to access the `Organization` class. Let's use Microsoft Expression Blend 4 to set the `ItemSource` property on the `ListBox` control. First, save the solution, and then open the solution in Blend so that it is open in both Expression Blend 4 and Visual Studio, as described in Recipe 1-5. Inside Expression Blend, open `MainPage.xaml`. Select the `ListBox` so that it is highlighted, and then enter Item in the Properties search box to bring the `ItemSource` to the top of the Properties window, as shown in Figure 2-2.

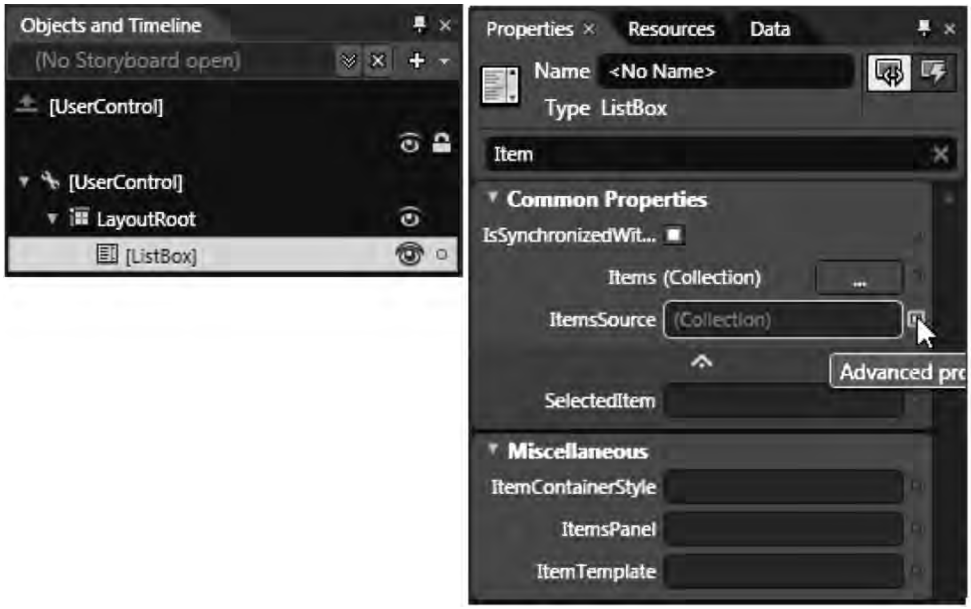


Figure 2-2. *The ListBox ItemSource property*

Notice in Figure 2-2 that there is a small button highlighted by the mouse pointer hovering over it. Clicking this button provides access to the Advanced property options menu, shown in Figure 2-3.

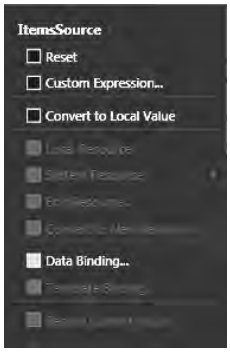


Figure 2-3. *The Advanced property options menu*

Click the Data Binding option to open the Create Data Binding dialog shown in Figure 2-4.The astute reader will notice in Figure 2-4 that, in addition to Data Field and Explicit Data Context, Element Property is no longer grayed out as it was in Silverlight 2 and Expression Blend 2 SP1. In Silverlight 3 and now in Silverlight 4, it is possible for controls to data bind to values of other elements or controls. We cover data binding to elements in Chapter 4 in detail.

Figure 2-4. *The Create Data Binding dialog*

For now, click the +CLR Object button to open the Define New Object Data Source dialog, shown in Figure 2-5.

Figure 2-5. *The Define New Object Data Source dialog*

Select Organization, and then click OK to create the `OrganizationDS` object. Select the `OrganizationDS` object in the Create Data Binding dialog and then expand the `Organization` object in the Fields pane on the right to display the `People` collection. Select the `People` collection, and click OK to set the `ItemSource` for the `ListBox` to the `People` collection. Save the solution in Expression Blend 4, and switch back to Visual Studio to view the generated XAML.

When you run the sample, the `ListBox` displays three items that contain the text `Ch02_ProgrammingModel.Recipe2_1.Person`, which is the type that is stored in the `People` collection. In Chapter 4, we cover how to use data templates to render the values for the type's properties, such as `FirstName` and `LastName`, instead of the name of the type.

Listing 2-1 shows the `Organization` class file.

Listing 2-1. *Recipe 2-1's Organization Class File*

```
using System.Collections.Generic;

namespace Ch02_ProgrammingModel.Recipe2_1
{
  public class Organization
  {
    private List<Person> _people;
    public List<Person> People
    {
      get
      {
        if (null == _people)
          return Populate();
        else
          return _people;
      }
    }

    private List<Person> Populate()
    {
      _people = new List<Person>
         { //C# 3.0 Object Initializers
          new Person {FirstName="John",LastName="Smith", Age=20},
          new Person{FirstName="Sean",LastName="Jones", Age=25},
          new Person{FirstName="Kevin",LastName="Smith", Age=30}
         };
      return _people;
    }
  }

   public class Person
  {
    public string FirstName { get; set; }
    public string LastName { get; set; }
    public int Age { get; set; }
  }
}
```

Listing 2-2 shows the resulting code to add a custom class as well as the additional code discussed below regarding adding a custom control and how to find a control in XAML. (Please note the use of some layout controls, `Grid` and `StackPanel`, to help segment the three bits of functionality into areas separated by blue rectangles.)

Listing 2-2. *The MainPage.xaml File*

```
<UserControl x:Class="Ch02_ProgrammingModel.Recipe2_1.MainPage”
  xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
  xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
  xmlns:data="clr-namespace:Ch02_ProgrammingModel.Recipe2_1"
  xmlns:SC="clr-namespace:SimpleControl;assembly=SimpleControl"
 mc:Ignorable="d" d:DesignHeight="300" d:DesignWidth="400"
xmlns:d="http://schemas.microsoft.com/expression/blend/2008"
  xmlns:mc=
"http://schemas.openxmlformats.org/markup-compatibility/2006" mc:Ignorable="d" >

  <UserControl.Resources>
    <data:Organization x:Key="OrganizationDS" d:IsDataSource="True"/>
  </UserControl.Resources><Grid x:Name="LayoutRoot" Background="White" DataContext="{Binding
Source={StaticResource OrganizationDataSource}}">
    <StackPanel>
      <ListBox x:Name="PeopleListBox" ItemsSource="{Binding People}" />
      <Rectangle Fill="Navy" Height="10" Margin="2"></Rectangle>
      <SC:SimpleControl FullName="Rob Cameron and Jit Ghosh" FontSize="18" />
      <Rectangle Fill="Navy" Height="10" Margin="2"></Rectangle>
      <Grid  Background="#FFD0D0D0" >
        <StackPanel Grid.RowSpan="2">
          <TextBlock x:Name="TextBlock1" Margin="4">TextBlock1</TextBlock>
          <TextBlock x:Name="TextBlock2" Margin="4">TextBlock2</TextBlock>
          <TextBlock x:Name="TextBlock3" Margin="4">TextBlock3</TextBlock>
          <TextBlock x:Name="TextBlock4" Margin="4">TextBlock4</TextBlock>
          <StackPanel >
                <TextBlock Margin="2" TextWrapping="Wrap" Text="Type the Name of a TextBlock
from the above list."></TextBlock>
                <TextBox x:Name="ControlName" KeyDown="ControlName_KeyDown"
                        Margin="2" Grid.Row="1" TextWrapping="Wrap"/>
                <Button Content="Click To Find the Name Entered." Margin="2"
                        Click="Button_Click"/>
          </StackPanel>
        </StackPanel>
      </Grid>
    </StackPanel>
  </Grid>
</UserControl>
```

Expression Blend 4 added a couple of `xmlns` statements to the `<UserControl>` element shown here:

```
xmlns:d="http://schemas.microsoft.com/expression/blend/2008"
xmlns:mc="http://schemas.openxmlformats.org/
markup-compatibility/2006" mc:Ignorable="d"
```

These namespaces are used by Expression Blend for code generation and can be removed if desired. However, you will need to edit the XAML in the code file as well if they use the `mc:` or `d:` namespace reference. Now, let's discuss the new resource added to the `UserControl` as part of configuring the data binding:

```
<UserControl.Resources>
  <data:Organization x:Key="OrganizationDS" d:IsDataSource="True"/>
</UserControl.Resources>
```

The resource uses the `data:` prefix you defined in Visual Studio to gain access to the `Organization` class and sets the `x:Key` property so that you can access the resource by name as `OrganizationDS`.

The other interesting markup change is the value configured on the `ListBox`'s `DataContext` property:

```
DataContext="{Binding Mode=OneWay, Path=People,
Source={StaticResource OrganizationDS}}"
```

You can see that the `DataContext` is set to the `People` collection via the `Path` property on the `Binding` object, which is available by setting the `Source` property to the static resource `OrganizationDS`. As a result, the `Listbox` will display the list of people in the UI. We cover data binding in detail in Chapter 4; here, we only cover what is required to make a custom class available in XAML.

Now, let's learn how to make a custom control available in XAML, which is very similar to making a class available.

In the `\Code\Ch02_ProgrammingModel\Recipe2.1\SimpleControl` folder that is part of the source code download for this book, you'll find the simple example control example solution. To run the code for this recipe, you must first open the `SimpleControl` solution and build it to create the `SimpleControl.dll` assembly. Next, open the Chapter 2 solution that contains the sample code for this chapter, and make sure the reference is available in the Recipe 2-1 project. To make the custom control available, add a reference to the assembly in your project to the `SimpleControl` assembly, and then add an `xmlns` import to the `<UserControl>` element just like you did with the custom class:

```
xmlns:SC="clr-namespace:SimpleControl;assembly=SimpleControl"
```

Once the control's namespace is imported, the control can be added to the XAML in Visual Studio using the SC: namespace (isolated from Listing 2-2 here):

```
<SC:SimpleControl FullName="Rob Cameron and Jit Ghosh" FontSize="18" />
```

Figure 2-6 shows the UI with the Listbox displaying the `Organization` custom class and the `SimpleControl` custom control.

Figure 2-6. *The Recipe 2-1 UI*

We do not list the source code for `SimpleControl` because we cover how to build custom controls for Silverlight 4 in Chapter 5.

The last bit of functionality related to adding a control is dynamically finding a control. In Listing 2-2, below the second rectangle in the XAML, there is a `Grid` control hosting a `StackPanel` with a few controls to implement the find logic. The user can enter a name of one of the `TextBlock` controls and click the `Button` to find the control name entered and scale its size a little bit if found. Listing 2-3 contains the codebehind file for this recipe where the programming logic exists to actually find the control.

Listing 2-3. The MainPage.xaml.cs File

```
using System.Windows;
using System.Windows.Controls;
using System.Windows.Input;
using System.Windows.Media;

namespace Ch02_ProgrammingModel.Recipe2_1
{
  public partial class MainPage : UserControl
  {
    public MainPage()
    {
      InitializeComponent();
    }

    private void Button_Click(object sender, RoutedEventArgs e)
    {
      TextBlock tb =
       (TextBlock)LayoutRoot.FindName(ControlName.Text);
      if (tb != null)
        tb.FontSize = 20.0;
      else
      {
        ControlName.Foreground = new SolidColorBrush(
             Color.FromArgb(255, 200, 124, 124));
        ControlName.Text = "Control not found! Please try again.";
      }
    }

    private void ControlName_KeyDown(object sender, KeyEventArgs e)
    {
      ControlName.Foreground =
         new SolidColorBrush(Color.FromArgb(255, 0, 0, 0));
    }
  }
}
```

There are two events in the codebehind file: one for clicking the button and another for the `KeyDown` for the `TextBox`. The `Button_Click` event tries to find a control with the name entered in the `TextBox`. If the entered value is valid and the control can be found, the `FontSize` is changed to 20 for the found `TextBlock`.

If the entered value is not valid, a message is put into the `TextBox` stating that the control was not found based on the entered value, and the font color is changed to a reddish color. The `KeyDown` event simply resets the font color for the `TextBox` back to black. We purposely did not use any of the great new animation features available in Silverlight and instead chose to have Windows Forms–like simple animation in the UI. In Chapter 3, we'll go into detail on how to take advantage of the great animation features in Silverlight.

Figure 2-7 shows the initial layout of the UI but with the additional UX for finding the control functionality.

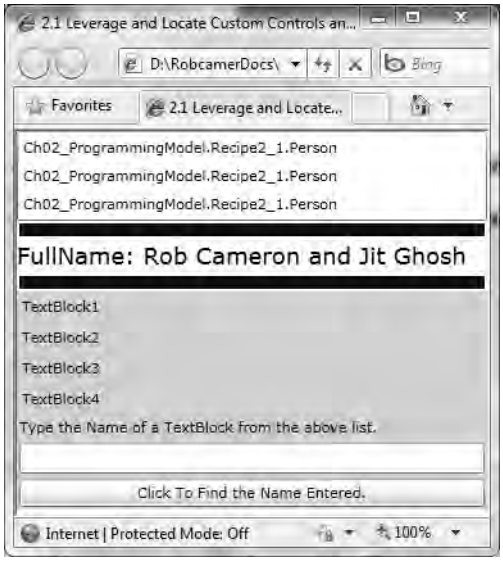


Figure 2-7. *Recipe 2-1 UI final layout*

Figure 2-8 shows the application when the correct value for the name of a `TextBlock` control is entered and the `Button` is clicked. `TextBlock2` is entered for the value, and the font size is changed to 20, enlarging the text in `TextBlock2`.

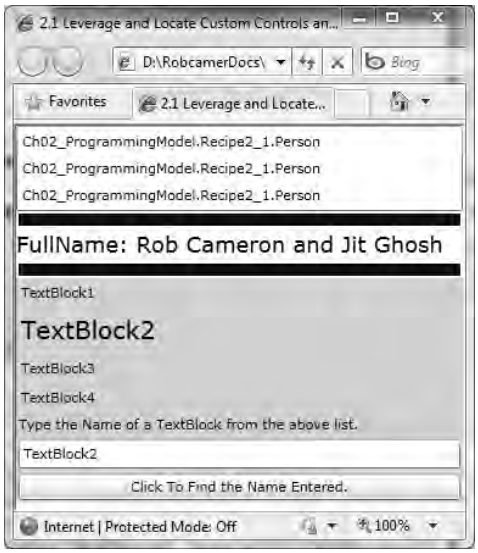


Figure 2-8. *Recipe 2-1's UI after entering a valid control name*

Figure 2-9 shows the UI when an incorrect value is entered. The font color is changed, and an error message is put into the `TextBox` control.

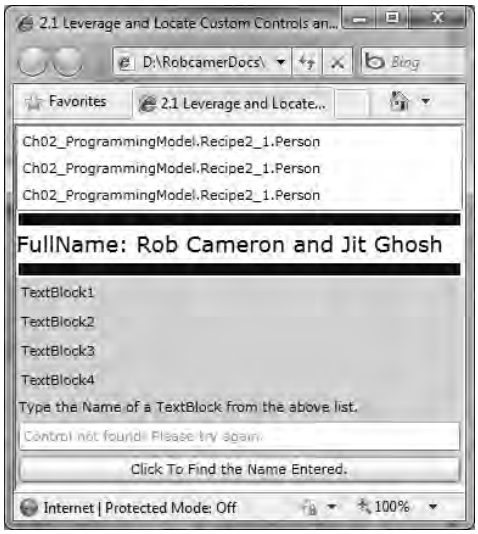


Figure 2-9. *Recipe 2-1's UI after entering an invalid control namee*

2-2. Dynamically Loading XAML

Problem

You need to load XAML dynamically at runtime from JavaScript or from Managed Code.

Solution

Use the `CreateFromXaml` method in JavaScript to dynamically load XAML markup at runtime into a Silverlight 4 application from JavaScript. Use `FindName` to locate the parent control where the XAML will be attached in the visual object tree. (We covered `FindName` in Recipe 2-1.) Use the `XamlReader` object to dynamically load XAML markup at runtime from managed code.

How It Works

Silverlight 4 runs as an Internet browser plug-in that is created from within an HTML `<object>` tag in the browser. Even though Silverlight 4 has a managed code execution model, the Silverlight 4 plug-in is still accessible from and can interoperate with HTML using JavaScript, as in Silverlight 1.0. Chapter 6 covers browser integration in detail, so this recipe focuses only on how to dynamically load XAML from JavaScript using `CreateFromXaml`.

To load XAML using managed code, use the XamlReader object. The `XamlReader` object sits in the `System.Windows.Markup` namespace. The static `Load` method takes a string of XAML and converts the string to an object or object tree, depending on what is contained within the XAML string. The static `Load` method then returns a reference to root element created of type `UIElement`, which can be added to the UI visual tree. Since all XAML elements inherit from `UIElement`, it makes sense that the return type from `Load` would also be `UIElement`. The string must consist of valid markup with the addition of two namespaces on the top-level element in the XAML contained in the string:

```
xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation
xmlns:x="xmlns:x='http://schemas.microsoft.com/winfx/2006/xaml"
```

Once you have a valid string of XAML, pass it to the `XamlReader.Load` method, and a `UIElement` object reference is returned. The final step is to convert the object to a `UIElement` or descendant class and add it as a child to the desired parent element in the visual tree.

The Code

There are two ways to approach this recipe: using an HTML page or using an ASP.NET page. The plain-old HTML page can be used as a guide for configuring Silverlight for non-Microsoft platforms.

For the ASPX page, you'll use the default test page created by Visual Studio 2010. You'll also add a button to the ASPX test page and a script reference to a JavaScript file that will load the XAML (in this case, one named `Recipe2.4.js` in the `/js` folder under the TestWeb project).

■ **Note** Silverlight 2 developer tools included an ASP.NET Silverlight control to configure a Silverlight application. In Silverlight 3 or later, the control has been removed. The techniques for hosting the Silverlight control covered here will work with any web technology because it is simply HTML with the <object> tag.

For the ASPX page, the Silverlight 4 plug-in is configured directly in an `<object>` tag located inside a `<div>` tag. The default ASPX test page created by Visual Studio 2010 does not include an `id` value in the `<object>` declaration, so set the value for `id` to `SilverlightPlugInID` so that it can be accessed in JavaScript using the `document.getElementById` method:

```
var slControl = document.getElementById("SilverlightPlugInID");
```

After obtaining a reference to the Silverlight plug-in, you can create a new Silverlight control, using the `CreateFromXaml` method on the `Content` property of the plug-in, and hold a JavaScript reference to it:

```
slControl.Content.CreateFromXaml(
 '<Ellipse Height="200" Width="200" Fill="Navy" />');
```

Next, call the `FindName` method on the Silverlight plug-in to access the XAML control tree in `MainPage.xaml` to obtain a reference to the default root `<Grid>` control with an `x:Name` of `"LayoutRoot"`:

```
var layoutRoot = slControl.content.FindName("LayoutRoot");
```

Once you have a reference to the `<Grid>` control, you can add the control you created with the `CreateFromXaml` method to the `Grid`'s `Children` collection using the `Add` method:

```
layoutRoot.Children.Add(e);
```

When you attach XAML to a visual tree, the added tree creates a new namescope for that XAML within the existing scope of the `Page` `UserControl` class. Calling `FindName` to locate a control within the newly added XAML from the `Page` level will not succeed, because the method will search inside the newly created namescope. The best way to manage this is to retain a reference to the newly added XAML and call `FindName` from the reference.

The only additional code you need to add to the ASPX test page is logic to enable the button after the Silverlight control is fully loaded. If you do not take this into account and call `FindName` before the Silverlight application is fully loaded, `FindName` will return `null`. The way to manage this is to put logic inside the `OnLoad` method for the Silverlight plug-in object that does not access or allow access to the control tree until the event fires:

```
function onSilverlightLoad(sender, args)
{
  var btn = document.getElementById("testButton");
  btn.disabled = false;
}
```

In the ASPX test page, the code in `onSilverlightLoad` simply enables the button. Otherwise, if the button was not disabled and the button is clicked before the control is fully loaded, a `null` reference exception occurs. To assign the `OnLoad` event to the Silverlight plug-in, set a `<param>` tag on the `<object>` tag:

```
<param name="onload" value="onSilverlightLoad" />
```

The MainPage.xaml is not modified for this recipe, so it is not listed here. All of the action occurs in the custom script file in Listing 2-4 and the HTML and ASP.NET test pages shown in Listings 2-5 and 2-6.

In Listing 2-4, you use the HTML getElementById to obtain a reference to the Silverlight control. Next, you create an ellipse, and add it to the existing XAML content. The JavaScript file in Listing 2-4 is referenced by the HTML and ASP.NET page.

Listing 2-4. *The Recipe2.2.js JavaScript File*

```
function createEllipse()
{
    var slControl = document.getElementById("SilverlightPlugInID");
    var e =
        slControl.Content.CreateFromXaml(
            '<Ellipse Height="200" Width="200" Fill="Navy" />');
    var layoutRoot = slControl.content.FindName("LayoutRoot");
    layoutRoot.Children.Add(e);
}

function onSilverlightLoad(sender, args)
{
  var btn = document.getElementById("testButton");
  btn.disabled = false;
}
```

Listing 2-5 includes the script file in Listing 2-4. Also in Listing 2-5, the onSilverlightLoad event from Listing 2-4 is assigned to the Silverlight control's onload event, dynamically adding the XAML to the LayoutRoot element in the XAML shown in Figure 2-10.

Listing 2-5. *Recipe 2-2's TestPage.aspx File*

```
<%@ Page Language="C#" AutoEventWireup="true" %>

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">\
<html xmlns="http://www.w3.org/1999/xhtml">
<head runat="server">
  <title>Test Page for Recipe 2.2</title>
  <script runat="server">

    protected void Page_Load(object sender, EventArgs e)
    {
      testButton.Attributes.Add("onclick", "createEllipse();");
    }
  </script>
  <style type="text/css">
    html, body
```

```
  {
    height: 100%;
    overflow: auto;
  }
  body
  {
    padding: 0;
    margin: 0;
  }
  #silverlightControlHost
  {
    height: 100%;
    text-align: center;
  }
</style>
<script src="js/Recipe2_2.js" type="text/javascript"></script>
<script type="text/javascript" src="Silverlight.js"></script>
<script type="text/javascript">
  function onSilverlightError(sender, args) {
    var appSource = "";
    if (sender != null && sender != 0) {
      appSource = sender.getHost().Source;
    }

    var errorType = args.ErrorType;
    var iErrorCode = args.ErrorCode;

    if (errorType == "ImageError" || errorType == "MediaError")
    {
      return;
    }

    var errMsg = "Unhandled Error in Silverlight Application "
    + appSource + "\n";

    errMsg += "Code: " + iErrorCode + "    \n";
    errMsg += "Category: " + errorType + "       \n";
    errMsg += "Message: " + args.ErrorMessage + "     \n";

    if (errorType == "ParserError") {
      errMsg += "File: " + args.xamlFile + "     \n";
      errMsg += "Line: " + args.lineNumber + "     \n";
      errMsg += "Position: " + args.charPosition + "     \n";
    }
    else if (errorType == "RuntimeError") {
```

```
        if (args.lineNumber != 0) {
          errMsg += "Line: " + args.lineNumber + "     \n";
          errMsg += "Position: " + args.charPosition + "     \n";
        }
        errMsg += "MethodName: " + args.methodName + "     \n";
      }

      throw new Error(errMsg);
    }
  </script>
</head>
<body>
  <form id="form1" runat="server" style="height: 100%">
  <asp:Button ID="testButton" runat="server" Enabled="false"
   Text="Click Me!" UseSubmitBehavior="false" /><br />
  <div id="silverlightControlHost">
    <object id="SilverlightPlugInID"
    data="data:application/x-silverlight-2,"
    type="application/x-silverlight-2"
      width="100%" height="100%">
      <param name="source" value="ClientBin/Ch02_ProgrammingModel.Recipe2_2.xap" />
      <param name="onError" value="onSilverlightError" />
      <param name="onload" value="onSilverlightLoad" />
      <param name="background" value="white" />
      <param name="minRuntimeVersion" value="4.0.50401.0" />
      <param name="autoUpgrade" value="true" />
      <a href="http://go.microsoft.com/fwlink/?LinkID=149156&v=4.0.50401.0" style="text-
decoration: none">
        <img src="http://go.microsoft.com/fwlink/?LinkId=161376" alt="Get Microsoft
Silverlight"
          style="border-style: none" />
      </a>
    </object>
    <iframe id="_sl_historyFrame" style="visibility: hidden; height: 0px; width: 0px;
      border: 0px"></iframe>
  </div>
  </form>
</body>
</html>
```

Listing 2-6. *Recipe 2-2's MainPage.xaml File*

```
<UserControl x:Class=" Ch02_ProgrammingModel.Recipe2_2.MainPage"
    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"
    mc:Ignorable="d"
    d:DesignHeight="300" d:DesignWidth="400">

  <Grid x:Name="LayoutRoot" Background="White">
    <Grid.RowDefinitions>
      <RowDefinition Height="138*" />
      <RowDefinition Height="162*" />
    </Grid.RowDefinitions>
    <StackPanel Grid.Row="1" >
      <Button Click="Button_Click" Margin="4" Content="Click To Load XAML from Managed Code"
/>
      <Grid x:Name="GridforManagedCode" Margin="4"></Grid>
    </StackPanel>
  </Grid>
</UserControl>
```

Now that you know how to load XAML using JavaScript, let's move on to showing you how to load XAML using managed code. In Listing 2-6, you can see a nested `Grid` control named `GridforManagedCode`. To load XAML using managed code, you can use the `XamlReader.Load(xamlString)` method. It takes a valid XAML fragment as a string. The string must contain the Silverlight namespace in the root of the XAML fragment. Here is the code from MainPage.xaml.cs with the namespace as part of the root `Ellipse` element:

```
string xamlString = "<Ellipse
xmlns=\http://schemas.microsoft.com/winfx/2006/xaml/presentation\
Height=\"200\" Width=\"200\" Fill=\"Navy\" Grid.Column=\"1\"
Grid.Row=\"1\" />";
      UIElement element = (UIElement)XamlReader.Load(xamlString);
      GridforManagedCode.Children.Add(element);
```

Figure 2-10 shows the output from Recipe 2-2.

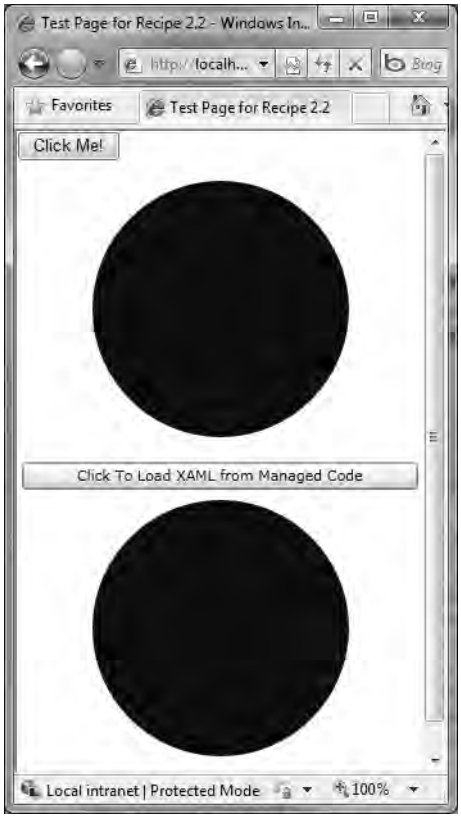


Figure 2-10. Recipe 2-2 Final Output

2-3. Persisting Data on the Client

Problem

You need to persist data on the end user's machine.

Solution

Use isolated storage to store data on the client.

How It Works

In some situations, you may want to store data to the client's computer, such as user-specific settings or application state information. However, it is not possible to use the regular file system of the operating

system from a web browser application, because native file system operations require full trust, but Web-based applications run in a partial-trust isolated sandbox.

■ **Note** Elevated OOB applications have much more access to the file system. We cover OOB applications and elevated trust OOB in Chapter 8.

Isolated storage provides a safe client-side storage area for partial-trust applications to persist information on a per-user basis. In Silverlight, all I/O operations are restricted to the isolated storage. Silverlight 4 includes the ability to run Silverlight applications OOB when online or offline. Offline Silverlight applications can still access the same isolated storage area as they can when running in the browser, so users have seamless access to their data. We cover offline Silverlight 4 applications in Chapter 8.

Besides storing settings, isolated storage can be used to improve user experience as well as reduce bandwidth by storing partially filled-out forms, so that the form data can be reloaded when the user returns, even if, for example, the user stored the data using Internet Explorer but accesses the application later using Firefox.

The `System.IO.IsolatedStorage` namespace contains types for creating and using a virtual file system. Table 2-1 lists the classes available in this namespace.

Table 2-1. *Classes Related to IsolatedStorage*

Class	Description
`IsolatedStorageException`	Exception that is thrown when an isolated storage operation fails
`IsolatedStorageFile`	Represents an isolated storage area containing files and directories
`IsolatedStorageFileStream`	Represents a file within isolated storage
`IsolatedStorageSettings`	Provides a `Dictionary` object that stores key-value pairs within isolated storage

Isolated storage is not unlimited. Administrators can set user quota restrictions that limit the amount of data that can be stored in isolated storage, so it is not suited for large amounts of data. The default size of isolated storage for in-browser Silverlight applications is 1MB. The default size of isolated storage for out-of-browser Silverlight applications at install time (called detach) is 25MB.

■ **Note** Isolated storage is not encrypted, though developers can encrypt and decrypt files stored in local storage if desired. Developers can also sign and validate signatures using the SHA1 hash function .

The quota can be increased further by the user through the UI thread, usually as a result of a UI event handler. Otherwise, the quota cannot be increased on a background thread or without user

action. Isolated storage remains intact even if the browser cache is cleared, but isolated storage can be manually deleted by the user or application by using the File I/O classes.

Applications can request more space by invoking the `IsolatedStorageFile.IncreaseQuotaTo` method in response to a user-initiated event, such as a mouse click or key press, as noted previously.

To work with isolated storage, first obtain an isolated store for the application using the `IsolatedStorageFile.GetUserStoreForApplication` method. This returns an `IsolatedStorageFile` object, which you can use to create directories using the `CreateDirectory` method and files using the `CreateFile` method. The `CreateFile` method returns an `IsolatedStorageFileStream` object. The `IsolatedStorageFileStream` class inherits from `FileStream`, so you can use the class with `StreamReader` and `StreamWriter` objects.

Another option is to use the `IsolatedStorageSettings` class, which is a `Dictionary` object that can be used to quickly store key/value pairs in isolated storage.

The Code

To test isolated storage, your sample does two things. It allows a user to store and update a setting using the `IsolatedStorageSettings` class and to save and reload form state between browser sessions. Figure 2-11 shows the UI with a mock form.

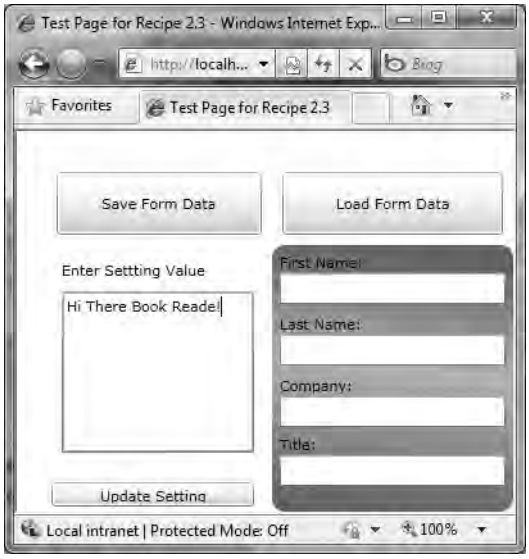


Figure 2-11. *Recipe 2-3's test application UI*

The Silverlight application shown in Figure 2-11 has a `TextBox` on the left with "Hi There Book Reader!" as a value. Any value entered in this `TextBox` is stored in the `IsolatedStorageSettings` dictionary object, which is a convenient place to store name/value pair settings or data. The `UserControl.Loaded` event handler pulls this setting out of the collection, and the `ButtonUpdateSetting` event handler stores the setting when the `Button` titled Update Setting is clicked.

The Save Form Data button and the Load Form Data button both work with the sample form fields located in the rounded green/silver area on the right side of the application. The Save Form Data button concatenates the text from the form data into a string, with each value separated by the pipe (|)

symbol. The Load Form Data button reads in the data as a `String` and calls `String.Split` to separate the fields into an array of string values.

The `SaveFormData_Click` event stores the form data into isolated storage. In general, any data that is persisted into `IsolatedStorage` is persisted between browser sessions. The `ReadFormData_Click` event retrieves the data from the file created in isolated storage. Listings 2-7 and 2-8 show the code for the Silverlight application's `MainPage` class.

Listing 2-7. *Recipe 2-3's MainPage.xaml File*

```
<UserControl x:Class="Ch02_ProgrammingModel.Recipe2_3.MainPage"

    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"
    mc:Ignorable="d"
    d:DesignHeight="300" d:DesignWidth="400">
  <Grid x:Name="LayoutRoot" Background="#FFFFFFFF">
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.06*"/>
      <ColumnDefinition Width="0.455*"/>
      <ColumnDefinition Width="0.485*"/>
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
      <RowDefinition Height="0.08*"/>
      <RowDefinition Height="0.217*"/>
      <RowDefinition Height="0.61*"/>
      <RowDefinition Height="0.093*"/>
    </Grid.RowDefinitions>
    <Button HorizontalAlignment="Stretch" Margin="8 " VerticalAlignment="Stretch"
     Grid.Column="1" Grid.Row="1" Content="Save Form Data"
     Click="SaveFormData_Click"/>
    <StackPanel HorizontalAlignment="Stretch" Margin="8,8,10,8" Grid.Column="1"
        Grid.Row="2">
      <TextBlock Height="Auto" Width="Auto" Text="Enter Setting Value"
         TextWrapping="Wrap" Margin="4,4,4,4"/>
      <TextBox Height="126" Width="Auto" Text="" TextWrapping="Wrap"
         Margin="4,4,4,4" x:Name="settingTextData"/>
    </StackPanel>
    <Button HorizontalAlignment="Stretch" Margin="8" VerticalAlignment="Stretch"
       Grid.Column="2" Grid.Row="1" Content="Load Form Data"
       Click="ReadFormData_Click"/>
    <Button HorizontalAlignment="Stretch" Margin="4,4,14,4"
      VerticalAlignment="Stretch"
       Grid.Column="1" Grid.Row="3" Content="Update Setting"
       Click="ButtonUpdateSetting"/>
```

```
    <Border Grid.Column="2" Grid.Row="2" Grid.RowSpan="2"
    CornerRadius="10,10,10,10">
      <Border.Background>
        <LinearGradientBrush EndPoint="0.560000002384186,0.00300000002607703"
           StartPoint="0.439999997615814,0.996999979019165">
          <GradientStop Color="#FF586C57"/>
          <GradientStop Color="#FFA3BDA3" Offset="0.536"/>
          <GradientStop Color="#FF586C57" Offset="0.968999981880188"/>
        </LinearGradientBrush>
      </Border.Background>
      <StackPanel Margin="4,4,4,4"  x:Name="FormData">
        <TextBlock Height="Auto" Width="Auto" Text="First Name:"
           TextWrapping="Wrap" Margin="2,2,2,0"/>
        <TextBox Height="Auto" Width="Auto" Text="" TextWrapping="Wrap" x:
           Name="Field1" Margin="2,0,2,4"/>
        <TextBlock Height="Auto" Width="Auto" Text="Last Name:"
           TextWrapping="Wrap" Margin="2,4,2,0"/>
        <TextBox Height="Auto" x:Name="Field2" Width="Auto" Text=""
          TextWrapping="Wrap" Margin="2,0,2,4"/>
        <TextBlock Height="Auto" Width="Auto" Text="Company:"
          TextWrapping="Wrap" Margin="2,4,2,0"/>
        <TextBox Height="Auto" x:Name="Field3" Width="Auto" Text=""
          TextWrapping="Wrap" Margin="2,0,2,2"/>
        <TextBlock Height="22.537" Width="182" Text="Title:"
           TextWrapping="Wrap" Margin="2,4,2,0"/>
        <TextBox Height="20.772" x:Name="Field4" Width="182" Text=""
           TextWrapping="Wrap" Margin="2,0,2,2"/>
      </StackPanel>
    </Border>
  </Grid>
</UserControl>
```

Listing 2-8 has the codebehind page for `MainPage.xaml` where the events are located. The code declares several class level variables such as `settings` that are used by the event handlers to load and save setting values to `IsolatedStorage`.

Listing 2-8. *Recipe 2-3's MainPage.xaml.cs Class File*

```
using System.Linq;
using System.Windows;
using System.Windows.Controls;
using System.IO;
using System.IO.IsolatedStorage;
using System.Text;

namespace Ch02_ProgrammingModel.Recipe2_3
```

```
{
  public partial class MainPage : UserControl
  {
    private IsolatedStorageSettings settings =
                          IsolatedStorageSettings.ApplicationSettings;
    private string setting = "MySettings";
    private string FormDataFileName = "FormFields.data";
    private string FormDataDirectory = "FormData";
    public MainPage()
    {
      InitializeComponent();
    }

    private void UserControl_Loaded(object sender, RoutedEventArgs e)
    {
      try
      {
        if (settings.Keys.Count != 0)
        {
          settingTextData.Text = settings[setting].ToString();
        }
      }
      catch (IsolatedStorageException ex)
      {
        settingTextData.Text = "Error saving setting: " + ex.Message;
      }
    }

    private void SaveFormData_Click(object sender, RoutedEventArgs e)
    {
      try
      {
        using (var store = IsolatedStorageFile.GetUserStoreForApplication())
        {
          //Use to control loop for finding correct number of textboxes
          int TotalFields = 4;
          StringBuilder formData = new StringBuilder(50);
          for (int i = 1; i <= TotalFields; i++)
          {
            TextBox tb = FindName("Field" + i.ToString()) as TextBox;
            if (tb != null)
              formData.Append(tb.Text);
            //If on last TextBox value, don't add "|" character to end of data
            if (i != TotalFields)
              formData.Append("|");
```

```
        }
        store.CreateDirectory(FormDataDirectory);
        IsolatedStorageFileStream fileHandle =
             store.CreateFile(System.IO.Path.Combine(
             FormDataDirectory, FormDataFileName));
        using (StreamWriter sw = new StreamWriter(fileHandle))
        {
          sw.WriteLine(formData);
          sw.Flush();
          sw.Close();
        }
      }
    }
    catch (IsolatedStorageException ex)
    {
      settingTextData.Text = "Error saving data: " + ex.Message;
    }
  }

  private void ReadFormData_Click(object sender, RoutedEventArgs e)
  {
    using (var store = IsolatedStorageFile.GetUserStoreForApplication())
    {
      //Load form data using private string values for directory and filename
      string filePath =
         System.IO.Path.Combine(FormDataDirectory, FormDataFileName);
      //Check to see if file exists before proceeding
      if (store.FileExists(filePath))
      {
        using (StreamReader sr = new StreamReader(
            store.OpenFile(filePath, FileMode.Open, FileAccess.Read)))
        {
          string formData = sr.ReadLine();
          //Split string based on separator used in SaveFormData method
          string[] fieldValues = formData.Split('|');
          for (int i = 1; i <= fieldValues.Count(); i++)
          {
            //Use the FindName method to loop through TextBoxes
            TextBox tb = FindName("Field" + i.ToString()) as TextBox;
            if (tb != null)
              tb.Text = fieldValues[i - 1];
          }
          sr.Close();
        }
      }
```

```
      }
    }
    private void ButtonUpdateSetting(object sender, RoutedEventArgs e)
    {
      try
      {
        settings[setting] = settingTextData.Text;
      }
      catch (IsolatedStorageException ex)
      {
        settingTextData.Text = "Error reading setting: " + ex.Message;
      }
    }
  }
}
```

2-4. Opening a Local File from a Silverlight Application

Problem

You need to select a local file on the client machine and upload it to the server.

Solution

Create an instance of the `OpenFileDialog` class, and display it to the user with the `ShowDialog` method. You can send the files to the server for processing, but we recommend that you let the user know anytime a file is sent to the server.

How It Works

The `OpenFileDialog` class displays a standard Windows, Mac, or Linux open file dialog depending on the platform that allows users to browse to files anywhere on their system. This dialog box is not available if running in Full Screen Mode.

The `OpenFileDialog` class has `Filter` and `FilterIndex` properties, which allow you to set the file filter in much the same way a .NET developer would do in a WPF or Windows Forms application. You can specify the types of files you wish to open by specifying `Filter` like this:

```
fileDlg.Filter = "Tiff Files (*.tif)|*.tif|All Files (*.*)|*.*";
```

This value suggests that a TIFF file is expected, but the `Filter` value can be overridden by the user. The format is a description of the filter, such as `Tiff Files (*.tif)`, followed by the filter pattern, such as `*.tiff`. Each filter option is separated by the pipe symbol. You can also have a more generic `Filter`, say for all image files, by separating the filter patterns with semicolons, like this:

```
Image Files(*.BMP;*.JPG;*.GIF)|*.BMP;*.JPG;*.GIF|All files (*.*)|*.*
```

You can set the `FileIndex` property to a zero-based index to configure which filter is the default; you can also allow the user to make multiple selections by setting the `Multiselect` property to `true`.

The `OpenFileDialog` class also has a `Multiselect` property, which defaults to `false`. When set to `true`, it allows the user to select multiple files. The `ShowDialog` method displays the dialog shown in Figure 2-12.

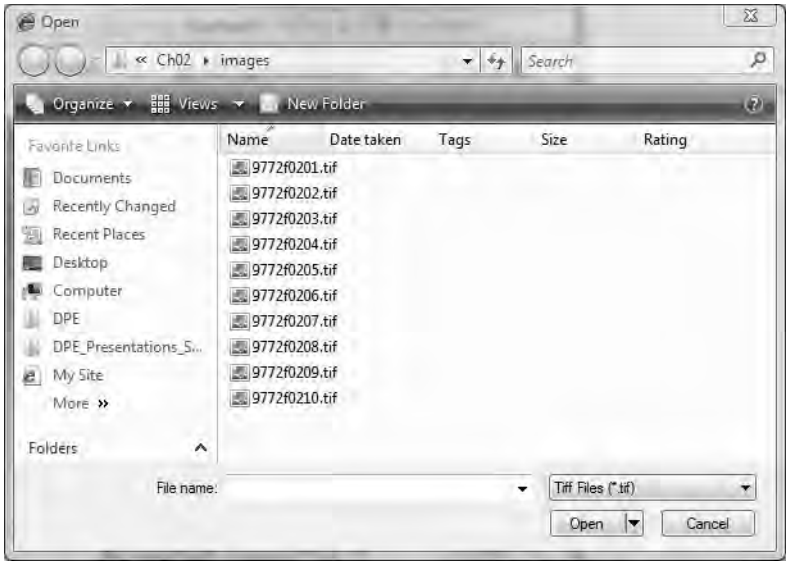


Figure 2-12. *The Open File dialog in Windows*

The Code

The sample code for this recipe has a button that allows the user to select files in the local file system, including instances where `Multiselect` is set to `true`. The files that are selected are listed in a `ListBox` control.

When the user clicks the Select Files button in the test application, an Open File dialog appears with a filter configured for TIFF files, as shown in Figure 2-12. Figure 2-13 shows the test application UI after the user selects several files and clicks the Open button in the dialog.

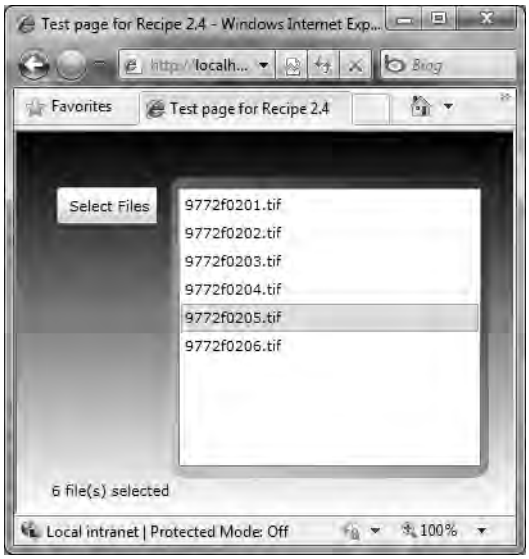


Figure 2-13. *Recipe 2-4's test application UI after selecting files using the Open File dialog*

Clicking Open in the operating system's Open File dialog causes the `ShowDialog` method to return `true`. Clicking Cancel causes the method to return `false`. When it returns `true`, you can use the `Count()` method on the `OpenFileDialog.Files` collection to determine the number of files returned.

To iterate over the selected files, you can use a `foreach` loop that steps through the `Files` collection. In the sample code, you simply add the filename to a `ListBox` object. However, the `Files` collection stores `FileDialogFileInfo` objects that contain two methods, `OpenRead` and `OpenText`. The `OpenRead` method returns a `Stream` object that allows a developer to read the file using a `StreamReader` class. The `OpenText` method returns a `StreamReader` with UTF-8 encoding that reads an existing text file. In Chapter 7, we'll cover Silverlight networking and web services that developers can use to upload a file to the server. Listings 2-9 and 2-10 show the code for the Recipe 2-4 test application.

Listing 2-9. *Recipe 2-4's MainPage.xaml File*

```
<UserControl x:Class="Ch02_ProgrammingModel.Recipe2_4.MainPage"
    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"
    mc:Ignorable="d"
    d:DesignHeight="300" d:DesignWidth="400">
  <Grid x:Name="LayoutRoot">
    <Grid.Background>
      <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
        <GradientStop Color="#FF000000"/>
        <GradientStop Color="#FFFFFFFF" Offset="1"/>
      </LinearGradientBrush>
```

```
    </Grid.Background>

    <Grid.RowDefinitions>
      <RowDefinition Height="0.117*"/>
      <RowDefinition Height="0.79*"/>
      <RowDefinition Height="0.093*"/>
    </Grid.RowDefinitions>
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.058*"/>
      <ColumnDefinition Width="0.252*"/>
      <ColumnDefinition Width="0.64*"/>
      <ColumnDefinition Width="0.05*"/>
    </Grid.ColumnDefinitions>
    <Button Height="28.9" HorizontalAlignment="Stretch" Margin="8,8,11,0"
     VerticalAlignment="Top" Width="81.8" Grid.Column="1" Grid.Row="1"
     Content="Select Files" d:LayoutOverrides="Height" x:Name="ButtonSelectFiles"
     Click="ButtonSelectFiles_Click"/>
    <TextBlock Margin="4,2,2,2" Grid.Column="1" Grid.Row="2" Text="Status"
       TextWrapping="Wrap" Grid.ColumnSpan="2" x:Name="StatusLabel"/>
    <Border Grid.Column="2" Grid.Row="1" Margin="0,0,0,0" CornerRadius="12">
      <Border.Background>
        <LinearGradientBrush EndPoint="0.916999995708466,0.0890000015497208"
           StartPoint="-0.0489999987185001,2.12400007247925">
          <GradientStop Color="#FF1D351E"/>
          <GradientStop Color="#FF1D351E" Offset="1"/>
          <GradientStop Color="#FFB7D8BA" Offset="0.509000003337860l1"/>
        </LinearGradientBrush>
      </Border.Background>
      <ListBox x:Name="FileList" Foreground="#FF000000" Height="217"
        Width="236" Opacity="1"/>
    </Border>
  </Grid>
</UserControl>
```

Listing 2-10. *Recipe 2-4's MainPage.xaml.cs Class File*

```
using System.Linq;
using System.Windows;
using System.Windows.Controls;

namespace Ch02_ProgrammingModel.Recipe2_4
{
  public partial class MainPage : UserControl
  {
    public MainPage()
```

```
    {
      InitializeComponent();
    }

    private void ButtonSelectFiles_Click(object sender, RoutedEventArgs e)
    {
      //Create dialog
      OpenFileDialog fileDlg = new OpenFileDialog();
      //Set file filter as desired
      fileDlg.Filter = "Tiff Files (*.tif)|*.tif|All Files (*.*)|*.*";
      fileDlg.FilterIndex = 1;
      //Allow multiple files to be selected (false by default)
      fileDlg.Multiselect = true;
      //Show Open File Dialog
      if (true == fileDlg.ShowDialog())
      {
        StatusLabel.Text =
            fileDlg.Files.Count() + " file(s) selected";
        foreach (var file in fileDlg.Files)
        {
          FileList.Items.Add(file.Name);
        }
      }
    }
  }
}
```

2-5. Accessing XML Data

Problem

You need to work with XML data in Silverlight using the `XmlReader` object as well as work with XML data in Silverlight using LINQ, because you would like to work with the XML data as a collection of objects.

Solution

Use the `XmlReader` object along with the necessary objects in the related `System.Xml` namespace to retrieve XML data. Use the language features first introduced in C# 3.0 and the `System.Xml` and `System.Linq` namespaces to query XML data.

How It Works

There are two ways to parse XML data in Silverlight: the `XmlReader` class and LINQ to XML, which is one of the new technologies that became available in .NET Framework 3.5 and later that we cover below.

The `XmlReader` class is a fast-forward–only, noncaching XML parser. For processing large XML files, `XmlReader` is better suited than LINQ to XML for performance reasons.

The Silverlight `XmlReader` works in a similar manner as the `XmlReader` in the full version of the .NET Framework. Visit this site for details on the differences between the .NET Framework and the .NET Framework for Silverlight versions of XmlReader: msdn.microsoft.com/en-us/library/cc189053(VS.95).aspx

What is great about Silverlight is that it is a rich subset of the full .NET Framework 3.5 and that it includes LINQ. There are many web sites, blogs, and books that cover LINQ, so we won't dive into all the details here.

■ **Note** A great resource on LINQ is Joseph C. Rattz Jr.'s *Pro LINQ: Language Integrated Query in C# 2008* (Apress, 2007).

The goal of the second part of this recipe is to show how to retrieve XML data using an `XmlResolver`, in this case the `XmlXapResolver`, which extracts XML from the xap, and then load the XML data into an `XDocument` object.

You call `XDocument.Load(XmlReader)` to load the contents into an `XDocument` so that it can be queried using LINQ. The `XDocument` class, located in the `System.Xml.Linq` namespace, is the key object in LINQ to XML functionality.

The Code

The `XmlReader` class can be used to read XML data from the `IsolatedStorage` file system as well as from streams retrieved via the network just like in the full .NET Framework. A unique Silverlight ability that you take advantage of in this recipe is to use an `XmlXapResolver` to retrieve XML data embedded into the application's `.xap` file, which is the container for Silverlight applications (see Recipe 1-3). An XML resolver in .NET resolves, or evaluates, external XML resources. An `XmlUrlResolver` is used to resolve the `Url` location passed into `XmlReader.Create`. The `XmalXapResolver` looks for the name passed into `XmlReader.Create` within the `.xap` file for the application:

```
XmlReaderSettings XmlRdrSettings = new XmlReaderSettings();
XmlRdrSettings.XmlResolver = new XmlXapResolver();
XmlReader reader = XmlReader.Create("ApressBooks.xml",
XmlRdrSettings);
```

The resolver is configured for the `XmlReaderSettings` object that is passed into the `Create` method. For more information on the `XmlReaderSettings` class, refer to the MSDN documentation at msdn.microsoft.com/en-us/library/system.xml.xmlreadersettings(VS.95).aspx

The first step to create the test application for this recipe is to add the XML file to the Silverlight project and set its build action to `Content`. This puts the XML file into the `assembly` that is deployed to the web site so that the `XmlReader` can find it using the `XmlXapResolver`. Figure 2-14 shows the test application for this recipe.

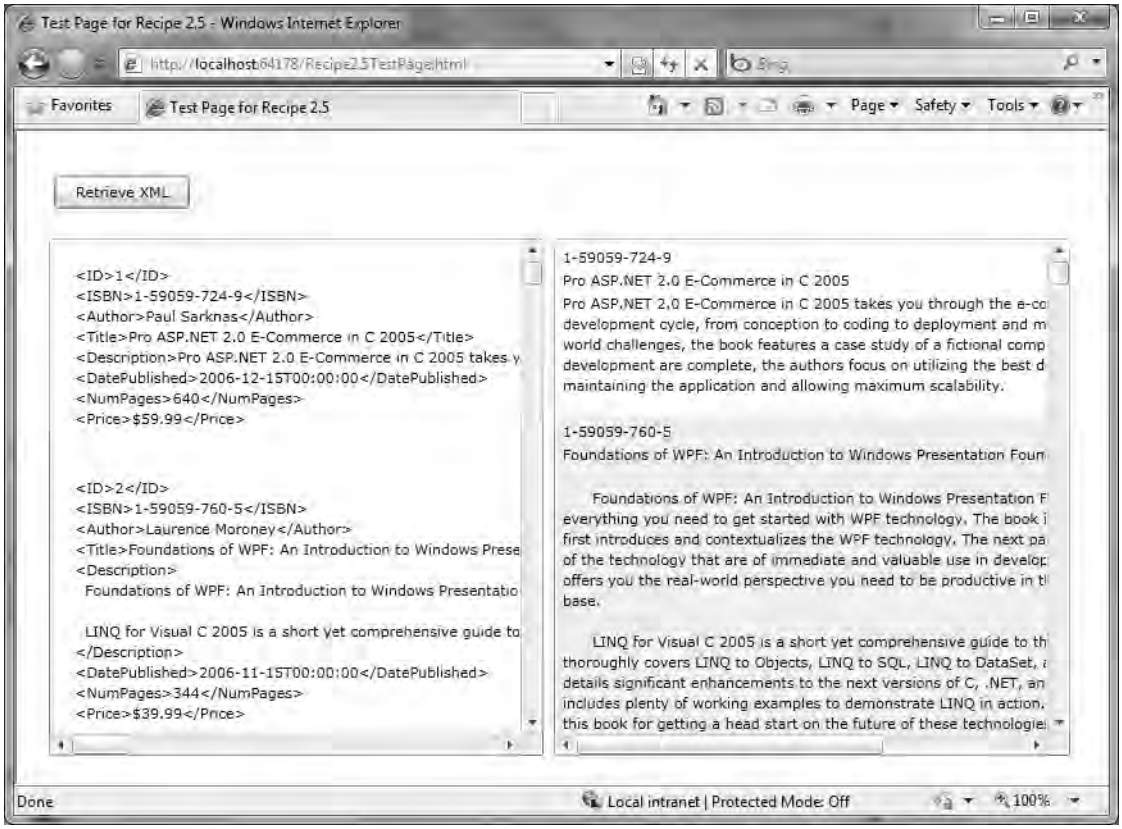


Figure 2-14. *Recipe 2-5's test application UI*

When you click the `Button` titled Retrieve XML, the event handler `ButtonReadXML_Click` uses the `XmlReader` and the `XmlXapResolver` to load the XML into a `ListBox` control using one line of code:

```
XmlData.Items.Add(reader.ReadInnerXml());
```

`XmlData` is the name of the `ListBox` control in the XAML for the recipe test application. The XML data is added to the `Items` collection for the `ListBox`. Listings 2-11 and 2-12 have the full code listings for this test application.

Listing 2-11. *Recipe 2-5's MainPage.xaml Class File*

```
<UserControl x:Class="Ch02_ProgrammingModel.Recipe2_5.MainPage"
    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:data="clr-namespace:Ch02_ProgrammingModel.Recipe2_5"
    mc:Ignorable="d"
    d:DesignHeight="337" d:DesignWidth="531">
  <UserControl.Resources>
    <data:ApressBooks x:Key="ApressBooksDS" />
  </UserControl.Resources>
  <Grid x:Name="LayoutRoot" Background="White">
    <Grid.RowDefinitions>
      <RowDefinition Height="9*"/>
      <RowDefinition Height="44*"/>
      <RowDefinition Height="273*"/>
      <RowDefinition Height="11*"/>
    </Grid.RowDefinitions>
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="13*"/>
      <ColumnDefinition Width="246*"/>
      <ColumnDefinition Width="257*" />
      <ColumnDefinition Width="15*"/>
    </Grid.ColumnDefinitions>
    <Button Height="27.1" HorizontalAlignment="Left" Margin="8,9,0,8"
VerticalAlignment="Stretch" Grid.Column="1" Grid.Row="1" Content="Retrieve XML"
d:LayoutOverrides="Height" x:Name="ButtonReadXML" Click="ButtonReadXML_Click" Width="106"/>
    <ListBox Margin="4" Grid.Column="1" Grid.Row="2" x:Name="XmlData"/>
    <Grid Grid.Column="2" Grid.Row="2" Background="White">
      <ListBox Margin="4,4,4,4" ItemsSource="{Binding Mode=OneWay, Path=ApressBookList,
Source={StaticResource ApressBooksDS}}"  >
        <ListBox.ItemTemplate>
          <DataTemplate>
            <StackPanel Margin="2,2,2,2">
              <TextBlock Text="{Binding Path=ISBN}" Margin="0,0,0,2"/>
              <TextBlock Text="{Binding Path=Title}" Margin="0,0,0,2"/>
              <TextBlock Width="550" Text="{Binding Path=Description}"
                         TextWrapping="Wrap" Margin="0,0,0,10"/>
            </StackPanel>
          </DataTemplate>
        </ListBox.ItemTemplate>
      </ListBox>
```

```
    </Grid>
  </Grid>
</UserControl>
```

Listing 2-12. *Recipe 2-5's MainPage.xaml.cs Class File*

```
using System.Windows;

using System.Windows.Controls;
using System.Xml;

namespace Ch02_ProgrammingModel.Recipe2_5
{
  public partial class MainPage : UserControl
  {
    public MainPage()
    {
      InitializeComponent();
    }

    private void ButtonReadXML_Click(object sender, RoutedEventArgs e)
    {

      XmlReaderSettings XmlRdrSettings = new XmlReaderSettings();
      XmlRdrSettings.XmlResolver = new XmlXapResolver();
      XmlReader reader = XmlReader.Create("ApressBooks.xml", XmlRdrSettings);

      // Moves the reader to the root element.
      reader.MoveToContent();

      while (!reader.EOF)
      {
        reader.ReadToFollowing("ApressBook");
        // Note that ReadInnerXml only returns the markup of the node's children
        // so the book's attributes are not returned.
        XmlData.Items.Add(reader.ReadInnerXml());
      }
      reader.Close();
    }
  }
}
```

For the second part of this recipe, you access XML data with LINQ to XML to avoid working with XmlDocument objects and walking the XML tree. Instead, you create a list of objects containing information on a few Apress books and display the data in a `ListBox` using a simple data template. We cover data templates in detail in chapter 4.

The relevant LINQ to XML functionality is located in the ApressBooks.cs class file. It contains an ApressBooks class that populates a List collection with another custom class called ApressBook, using the ApressBooks.RetrieveData method.

The code in Listing 2-12 above is a bit more involved so let's go through it line by line. The private member variable backing the public ApressBookList property is declared like this:

```
private List<ApressBook> _apressBookList;
```

This section of code is the actual LINQ query:

```
from b in xDoc.Descendants("ApressBook")
select….
```

The b variable is simply an anonymous type for retrieving a collection of objects from the XML file that are returned by the call to xDoc.Descendants("ApressBook"). The select keyword in the sample code creates an instance of the ApressBook class, but if you wanted to simply return a collection of strings containing the ISBN, you could use this code:

```
from b in xDoc.Descendants("ApressBook")
select b.Element("ISBN").Value
```

Instead, you take advantage of LINQ functionality to streamline creating a collection of ApressBook objects by using this code:

```
select new ApressBook()
{
   Author = b.Element("Author").Value,
   Title = b.Element("Title").Value,
   ISBN = b.Element("ISBN").Value,
   Description = b.Element("Description").Value,
   PublishedDate = Convert.ToDateTime(b.Element("DatePublished").Value),
   NumberOfPages = b.Element("NumPages").Value,
   Price = b.Element("Price").Value,
   ID = b.Element("ID").Value
}
```

The select new code is simply creating an instance of a collection containing ApressBook objects using C# 3.0 object initializer functionality. The value used to set each property for the ApressBook objects is data retrieved from the XML document, such as b.Element("Author").Value. Figure 2-14 shows the test application for this recipe.

Unlike in Recipe 2-1, where you demonstrated how to add a class reference to an application but did not specify a data template, you do implement a simple data template for the ListBox control here to show that the XML data is read in properly.

2-6. Managing Unhandled Exceptions

Problem

You need to manage unhandled exceptions in Silverlight.

Solution

Use the `Application.UnhandledException` event and the private ReportErrorToDom member function Error! Bookmark not defined for your application.

How It Works

When you create a new Silverlight 4 application, the Visual Studio 2010 project template automatically implements a shell for the `Application.UnandledException` event with basic error handling and comments to help you get started in the `App.xaml.cs` file. This event handler can handle managed exceptions that originate from within your custom application code.

It is up to you, the developer, to decide whether or not an exception is fatal for the application. As an example, if you have a `Button` click event that retrieves data over the network but fails, the exception will be caught by the `Application.UnhandledException` event if there isn't a local exception handler in the `Button` click event. You can decide whether to prompt the user to retry or tell the user that the request cannot be performed and visually indicate that there is an unrecoverable error. The `Application.UnhandledException` event makes it convenient to implement centralized error handling and error reporting for a Silverlight application.

The `Application.UnhandledException` event cannot handle exceptions that originate from the Silverlight platform code (i.e., the plug-in itself). Platform code exceptions as well as exceptions that are not handled with the `UnhandledException` event are passed to the native/unmanaged error handler in the Silverlight plug-in. To handle exceptions at this level, implement a JavaScript `OnError` event handler in the Silverlight plug-in. To implement the `OnError` event handler, create a JavaScript event handler that follows this signature:

```
function onSLError(sender, args)
{
//error handling logic goes here
}
```

For an example of how to implement an `OnError` JavaScript handler, look no further than any one of the HTML or `.aspx` test pages that are automatically generated by the Visual Studio 2010 project template. Inside the HTML `<script>` tag is a function called `onSilverlightError` that implements basic error handling for the test page. Further down in the HTML or `.aspx` page, in the `<object>` tag for instantiating the Silverlight plug-in, the `onerror` parameter is passed a value of `onSilverlightError`:

```
<param name="onerror" value="onSilverlightError" />
```

There isn't any code for this recipe, since Visual Studio 2010 generates most of the sample code for you as part of the project template. Refer to the generated `.aspx` and HTML files for code examples on where to manage exceptions.

2-7. Executing Work on a Background Thread with Updates

Problem

You need to execute work in the background that provides updates on progress so that the UI can be responsive.

Solution

Use a background worker thread to execute work in the background.

How It Works

Silverlight 4 includes the `System.Threading.Thread` and `System.Threading.ThreadPool` classes as part of the .NET Framework for Silverlight. However, we recommend that you instead use the `System.ComponentModel.BackgroundWorker` class to execute work in the background of the UI, such as loading or saving data to isolated storage, accessing a remote service, etc. The `BackgroundWorker` class provides a nice abstraction layer over the gory details of safely synchronizing with the UI thread when using one of the lower-level classes like `Thread` and `ThreadPool`.

The `BackgroundWorker` class lets you indicate operation progress, completion, and cancellation in the Silverlight UI. For example, you can check whether the background operation is completed or canceled and display a message to the user.

To use a background worker thread, declare an instance of the `BackgroundWorker` class at the class level, not within an event handler:

```
BackgroundWorker bw = new BackgroundWorker();
```

You can specify whether you want to allow cancellation and progress reporting by setting one or both of the `WorkerSupportsCancellation` and `WorkerReportsProgress` properties on the `BackgroundWorker` object to `true`. The next step is to create an event handler for the `BackgroundWorker.DoWork` event. This is where you put the code for the time-consuming operation. Within the `DoWork` event, call the `ReportProgress` method to pass a percentage complete value that is between 0 and 100, which raises the `ProgressChanged` event on the `BackgroundWorker` object. The UI thread code can subscribe to the event and update the UI based on the progress. If you call the `ReportProgress` method when `WorkerReportsProgress` is set to `false`, an exception will occur.

Check the `CancellationPending` property of the `BackgroundWorker` object to determine if there is a pending request to cancel the background operation within the `worker_DoWork` member function. If `CancellationPending` is `true`, set `BackgroundWorker.Cancel` to `true`, and stop the operation. To pass data back to the calling process upon completion, set the `Result` property of the `DoWorkerEventArgs` object that is passed into the event handler to the object or collection containing the data. The `DoWorkerEventArgs.Result` is of type `object` and can therefore be assigned any object or collection of objects. The value of the `Result` property can be read when the `RunWorkerCompleted` event is raised upon completion of the operation.

The `BackgroundWorker` class tries to prevent deadlocks or cross-thread invocations that could be unsafe. There are some calls that are always assumed to be called on the UI thread, such as calling into the HTML Document Object Model (DOM) or a JavaScript function, so you are not allowed to call them from a `BackgroundWorker` class.

A deadlock occurs when two threads each hold on to a resource while requesting the resource that the other thread is holding. A deadlock will cause the browser to hang. It is easy to create a deadlock with two threads accessing the same resources in an application. Silverlight includes locking primitives, such as `Montior` or `lock`, as well as the `ManualResetEvent` class.

Exceptions must be caught within the background thread, because they will not be caught by the unhandled exception handler at the application level. If an exception occurs on the background thread, one option is to catch the exception and set `Result` to `null` as a signal that there was an error. Another option is to set a particular value to `Result` as a signal that a failure occurred.

The Code

In the sample code, you start with the code from Recipe 2-3, which includes a form that saves and loads data from isolated storage. You will save and load data from isolated storage while the background worker thread is executing to prove that the UI is not locked up by the long-running operation. You'll modify the UI to include a button to start the long-running operation as well as a bit of UI work to show what is going on. Figure 2-15 shows the UI.

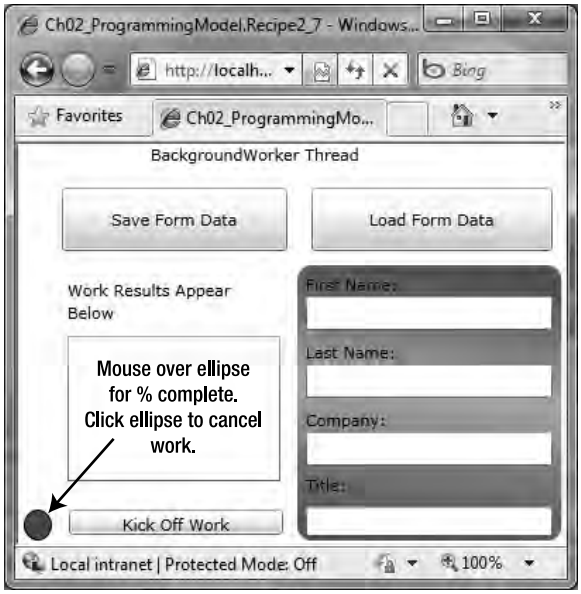


Figure 2-15. *Recipe 2-7s test UI*

To help keep things clean, the code that was copied from Recipe 2-3 is located in `#region` blocks so that it is not a distraction. There is a bit more code in this recipe, so let's walk through the major code sections. First, you declare a `BackGroundWorker` object named `worker` and initialize it in the constructor `Page()` for the `Page` class:

```
worker.WorkerReportsProgress = true;
worker.WorkerSupportsCancellation = true;
worker.DoWork += new DoWorkEventHandler(worker_DoWork);
worker.ProgressChanged +=
   new ProgressChangedEventHandler(worker_ProgressChanged);
worker.RunWorkerCompleted += new
RunWorkerCompletedEventHandler(worker_RunWorkerCompleted);
```

You configure the `BackgroundWorker` to support cancellation and progress reporting so that you can provide a simple UI to give status. Next, you wire up the `DoWork`, `ProgressChanged`, and `RunWorkerCompleted` events to handlers.

The DoWork event contains the code that the BackgroundWorker thread executes. This is where the long-running operation goes. ProgressChanged and RunWorkerCompleted are events where the UI thread can update status in the UI while the background work is safely executing.

In your DoWork event, you first check to see if there is a cancel request pending and break out of the loop if there is. Otherwise, you call Thread.Sleep to delay execution and ReportProgress to provide an updated percentage complete. The results of the background worker thread's effort are passed back to the main thread as the value of e.Result:

```
e.Result = Environment.NewLine + "Completed: " + DateTime.Now.ToString();
```

In your case, you simply pass back a string, but in a scenario with real background work, this could be a collection of data or objects received over the network. It is not safe to update the UI from DoWork, so that is why you must pass back results via the events.

To get the work started from the UI, you have a Kick Off Work button that has an event handler with the name DoWorkButton_Click. The code checks to see if the worker is already busy. If not, you set the status by adding text to the WorkResultsTextData TextBox to indicate that work has started, and you call worker.RunWorkerAsync to kick off the work.

To display a dynamic status in the UI, you have a simple ellipse with a Storyboard named AnimateStatusEllipse. (We will cover storyboards and animation in Chapter 3.) In the button event handler, you call Begin on this object and set it to run continuously. The animation changes the color from green to yellow and then back to green, over and over, to indicate that work is in progress.

In the worker_ProgressChanged event handler, the UI thread receives the latest status from the background worker, available in the e.ProgressPercentage value. It is safe to update the UI in this method, so you set the tooltip on the status ellipse with the latest value.

The worker_RunWorkerCompleted event fires when the work successfully completes as well as when the background worker is cancelled by the UI thread, so you first check to see if e.Cancelled is not true. If the work successfully completes, you set the ellipse to green, update the tooltip to indicate that it is complete, and take the value passed in as e.Result and add it to the TextBox.Text value.

When the user clicks the ellipse, a dialog is displayed with two buttons so that the user can click Yes to cancel or decide not to cancel, as shown in Figure 2-16.

Figure 2-16. *The cancel operation dialog, where the user makes the choice.*

The StatusEllipse_MouseLeftButtonDown event checks to see if the background worker thread is actually running and then sets PromptCancelCanvas.Visibility to Visibility.Visible. That displays the dialog that simply consists of a large rectangle with a transparent look and a rounded white rectangle with the two buttons. Clicking Yes fires the ButtonConfirmCancelYes_Click event handler that calls the worker.CancelAsync method.

That completes the walkthrough of the code. Most of the other UI code is generated using Expression Blend, which is covered in Chapter 3. We recommend playing with the UI a bit to understand what it does and then reviewing the corresponding code. Listings 2-13 and 2-14 list the code for this recipe's test application. We don't show the keyframe animation in the AnimateStatusEllipse to make Listing 2-14 easier to navigate.

Listing 2-13. *Recipe 2-7's MainPage.xaml File*

```
<UserControl x:Class="Ch02_ProgrammingModel.Recipe2_7.MainPage"

 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"
   mc:Ignorable="d"
  d:DesignHeight="300" d:DesignWidth="400">
  <UserControl.Resources>
    <Storyboard x:Name="AnimateStatusEllipse">
    ….
    </Storyboard>
  </UserControl.Resources>
  <Grid x:Name="LayoutRoot" Background="#FFFFFFFF">
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.068*"/>
      <ColumnDefinition Width="0.438*"/>
      <ColumnDefinition Width="0.495*"/>
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
      <RowDefinition Height="0.08*"/>
      <RowDefinition Height="0.217*"/>
      <RowDefinition Height="0.61*"/>
      <RowDefinition Height="0.093*"/>
    </Grid.RowDefinitions>
    <Button HorizontalAlignment="Stretch" Margin="5,8,5,8"
     VerticalAlignment="Stretch" Grid.Column="1" Grid.Row="1"
      Content="Save Form Data" Click="SaveFormData_Click"/>
    <StackPanel HorizontalAlignment="Stretch"
    Margin="5,8,6,8" Grid.Column="1" Grid.Row="2">
      <TextBlock Height="Auto" Width="Auto" Text="Work Results Appear Below"
      TextWrapping="Wrap" Margin="4,4,4,4"/>
      <TextBox Height="103" Width="Auto" Text="" TextWrapping="Wrap"
      Margin="4,4,4,4" x:Name="WorkResultsTextData"/>
```

```
</StackPanel>
<Button HorizontalAlignment="Stretch" Margin="12,8,8,8"
  VerticalAlignment="Stretch"
 Grid.Column="2" Grid.Row="1" Content="Load Form Data"
 Click="ReadFormData_Click"/>
<Button HorizontalAlignment="Stretch" Margin="10,2,8,6"
  VerticalAlignment="Stretch"
   Grid.Column="1" Grid.Row="3" Content="Kick Off Work" x:Name="DoWorkButton"
   Click="DoWorkButton_Click"/>
<Border Grid.Column="2" Grid.Row="2" Grid.RowSpan="2" CornerRadius="10,10,10,10"
   Margin="1.802000004577637,2,2,2">
  <Border.Background>
    <LinearGradientBrush EndPoint="0.560000002384186,0.003000000002607703"
       StartPoint="0.439999997615814,0.996999979019165">
      <GradientStop Color="#FF586C57"/>
      <GradientStop Color="#FFA3BDA3" Offset="0.536"/>
      <GradientStop Color="#FF586C57" Offset="0.968999981880188"/>
    </LinearGradientBrush>
  </Border.Background>
  <StackPanel Margin="4,4,4,4"  x:Name="FormData">
    <TextBlock Height="Auto" Width="Auto" Text="First Name:" TextWrapping="Wrap"
    Margin="2,2,2,0"/>
    <TextBox Height="Auto" Width="Auto" Text="" TextWrapping="Wrap" x:
      Name="Field1" Margin="2,0,2,4"/>
    <TextBlock Height="Auto" Width="Auto" Text="Last Name:"
       TextWrapping="Wrap" Margin="2,4,2,0"/>
    <TextBox Height="Auto" x:Name="Field2" Width="Auto" Text=""
      TextWrapping="Wrap" Margin="2,0,2,4"/>
    <TextBlock Height="Auto" Width="Auto" Text="Company:"
      TextWrapping="Wrap" Margin="2,4,2,0"/>
    <TextBox Height="Auto" x:Name="Field3" Width="Auto" Text=""
      TextWrapping="Wrap" Margin="2,0,2,2"/>
    <TextBlock Height="22.537" Width="182" Text="Title:"
      TextWrapping="Wrap" Margin="2,4,2,0"/>
    <TextBox Height="20.772" x:Name="Field4" Width="182" Text=""
      TextWrapping="Wrap" Margin="2,0,2,2"/>
  </StackPanel>
</Border>
<Ellipse x:Name="StatusEllipse" Margin="4,2,2,2" Grid.Row="3" Stroke="#FF000000"
  Fill="#FF2D4DE0" MouseLeftButtonDown="StatusEllipse_MouseLeftButtonDown"
  RenderTransformOrigin="0.5,0.5" >
  <Ellipse.RenderTransform>
    <TransformGroup>
      <ScaleTransform/>
      <SkewTransform/>
```

```
          <RotateTransform/>
          <TranslateTransform/>
        </TransformGroup>
      </Ellipse.RenderTransform>
      <ToolTipService.ToolTip>
        <ToolTip Content="Click button to start work." />
      </ToolTipService.ToolTip>
    </Ellipse>
    <Canvas HorizontalAlignment="Stretch" Margin="0,0,2,8" Grid.RowSpan="4"
      Grid.ColumnSpan="3" x:Name="PromptCancelCanvas" Visibility="Collapsed">
      <Rectangle Height="300" Width="400" Fill="#FF808080" Stroke="#FF000000"
        Stretch="Fill" Opacity="0.6"/>
      <Canvas Height="106" Width="289" Canvas.Left="46" Canvas.Top="85">
        <Rectangle Height="106" Width="289" Fill="#FFFFFFFF" Stroke="#FF000000"
          RadiusX="23" RadiusY="23" Opacity="0.85"/>
        <Button Height="34" x:Name="ButtonConfirmCancelYes" Width="100"
          Canvas.Left="15" Canvas.Top="49" Content="Yes"
          Click="ButtonConfirmCancelYes_Click"/>
        <Button Height="34" x:Name="ButtonConfirmCancelNo" Width="100"
          Canvas.Left="164" Canvas.Top="49" Content="No" Click=
         "ButtonConfirmCancelNo_Click"/>
        <TextBlock Width="134.835" Canvas.Left="75" Canvas.Top="12.463"
          Text="Cancel Operation?" TextWrapping="Wrap"/>
      </Canvas>
    </Canvas>
    <TextBlock Margin="67.8270034790039,0,-88.802001953125,0" Grid.Column="1"
      Grid.ColumnSpan="1" Text="BackgroundWorker Thread" TextWrapping="Wrap"/>
  </Grid>
</UserControl>
```

Listing 2-14. *Recipe 2-7's MainPage.xam.cs File*

```
using System;
using System.ComponentModel;
using System.IO;
using System.IO.IsolatedStorage;
using System.Linq;
using System.Text;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Input;
using System.Windows.Media;
using System.Windows.Media.Animation;

namespace Ch02_ProgrammingModel.Recipe2_7
```

```
{
  public partial class MainPage : UserControl
  {
    private int WorkLoops=30;
    private BackgroundWorker worker = new BackgroundWorker();
    #region Recipe 2-3 Declarations
    private IsolatedStorageSettings settings =
              IsolatedStorageSettings.ApplicationSettings;
    private string FormDataFileName = "FormFields.data";
    private string FormDataDirectory = "FormData";
    #endregion
    public MainPage()
    {
      InitializeComponent();

      //Configure BackgroundWorker thread
      worker.WorkerReportsProgress = true;
      worker.WorkerSupportsCancellation = true;
      worker.DoWork += new DoWorkEventHandler(worker_DoWork);
      worker.ProgressChanged +=
          new ProgressChangedEventHandler(worker_ProgressChanged);
      worker.RunWorkerCompleted += new
      RunWorkerCompletedEventHandler(worker_RunWorkerCompleted);
    }

    void worker_DoWork(object sender, DoWorkEventArgs e)
    {
      for (int i = 1; i <= WorkLoops; i++)
      {
        //Check to see if the work has been canceled
        if ((worker.CancellationPending == true))
        {
          e.Cancel = true;
          break;
        }
        else
        {
          // Perform a time consuming operation and report progress.
          System.Threading.Thread.Sleep(1000);
          worker.ReportProgress((int)
              System.Math.Floor((double)i / (double)WorkLoops * 100.0));
        }
      }
      e.Result = Environment.NewLine + "Completed: " + DateTime.Now.ToString();
    }
```

```
void worker_RunWorkerCompleted(object sender, RunWorkerCompletedEventArgs e)
{
  AnimateStatusEllipse.Stop();
  if (!e.Cancelled)
  {
    StatusEllipse.Fill = new SolidColorBrush(Color.FromArgb(255, 0, 255, 0));
    WorkResultsTextData.Text = WorkResultsTextData.Text + e.Result.ToString();
    ToolTipService.SetToolTip(StatusEllipse, "Work Complete.");
  }
  else
  {
    StatusEllipse.Fill = new SolidColorBrush(Color.FromArgb(255, 255, 255, 0));
    WorkResultsTextData.Text = WorkResultsTextData.Text +
      Environment.NewLine + "Canceled @: " + DateTime.Now.ToString();
    ToolTipService.SetToolTip(StatusEllipse, "Operation canceled by user.");
  }

}

void worker_ProgressChanged(object sender, ProgressChangedEventArgs e)
{
  if (PromptCancelCanvas.Visibility == Visibility.Collapsed)
    ToolTipService.SetToolTip(StatusEllipse, e.ProgressPercentage.ToString() +
      "% Complete.  Click to cancel...");
}

private void DoWorkButton_Click(object sender, RoutedEventArgs e)
{
  if (worker.IsBusy != true)
  {
    WorkResultsTextData.Text = "Started: "+DateTime.Now.ToString();
    worker.RunWorkerAsync(WorkResultsTextData.Text);
    AnimateStatusEllipse.RepeatBehavior = RepeatBehavior.Forever;
    AnimateStatusEllipse.Begin();
  }
}

private void StatusEllipse_MouseLeftButtonDown
    (object sender, MouseButtonEventArgs e)
{
  if (worker.IsBusy)
    PromptCancelCanvas.Visibility = Visibility.Visible;
}

private void ButtonConfirmCancelYes_Click(object sender, RoutedEventArgs e)
```

```
{
  worker.CancelAsync();
  PromptCancelCanvas.Visibility = Visibility.Collapsed;
}

private void ButtonConfirmCancelNo_Click(object sender, RoutedEventArgs e)
{
  PromptCancelCanvas.Visibility = Visibility.Collapsed;
}
#region Recipe 2-3 Event Handlers
private void SaveFormData_Click(object sender, RoutedEventArgs e)
{
  try
  {
    using (var store = IsolatedStorageFile.GetUserStoreForApplication())
    {
      //Use to control loop for finding correct number of textboxes
      int TotalFields = 4;
      StringBuilder formData = new StringBuilder(50);
      for (int i = 1; i <= TotalFields; i++)
      {
        TextBox tb = FindName("Field" + i.ToString()) as TextBox;
        if (tb != null)
          formData.Append(tb.Text);
        //If on last TextBox value, don't add "|" character to end of data
        if (i != TotalFields)
          formData.Append("|");
      }
      store.CreateDirectory(FormDataDirectory);
      IsolatedStorageFileStream fileHandle = store.CreateFile(System.IO.Path.
      Combine(FormDataDirectory, FormDataFileName));

      using (StreamWriter sw = new StreamWriter(fileHandle))
      {
        sw.WriteLine(formData);
        sw.Flush();
        sw.Close();
      }
    }
  }
  catch (IsolatedStorageException ex)
  {
    WorkResultsTextData.Text = "Error saving data: " + ex.Message;
  }
}
```

```
    private void ReadFormData_Click(object sender, RoutedEventArgs e)
    {
      using (var store = IsolatedStorageFile.GetUserStoreForApplication())
      {
        //Load form data using private string values for directory and filename
        string filePath =
           System.IO.Path.Combine(FormDataDirectory, FormDataFileName);
        //Check to see if file exists before proceeding
        if (store.FileExists(filePath))
        {
          using (StreamReader sr = new StreamReader(
              store.OpenFile(filePath, FileMode.Open, FileAccess.Read)))
          {
            string formData = sr.ReadLine();
            //Split string based on separator used in SaveFormData method
            string[] fieldValues = formData.Split('|');
            for (int i = 1; i <= fieldValues.Count(); i++)
            {
              //Use the FindName method to loop through TextBoxes
              TextBox tb = FindName("Field" + i.ToString()) as TextBox;
              if (tb != null)
                tb.Text = fieldValues[i - 1];
            }
            sr.Close();
          }
        }
      }
    }
    #endregion
  }
}
```

2-8. Updating the UI from a Background Thread

Problem

You need to update the UI from a background thread so that the UI can be responsive.

Solution

The `Dispatcher` class offers a safe way to call a method that updates the UI asynchronously from a background thread by providing services for managing the queue of work items for a thread. Both the `Dispatcher` and the `BackgroundWorker` classes can perform work on a separate thread. The

`BackgroundWorker` class supports progress reporting and cancellation. The `Dispatcher` class is useful when you need a simple way to queue up background work without progress reporting or cancellation.

How It Works

The .NET Framework for Silverlight includes the `System.Threading` namespace, which contains classes needed to manage a thread pool, launch threads, and synchronize threads, just like the full version of the .NET Framework.

As with most UI programming models such as Visual Basic 6, .NET Windows Forms, or WPF, it is not safe to access UI objects from a background thread. UI objects, such as `Button`, `TextBox`, and `TextBlock` objects, can only be safely accessed on the UI thread.

The role of the `Dispatcher` is to provide a way for a background thread to invoke a method that runs on the main thread so that it can safely update the UI. This approach is useful when you're retrieving data from the server using the asynchronous `WebRequest` class, as demonstrated in this recipe. Figure 2-17 shows the UI for the application after the data is downloaded.

Figure 2-17. *Recipe 2-7 test UI*

The Code

The sample application for this recipe contains a button titled Retrieve XML and Load that when clicked fires the event `RetrieveXMLandLoad_Click`. This event creates an `HttpWebRequest` object that points to the location where Recipe 2-5's `ApressBooks.xml` file was copied:

```
Uri location =
   new Uri("http://localhost:9090/xml/ApressBooks.xml",UriKind.Absolute);
WebRequest request = HttpWebRequest.Create(location);
request.BeginGetResponse(
    new AsyncCallback(this.RetrieveXmlCompleted), request);
```

When the asynchronous web request completes, the code in the callback method `RetrieveXmlCompleted` executes. The following code retrieves the XML document from the response stream and stores it in an `XDocument` object:

```
HttpWebRequest request = ar.AsyncState as HttpWebRequest;
WebResponse response = request.EndGetResponse(ar);
Stream responseStream = response.GetResponseStream();
using (StreamReader streamreader = new StreamReader(responseStream))
{
  XDocument xDoc = XDocument.Load(streamreader);
…
```

The rest of the code in the callback method `RetrieveXmlCompleted` executes the same LINQ to XML as in Recipe 2-5 to obtain a `List` of `ApressBook` objects. The last line of code calls the `Dispatcher` object to queue UI work by calling `BeginInvoke` to execute the delegate and passing in the method `DataBindListBox` on the UI thread passing in the `List` of `ApressBook` objects:

```
Dispatcher.BeginInvoke(() => DataBindListBox(_apressBookList));
```

The syntax looks a bit strange if you are not familiar with C# lambda expressions. The syntax is shorthand for creating a delegate object and mashing the parameters into the call. The method `DataBindListBox` has a single line of code to assign the `ItemsSource` property on the `BooksListBox` object:

```
BooksListBox.ItemsSource = list;
```

If you skip using the `Dispatcher` in the callback method `RetrieveXmlCompleted` for the `HttpWebRequest` and instead put the line of code to assign the `ItemsSource` property in the callback method directly, the UI will not be updated because the callback method returns on the background thread of the `HttpWebRequest`, not the UI thread. By calling `Dispatcher.BeginInvoke` to update the UI from the `HttpWebRequest` callback background thread, you queue the work to assign the `List` object to the `ItemsSource` so that it safely executes when the main UI thread literally has cycles available. Listings 2-15 and 2-16 show the source code for this recipe's test application.

Listing 2-15. *Recipe 2-8's MainPage.xaml File*

```
<UserControl x:Class="Ch02_ProgrammingModel.Recipe2_8.MainPage"
    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"
```

```
    mc:Ignorable="d"
    d:DesignHeight="300" d:DesignWidth="400">  <Grid x:Name="LayoutRoot" Background="White"
Margin="6,6,6,6">
    <StackPanel>
      <Button Content="Retrieve XML and Load"
            Click="RetrieveXMLandLoad_Click"></Button>
      <ListBox x:Name="BooksListBox" Margin="4,4,4,4" Height="452"  >
        <ListBox.ItemTemplate>
          <DataTemplate>
            <StackPanel Margin="2,2,2,2">
              <TextBlock Text="{Binding Path=ISBN}" Margin="0,0,0,2"/>
              <TextBlock Text="{Binding Path=Title}" Margin="0,0,0,2"/>
              <TextBlock Width="550" Text="{Binding Path=Description}"
                       TextWrapping="Wrap" Margin="0,0,0,10"/>
            </StackPanel>
          </DataTemplate>
        </ListBox.ItemTemplate>
      </ListBox>
    </StackPanel>
  </Grid>
</UserControl>
```

Listing 2-16. *Recipe 2-8's MainPage.xaml.cs File*

```
using System;
using System.Collections.Generic;
using System.IO;
using System.Linq;
using System.Net;
using System.Windows;
using System.Windows.Controls;
using System.Xml.Linq;

namespace Ch02_ProgrammingModel.Recipe2_8
{
  public partial class MainPage : UserControl
  {
    public MainPage()
    {
      InitializeComponent();
    }

private void RetrieveXMLandLoad_Click(object sender, RoutedEventArgs e)
    {
      Uri location =
```

```
        new Uri("http://localhost:9090/xml/ApressBooks.xml", UriKind.Absolute);
    WebRequest request = HttpWebRequest.Create(location);
    request.BeginGetResponse(
        new AsyncCallback(this.RetrieveXmlCompleted), request);
  }

  void RetrieveXmlCompleted(IAsyncResult ar)
  {
    List<ApressBook> _apressBookList;
    HttpWebRequest request = ar.AsyncState as HttpWebRequest;
    WebResponse response = request.EndGetResponse(ar);
    Stream responseStream = response.GetResponseStream();
    using (StreamReader streamreader = new StreamReader(responseStream))
    {
      XDocument xDoc = XDocument.Load(streamreader);
      _apressBookList =
      (from b in xDoc.Descendants("ApressBook")
       select new ApressBook()
       {
         Author = b.Element("Author").Value,
         Title = b.Element("Title").Value,
         ISBN = b.Element("ISBN").Value,
         Description = b.Element("Description").Value,
         PublishedDate = Convert.ToDateTime(b.Element("DatePublished").Value),
         NumberOfPages = b.Element("NumPages").Value,
         Price = b.Element("Price").Value,
         ID = b.Element("ID").Value
       }).ToList();
    }
    //Could use Anonymous delegate (does same as below line of code)
    //Dispatcher.BeginInvoke(
    //  delegate()
    //  {
    //    DataBindListBox(_apressBookList);
    //  }
    // );
    //Use C# 3.0 Lambda
    Dispatcher.BeginInvoke(() => DataBindListBox(_apressBookList));
  }

  void DataBindListBox(List<ApressBook> list)
  {
    BooksListBox.ItemsSource = list;
  }
}
```

```
  public class ApressBook
  {
    public string Author { get; set; }
    public string Title { get; set; }
    public string ISBN { get; set; }
    public string Description { get; set; }
    public DateTime PublishedDate { get; set; }
    public string NumberOfPages { get; set; }
    public string Price { get; set; }
    public string ID { get; set; }
  }
}
```

2-9. Managing XAML Resources

Problem

You want to create a consistent UI without having to replicate styles, colors, templates, and so forth on individual elements, much in the same way that CSS resources are shared in a web application.

Solution

Take advantage of `ResourceDictionary` objects to store resources that can be accessed using the `StaticResource` markup extension. The `Resources` member introduced in the `FrameworkElement` class is of type `ResourceDictionary`, which is a `Dictionary` collection accessible via name/value pairs. The `Resources` member can be used to organize common styles, brushes, and colors for use across an application.

How It Works

A markup extension provides additional evaluation for a value set on an attribute in XAML. For example, a value can be configured for `Background` equal to the string `"Green"`, which is evaluated by a `TypeConverter` that takes the string value and converts it to the `Colors.Green` enumerations value. You can also set `Background` equal to the hexadecimal value, such as `#FF008000`, which also equals the color `Green`.

Type converters are great for single string values converted to a particular type, which we cover in Chapter 5. A markup extension, such as `StaticResource`, allows more complex string values that consist of multiple types to be evaluated or substituted for the placeholder value of an attribute. A `StaticResource` value can be configured for any XAML property attribute except for event attributes. All markup extensions have the following syntax:

```
<element attribute="{MarkupExtensionName Value}"  />
```

When you first see this syntax, it looks a bit confusing, but once you understand it, you see the power that markup extensions provide. For the `StaticResource` markup extension, `Value` represents an

x:key name for a resource located in a Resources collection in the application. Usually resources are located at the Application or UserControl (page) level, but they can be located on any element that inherits from FrameworkElement, such as Grid or StackPanel objects.

Silverlight 4 added the ability to have a merged resource dictionary, which means that you can place the contents of a resource dictionary in a separate file but have the resources treated as a logical part of the main XAML file. Resources stored in a merged resource dictionary are accesses only after all resources in the main XAML code file are checked for a match. The MergedDictionaries is a collection the UIElement.ResourceDictionary object. Here is an example:

```
<ResourceDictionary>
      <SolidColorBrush Color="#FFFFFFFF" x:Key="darkBrush"/>
      <ResourceDictionary.MergedDictionaries>
        <ResourceDictionary Source="/GradientsResourceDictionary.xaml">
        <ResourceDictionary Source="/StylesResourceDictionary.xaml">
      </ResourceDictionary.MergedDictionaries>
    </ResourceDictionary>
```

The separate resource dictionary files contain a <ResourceDictionary> declaration as the root element with the resources identified as if part of the MainPage.ResourceDictonary directly.

The Code

The sample application for this recipe includes a number of resources defined in the MainPage class. Here is an example resource defined at the <UserControl> level:

```
<UserControl.Resources>
  <Color x:Key="Pumpkin">#FFD5901F</Color>
  <Color x:Key="Lime">#FF75E564</Color>
  <LinearGradientBrush x:Key="PumpkinLimeBrush"
           EndPoint="0.5,1" StartPoint="0.5,0">
    <GradientStop Color="{StaticResource Lime}"/>
    <GradientStop Color="{StaticResource Pumpkin}" Offset="1"/>
  </LinearGradientBrush>
</UserControl.Resources>
```

Three resources are defined with two color resources and a brush resource. The brush is a LinearGradientBrush that references the color resources for the GradientStop Color value using the syntax discussed earlier:

```
{StaticResource Lime}
```

■ **Note** For performance reasons, if a resource consists of other resources, define the resources in order of dependency as shown in the preceding example so that forward references can be avoided.

Notice that every resource has a name defined by the x:Key attribute, which is different than the x:Name attribute used to name XAML elements. This is the value used to reference a resource with the

XAML on the page. For example, you add a `StackPanel` to `Grid.Row="0"` and `Grid.Column="0"` and configure the `Background` attribute to this value:

```
Background="{StaticResource PumpkinLimeBrush}"
```

Figure 2-18 shows the result.

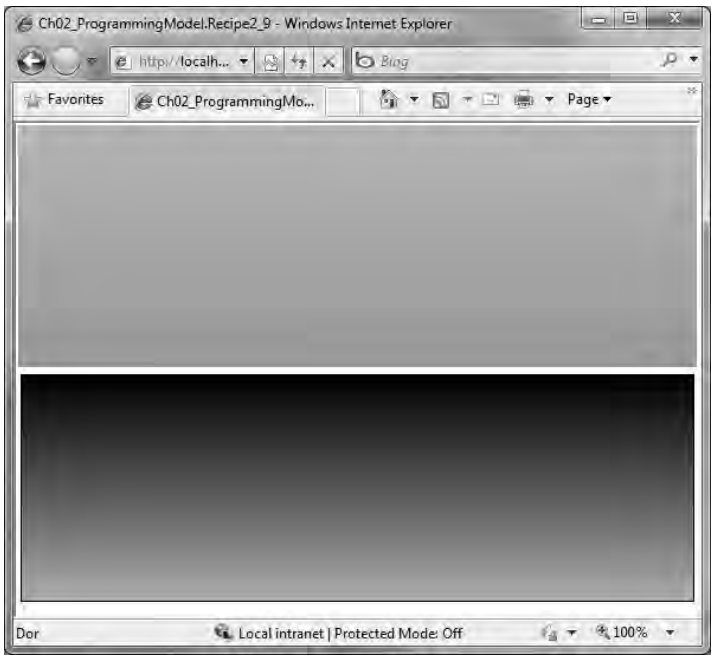


Figure 2-18. *Applying the PumpkinLimeBrush resource to a StackPanel*

Expression Blend 4 provides great support to create and manage resources. There is a Resources tab next to the Project and Properties tabs in the UI. You can expand the tree in the Resources tab to view resources created as part of the available objects, such as the `Application`, `MainPage`, and `StackPanel` levels, as shown in Figure 2-19.

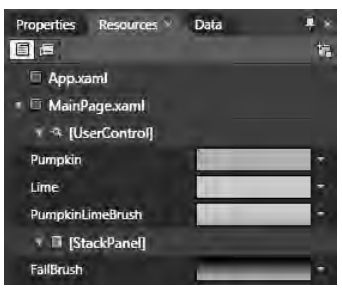


Figure 2-19. *The Resources tab in Expression Blend 4*

Expression Blend 4 provides a drop-down editor for modifying resources right on the Resources tab, as shown in Figure 2-20.

Figure 2-20. *In-place editing in the Resources tab*

Resources can be defined deeper in the XAML tree, such as on a `Grid` or `StackPanel` control, or even on a `Rectangle` directly. Any object that inherits from `FrameworkElement` has the `Resources` collection. Click the Advanced Properties Option button next to Background, and select Convert to New Resource in the pop-up menu in Expression Blend 4, as shown in Figure 2-21. The Create Brush Resource dialog displays the two available options to store a resource; either at the application or page level, as shown in the Define In section of Figure 2-21.

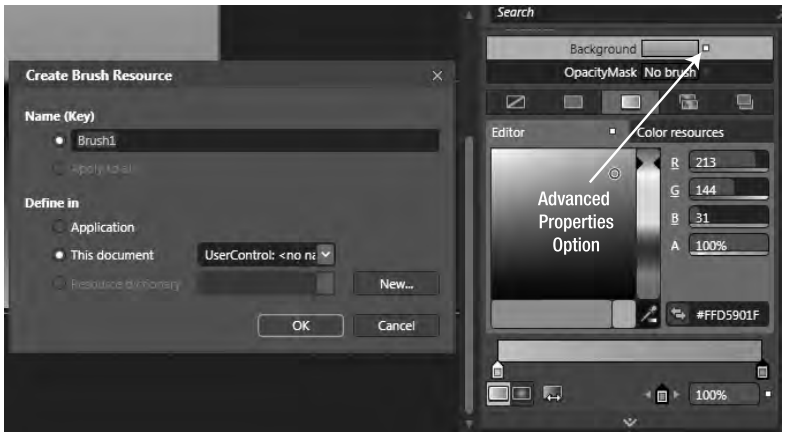


Figure 2-21. *Converting a brush to a resource*

If you want to define a resource at a different level, you can use Expression Blend 4 to create a resource at the document or `UserControl` level and then copy it to the location where you want it. As an example, define a new brush called `FallBrush` at the `UserControl` level and then move it to a new location, in this case a `StackPanel`, using the following code:

```
<StackPanel Grid.Column="0" Grid.Row="1"  Margin="2,2,2,2">
  <StackPanel.Resources>
    <LinearGradientBrush x:Key="FallBrush" EndPoint="0.5,1" StartPoint="0.5,0">
      <GradientStop Color="#FF000000"/>
      <GradientStop Color="#FFFFA500" Offset="1"/>
    </LinearGradientBrush>
  </StackPanel.Resources><Rectangle Margin="2,2,2,2" Stroke="#FF000000"
    Fill="{StaticResource FallBrush}" Height="193"/>
</StackPanel>
```

You've moved the `FallBrush` resource from the `UserControl.Resources` to `StackPanel.Resources` and applied it to a `Rectangle`, resulting in the UI as shown in Figure 2-18 above. This limits use of the resource within the `StackPanel` only. For resources that need to be shared across the application, locate the resource at the page or application level.

For this recipe, all of the modifications are in the XAML, shown in Listing 2-17.

Listing 2-17. *Recipe 2-9's MainPage.xaml File*

```
<UserControl x:Class="Ch02_ProgrammingModel.Recipe2_9.MainPage"
  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"
  mc:Ignorable="d" d:DesignHeight="300"
d:DesignWidth="400">  <UserControl.Resources>
    <Color x:Key="Pumpkin">#FFD5901F</Color>
    <Color x:Key="Lime">#FF75E564</Color>
    <LinearGradientBrush x:Key="PumpkinLimeBrush"
      EndPoint="0.5,1" StartPoint="0.5,0">
      <GradientStop Color="{StaticResource Lime}"/>
      <GradientStop Color="{StaticResource Pumpkin}" Offset="1"/>
    </LinearGradientBrush>
  </UserControl.Resources>
  <Grid x:Name="LayoutRoot">
    <Grid.RowDefinitions>
      <RowDefinition Height="0.5*"/>
      <RowDefinition Height="0.5*"/>
    </Grid.RowDefinitions>
    <StackPanel Grid.Row="0" Background=
    "{StaticResource PumpkinLimeBrush}" Margin="2,2,2,2">
    </StackPanel>
    <StackPanel Grid.Row="1"  Margin="2,2,2,2">
```

```
      <StackPanel.Resources>
        <LinearGradientBrush x:Key="FallBrush" EndPoint="0.5,1" StartPoint="0.5,0">
          <GradientStop Color="#FF000000"/>
          <GradientStop Color="#FFFFA500" Offset="1"/>
        </LinearGradientBrush>
      </StackPanel.Resources>
      <Rectangle Margin="2,2,2,2" Stroke="#FF000000" Fill=
        "{StaticResource FallBrush}" Height="193"/>
    </StackPanel>
  </Grid>
</UserControl>
```

2-10. Managing Embedded Resources

Problem

You want to store resources inside of the Silverlight application container (the `.xap` file) and retrieve them at runtime, as opposed to simply putting the resources, such as images, in the file system and referencing as a URL.

Solution

Use the `Assembly.GetManifestResourceNames` and `Assembly.GetManifestResourceStream` methods to enumerate and retrieve resources embedded in a Silverlight application.

How It Works

To read embedded resources, you have to first embed them into the application. To embed resources such as images, video, and XML data, add the resources to the Silverlight application project, and set the build action for each resource to Embedded Resource. The next time you build the project, the resources will be embedded into the application.

To obtain a list of resources available in the application, you can call `Assembly.GetManifestResourceNames` to obtain the names as a string array:

```
Assembly app = Assembly.GetExecutingAssembly();
string[] resources = app.GetManifestResourceNames();
```

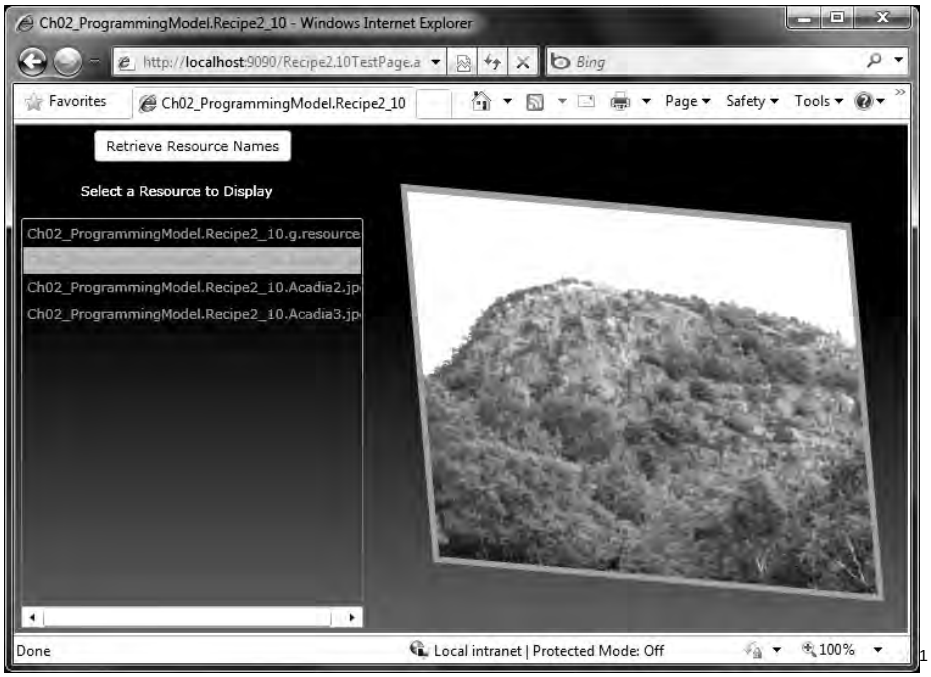
Once you have the name of the desired resource, you can call `Assembly.GetManifestResourceStream` to obtain the resource as a byte array and then convert it to the appropriate type.

The Code

The sample application for this recipe includes three images that have been configured to be an embedded resource in the assembly. The UI for the recipe has a simple gradient for the root `Grid Background`, a `Button` named `RetrieveResourceNames` to retrieve the resource names of embedded resources that are available, and a `ListBox` control named `ResourceNames` to display the names.

The application also has a `Border` control to provide a color outline for a nested `Image` control, which is where the embedded resources are displayed. You apply a simple 5% skew transformation to the `Border`. (We cover transformations in Chapter 3.)

When the application runs, the user can click the button to obtain a list of available resources, which includes the three images. Selecting an image name in the `ListBox` displays the image within the `Border` control. Figure 2-22 shows the application UI with an image selected.



[1]

Figure 2-22. *Recipe 2-10 UI with an image selected*

The images are named `Acadia1`, `Acadia2`, and `Acadia3` in the project file system. However, when they are embedded into the application binary, the namespace is added to the filename. Keep this in mind when loading resources if you're not first getting their names using the `GetManifestResourceNames`.

Notice the first resource listed in Figure 2-22. This resource is automatically generated as part of compiling and generating the application. When the first resource is clicked, simply ignore it since it isn't an image.

This application has a simple UI to demonstrate the functionality but here is the minor configuration: the `ListBox` is transparent, and the foreground color for the items is orange; the `ListBox`'s `Foreground` property is configured with a `SolidColorBrush` to provide the orange text; the `ListBox`'s `Background` property is set to `Transparent`, which results in the transparency; and the `ListBox`'s `ItemContainerStyle` defaults to a white background, which is modified with this XAML for the style:

```
<ListBox.ItemContainerStyle>
  <Style TargetType="ListBoxItem">
```

[1]

```
    <Setter Property="Background" Value="Transparent"/>
  </Style>
</ListBox.ItemContainerStyle>
```

We cover styling controls in Chapter 5; this XAML is just a simple example of applying a style. Styles can also be resources that are loaded using the `StaticResource` markup extension.

The code file has two events: one to retrieve the list of resource names for the button click event and another that loads the resource into the `Image` object. As mentioned earlier, the `GetManifestResourceNames` returns a string array of resource names, so that is easy enough to do. The somewhat more complex code is actually retrieving the resource as a byte array and converting it to an image.

You use a stream object to obtain the array of bytes that represents the binary resource data. You create a new `System.Windows.Media.Imaging.BitMapImage` object and call the `SetSource` method, passing in the stream of bytes:

```
BitmapImage bImage = new BitmapImage();
bImage.SetSource(stream);
```

This code loads the bytes into a `BitmapImage` object, which is then set as the `Source` for the `Image` control named `ImageDisplay` that renders the image to the screen. Listings 2-18 and 2-19 have the full code listing.

Listing 2-18. *Recipe 2-10's MainPage.xaml File*

```
<UserControl x:Class="Ch02_ProgrammingModel.Recipe2_10.MainPage"
    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"
    mc:Ignorable="d" d:DesignHeight="300" d:DesignWidth="400">  <Grid x:Name="LayoutRoot">
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.41*"/>
      <ColumnDefinition Width="0.59*"/>
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
      <RowDefinition Height="0.172*"/>
      <RowDefinition Height="0.828*"/>
    </Grid.RowDefinitions>
    <Grid.Background>
      <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
        <GradientStop Color="#FF000000"/>
        <GradientStop Color="#FF696767" Offset="1"/>
      </LinearGradientBrush>
    </Grid.Background>
    <ListBox x:Name="ResourceNames" Background="Transparent"
     HorizontalAlignment="Stretch" Margin="4,4,15,4" Grid.Row="1"
     SelectionChanged="ResourceNames_SelectionChanged">
      <ListBox.Foreground>
```

```
        <SolidColorBrush Color="#FFD18726"/>
      </ListBox.Foreground>
      <ListBox.ItemContainerStyle>
        <Style TargetType="ListBoxItem">
          <Setter Property="Background" Value="Transparent"/>
        </Style>
      </ListBox.ItemContainerStyle>
    </ListBox>
    <Button Height="26.4" HorizontalAlignment="Stretch"
     Margin="64,4,74,0" x:Name="RetrieveResourceNames"
     VerticalAlignment="Top" Content="Retrieve Resource Names"
     d:LayoutOverrides="VerticalAlignment, Height"
     Click="RetrieveResourceNames_Click"/>
    <TextBlock HorizontalAlignment="Stretch" Margin="53,0,74,4"
     VerticalAlignment="Bottom" Text="Select a Resource to Display"
     TextWrapping="Wrap" Foreground="#FFFFFFFF" Height="22"/>
    <Border Margin="29.2129993438721,
     -15.206000328064,32.7869987487793,35.6059989929199"
    HorizontalAlignment="Stretch" BorderBrush="#FF000000"
    x:Name="ImageBorder" RenderTransformOrigin="0.5,0.5"
    Visibility="Collapsed" Height="310.8" VerticalAlignment="Stretch"
    Grid.Column="1" Grid.ColumnSpan="1" Grid.Row="1" Grid.RowSpan="1"
    d:LayoutOverrides="Height">
      <Border.Background>
        <SolidColorBrush Color="#FFD28826"/>
      </Border.Background>
      <Border.RenderTransform>
        <TransformGroup>
          <ScaleTransform/>
          <SkewTransform AngleX="5" AngleY="5"/>
          <RotateTransform/>
          <TranslateTransform/>
        </TransformGroup>
      </Border.RenderTransform>
      <Image x:Name="ImageDisplay" Margin="5,5,5,5" Width="400"
        Height="300" OpacityMask="#FF000000" />
    </Border>
  </Grid>
</UserControl>
```

Listing 2-19. *Recipe 2-10's MainPage.xaml.cs File*

```
using System.IO;
using System.Reflection;
using System.Windows;
```

```
using System.Windows.Controls;
using System.Windows.Media.Imaging;

namespace Ch02_ProgrammingModel.Recipe2_14
{
  public partial class MainPage : UserControl
  {
    public MainPage()
    {
      InitializeComponent();
    }

    private void RetrieveResourceNames_Click(object sender, RoutedEventArgs e)
    {
      Assembly app = Assembly.GetExecutingAssembly();
      string[] resources = app.GetManifestResourceNames();
      ResourceNames.Items.Clear();
      foreach (string s in resources)
      {
        ResourceNames.Items.Add(s);
      }
    }

    private void ResourceNames_SelectionChanged(object sender,
    SelectionChangedEventArgs e)
    {
      if ((ResourceNames.SelectedIndex != -1) && (ResourceNames.SelectedIndex != 3))
      {
        Assembly app = Assembly.GetExecutingAssembly();
        using (Stream stream = app.GetManifestResourceStream
        (ResourceNames.SelectedItem.ToString()))
{
          BitmapImage bImage = new BitmapImage();
          bImage.SetSource(stream);
          ImageDisplay.Source = bImage;
          ImageBorder.Visibility = Visibility.Visible;
        }
      }
    }
  }
}
```

2-11. Creating Silverlight Using Ruby, Python, or JScript

Problem

You want to program Silverlight using either the IronRuby, IronPython, or Managed JScript dynamic languages.

Solution

Download and install the Dynamic Language Runtime SDK for Silverlight on Windows or on a Mac OS X system.

How It Works

The first step is to download the latest Silverlight Dynamic Languages SDK from CodePlex at `sdlsdk.codeplex.com/Release/ProjectReleases.aspx?ReleaseId=25120`. This URL takes you to the most recent version available (version 0.5.0 at the time of this writing), so be sure to check the Releases section to see if a more up-to-date version is available.

■ **Note** While this book targets Silverlight 4 RTW, we performed these steps with the Silverlight 3 version of the Dynamic Languages SDK because it was the most recent version available at the time.

Download the `agdlr-version# (Everything)` package and unzipped the contents to the `Code\Ch02_ProgrammingModel\DLR_Download\` folder. Then, copy the contents over to a directory named `c:\SagDLR`. The package includes the IronRuby and IronPython languages as part of the "everything" download.

■ **Note** To program in IronRuby, download Ruby from `rubyforge.org/frs/?group_id=167` and install using the OneClick Installer for Windows. It will install Ruby at `c:\Ruby` on your hard drive.

After installing the Silverlight Dynamic Languages SDK and Ruby, you can build applications using the IronRuby, IronPython, or Managed JScript dynamic languages. At the time of this writing, there are no Visual Studio 2010 templates for dynamic languages. The Silverlight Dynamic Languages SDK includes a tool named Chiron (`Chiron.exe`) that allows you to work with Silverlight and the dynamic languages; however, there is an additional alternative available for dynamic language development with Silverlight highlighted at these links:

```
Creating Interactive Bing Maps with Silverlight and IronRuby
msdn.microsoft.com/en-us/magazine/ee291739.aspx
```

```
Back to "Just Text"
ironpython.net/browser/sl-back-to-just-text.pdf
```

Whatever tool you choose to use to build dynamic Silverlight applications, the code itself remains the same.

The Code

The simplest Silverlight application that uses a dynamic language consists of an HTML or ASPX file to host the application just as in a compiled Silverlight application and an `app.xaml` file that defines the Silverlight UI, much as `MainPage.xaml` does for a compiled Silverlight application. The codebehind for `app.xaml` in a dynamic language application can be one of the following, depending on the language:

- `app.py`: The IronPython code-behind file
- `app.rb`: The IronRuby code-behind file
- `app.jsx`: The Managed JScript code-behind file

The ReadMe file that ships with the Silverlight Dynamic Languages SDK provides some instructions on how to create a new Silverlight application like the one we describe here.

To create a new application, open a command prompt, and navigate to the script directory, which in your configuration is `c:\SLDLR\script`. To create a dynamic language Silverlight application, run the following command, but replace `language` with `ruby`, `python`, or `jscript`:

```
sl.bat language <application_name>
```

Create an application named `SilverlightDynamicApp` with the IronPython language using this command:

```
Sl.bat python SilverlightPythonApp
```

This code creates an application directory in the `c:\SLDLR\script\` directory named `SilverlightPythonApp`. In the `SilverlightPythonApp` directory, it creates three folders named `javascripts`, `python`, and `stylesheets`, as well as an HTML file named `index.html`.

The `javascripts` folder contains an `error.js` file with the typical `onSilverlightError` handler in it. The `stylesheets` directory contains two CSS files named `error.css` and `screen.css`: `screen.css` provides basic styling for the HTML page, and `error.css` provides highlighting for any errors that occur.

■ **Note** The `SilverlightPythonApp` directory can be found in the `Code\Ch02_ProgrammingModel\DLR_Download\script\` directory of the accompanying source code for this book.

Since you created a Python-based application, the `python` directory contains `app.xaml` and `app.py`. As mentioned earlier, in a dynamic language application, `app.xaml` contains the UI code and `app.py` is the codebehind written in IronPython. Listings 2-20 and 2-21 show the contents of these files.

Listing 2-20. *Recipe 2-11's app.xaml File*

```
<UserControl x:Class="System.Windows.Controls.UserControl"
             xmlns="http://schemas.microsoft.com/client/2007"
```

```
            xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml">

  <Grid x:Name="layout_root" Background="White">
    <TextBlock x:Name="Message" FontSize="30" />
  </Grid>
</UserControl>
```

Listing 2-21. *Recipe 2-11 app.py Code File*

```
from System.Windows import Application
from System.Windows.Controls import UserControl

class App:
  def __init__(self):
    root = Application.Current.LoadRootVisual(UserControl(), "app.xaml")
    root.Message.Text = "Welcome to Python and Silverlight!"

App()
```

Listing 2-20 contains the UI XAML file, which looks similar to the typical `MainPage.xaml` file created as part of a compiled Silverlight application. If you are not familiar with the Python language, Listing 2-21 may look a bit strange, but you can generally understand that it imports a couple of namespaces with this code:

```
from System.Windows import Application
from System.Windows.Controls import UserControl
```

The class declaration is:

```
class App:
  def __init__(self):
    root =
      Application.Current.LoadRootVisual(UserControl(), "app.xaml")
    root.Message.Text = "Welcome to Python and Silverlight!"
```

This last bit of code creates an instance of the `App` class:

```
App()
```

To compile and run this application, execute this command in the `C:\SLDLR\script\SilverlightPythonApp` directory:

```
C:\SLDLR\script\server.bat /b
```

The `server.bat` batch command launches `Chiron.exe`, which is a command-line utility that creates Silverlight XAP files as well as enables packageless development of dynamic Silverlight applications. Chiron creates the output from your simple dynamic language Silverlight application. Please follow the guidance at these links to not have to use Chiron:

```
Creating Interactive Bing Maps with Silverlight and IronRuby
msdn.microsoft.com/en-us/magazine/ee291739.aspx
```

```
Back to "Just Text"
ironpython.net/browser/sl-back-to-just-text.pdf
```

The `server.bat` batch command also opens the default web browser to `http://localhost:2060` and maps the root directory to the directory where the batch command executes, which in this example is `C:\SLDLR\script\SilverlightPythonApp`, as shown in Figure 2-23.

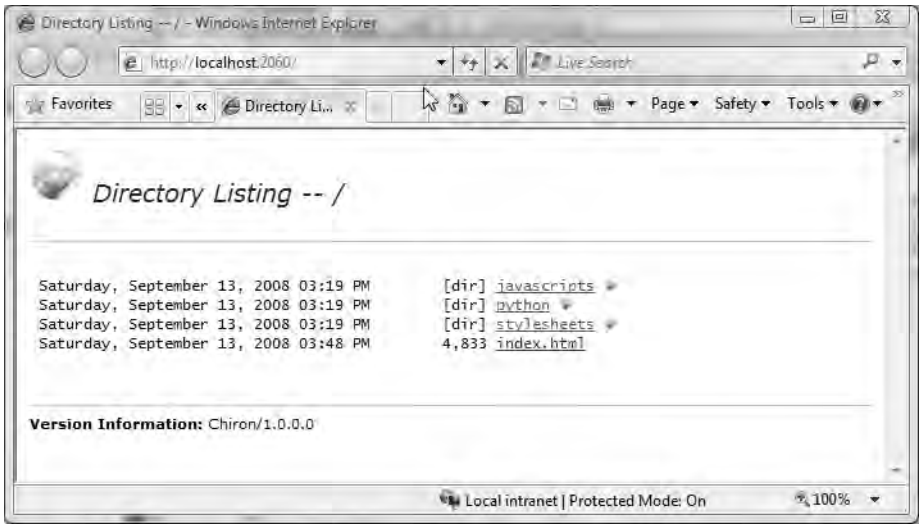


Figure 2-23. *Recipe 2-11's application running the SilverlightPythonApp*

Figure 2-24 displays the UI when you click `index.html`.

Figure 2-24. *Recipe 2-11's SilverlightPythonApp UI*

2-12. Creating Application Services

Problem

You want to package application functionality into reusable services and make those services available within a Silverlight project so that they are available for the lifetime of the application.

Solution

Create a class that implements the `IApplicationService` interface and possibly the `IApplicationLifetimeAware` interface. Add the class to the `Application.ApplicationLifetimeObjects` collection for the Silverlight application.

How It Works

Silverlight 3 and later includes support for services that are created by the `Application` object and added to the `ApplicationLifetimeObjects` collection on the `Application` object. The services are created before the `MainPage UserControl` and can hook into various events associated with application lifetime.

A class that implements `IApplicationService` interface implements the following methods:

```
IApplicationService.StartService(ApplicationServiceContext context)

IApplicationService.StopService()
```

The `StartService` method fires before `UserControl_Loaded` to allow the application service to initialize itself. Likewise, `StopService` fires after the `MainPage UserControl` is unloaded. This allows for service setup and teardown as necessary, though you need to take extra steps to ensure setup completes (detailed below in the code section).

Notice on the `StartService` method, there is a parameter passed in named `context`. The `context` parameter provides access to the initialization parameters via its `ApplicationInitParams` property that can be configured on an HTML `<param>` tag within the `<object>` tag that creates the Silverlight plug-in. Developers can provide information to the application service via the configured parameters on the plug-in. (We cover initialization parameters in detail in Chapter 6.)

Implementing the `IApplicationService` interface is the minimum requirement to create an application service. For more fine-grained control or interaction between the service and the application, developers can also implement the `IApplicationLifetimeAware` interface, which adds these additional methods to the application service:

- `IApplicationLifetimeAware.Exited()`
- `IApplicationLifetimeAware.Exiting()`
- `IApplicationLifetimeAware.Started()`
- `IApplicationLifetimeAware.Starting()`

The above events fire on the application service with respect to state of the application. For example, the `Starting` event fires before the `Application_Startup` event, while the `Started` event fires after the `Application_Startup` event. Likewise, the `Exiting` event fires before the `Application_Exit` event, while the `Exited` event fires after the `Application_Exit` event.

All of the `IApplicationLifetimeAware` interface events are bracketed by the two `IApplicationService` events, meaning that `IApplicationService.StartService` fires before

`IApplicationLifetimeAware.Starting` and `IApplicationService.StopService` fires after `IApplicationLifetimeAware.Exited` event.

The Code

The example for this recipe performs application functions related to configuration. The first function stores a copy of plug-in initialization parameters as a public property on the application service instance. The second function is a service that retrieves an XML file from the server to obtain configuration settings.

The application service is implemented in a code file named `ConfigurationSettingsService.cs`, which implements both the `IApplicationService` and `IApplicationLifetimeAware` interfaces. You modify the default `Application_Startup` event in the `App.xaml.cs` class file so that it handles initialization correctly.

You also modify the `MainPage_Loaded` event in `MainPage.xaml.cs` file so that it data binds to the `ConfigSettings Dictionary` object on the service. Finally, you add a `TextBlock` and `ListBox` to `MainPage.xaml` to display the configuration settings. Listings 2-22 through 2-25 show the contents of these files. Listing 2-26 shows `App.xaml` for the recipe, which is where the application service is declared.

Listing 2-22. *Recipe 2-12's ConfigurationSettingsService.cs File*

```
using System;
using System.Collections.Generic;
using System.IO;
using System.Linq;
using System.Net;
using System.Windows;
using System.Xml.Linq;

namespace Ch02_ProgrammingModel.Recipe2_12.Services
{
  public class ConfigurationSettingsService : IApplicationService,
  IApplicationLifetimeAware
  {
    //Event to allow the Application object know it is safe
    //to create the MainPage UI
    //i.e. the ConfigurationSettingsService is fully populated
    public event EventHandler ConfigurationSettingsLoaded;

    #region IApplicationService Members
    void IApplicationService.StartService(ApplicationServiceContext context)
    {
      InitParams = context.ApplicationInitParams;
      LoadConfigSettings();
    }

    private void LoadConfigSettings()
    {
      if (InitParams["configUrl"] != "")
```

```
    {
      WebClient wc = new WebClient();
      wc.OpenReadCompleted += wc_OpenReadCompleted;
      wc.OpenReadAsync(new Uri(InitParams["configUrl"]));
    }
  }

  void IApplicationService.StopService()
  {
  }
  #endregion

  #region IApplicationLifetimeAware Members
  public void Exited()
  {
  }

  public void Exiting()
  {
  }

  public void Started()
  {
  }

  public void Starting()
  {
  }
  #endregion

  private void wc_OpenReadCompleted(object sender, OpenReadCompletedEventArgs e)
  {
    if (e.Error != null)
    {
      return;
    }
    using (Stream s = e.Result)
    {
      XDocument xDoc = XDocument.Load(s);
      ConfigSettings =
      (from setting in xDoc.Descendants("setting")
       select setting).ToDictionary(n => n.Element("key").Value, n =>
        n.Element("value").Value);

      //Check to see if the event has any handler's attached
```

```
        //Fire event if that is the case
        if (ConfigurationSettingsLoaded != null)
          ConfigurationSettingsLoaded(this, EventArgs.Empty);
      }
    }

    //Store initialization parameters from <object> tag
    public Dictionary<string, string> InitParams { get; set; }
    //Stores configuraiton settings retrieved from web server
    public Dictionary<string, string> ConfigSettings { get; set; }
  }
}
```

Listing 2-23. *Recipe 2-12's App.xaml.cs (partial) File*

```
private void Application_Startup(object sender, StartupEventArgs e)
{
  ConfigurationSettingsService service =
App.Current.ApplicationLifetimeObjects[0]
    as ConfigurationSettingsService;

  //Wire up an anonymouse event handler that is fired when the
  //ConfigurationService is fully populated
  //This ensures that we can access the ConfigSettings properties
  //in MainPage_Loaded
  service.ConfigurationSettingsLoaded +=
                          new EventHandler((s, args) =>
  {
    this.RootVisual = new MainPage();
  });
}
```

Listing 2-24. *Recipe 2-12's MainPage.xaml.cs (partial) File*

```
void MainPage_Loaded(object sender, RoutedEventArgs e)
{
  ConfigurationSettingsService service =
App.Current.ApplicationLifetimeObjects[0]
    as ConfigurationSettingsService;

  //Simple data bind to the ConfigSettings Dictionary
  SettingsList.ItemsSource = service.ConfigSettings;
}
```

Listing 2-25. *Recipe 2-12's MainPage.xaml (partial) File*

```
<UserControl x:Class="Ch02_ProgrammingModel.Recipe2_16.MainPage"
    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"
    mc:Ignorable="d"
    d:DesignHeight="300" d:DesignWidth="400">
   <StackPanel>
     <TextBlock HorizontalAlignment="Left" VerticalAlignment="Top"
                Text="Configuration Settings" TextWrapping="Wrap" Margin="6"/>
     <ListBox x:Name="SettingsList" Height="100" Margin="6,6,0,6"/>
  </StackPanel>
  </Grid>
</UserControl>
```

Listing 2-26. *Recipe 2-12's App.xaml File*

```
<Application xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
             xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
             x:Class="Ch02_ProgrammingModel.Recipe2_12.App"
             xmlns:MyServices="clr-namespace:
             Ch02_ProgrammingModel.Recipe2_12.Services">
    <Application.Resources>

    </Application.Resources>
  <Application.ApplicationLifetimeObjects>
    <MyServices:ConfigurationSettingsService x:Name="ConfigService"/>
  </Application.ApplicationLifetimeObjects>
</Application>
```

The URL used to retrieve the configuration file is configured on the plug-in control via initialization parameters so that it is not hard-coded into the Silverlight application itself.

The "How it works" section for this recipe describes in detail the order in which the various events fire. As mentioned, the `MainPage_Loaded` event on the `UserControl` fires after the `IApplicationService.StartService` event. However, in testing the application, the `ConfigSettings` collection was not populated in `MainPage_Loaded` as expected. If you think about it, this makes sense, because you need to make an asynchronous web request to retrieve settings from a URL. In this example, the `webClient.OpenReadCompleted` event was firing after `MainPage_Loaded` executed, making it impossible to access configuration settings at load time within the application itself.

The application pattern you utilize to maintain the proper event ordering is to add an event to the application service class, which in this example is declared in `ConfigurationSettingsService.cs` like so:

```
public event EventHandler ConfigurationSettingsLoaded;
```

In the `WebClient.OpenReadCompleted` event handler that fires after the web request call succeeds, you fire the event as long as there is an event subscriber:

```
if (ConfigurationSettingsLoaded != null)
  ConfigurationSettingsLoaded(this, EventArgs.Empty);
```

In this application pattern, there an event subscriber created as shown in Listing 2-23. It is an anonymous event handler show here:

```
service.ConfigurationSettingsLoaded += new EventHandler((s, args) =>
{
  this.RootVisual = new MainPage();
});
```

Using this pattern ensures that the application service is fully configured before the `MainPage` is instantiated, permitting the application to function as expected. Figure 2-25 shows the settings displayed in the basic UI.

Figure 2-25. *Recipe 2-12 The Configuration Settings UI*

2-13. Managing Resources in Large Projects

Problem

You have a large project with many custom controls, templates, styles, etc. that exists in `ResourceDictionary` objects. You would like to be able to store these `ResourceDictionary` objects in separate XAML files or assemblies to keep source code more manageable, while also allowing updating assemblies to be updated separately from the main application code.

Solution

Use a merged resource dictionary to reference external XAML files and assemblies to better organize code.

How It Works

WPF has supported merged resource dictionaries as a way to improve organization for large applications. Merged resource dictionaries make it possible to share resources across applications and are also more conveniently isolated for localization than with Silverlight 2 where merged resource dictionaries where not available.

Resources in a merged dictionary occupy a location in the resource lookup scope just after the scope of the main resource dictionary they are merged into. Although a resource key must be unique within any individual dictionary, a key can exist multiple times in a set of merged dictionaries, because they are separate namescopes. (We covered namescopes in Recipe 2-2.)

Silverlight 3 added support for merged resource dictionaries, making it more like WPF. Silverlight 3 or later leverages the packed URI format for referencing resources available in WPF except that you do not have to specify the `pack://` protocol reference. The details of how to reference merged resource dictionaries are covered next in "The Code" section.

The Code

Expression Blend makes it easy to create a resource dictionary for your application that is merged with resources within the application itself. In Expression Blend, clicking the Create New Resource Dictionary button indicated by the arrow in Figure 2-26 opens the New Item dialog also shown in the figure.

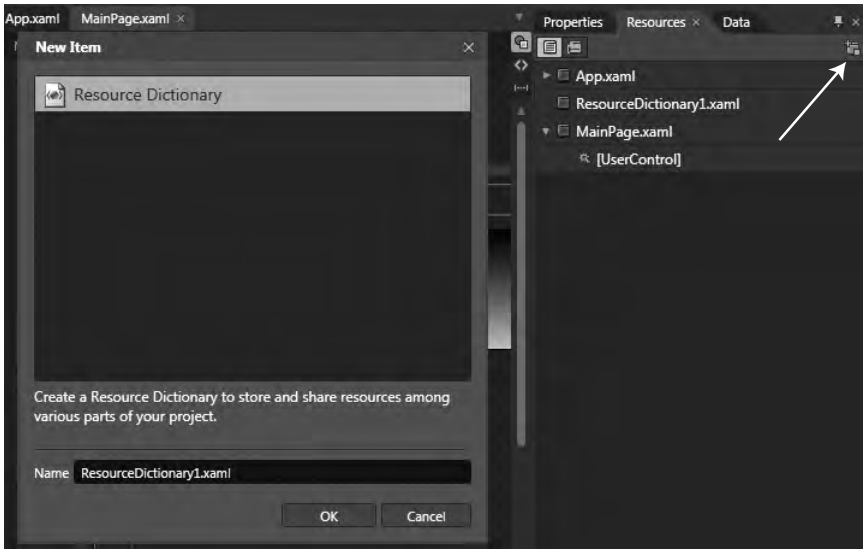


Figure 2-26. *Clicking the Create New Resource Dictionary*

When you click OK, Expression Blend creates a new file in your project with the name specified. It also modifies the `app.xaml` file by adding the following `ResourceDictionary.MergedDictionaries` XAMLelement to the `Application.ResourceDictionary` element:

```
<Application.Resources>
        <ResourceDictionary>
```

```
            <ResourceDictionary.MergedDictionaries>
                    <ResourceDictionary Source="ResourceDictionary1.xaml"/>
            </ResourceDictionary.MergedDictionaries>
        </ResourceDictionary>
</Application.Resources>
```

To place a style resource into a merged resource dictionary, select the element in Expression Blend and then click the Object ➤ Edit Style ➤ Create Empty menu item. To place a control template resource into a merged resource dictionary, follow the same steps but instead of clicking Edit Style, select Edit Template. Figure 2-27 shows what it looks like when you select the Rectangle and want to edit its Style. Notice that the Resource Dictionary has been selected as the location where you want to define your new style.

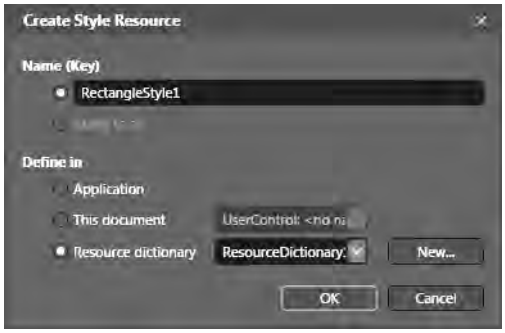


Figure 2-27. *The Create Style Resource dialog*

Clicking OK brings up the style editor in Expression Blend . Next, edit the style, and save it. We cover creating styles in Chapters 3 and 5, but for now, we are focusing on the merged resource dictionary functionality.

When you view the `Rectangle` in the designer, it now has the style applied to it that you just created. (We covered how to apply styles in Recipe 2-9.) Listing 2-27 has the source code for the `Rectangle` where the style is applied.

Listing 2-27. *Recipe 2-13's MainPage.xaml File*

```
<UserControl x:Class="Ch02_ProgrammingModel.Recipe2_13.MainPage"
    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"
    mc:Ignorable="d" d:DesignWidth="640" d:DesignHeight="480">
  <Grid x:Name="LayoutRoot">
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.047*"/>
      <ColumnDefinition Width="0.953*"/>
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
```

```
      <RowDefinition Height="0.052*"/>
      <RowDefinition Height="0.948*"/>
    </Grid.RowDefinitions>
    <StackPanel Margin="8" Grid.Column="1" Grid.Row="1">
      <Rectangle Stroke="Black" Height="100"
               Style="{StaticResource RectangleStyle1}">
      </Rectangle>
      <TextBlock Text="I'm a TextBlock" TextWrapping="Wrap" Margin="4"/>
      <TextBlock Text="I'm another TextBlock" TextWrapping="Wrap" Margin="4"/>
      <Button Content="Button" Margin="4"/>
    </StackPanel>
  </Grid>
</UserControl>
```

You can see that the style `RectangleStyle1` is applied to the `Rectangle`. This recipe shows how the merged resource dictionary is referenced in the `App.xaml` file. Listing 2-28 has the source code for the merged resource dictionary.

Listing 2-28. *Recipe 2-13's ResourceDictionary1.xaml File*

```
<ResourceDictionary
  xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
  xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml">  <Style x:Key="RectangleStyle1"
TargetType="Rectangle">
    <Setter Property="Margin" Value="4"/>
    <Setter Property="Fill">
      <Setter.Value>
        <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
          <GradientStop Color="#FF243300"/>
          <GradientStop Color="#FFDEF3AB" Offset="1"/>
        </LinearGradientBrush>
      </Setter.Value>
    </Setter>
  </Style>
  <!-- Resource dictionary entries should be defined here. -->
</ResourceDictionary>
```

In Listing 2-28, you can see the style named `RectangleStyle1` is defined. You can also define merged resource dictionaries in other assemblies as well. Please refer to the Silverlight 4 documentation for more information.

2-14. Save a File Anywhere on the User's System

Problem

You want to allow the user to save a file anywhere on their system without the constraints of isolated storage.

Solution

Use the `SaveFileDialog` object to persist a file to the user's file system from within a user-initiated event handler, such as a button click or key press.

How It Works

Silverlight 3 introduced the new `SaveFileDialog` object, which allows the user to select a file location that the Silverlight application can save a file outside of isolated storage. In Recipe 2-4, we covered the `OpenFileDialog` object. Like the `OpenFileDialog`, the `SaveFileDialog` must be raised in an event handler resulting from user interaction such as a key press or button click. Once that's accomplished, using the `SaveFileDialog` is very straightforward, as you'll see in this recipe's "The Code" section.

Out-of-browser (OOB) elevated trust applications have more access to the file system and are not limited to isolated storage. (We cover OOB applications in Chapter 8.)

The Code

The code presents a simple UI with a button that the user can click to bring up the `SaveFileDialog` object (see Figure 2-28).

Figure 2-28. *Recipe 2-14's SaveFileDialog In Action*

Just as with most any file-related dialog box, developers can configure the filter (e.g., `.txt` or `.tiff`) as well as the default file type. You are going to write out a simple text file, so you'll use `Text Files (*.txt)` as the default filter as shown in Figure 2-31. Listing 2-36 has the source code that displays the `SaveFileDialog` object and writes out the file to the returned stream by calling the `OpenFile()` method.

Listing 2-29. *Recipe 2-14's MainPage.xaml.cs File*

```
using System.IO;
using System.Text;
using System.Windows;
using System.Windows.Controls;

namespace Ch02_ProgrammingModel.Recipe2_14
{
  public partial class MainPage : UserControl
  {
    public MainPage()
    {
      InitializeComponent();
    }

    private void btnSaveFile_Click(object sender, RoutedEventArgs e)
    {
      SaveFileDialog sfd = new SaveFileDialog();
      sfd.Filter = "Text Files (*.txt)|*.txt|All Files (*.*)|*.*";
      sfd.FilterIndex = 1;
      if (true == sfd.ShowDialog())
      {
        using (Stream fs = sfd.OpenFile())
        {
          byte[] textFileBytes = (new UTF8Encoding(true)).GetBytes(
          "Welcome to Silverlight 4!!!! \r\n\r\nYour Authors,\r\n\r\nRob and Jit");
          fs.Write(textFileBytes, 0, textFileBytes.Length);
          fs.Close();
        }
      }
    }
  }
}
```

CHAPTER 3

Developing User Experiences

This chapter outlines recipes involving the graphics subsystem. We will cover graphics fundamentals, animations, layout, image handling, keyboard handling, document features, and ink, just to name a few.

In the previous two chapters, we provided an introduction to the Silverlight project model, the developer and designer tools, as well as an overview of the programming model, without getting too deep into the object model. In this chapter, we focus on the graphic primitive classes, animations, layout, image handling, handling keyboard input, document features, and ink, just to name a few.

While we cover controls in Chapter 5, it would be difficult not to spend some time on layout and the corresponding layout controls since we are focused on user experience. So we start off this chapter by offering an overview of the base classes that provide layout support as well as other functionality for both the graphic primitive and control classes.

As with all of .NET, the root base class is `Object`. Next in line from `Object` is `DependencyObject`, which you will find in Windows Presentation Foundation (WPF) and Silverlight. `DependencyObject` provides dependency property system services to derived classes. The property system's primary function is to compute the values of properties and to provide system notification about values that have changed. We cover dependency properties in much more detail in Chapter 5.

`The UIElement` class inherits from the `DependencyObject class` and serves as the base class for most objects that have visual appearance and that can process basic input. Example properties and events are `Visibility`, `Opacity`, `Clip`, `GotFocus`, `KeyDown`, and `MouseLeftButtonDown`.

`The FrameworkElement class` is the common base class for `System.Windows.Shapes` namespace classes like `Shape`, `Ellipse`, and `Rectangle` and `System.Windows.Controls` namespace classes like `Control`, `Button`, and `TextBox`. `FrameworkElement` s implements layout, data binding, and the visual object tree functionality. Properties and events implemented in `FrameworkElement` include `Margin`, `Padding`, `Height`, `Width`, `SizeChanged`, and `LayoutUpdated`. This chapter primarily focuses on classes in the `Shapes` namespace, but we include a few classes in the `Controls` namespace to help demonstrate layout and UI concepts. As we mentioned above, Chapter 5 covers controls in detail.

This chapter won't make you a designer, but it should help you understand how you can use Expression Blend 4 with the graphic primitives as well as how to use the layout features of Silverlight 4. If you are a designer, this chapter provides a high-level overview of the Expression Design and Expression Blend tools as well as the user interface (UI) elements available for designing Silverlight applications.

In this chapter, we describe the graphic primitive basics in the first couple of recipes but do not go through every single object available, detailing properties and methodsWe recommend that you read a Silverlight 4 book such as Mathew MacDonald Pro Silverlight 4 in C# (Apress, 2010) as well as check out the documentation on MSDN located here:

`http://msdn.microsoft.com/en-us/library/cc838158(VS.96).aspx`

After we cover the basics, we move on to more advanced animation control using keyframes, transformations, and keyboard input, and we discuss how to work with ink. In the previous edition, we added eight new recipes covering additional topics available in Silverlight 3:

- 3-13 Adding 3-D Effects to UI Elements
- 3-14 Dynamically Creating Bitmaps
- 3-15 Improving Graphic Animation and Video Performance
- 3-16 Improve Animation with Custom Easing Functions
- 3-17 Adding Pixel Shader Visual Effects
- 3-18 Create and Work with Design-Time Data in Expression Blend

3-19 Reuse Application Interactivity with Expression Blend BehaviorsAs the fundamentals of Silverlight become more commonly known, we combined a few recipes in this edition to make room for the new recipes added covering Silverlght 4:

- 3-20 Customizing the Right-Click Context Menu
- 3-21 Accessing the Clipboard
- 3-22 Supporting Right-to-Left Text

3-1. Importing Art from Expression Design

Problem

You need to use assets in a Silverlight application created by a designer in a design tool such as Expression Design. Or, you are a designer and need to share assets with Silverlight developers.

Solution

Take advantage of the built-in export capabilities in the design tool or add-ins available for the designer's favorite tool.

How It Works

As we mentioned in Chapter 1, Silverlight UI elements are created using a declarative markup language known as Extensible Application Markup Language (XAML). XAML is a vector-based markup language that uses XML syntax, making it easy to input and export XAML in tools such as Expression Design and Expression Blend.

Expression Blend is a design tool geared toward technical designers and developers. Expression Design is a design tool geared toward pure designers. You can download a 60-day trial of Expression Studio 4 here:

```
http://www.microsoft.com/expression/
```

The underlying markup is not viewable in Expression Design. It is a pure GUI design tool, to make it friendlier for designers to use. It can generate content usable in Expression Blend as well as web-design tools such as Expression Web. Figure 3-1 shows the Expression Design UI with our attempt at creating an ice cream cone using the built-in textures available in the Expression Design color palette drop-down.

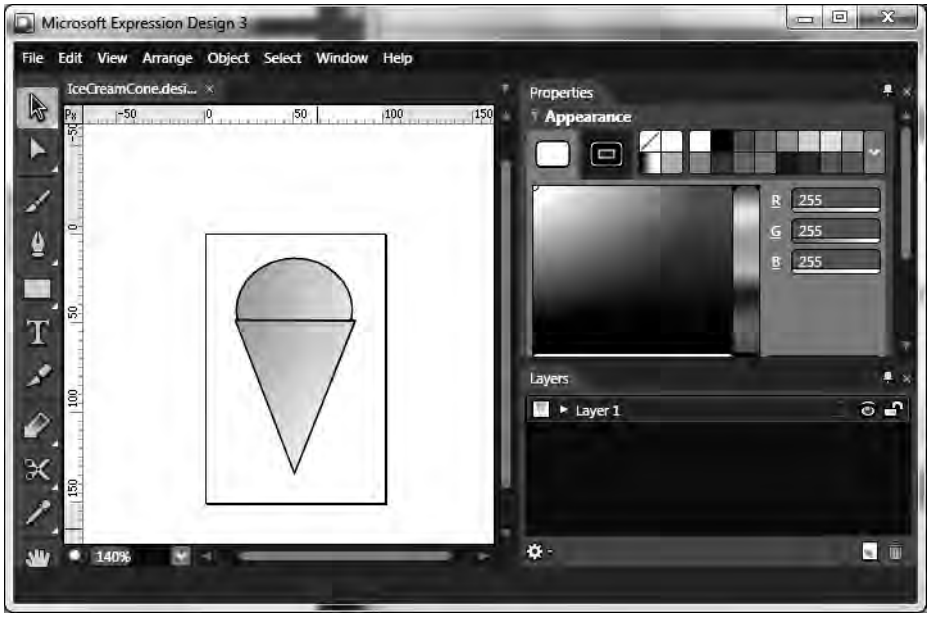


Figure 3-1. *Expression Design UI*

We don't cover all of the features available in Expression Design. To learn more, visit this site for self-study tutorials, starter kits, training videos, virtual labs, and webcasts:

`hhttp://expression.microsoft.com/en-us/cc136532.aspx`

The one feature we do want to cover is how to make assets created in Expression Design available in Expression Blend and to developers. After the design is completed, choose File ❞ Export to open the Export dialog box, shown in Figure 3-2.

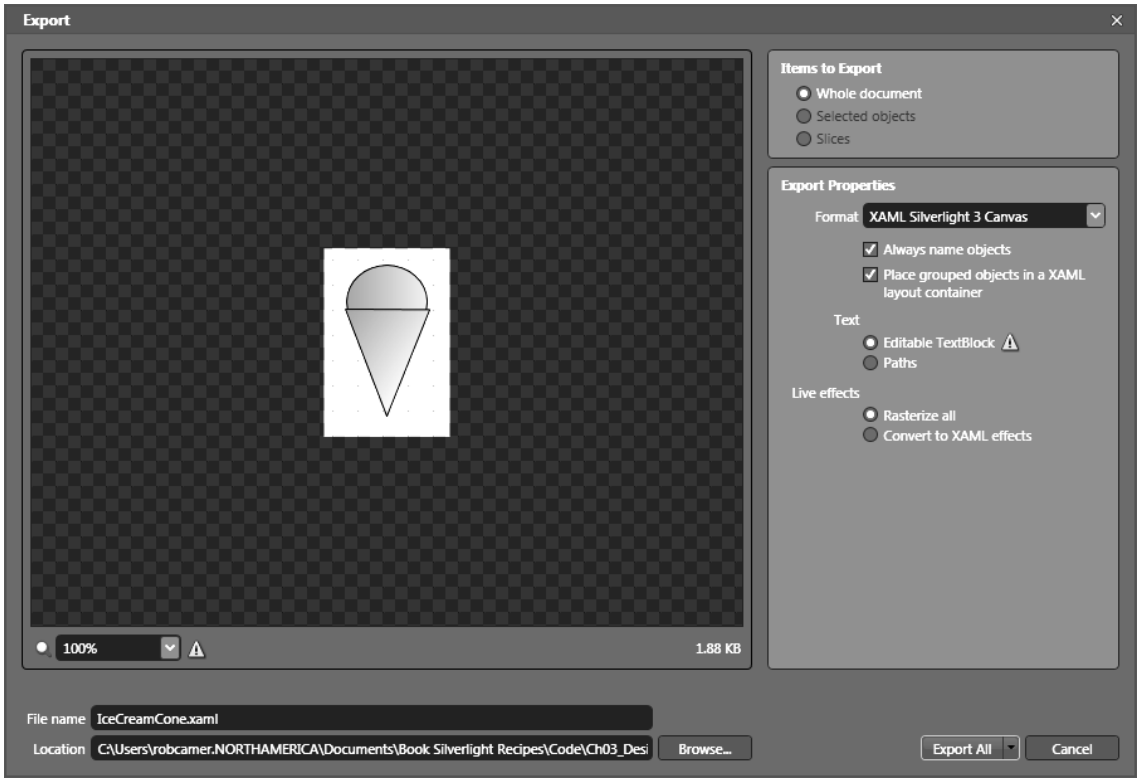


Figure 3-2. *Expression Design Export dialog box*

In the dialog box, select XAML Silverlight 4 Canvas as the format, and browse to the desired location to save the `.xaml` file. Then, click Export All to generate the `IceCreamCone.xaml` file (we put the file into the `Recipe3.1` directory). Next, add the exported file to the Recipe 3-1 Visual Studio project to make it available in Visual Studio, and copy the desired XAML from the `IceCreamCone.xaml` file into `MainPage.xaml`. In this case, the XAML is essentially just the ice cream cone, which is contained in the third nested `<canvas>` object with the `x:Name` of `Group`. Now that the object is part of the project, open the solution in Expression Blend to fine-tune the object and placement as needed. You can also add the exported `IceCreamCone.xaml` file to the Recipe 3-1 project directly within Expression Blend without going through the steps in Visual Studio, which may be best for non-developers working in the Expression tools.

■ **Note** XAML can be created with any text editor, among other tools such as Aurora, Electric Rain Xam3D, Windows Flip 3D, and Telestream, to name a few. In addition, Expression Design 4 and Expression Blend 4 can import files from a variety of tools, including Adobe Illustrator and Adobe Photoshop.

Figure 3-3 shows the ice cream cone in the web browser.

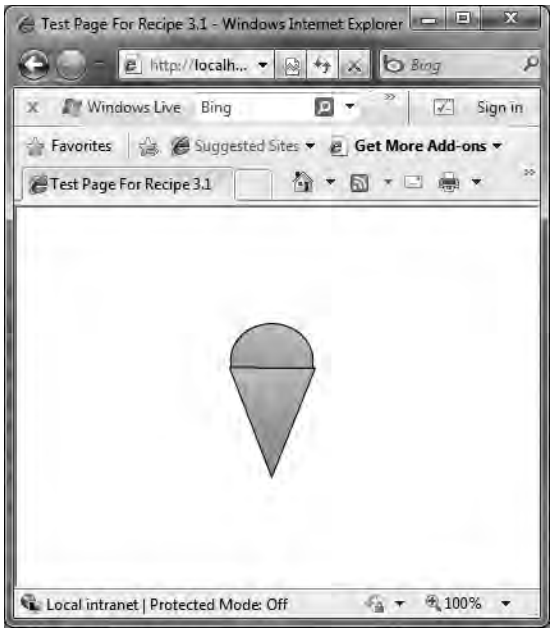


Figure 3-3. *The ice cream cone in the browser*

3-2. Working with Color and Gradients in Blend

Problem

You need to create and manipulate colors and gradients in Silverlight 4.

Solution

Use Expression Blend to create and manipulate classes that inherit from `System.Windows.Media.Brush`, such as `SolidColorBrush` and `GradientBrush`, to create colors and gradients.

How It Works

When you are working with brushes such as `SolidColorBrush` or `GradientBrush` objects, Expression Blend is useful. It has a dedicated section titled Brushes in the properties window, as shown in Figure 3-4, with a descendent of the `Shape` class selected in the Visual Tree.

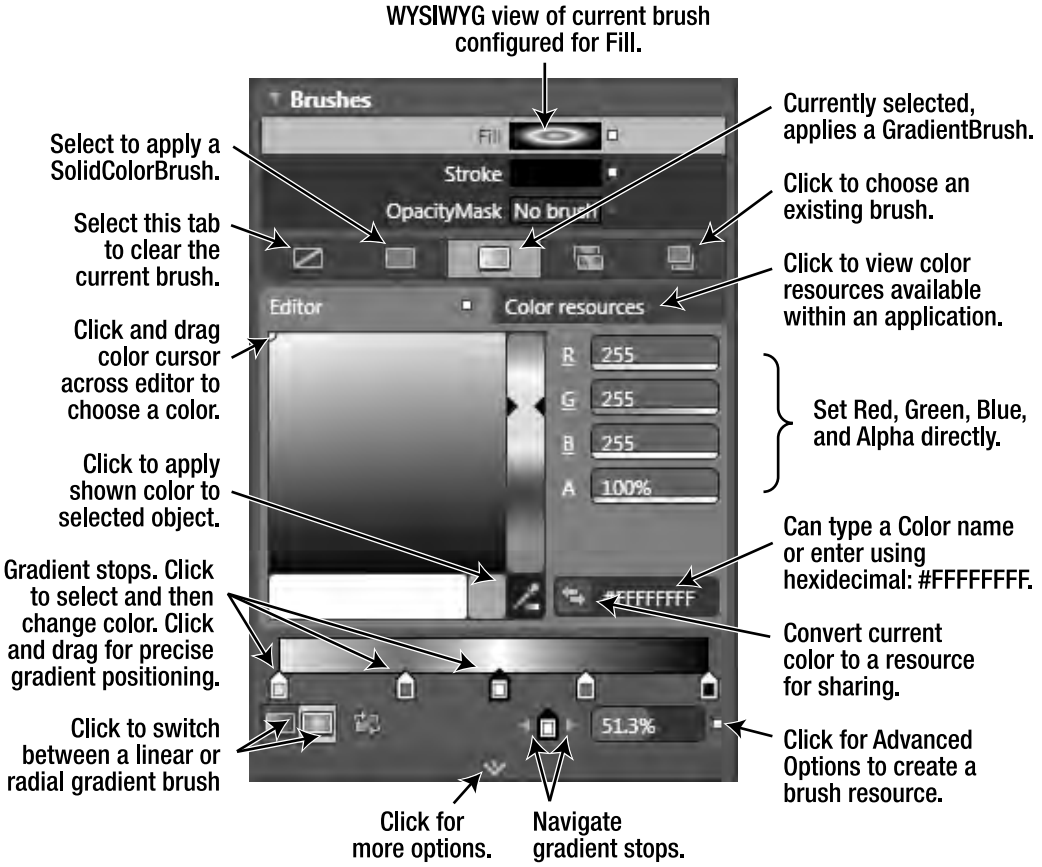


Figure 3-4. *The powerful brush editor*

Take a close look at Figure 3-4, and you will see that Expression Blend provides extensive visual editing tools for colors and gradients, as well as powerful support to create color resources and brush resources. Color resources help ensure consistency and reduce typing errors when you are entering the same color values over and over. Brush resources also help ensure consistency and promote reuse throughout an application.

In Silverlight 3 or later, Expression Blend has additional options. Click the More Options button shown in Figure 3-4 to bring up the brush-editing options shown in Figure 3-5.

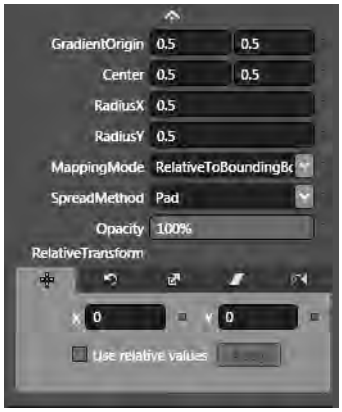


Figure 3-5. *Additional brush-editing options for radial gradients*

Figure 3-5 shows the additional options available when you are editing a gradient brush. When you edit a solid color brush, the only option available is opacity.

Notice in Figure 3-4 that after you select a `Shape` object such as an `Ellipse`, the top portion of the brush editor allows you to choose the `Fill`, `Stroke`, or `OpacityMask`. When you pick one of those three, you then decide whether to apply No Brush, a `SolidColorBrush`, a `GradientBrush`, or an existing brush resource by clicking one of the four tabs just below `Fill`, `Stroke`, and `OpacityMask`.

■ **Note** We won't dive any further into `OpacityMask`, which applies varying levels of opacity to different parts of the object. You can find a thorough article about `OpacityMask` at `http://msdn.microsoft.com/en-us/library/system.windows.uielement.opacitymask(VS.96).aspx (VS.96).`.

Notice that the options shown in the Brushes section of the properties window depend on the type of object selected. For example, selecting a `TextBox` gives the options shown in Figure 3-6.

In Figure 3-6, you see a different set of brushes available for the `TextBox` control. In this case, the `SelectionBackground` option is configured with a gradient that renders when text is selected at runtime, as shown in the right portion of Figure 3-6. Silverlight with Expression Blend adds the option to visually edit the `CaretBrush` as well.

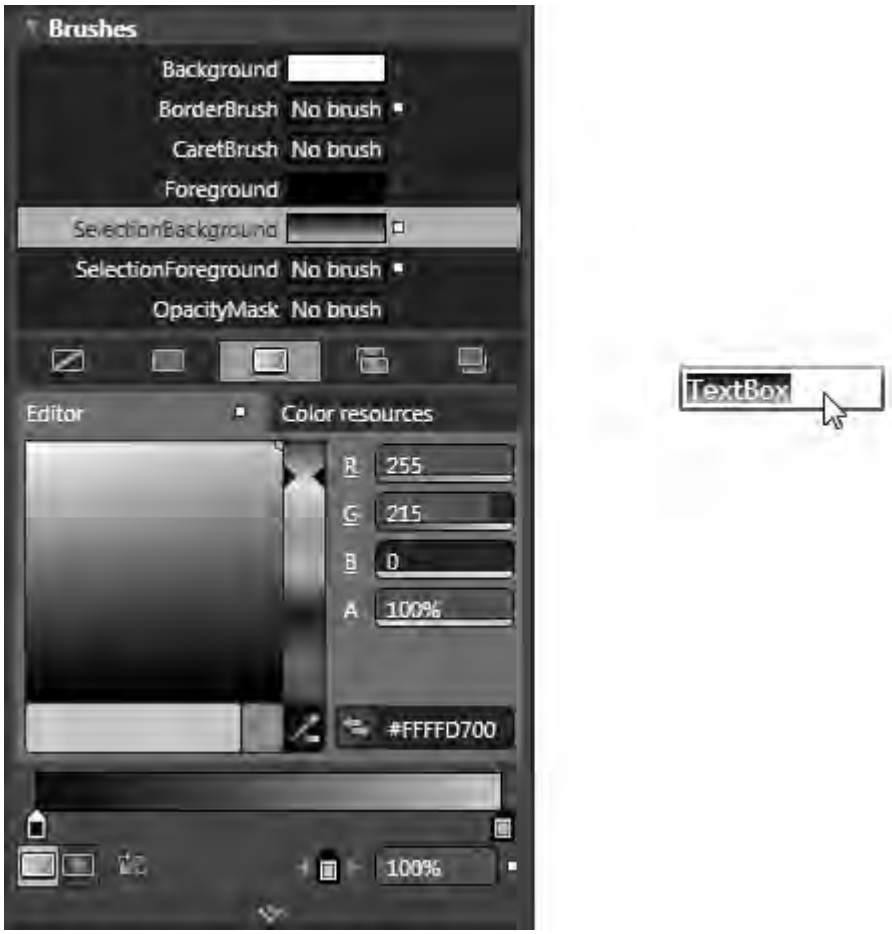


Figure 3-6. *The Brushes section when a* `TextBox` *control is selected*

The Code

For the code example in this recipe, we use the tools in Expression Blend to create various colors and gradients and apply them to objects. Listing 3-1 (which you'll see in a moment) has the full XAML, but let's walk through the code first.

Gradient brushes can produce interesting effects, create impressions of light and shadow, and give your UI elements a three-dimensional feel. Figure 3-7 compares a linear and a radial version of a gradient brush.

Figure 3-7. *Same gradient in radial (left) and linear (right) applied to an ellipse*

Both brushes in Figure 3-7 use the same gradient stops but with a different spread. Below the two ellipses in Figure 3-7 is a screen capture of the gradient stops with a faint off-white color on the left and black on the right. These correspond to the colors shown in the ellipses. For the radial spread on the left, the black gradient stop corresponds to the outer edge in a circular fashion. For the linear spread, the black gradient stop corresponds to the bottom of the right ellipse. The colors applied in the respective spread correspond to the gradient stops.

Earlier, Figure 3-4 showed the complete Expression Blend brush editor. As the instructions in the figure say, to create a gradient stop, you click the Gradient bar after selecting a gradient brush at the top of the editor. To remove a gradient stop, you drag it off of the Gradient bar.

Let's now introduce an additional tool to help customize a gradient's appearance: the Brush Transform tool, located in the Asset Manager on the left side of Expression Blend. The Brush Transform tool allows you to change the orientation of, stretch, and move a gradient applied to an element visually on the Artboard or design surface in Expression Blend, resulting in a new gradient value in the XAML. From an XAML perspective, when you use the Brush Transform tool, you are visually modifying the `StartPoint` and `EndPoint` of the gradient object.

Figure 3-8 shows four circles on the Artboard: at left, one with the default linear gradient; two with the same gradient as the first but with a different orientation and position applied using the Brush Transform tool; and a circle with a `Green SolidColorBrush` applied. The gradient for the first circle has the following `StartPoint` and `EndPoint`:

```
EndPoint="0.5,1" StartPoint="0.5,0"
```

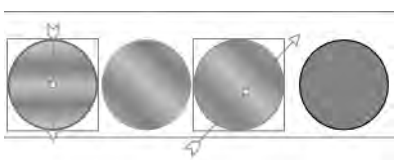


Figure 3-8. *Modifying a gradient with a brush transform*

We show a copy of the modified circle with the brush transform (the arrow from lower left to upper right) in the third circle from the left. The gradient for the third circle has the following `StartPoint` and `EndPoint` after we used the Brush Transform tool:

```
EndPoint="1.1,0.0" StartPoint="0.05,1.12"
```

The first circle shows the default position of the brush transform so that you can see how the orientation, position, and size of the brush transform (arrow) were modified to create the second and third circles. To use the Brush Transform tool, grab the arrow to move, rotate, or stretch the gradient and thus visually modify the `StartPoint` and `EndPoint` for the gradient. Even with the simplest modifications, gradients can provide a far more interesting interface than a `SolidColorBrush` in many scenarios.

The previous example demonstrated a linear gradient. We now turn to a radial gradient. In this case, use Expression Blend to create a donut, which we demonstrate in Recipe 3-7, using two `Ellipses`. Then, choose Combine ➤ Subtract to create a `Path` that is transparent in the middle, thus letting the background color show through. Apply a solid color brush to the left donut, as shown in Figure 3-9. Apply a linear gradient as before to the middle donut, which does not do much for its appearance. However, by switching the gradient from a linear to a radial gradient in the donut on the right, you make the appearance more appealing, as shown in Figure 3-9.

Figure 3-9. *From SolidColorBrush to radial gradient*

We next demonstrate how to apply an image brush to an object. Drag a `Rectangle` onto the design surface or Artboard in Expression Blend, name it `RectImageBrush`, apply rounded corners by modifying the `RadiusX` and `RadiusY` properties, and then set the `Fill` property to No Brush in the Brush Editor. Next, add an `ImageBrush` to the `Rectangle` in XAML:

```
<Rectangle HorizontalAlignment="Stretch" Margin="86,4,118,4"
VerticalAlignment="Stretch" Grid.Row="2" Stroke="#FF000000" RadiusY="38"
RadiusX="38" x:Name="RectImageBrush">
<Rectangle.Fill>
<ImageBrush ImageSource="/img/Landscape2.jpg"  Stretch="Fill" />
</Rectangle.Fill>
</Rectangle>
```

The `ImageBrush` paints the UIElement with the image contents. The image is located in the `TestWeb/ClientBin/img` directory. We apply a `SkewTransform` like this:

```
<Rectangle.RenderTransform>
<SkewTransform AngleX="20" AngleY="10"/>
</Rectangle.RenderTransform>
```

Figure 3-10 shows the results.

Figure 3-10. *Rectangle with ImageBrush applied*

The results in Figure 3-10 are similar to applying a `Border` object to an `Image` object, as shown in Recipe 3-10 later in this chapter, but with the addition of a `SkewTransform`, which we cover in Recipe 3-13.

Although an `ImageBrush` can create a static but compelling UI, a `VideoBrush` takes it one step further. You can apply a `VideoBrush` to the `Foreground` color of a `TextBlock` to create an interesting effect. Here is a snippet from MainPage.xaml for Recipe 3-2:

```
<TextBlock Margin="214,38.2000007629395,24,61"
Grid.Row="3" TextWrapping="Wrap" Text="TextBlock" FontSize="72"
FontFamily="Comic Sans MS" FontWeight="Bold">
<TextBlock.Foreground>
<VideoBrush SourceName="mElement" Stretch="UniformToFill" />
</TextBlock.Foreground>
</TextBlock>
```

We had to hand-edit the XAML in order to apply the VideoBrush. The VideoBrush allows you to paint a UIElement with a video. Notice the `SourceName` attribute on the `VideoBrush` object. This value must refer to the name of a `MediaElement` object, also in the XAML markup:

```
<MediaElement x:Name="mElement" AutoPlay="True" HorizontalAlignment="Stretch"
Margin="4,4,421,0" Grid.Row="3" Width="175" Height="90"
d:LayoutOverrides="Height" VerticalAlignment="Top"
Source="/video/video.wmv"/>
```

You can set the opacity to 0 on the `MediaElement` object if you don't want it visible—it won't affect the video output for the `VideoBrush` object. In this example, we left the opacity of the `MediaElement` at 100% so that you can see how the `TextBlock`'s `Foreground` color corresponds with the output in the `MediaElement`. The video is not included in the source code download at the Apress website, but you can copy a video from the sample videos on your computer to the `TestWeb/ClientBin/Video/` folder and name the file `video.wmv`. Figure 3-11 shows the video playing as the `Foreground` color of the `Text`.

Figure 3-11. *Foreground property as a VideoBrush*

We don't show the code because all of the action is within the Expression Blend The XAML is simply the output of this work, however, the code is available in the accompanying source code download.

3-3. Positioning UI Elements

Problem

You need to understand how to position UI elements using using the layout controls such as the Canvas, StackPanel, and Grid.

Solution

For absolute positioning, learn how to work with the `Canvas` layout control that allows child controls to be placed using coordinates for the left and top values. To stack controls either horizontally or vertically, learn to use the StackPanel along with Margin and Padding to layout controls. Finally, to have complete control over layout, learn to use the Grid control along with Margin and Padding.

How It Works

In this section we cover how to work with the Canvas, StackPanel, and Grid. Before we dive in with the `Canvas` object, we first provide a frame of reference for object positioning in a Windows Forms application. In a Windows Forms application, the fundamental UI container is the `Form` class. Another container would be a `Panel` class located within a `Form` object. For both the `Form` and `Panel` containers in Windows Forms applications, you position objects by specifying a `Left` and `Top` property for controls like the `TextBox` object. Hard-coding the `Left` and `Top` properties for controls does not provide dynamic UI layout in terms of resizing for different dots per inch (dpi) settings or screen resolutions, let alone provide a flexible UI when displaying data in a `DataGrid` with many columns of data.

Docking was introduced into Windows Forms to help provide a more dynamic UI by putting controls into panels and having them stick to one side or the other, leaving a dynamically resizing client area for a panel containing a `DataGrid` or similar control. Other tricks let you build a homegrown layout system in Windows that dynamically scales by recalculating object positions for dpi settings, screen resolutions, or the size of data displayed. All in all, these efforts have resulted in limited UI flexibility.

One of the most important features in Windows Presentation Foundation (WPF) that made it into Silverlight 4 is the layout system. The Silverlight 4 layout system enables dynamic positioning of vector-based UI elements using device-independent units or pixels that defaults to 96 units per inch, regardless of display resolution.

For example, if you set a `rectangle` to be 96 units high and 96 units wide in Expression Blend, the `rectangle` will be one inch square by default in Windows because the Windows default is 96 dpi. If you switch Windows to, say, 120 dpi, the rectangle in Expression Blend will still report as 96 units wide and tall, but the actual number in Windows will be 120 pixels wide and tall.

The Silverlight 4 layout system, which we cover in Recipe 3-4 in the "How It Works" section, includes containers that manage the size and position of controls placed within the container. UI elements are placed into one of three primary containers that inherit from the `Panel` base class:

- `Canvas`: Defines an area within which you can explicitly position child elements by coordinates relative to the `Canvas` area, which we cover in this recipe.
- `StackPanel`: Arranges child elements into a single line that can be oriented horizontally or vertically. We cover the `StackPanel` in Recipe 3-4.
- `Grid`: Defines an area containing rows and columns where elements can be placed. We cover the `Grid` in Recipe 3-5.

■ **Note** Silverlight 3 and later has the `TabPanel`, `DockPanel`, and `WrapPanel` as well. Please refer to Chapter 5 for more information.

Canvas

The `Canvas` object may feel most comfortable to developers who are not familiar with WPF or Silverlight and have built UIs in technologies similar to .NET Windows Forms. The `Canvas` container allows absolute positioning of UI elements, very similar to Windows Forms.

StackPanel

In the previous subsection, we covered how to absolutely position elements using a `Canvas` panel within an application using coordinates for the `Canvas.Top` and `Canvas.Left` attached properties. However, the `Canvas` container does not fully integrate with the layout system in Silverlight because the positions of child elements are fixed regardless of whether the user is resizing the browser, etc.

The `StackPanel` is a great way to lay out controls either vertically or horizontally via the Orientation property within a general UI design that fully integrates with the sizing and positioning functionality of the layout system. The layout system is a recursive operation that first sizes, then positions, and finally draws elements onscreen. It is a two-pass system that is applied starting at the top of the visual XAML tree and that works its way through the `Children` collection of each control. During the Measure pass, the desired size of each child element is determined. In the Arrange pass, each child element's size and position are finalized.

Two additional topics related to layout are `Margin` and `Padding`. Whereas all `FrameworkElements` have the `Margin` property, only objects that inherit from `Control` and the `Border` `FrameworkElement` have a `Padding` property. The difference is that `Margin` defines the extra space placed around the outside edges of the element, and `Padding` defines the extra spaced placed around the inside edges of the control.

You can use `Margin` and `Padding` to force mandatory separation between controls in a StackPanel, Grid, WrapPanel, etc.; it is applied by the layout system as the UI is resized, either programmatically or as the user resizes the browser. Values for `Margin` and `Padding` can be specified using three notations: a unique value for each edge, such as "1,2,3,4"; two numbers, such as "3,5", which applies 3 for the left and right and 5 for the top and bottom; or a single value such as "4". If you set the property to a single value, that `Margin` or `Padding` will be applied to the left, top, right, and bottom edges of the control. If you set each edge explicitly to "1,2,3,4", the order applied is left, top, right, bottom.

Grid

The Grid control is the most powerful and flexible layout control available in the Silverlight layout system. In most scenarios, an application is a combination of Grid and StackPanel controls to lay out resizable UIs, using Canvas panels to create absolutely positioned content where needed.

When we discussed the StackPanel in the previous subsection, we also provided an overview of the layout system and examined Margin and Padding. Margin and Padding also apply to the Grid object, and we demonstrate how to combine Margin and Padding in the code section.

The Grid control is similar to an HTML table in laying out controls. It supports multiple rows and columns in the RowDefinitions and ColumnDefinitions collections. By default, if a control is nested inside a Grid without any rows or columns defined, the control renders in the upper-left corner, which represents row zero and column zero.

When you define columns and rows on a Grid, you can specify the Width in the ColumnDefinition object for a column and the Height in the RowDefinitions object for a row in pixels. You can also leave Width and Height set at their default value of Auto or specify Auto explicitly if you want to reset to the default.

Leaving Width and Height set to Auto causes the Grid to size rows and columns equally as much as possible; however, the ultimate size is determined by the layout system, which takes into account the size of the content. For example, if a Grid has two rows defined with the default of Auto, but the content in the first row has a minimum size that is twice that of the content in the second row, the layout system causes the first row to be twice the width of the second.

The Grid supports a much more powerful method of sizing columns and rows: *star sizing*. When you specify a star (*) as the Width or Height of a column or row, the column or row receives a proportional amount of space. This XAML has the same effect as setting Width and Height to the default of Auto:

```
<Grid.ColumnDefinitions>
<ColumnDefinition Width="*"/>
<ColumnDefinition Width="*"/>
</Grid.ColumnDefinitions>
<Grid.RowDefinitions>
<RowDefinition Height="*"/>
<RowDefinition Height="*"/>
</Grid.RowDefinitions>
```

It gets interesting when you prepend an integer to * for Width or Height. For example, to give up to twice the amount of available space to the second column and second row, specify 2* for both the Width and Height, like this:

```
<Grid.ColumnDefinitions>
<ColumnDefinition Width="*"/>
<ColumnDefinition Width="2*"/>
</Grid.ColumnDefinitions>
<Grid.RowDefinitions>
<RowDefinition Height="*"/>
<RowDefinition Height="2*"/>
</Grid.RowDefinitions>
```

Note that we said "up to twice the amount"; that is because the layout system takes into account the minimum size required for content. If the second column wants twice as much space as the first

column, the content in the first column may prevent the second column from getting all the requested space, depending on the minimum width values configured on the content in the first column.

■ **Note** The `GridSplitter` control allows the user to resize the `Grid` at runtime. Refer to this site for more information: `http://msdn.microsoft.com/en-us/library/system.windows.controls.gridsplitter(VS.96).aspx`.

Like the `Canvas` object, the `Grid` also has attached properties for specifying where nested controls should be located. As we explained in Recipe above, you use `Canvas.Left` and `Canvas.Top` to absolutely position nested content. For a `Grid` object, you specify the row and column for nested content; the Silverlight layout system positions the nested content, taking into account `Margin`, `Padding`, `Alignment`, and so forth.

To position a `StackPanel` in the second column and second row, you use a zero-based value like this:

```
<StackPanel Grid.Column="1" Grid.Row="1" >
```

To have a `StackPanel` positioned in row three, column two but span two columns and two rows, the XAML looks like this:

```
<StackPanel Grid.Column="1" Grid.ColumnSpan="2"
Grid.Row="2" Grid.RowSpan="2">
```

The Code

We start out with a new Visual Studio Silverlight 4 project and divide the default Grid into four sections. We cover the code for the Canvas, StackPanel, and Grid in the sample project for this recipe in the next three subsections.

Code for Canvas

To try out the `Canvas` object, we add a canvas to the default Grid in the upper right quadrant:

```
<Canvas x:Name="CanvasTest"
Grid.Column="1" Grid.Row="0" Margin="20" >  <TextBlock>Hi There</TextBlock>
</Canvas>
```

This results in the text "Hi There" appearing in the upper-right corner of the `Canvas` object. To position the `TextBlock` 20 pixels in and 20 pixels down, you might be tempted to try to use a `Left` or `Top` attribute for the `TextBlock` as you would if you were using absolute positioning in ASP.NET or Windows Forms; but you won't find such an attribute. To position the `TextBlock`, use the following markup to set `Left` and `Top` for the control using attached-property syntax:

```
<TextBlock Canvas.Left="20" Canvas.Top="20">Hi There
</TextBlock>
```

Attached properties are a special form of dependency properties that can be added to a child UI element. Dependency properties are a new type of property used extensively in WPF and Silverlight to enable styling, animation, automatic data binding through change notification, and other capabilities. For more information about dependency properties, refer to Chapters 4 and 5 as well as the MSDN documentation for Silverlight:

```
http://msdn.microsoft.com/en-us/library/cc221408(VS.96).aspx
```

When you invoke IntelliSense for the `TextBlock`, you see a list similar to the one shown in Figure 3-12.

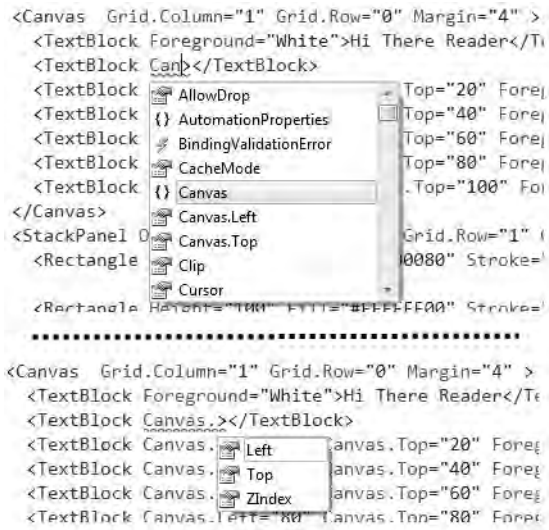


Figure 3-12. *Attached properties in IntelliSense*

The `Canvas` namespace appears in the IntelliSense list along with the other properties for the child control, in this case a `TextBlock`. When you select `Canvas` in the list, `Canvas` is added as an attribute to the `TextBlock` and the list of available attached properties displays as shown in Figure 3-12, resulting in this syntax for the `TextBlock`:

```
<TextBlock Canvas.Left="20" Canvas.Top="20">Hi There</TextBlock>
```

You can make copies of the `TextBlock` and adjust the text and position to have them display across the `Canvas` object.

The UI for the work with the Canvas looks like Figure 3-13.

Figure 3-13. *A* `Canvas` *with* `TextBlock` *objects positioned using attached-property syntax*

The Canvas is an improvement over traditional layout available in Windows Forms or similar technology, because it allows positioning in device-independent pixels. But the Canvas generally is not used for general application UI layout because it does not account for browser or window resizing like the StackPanel and Grid, which we cover in Recipes 3-4 and 3-5. A Canvas can be useful when you are building parts of a general application layout that require precise positioning that must not change, such as when you are building online games in Silverlight.

Code for StackPanel

For the StackPanel, we drag and drop a Stackpanel across the lower two quadrants of the root Grid in Expression Blend resulting in the UI shown in Figure 3-14.

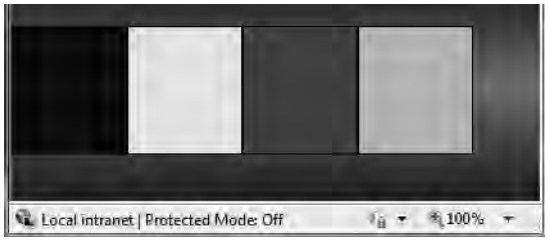


Figure 3-14. *A StackPanel with four Rectangle objects arranged horizontally*

Unlike the Canvas, the StackPanel does not have any attached properties. You cannot specify a Top or Left property to position the elements. When you add elements by double-clicking the element in the Expression Blend Asset Library toolbar, the element is added to the current container (the element with the yellow box around it in the Objects and Timeline Visual Tree tool window) on the Artboard. The order of the elements displayed in the StackPanel is the order in which they are listed in the XAML Visual Tree.

By default, Rectangle elements are added with a Height of 100. The Width is not set, which means it has a default value of Auto. For the StackPanel, the Auto value causes the Rectangle to stretch to fill the width. Here is an example of the markup for the first Rectangle:

```
<Rectangle Height="100" MinWidth="90" Fill="#FF000080" Stroke="#FF000000"/>
```

We configure MinWidth, Fill, Stroke, and Height on the Rectangles so that the Rectangles can be distinguished. The Rectangles are pushed up against the edge of the browser plug-in's edges as well as next to each other. Let's set a value for Margin on each Rectangle to see the effect. Apply these values for Margin to the Rectangles from top to bottom:

```
Margin="8"
Margin="0,0,4,0"
Margin="4"
Margin="4"
```

This results in the UI shown in Figure 3-15.

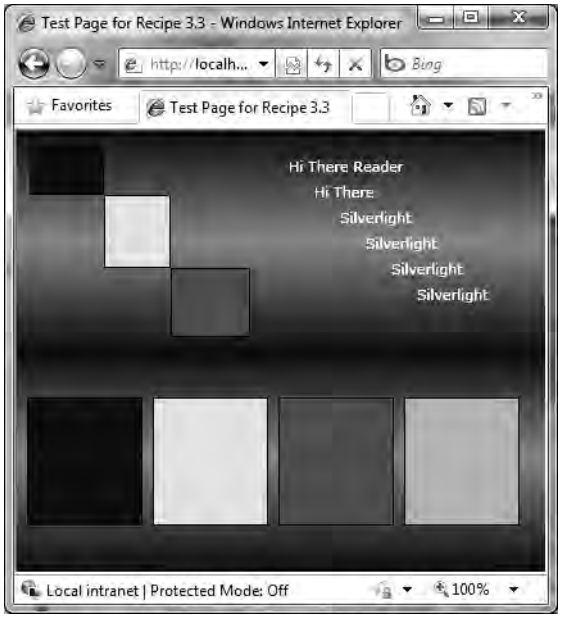


Figure 3-15. *A StackPanel with four Rectangles and Margin set*

Setting `Margin="4"` applies a 4-pixel margin to all four sides. Setting individual values such as `Margin="1,2,3,4"` applies a 1-pixel margin to the left side, 2 pixels to the top, 3 pixels to the right side, and 4 pixels to the bottom. Setting `Margin="4,5"` applies a 4-pixel margin to the left and right sides and a 5-pixel margin to the top and bottom.

In addition to the normal customization options such as `Background` `HorizontalAlignment`, the `StackPanel` has an `Orientation` property, with a default of `Vertical`. We set it to Horizontal in our example. We also configured a `MinWidth` for each `Rectangle`, otherwise they would not render when configured to stack horizontally.

Code for the Grid

By default, when you create a new project in Silverlight, it sets the root element to a `Grid`. For the sample application, we add a grid to the upper left corner of the root layout `Grid`. We also arrange four `Rectangle` objects diagonally as shown in Figure 3-15. We arrange the Rectangle objects by adding row and grid definiitions, shown visually at design-time in Visual Studio 2010 in Figure 3-16.

Figure 3-16. *A Grid with "tic-tac-toe" grid lines*

Here are the column and row definitions for the `Grid`.

```
<Grid.RowDefinitions>
<RowDefinition Height="40*" />
<RowDefinition Height="56*" />
<RowDefinition Height="53*" />
</Grid.RowDefinitions>
<Grid.ColumnDefinitions>
<ColumnDefinition Width="63*" />
<ColumnDefinition Width="56*" />
<ColumnDefinition Width="67*" />
</Grid.ColumnDefinitions>
```

The `Grid` object has many additional configuration options, such as setting the minimum and maximum size on rows and columns as well as various ways to specify the size of rows and columns. For more information, refer to the MSDN documentation here:

`http://msdn.microsoft.com/en-us/library/system.windows.controls.grid(VS.96).aspx`

■ **Note** When you are building a UI, set the height and width of the user control to the desired size before laying out controls. Silverlight UIs are vector based and infinitely scalable, but it helps to have the right relationship between controls if they are laid out at the desired resolution. Otherwise, adjusting the desired size of the user control after building the UI will scale up or down the entire layout, which may not achieve the desired perspective without additional modification.

In general, you may be tempted to set Width and Height properties on controls without thinking; but doing so can alter how layout occurs for controls, usually to the detriment of the developer. And sometimes, when you lay out controls in Expression Blend, the program automatically sets Height and Width values for you even though the default is Auto. Our recommendation is to leave sizing values to the default value of Auto and then decide whether to specify a size or minimum size for a control. If you don't set a value for Height or Width, the default value is Auto.

When you are building a UI with nested containers like Grid and StackPanel in Expression Blend, you may find that you cannot directly select a nested UI element like a TextBox with the default Selection tool. The black arrow at the top of the Asset Library toolbar is the Selection tool, which selects immediate children only of the control that has the blue box around it in the Objects and Timeline window. You can move the blue box to any nested container control by clicking a container control in the Objects and Timeline windows; another option is to use the Direct Selection tool (hotkey A), which is the white arrow just below the Selection tool in the Asset Library toolbar. The Direct Selection tool allows deep selection of an object on the design surface or Artboard.

To demonstrate the automatic layout and resizing capabilities of the Grid and StackPanel, run the sample and grab the lower right corner of the browser window and resize teh application. This allows the Silverlight layout system to determine the size of objects based on the size of the overall browser window as well as any minimum size values for controls. Listing 3-1 has the complete source code for this recipe.

Listing 3-1. *Recipe 3.3 MainPage.xaml File*

```
<UserControl x:Class="Ch03_DevelopingUX.Recipe3_3.MainPage"
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"
mc:Ignorable="d"
d:DesignHeight="300" d:DesignWidth="400">
<Grid x:Name="LayoutRoot" >
<Grid.Background>
<LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
<GradientStop Color="#FF26302B"/>
<GradientStop Color="#FF26302B" Offset="1"/>
<GradientStop Color="#FF26302B" Offset="0.50400000810623169"/>
<GradientStop Color="#FF748A7F" Offset="0.25"/>
<GradientStop Color="#FF748A7F" Offset="0.7369999885559082"/>
</LinearGradientBrush>
</Grid.Background>
<Grid.ColumnDefinitions>
<ColumnDefinition Width="186*" />
<ColumnDefinition Width="214*" />
</Grid.ColumnDefinitions>
<Grid.RowDefinitions>
<RowDefinition Height="149*" />
<RowDefinition Height="151*" />
</Grid.RowDefinitions>
```

```
<Grid x:Name="GridTest" Margin="10">
<Grid.RowDefinitions>
<RowDefinition Height="40*" />
<RowDefinition Height="56*" />
<RowDefinition Height="53*" />
</Grid.RowDefinitions>
<Grid.ColumnDefinitions>
<ColumnDefinition Width="63*" />
<ColumnDefinition Width="56*" />
<ColumnDefinition Width="67*" />
</Grid.ColumnDefinitions>
<Rectangle Fill="#FF000080" Stroke="#FF000000" />
<Rectangle Fill="#FFFFFF00" Stroke="#FF000000"
Grid.Row="1" Grid.Column="1" />
<Rectangle Fill="#FF008000" Stroke="#FF000000"
Grid.Column="2" Grid.Row="2" />
</Grid>
<Canvas x:Name="CanvasTest"  Grid.Column="1" Grid.Row="0" Margin="20" >
<TextBlock Foreground="White">Hi There Reader</TextBlock>
<TextBlock Canvas.Left="20" Canvas.Top="20" Foreground="White">Hi There</TextBlock>
<TextBlock Canvas.Left="40" Canvas.Top="40" Foreground="White">Silverlight</TextBlock>
<TextBlock Canvas.Left="60" Canvas.Top="60" Foreground="White"> Silverlight</TextBlock>
<TextBlock Canvas.Left="80" Canvas.Top="80" Foreground="White"> Silverlight</TextBlock>
<TextBlock Canvas.Left="100" Canvas.Top="100" Foreground="White"> Silverlight</TextBlock>
</Canvas>
<StackPanel Orientation="Horizontal" Grid.Row="1" Grid.ColumnSpan="2">
<Rectangle Height="100" Fill="#FF000080" Stroke="#FF000000" Margin="8"
MinWidth="90"/>
<Rectangle Height="100" Fill="#FFFFFF00" Stroke="#FF000000"
Margin="0,0,4,0" MinWidth="90"/>
<Rectangle Height="100" Fill="#FF008000" Stroke="#FF000000" Margin="4"
MinWidth="90"/>
<Rectangle Height="100" Fill="#FF00FFFF" Stroke="#FF000000" Margin="4"
MinWidth="90"/>
</StackPanel>
</Grid>
</UserControl>
```

3-4. Drawing with Shapes, Paths, and Geometries

Problem

You need to draw objects when building a Silverlight UI in Expression Blend.

Solution

Learn how to draw with shapes, paths, and geometries in Expression Blend.

How It Works

Silverlight provides tools to draw with primitive shapes, paths, and geometries. We cover each option in the next subsections.

Drawing with Shapes

Silverlight includes vector graphic primitives that are infinitely scalable and easy to manipulate. The basic shapes include `Ellipse` and `Rectangle`, which can be combined into `Path` objects, which we cover in this section.

The `Ellipse` and `Rectangle` objects are predefined shapes that can be combined to create pretty much any other shape. They are less flexible than `Path` objects, but they can be easier to work with because they provide structure that is malleable.

For example, it is easy to visually create a perfect circle with an `Ellipse` by drawing an `Ellipse` on the surface and then adjusting the drawing by grabbing a corner and sliding the selection frame left, right, up, or down so that the bounding rectangle around the `Ellipse` has the same width and height. You can also set the `Width` and `Height` properties directly in the Expression Blend properties window. Figure 3-17 shows the mouse adjusting an `Ellipse` so that it is 102 by 102 pixels, forming a perfect circle.

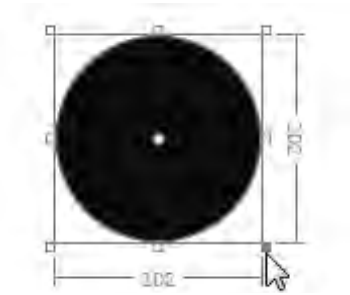


Figure 3-17. *Adjusting an Ellipse to create a perfect circle in Expression Blend*

You can also create a circle with a `Rectangle` shape. The first step is to drag a `Rectangle` onto the design surface or Artboard in Expression Blend and size it as when working with the `Ellipse`, to 100 5 100 pixels. Next, with the mouse, grab the handle in the upper-left corner of the `Rectangle`, and drag it as far as it will go down and to the right. Doing so yields a circle, as shown in Figure 3-18.

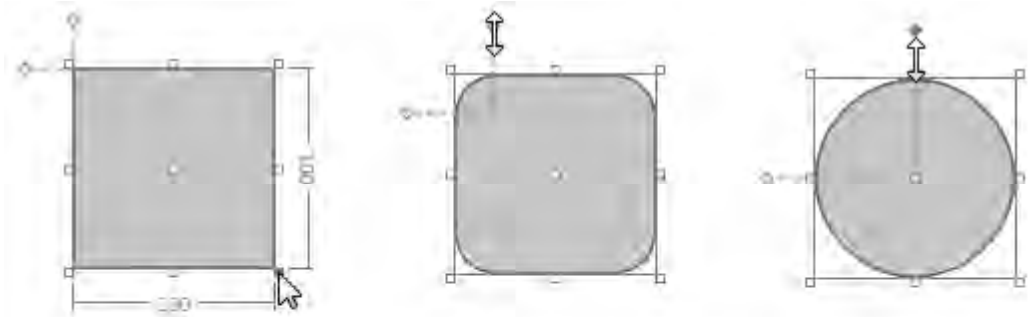


Figure 3-18. *Adjusting a Rectangle to create a perfect circle in Expression Blend*

What is accomplished visually can also be accomplished programmatically by setting the `RadiusX` and `RadiusY` value to half the length or width, assuming the length and width are the same on the `Rectangle`. If the length and width are not equal in value, you will create a circular shape, but it won't be a perfectly round circle.

As mentioned earlier, you can create drawings with shapes by combining them in Expression Blend. As an example, let's say you want to create a puffy cloud shape. Draw a circle using an `Ellipse` shape object that is 100 x 100 pixels. Make two copies, fill them with gray for a storm-cloud appearance, and arrange them as shown in Figure 3-19.

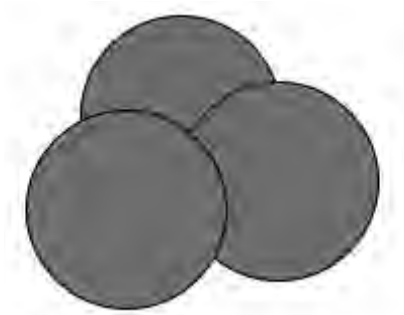


Figure 3-19. *Drawing a cloud with three Ellipses*

To create more of a cloud-like experience, you can use Expression Blend to combine the three shapes into a `Path`. First, select all three `Ellipse` objects by either Shift-clicking in the Objects and Timeline window or pressing Ctrl and left-clicking each `Ellipse` until all three are selected. Then, right-click either the objects listed in the Objects and Timeline window or the Artboard to bring up the Combine menu, as shown in Figure 3-20.

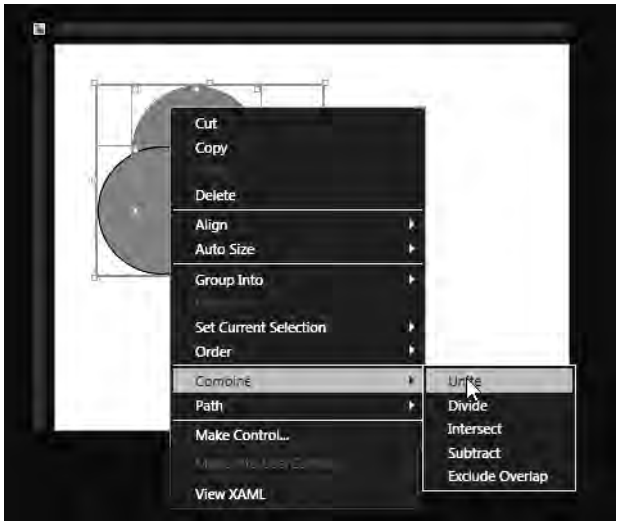


Figure 3-20. *Combine three Ellipses using Unite*

Select the Unite option, and Expression Blend combines the three shapes into a `Path` object, as shown in Figure 3-21.

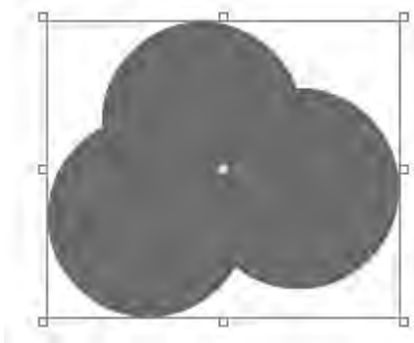


Figure 3-21. *Results of combining with Unite*

The three `Ellipse` shapes are now a single object that you can manipulate by resizing it or by applying a transform to rotate or skew it. To see what happened, here is the XAML before combining the `Ellipses`:

```
<Grid>
<Ellipse Height="100" HorizontalAlignment="Left" Margin="60,32,0,0"
VerticalAlignment="Top" Width="100" Fill="#FF808080" Stroke="#FF000000"/>
<Ellipse HorizontalAlignment="Stretch" Margin="108,65,192,135"
VerticalAlignment="Stretch" Fill="#FF808080" Stroke="#FF000000"/>
<Ellipse HorizontalAlignment="Left" Margin="33,79,0,121"
```

```
VerticalAlignment="Stretch" Fill="#FF808080" Stroke="#FF000000" Width="100"/>
</Grid>
```

Here is the XAML after combining the `Ellipses` with Unite into a `Path` object:

```
<Grid>
<Path HorizontalAlignment="Stretch" Margin="33,32,192,121"
VerticalAlignment="Stretch" Fill="#FF808080" Stretch="Fill" Stroke="#FF000000"
Data="M77,0.5 C78.708633,0.49999899 80.397……..77,0.5 z"/>
</Grid>
```

We didn't copy the exact resulting XAML (see the book's code for the full XAML) because it is almost a page of nothing but floating-point values for the `Data` property on the `Path` object; but you can see that the three `Ellipses` are now a single `Path` object. Let's explore the remaining options on the Combine menu:

- Subtract is interesting because parts of shapes under the first shape selected are removed or subtracted. Suppose you have three shapes, as shown at left in Figure 3-22, and you select the topmost `Ellipse` and then select Subtract. The results of the operation are shown in Figure 3-23 with the title "Subtract."
- Intersect does what you would expect: it removes all parts of the shapes except the interception of the shapes.
- Exclude Overlap excludes areas that are overlapped by some but not all shapes.
- Divide preserves all strokes but uses the fill of the topmost shape as the fill of all selected shapes, as shown at right in Figure 3-22.

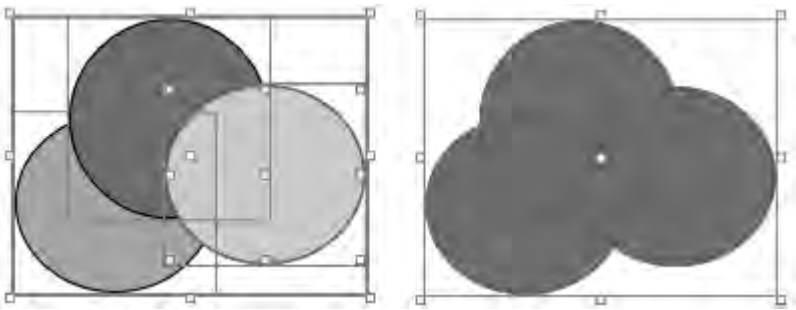


Figure 3-22. *The Divide option, before (left) and after*

Figure 3-23 shows the results of all of the Combine options.

By performing these types of combination options, you can create just about any shape required. As an example, let's say you need to create a ring. You could stick with an `Ellipse` and apply a relatively large number for the stroke, but that approach is limited because you cannot see clear inner and outer borders for the ring. Instead, let's use Combine ➤ Subtract.

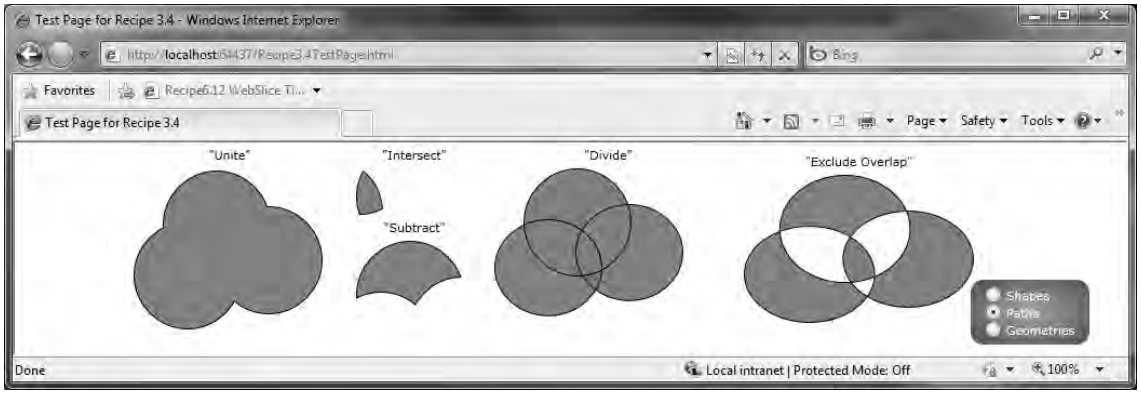


Figure 3-23. *The results of all the Combine options*

First, create an `Ellipse` that is 100 5 100 pixels in its rectangle bounding box when selected. Fill it with gray. Next, drag another `Ellipse` that is 70 5 70 pixels in size. Select both `Ellipses`. Then, in the Object menu, select Align ➤ Horizontal Centers and Vertical Centers so that the smaller `Ellipse` is perfectly aligned with the larger `Ellipse`. The order of selection matters, so first select the smaller `Ellipse` that you want to subtract from the larger `Ellipse`. While both `Ellipses` are selected, right-click, and select Combine ➤ Subtract. The result is a `Path` object that is a ring or donut with a transparent center, as shown in
Figure 3-24.

Figure 3-24. *Path shaped as a ring via Combine ➤ Subtract*

Exclude Overlap could also generate Figure 3-24. Combine operations are not limited to shapes. You can include `Path` objects as well, as we cover in the next recipe. However, we first discuss the other available menu options that help designers quickly create complex drawings and reusable drawings.

Other menu options available in Expression Blend when you right-click an object (shape and/or `Path`) or selected objects are Group Into, Make Control, and the Path menu. Group Into allows you to quickly put an object or selected objects into a `Grid`, `StackPanel`, `Canvas`, `ScrollViewer`, or `Border` control; all of these inherit from `Panel` and are container controls. We covered `Grid` and StackPanel in Recipe 3-3. We cover `ScrollViewer` in Recipe 3-5 and `Border` in Recipe 3-6.

Make Control lets you quickly create a simple control out of the selected objects. For example, say you first select the `StackPanel` that contains the `TextBox` with the title "Exclude Overlap" and the `Path` where the Exclude Overlap operation was performed, as shown in Figure 3-23 earlier. Right-click and select Make Into UserControl to display the Make Into UserControl dialog, shown in Figure 3-25.

Figure 3-25. *The Make Into UserControl dialog*

As shown in Figure 3-25, name the control `ExcludeOverlapControl`, and leave the check box unchecked. If you check the check box, Expression Blend leaves the original content in place but puts a copy into a separate `.xaml` file. This is useful if you want to use the content as a separate control later. However, if you leave the check box unchecked, the content is removed from the `MainPage.xaml` file, put into a separate `.xaml` file as a custom control, and then added back to the `MainPage.xaml` file as a control reference. This custom control is available for use in other pages as well.

An `.xaml` file named `ExcludeOverlapControl.xaml` that contains the control is added to the project. To make the control more useful, remove the `White Background` color from the `LayoutRoot` object in the new control's Visual Tree in the Objects and Timeline window. This makes the object's background transparent, which may be desirable when you use the newly created control.

In the original `MainPage.xaml` file, a new namespace is added to the `UserControl` root object:

```
xmlns:Shapes="clr-namespace:Shapes"
```

The original XAML markup for the `StackPanel` containing the `TextBox` and `Path` object is converted to this XAML, which references the new control:

```
<Shapes:ExcludeOverlapControl Margin="8,8,8,8" Grid.Column="3"/>
```

Although we don't cover the details of building controls in this chapter, we discuss them in Chapter 5. We show this functionality here for a scenario such as creating a drawing with controls, shapes, and path objects that represent something like a game piece in a computer game, when you want to be able to treat the result as a stand-alone control. At this point, a developer can add properties, methods, and events to the composite control by editing the code-behind file that is automatically created.

Drawing with Path Objects

The drawing tools included in Silverlight are the Pen, Line, and Pencil, which are located on the Asset Library toolbar in Expression Blend. `Ellipse` and `Rectangle` are predefined shapes that you can combine to create pretty much any other shape, as we covered in the previous subsection.
The other tools create `Path` objects or lines that can be straight, curved, or free-form. Closing a `Path` causes the drawing to look like a shape. You can use the Pen tool to create paths containing straight lines and curves. The Line tool creates straight lines. You use the Pencil tool to create free-form `Paths`.

In Expression Blend, a Path menu option is available on the context menu when you right-click an object or selected objects. The Path menu has the submenu items listed in Table 3-1.

Table 3-1. *Path Context Menu Suboptions*

Submenu Option	Description
Convert to Path	Converts the selected object or objects on the Artboard into a `Path` object or multiple `Path` objects. It does not combine the objects into a single `Path` object if multiple objects are selected.
Make Clipping Path	Requires two objects, one located in front of the other. The shape or `Path` in front clips the shape or `Path` behind it, meaning that portions of the shape or `Path` behind the clipping\shape or `Path` are no longer visible. When you apply a clipping `Path` to an object, a `Clip` attribute is added to the object.
Release Clipping Path	Removes the `Clip` attribute from the object, making it a separate `Path` object on the Artboard, undoing the Make Clipping Path option.
Make Compound Path	Converts the selected objects on the Artboard into a single `Path` object. This is similar to the Combine ❜ Exclude Overlap option discussed earlier in that individual strokes are preserved and areas where not all of the objects overlap are clipped.
Release Compound Path	Reverses the Make Compound Path option, except that it converts the individual objects to `Path` objects. For example, if you select three `Ellipse` objects and then select Make Compound Path, the three `Ellipse` objects are converted into a single `Path` object. If you then select Release Compound Path, the single `Path` object is converted to three individual `Path` objects. Each `Path` object looks like the original `Ellipse`, but they are still `Path` objects under the covers.

As we mentioned earlier, the `Path` object represents a line that can be drawn directly with three different tools in Expression Blend: Line, Pen, and Pencil. As we noted when discussing the features of Expression Blend in Recipe this recipe, the output of various menu options is usually a `Path` object with a fairly large string of values for the `Data` attribute on the `Path` object. The `Data` attribute defines the shape of the line, which is essentially a series of points.

Drawing with Geometries

In this subsection we cover how to work with geometries like EllipseGeometry, PathGeometry, and LineGeometry, and segments like ArcSegment and GeometryGroup. Geometry objects such as EllipseGeometry, PathGeometry, and GeometryGroup are not visual objects like Ellipse, Path, and Rectangle. Shapes like Rectangle and Ellipse are UIElement objects and can render themselves. Geometries inherit directly from DependencyObject.

As we described in the previous subsections, `Shape` and `Path` objects are readily usable for drawing. Geometries, on the other hand, do not inherit from `UIElement` and cannot render themselves. Geometries describe how to draw two-dimensional shapes. Both the `Path` object and objects that inherit from `UIElement` can take a geometry as a property and then draw it. For `Path`, it is the `Data` property; for `UIElement`, it is the `Clip` property.

You saw in the previous subection that when you draw a `Path` using the Pen tool, the `Data` property is set to a value that follows the syntax of the Path Mini-Language. For example, you can draw a `Path` that describes a straight line to generate this XAML:

```
<Path Stroke=”Black” StrokeThickness=”1” Margin=”2,2,2,2”
Data=”M0,0 100,114 100,114”/>
```

In the test code for geometries, here is the XAML for the same line drawn with the `Data` property, using a geometry to define how to draw the `Path` object:

```
<Path Stroke=”Black” StrokeThickness=”1” Margin=”2,2,2,2” >
<Path.Data>
<LineGeometry StartPoint=”0,0” EndPoint=”100,114” />
</Path.Data>
</Path>
```

The Code

We cover how to work with shapes in the above “How it Works” section because it is primarily an exercise in Expression Blend. However, we cover the details on Paths and Geometries in the next two subsections.

Drawing with Paths

This recipe starts with the code work we did with the shapes where you drop three `Ellipse` objects on the Expression Blend Artboard and use the various Combine menu options to create complex `Path` objects.

If you use the Direct Selection tool to click the shape that results from choosing Combine ➤ Unite for the three `Ellipses` above, you see all the points that resulted from the Unite operation (see Figure 3-26).

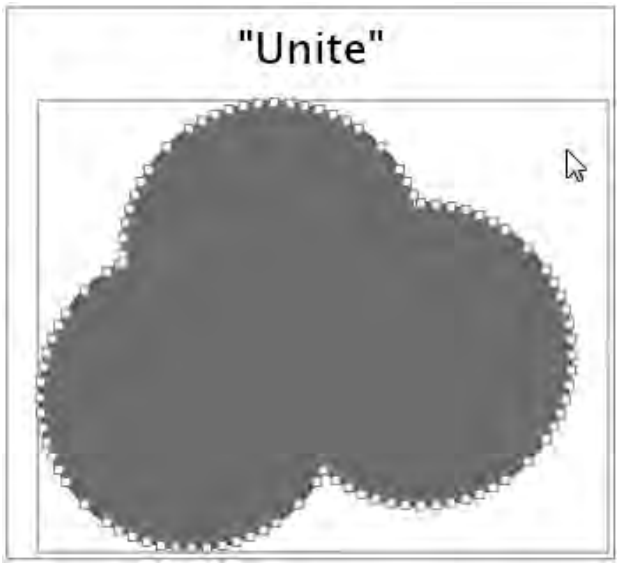


Figure 3-26. *The points of a Path resulting from combining three Ellipses with Unite*

The *Path Mini-Language* is the syntax used to define geometric paths. The value set for the `Data` attribute of a `Path` object as well as the `Clip` attribute for a shape is defined in the Path Mini-Language. As an example, draw a `Rectangle` that is 50 pixels square, and then convert it to a `Path` object by right-clicking and selecting Path | Convert to Path option. Here's the value for the `Path`'s `Data` attribute after the `Rectangle` is converted to a `Path`:

```
Data=" M0.5,0.5 L49.5,0.5 L49.5,49.5 L0.5,49.5 z"
```

`M` specifies the start point. The three `L` commands specify drawing a line. The `z` command closes the current figure. This is a simple example, and the Path Mini-Language is capable of describing how to draw very complex objects. For more information, see the Silverlight 4 documentation on MSDN for a full description of the Path Mini-Language syntax:

```
http://msdn.microsoft.com/en-us/library/cc189041(VS.96).aspx
```

Although you can learn the full syntax of the Path Mini-Language, another option is to start drawing `Path` objects with the Line, Pen, or Pencil tool in conjunction with shapes such as `Rectangle` and `Ellipse` objects to create complex drawings. We covered shapes in the previous recipe, so we begin here with the Line tool.

The Line tool is located with `Ellipse` and `Rectangle` on the Asset Library toolbar. It draws straight `Path` objects by default. You can create a smooth curve with a `Path` drawn using the Line tool by selecting the `Path` with the Direct Selection or Pen tool, holding down the Alt key (which changes the mouse pointer to an angle shape), and then dragging the line to the desired curve, as shown in Figure 3-27.

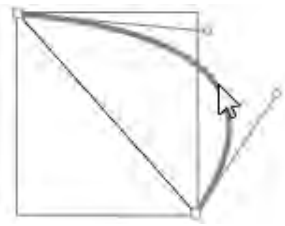


Figure 3-27. *Using the Direct Selection tool with the Alt key to curve a Path*

At first, this type of operation may not seem interesting. But if you draw a few `Path` objects with the Line tool and then apply a curve following the steps just explained, you can create a simple three-dimensional wireframe (see Figure 3-28).

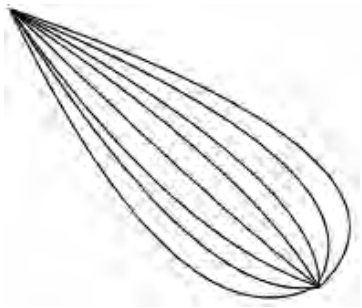


Figure 3-28. *Creating curves with the Line tool*

You don't want eight `Path` objects sitting in the Visual Tree. Multiselect all the `Path` objects, right-click one, and select the Group Into ❱ Canvas command, as shown in Figure 3-29, to combine everything into a single object in the Visual Tree.

Drawing with the Pen tool is similar to using the Line tool, but the Pen tool makes it easier to draw additional connected segments. With the Pen tool, you click where you want to start and then click where you want to add a connected point. Expression Blend draws the line for you between clicks or points.

Figure 3-29. *Group Into menu in Expression Blend*

To close a drawing with the Pen tool, click back on a previous node on the line. To avoid adding another segment and also close a drawing, click back on the just previously added node, which adds the Path Mini-Language `z` to the value in the `Data` attribute. For example, if you want to create a two-node line, first click the Artboard to start the line, again click the Artboard where you want the second point to be located, and finally click back on the first node to close out the line. Clicking back on the first node does not add another segment; it results in the Path Mini-Language `z` being appended to the value in the `Data` attribute on the `Path` object.

You don't have to close a drawing with the Pen tool. You can draw a crooked line by clicking numerous points at odd angles, as in Figure 3-30.

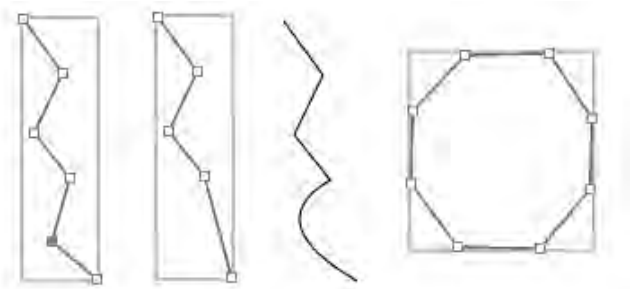


Figure 3-30. *Drawing with the Pen (left) and modifying with Alt (third from left)*

In Figure 3-30, we used the Pen tool to draw a line by clicking in a zigzag pattern down the Artboard. Notice that the second-from-the-bottom point is shaded a darker color in the drawing on the left, which indicates that the point is selected with either the Pen or Direct Selection tool. Clicking the Delete key results in the drawing that's second from the left. Finally, holding down Alt with the mouse over the bottom segment and applying a curve yields the drawing that's third from the left. It is also possible to draw shapes and close them out so that the start point and end point are the same, as in the drawing at far right.

Another way to draw with the Pen tool is to use the control handles. Select the Pen tool, and then left-click once where you want one end of the curve to be. Next, left-click the Artboard, but do not release the mouse button. Instead, drag, and you see a control handle appear that is tangent to the curve. Drag the control handle until you create the desired curve. If you click and drag again, another point is added, and a control handle appears for the new segment. When you are done drawing, you can click a point on a `Path` with the Direct Selection or Pen tool, and the control handles appear.

Control handles are a great way to smooth out the curve between connection points by lining up the tangents for each control handle on either side of a point. You can manipulate control handles with the mouse even after drawing the `Path` by clicking a point and then selecting the circle at the end of the control handle, as shown in Figure 3-31.

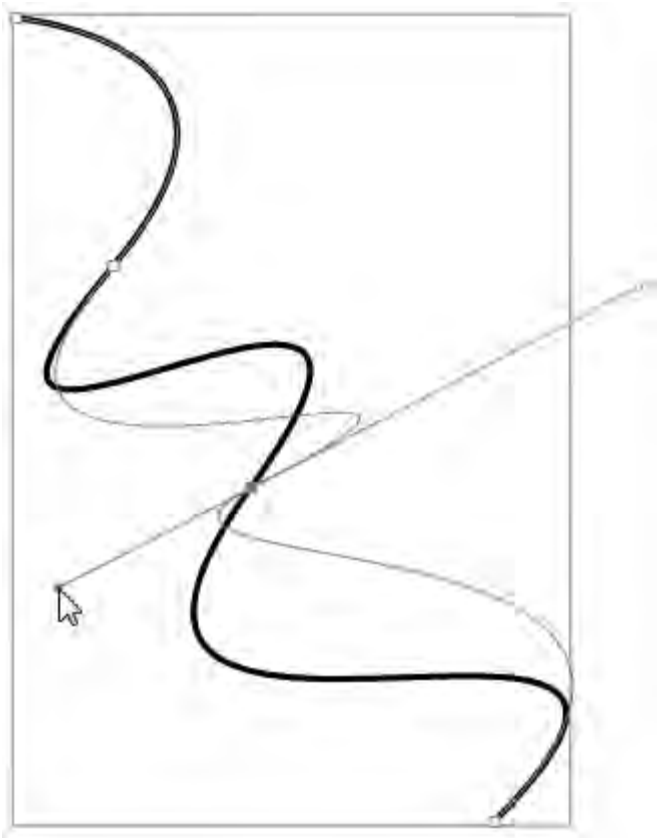


Figure 3-31. *Using a control handle to change the curve (dark color) to a new curve (lighter color)*

To add a node to an existing `Path`, select the `Path` with the Direct Selection tool, and then switch to the Pen tool. Move the mouse cursor over the desired location of the existing `Path`; the Pen tool displays a small plus sign at lower right. Click when the plus sign appears to add a node to the `Path`.

To add a node at the end of a `Path`, click the end point of a `Path` with the Pen tool, and then click on the Artboard where you want the new end point to be located. Expression Blend adds another node to the existing `Path`. If you miss clicking the end point and create a new `Path` object by mistake, click Undo (or press Ctrl+Z), and then try zooming in before clicking the end point.

To close a `Path` so that it is a fully enclosed shape, click one end of the `Path`, and then move the cursor over the other end of the `Path`. Click when the symbol at the Pen's lower right changes to a circle.

So far, we have covered the Line and Pen tools. Next, we cover the Pencil tool, which provides freehand drawing capabilities. Select the Pencil tool, and then begin drawing by left-clicking and holding down the mouse button. As you draw with the mouse, Expression Blend decides where to add points along the way. Figure 3-32 shows an attempt at drawing a box.

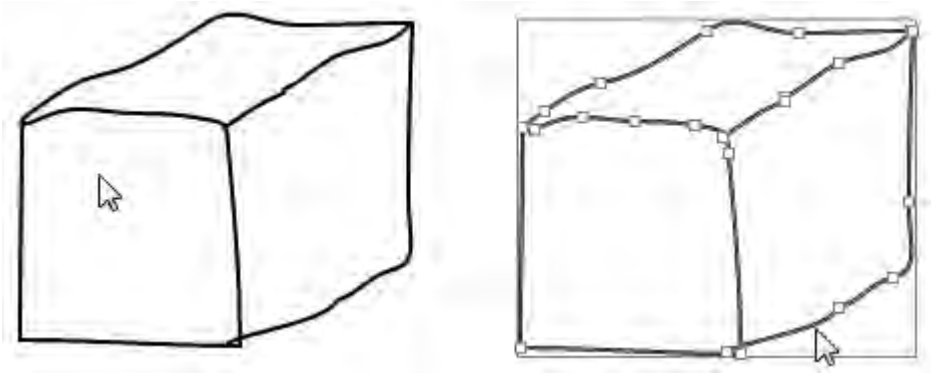


Figure 3-32. *Freehand drawing with the Pencil tool*

In Figure 3-32, the image on the right shows the points that were automatically added by Expression Blend when we draw with the Pencil tool. At this point, you can switch to the Pen tool and manipulate the points on the `Path` just like before, to smooth out areas, remove extra points, and so forth. The Pencil tool is very useful for a graphic designer with the right type of hardware tools, such as a stylus, to freehand-sketch a layout that can then be manipulated into the desired drawing.

We don't list the code for this recipe because it consists of the XAML markup of all the drawing activities in Expression Blend that we describe earlier, which is mostly `Path` objects with very long values for the `Data` attribute. Refer to the sample code for this recipe to see the drawings and try some of your own.

Drawing with Geometries

In order to cover a few geometries, we have one application with several geometries drawn in it. We walk through each geometry to explain what we are trying to demonstrate.

As long as you define the `Fill` or `Stroke` property, you can render a geometry with a `Path` object. Here are a few examples that draw a `Rectangle` and an `Ellipse`, from the sample code for this recipe:

```
<Path Grid.Column="1" Fill="AliceBlue" Grid.Row="0" Stroke="Black"
StrokeThickness="1" Margin="2,2,2,2" >
<Path.Data>
<RectangleGeometry  Rect="20,20,70,40" />
</Path.Data>
</Path>
<Path Grid.Column="2" Fill="AliceBlue" Grid.Row="0" Stroke="Black"
StrokeThickness="1" Margin="2,2,2,2" >
<Path.Data>
<EllipseGeometry Center="50,50" RadiusX="30" RadiusY="30" />
</Path.Data>
</Path>
<Path Grid.Column="2" Fill="AliceBlue" Grid.Row="1" Stroke="Black"
StrokeThickness="1" Margin="2,2,2,2" >
<Path.Data>
```

```
<GeometryGroup>
<LineGeometry StartPoint="0,50" EndPoint="140,50" />
<RectangleGeometry  Rect="10,30,70,40" />
<EllipseGeometry Center="100,50" RadiusX="30" RadiusY="30" />
</GeometryGroup>
</Path.Data>
</Path>
```

The last `Path` object in the sample code uses a `GeometryGroup` to combine multiple geometries (see Figure 3-33).

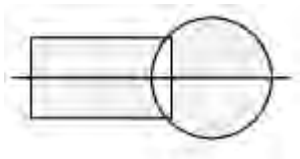


Figure 3-33. *Path object with a GeometryGroup containing multiple geometries*

We mentioned earlier in this recipe that you can set the `Clip` property of objects that inherit from `UIElement` to a geometry value. The `Image` control inherits from `UIElement`, so you can set its `Clip` property to a geometry to yield a nice effect. First, set the background to a light blue color so that the clipping effect is more obvious than it would be with a white background.

Add two `Image` objects that point to the same image, which is 100 5 75 pixels in size. For the second `Image` object, apply a simple `RectangleGeometry` that has rounded corners to clip the image:

```
<Image.Clip>
<RectangleGeometry Rect="0,0,100,75" RadiusX="25"  RadiusY="25"/>
</Image.Clip>
```

The results of setting the `Clip` property are shown in Figure 3-34, which compares the two images.

■ **Note** The image used in this recipe's sample code is located at the TestWeb web site in a folder named `img` under `ClientBin`.

Figure 3-34. *The results of setting the Clip property*

You can see that the bottom image has rounded corners for a smoother look. In the same manner, you can apply a geometry to a `MediaElement` so that the video appears to be playing on an old glass television set with rounded corners.

The last geometry we cover from the recipe's sample code is the `PathGeometry` object. The `PathGeometry` object can contain multiple segment objects such as `LineSegment`, `ArcSegment`, `BezierSegment`, `QuadraticBezierSegment`, and `PolyQuadraticBezierSegment`. These can be applied in unison as part of a `PathFigure` element collection in `PathGeometry`. Here is an example from Listing 3-5 that uses an `ArcSegment` and a `BezierSegment`:

```
<Path Stroke="Black" Grid.Row="2" Grid.Column="2" Margin="4,4,4,4">
<Path.Data>
<PathGeometry>
<PathFigure StartPoint="20,20">
<BezierSegment Point1="10,40" Point2="200,70" />
<ArcSegment Point="100,10" Size="200,150" RotationAngle="25"
```

```
IsLargeArc="False"  SweepDirection="Counterclockwise"/>
</PathFigure>
</PathGeometry>
</Path.Data>
</Path>
```

Figure 3-35 shows the output for the `BezierSegment` and `ArcSegment`.

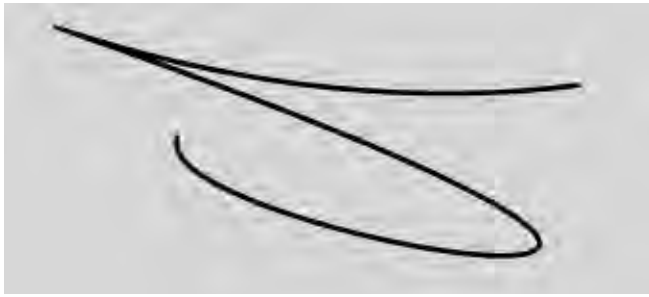


Figure 3-35. *The Bezier curve*

We don't get into the details of all the different segment objects available for drawing. Refer to the Silverlight 4 MSDN documentation for more information:

`http://msdn.microsoft.com/en-us/library/cc189068(VS.96).aspx`

■ **Note** If you are building drawings in code, you must use geometry objects. The Path Mini-Language is available only in markup.

One last item to note is that when you work with `Path` objects in Expression Blend, it defaults to using the Path Mini-Language syntax for the `Data` value (or for the `Clip` property on `UIElement` objects). Keep this in mind if you wish to use geometries, because if you attempt to modify the appearance of a `Path` that uses geometries in Expression Blend, Blend converts the `Path`'s `Data` value from a geometry declaration to a string containing Path Mini-Language. This may not be a concern, and we highly recommend using Expression Blend for the productivity that it provides; but we thought we should mention it just in case.

To provide simple navigation for the recipe, we have a main page for this recipe that allows the user to select what drawings they would like to see, whether, Shapes, Paths, or Geometries. Clicking a radio button loads one of the following user controls:

- DrawingWithShapes
- DrawingWithPaths
- DrawingWithGeometries

Listing 3-2 and 3-3 shows the XAML and code-behind for the `MainPage`.

Listing 3-2. *Recipe 3.4 MainPage.xaml File*

```
<UserControl x:Class="Ch03_DevelopingUX.Recipe3_4.MainPage"
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"
mc:Ignorable="d"
d:DesignHeight="700" d:DesignWidth="900">
<Grid x:Name="LayoutRoot" Background="White">
<Grid.RowDefinitions>
<RowDefinition Height="0.956*"/>
<RowDefinition Height="0.044*"/>
</Grid.RowDefinitions>
<Grid.ColumnDefinitions>
<ColumnDefinition Width="0.967*"/>
<ColumnDefinition Width="0.033*"/>
</Grid.ColumnDefinitions>
<Grid x:Name="ControlPlaceholder" Height="600" Width="800"></Grid>
<Border x:Name="ControlUserView" Height="60" HorizontalAlignment="Right"
VerticalAlignment="Bottom" Width="110" CornerRadius="12" Padding="6">
<Border.Background>
<RadialGradientBrush RadiusY="0.996" RadiusX="0.996">
<GradientStop Color="#FF292929" Offset="1"/>
<GradientStop Color="DarkGray"/>
</RadialGradientBrush>
</Border.Background>
<StackPanel HorizontalAlignment="Center" VerticalAlignment="Center">
<RadioButton x:Name="rbShapes" Content="Shapes" Height="16"
HorizontalAlignment="Left"  VerticalAlignment="Top"
Foreground="#FFFFFBFB" GroupName="UCChoice"
Checked="rbShapes_Checked" />
<RadioButton x:Name="rbPaths" Content="Paths" Height="16"
HorizontalAlignment="Left" VerticalAlignment="Top"
Foreground="#FFFFFBFB" GroupName="UCChoice"
Checked="rbPaths_Checked"/>
<RadioButton x:Name="rbGeometries" Content="Geometries" Height="16"
HorizontalAlignment="Left" VerticalAlignment="Top"
Foreground="#FFFFFBFB" GroupName="UCChoice"
Checked="rbGeometries_Checked" />
</StackPanel>
</Border>
</Grid>
</UserControl>
```

Listing 3-3. *Recipe 3.4 MainPage.xaml.cs File*

```
using System.Windows;
using System.Windows.Controls;

namespace Ch03_DevelopingUX.Recipe3_4
{
public partial class MainPage : UserControl
  {
public MainPage()
    {
InitializeComponent();
    }

private void rbShapes_Checked(object sender, RoutedEventArgs e)
    {
ControlPlaceholder.Children.Add(new DrawingWithShapes());
    }

private void rbPaths_Checked(object sender, RoutedEventArgs e)
    {
ControlPlaceholder.Children.Add(new DrawingWithPaths());
    }

private void rbGeometries_Checked(object sender, RoutedEventArgs e)
    {
ControlPlaceholder.Children.Add(new DrawingWithGeometries());

}
}
```

3-5. Providing Scrollable Content

Problem

You need to provide scrollable content for layout purposes, or you need to apply a border to a control.

Solution

To provide scrollable content, use `ScrollViewer` as a container for the content. `ScrollViewer` can have exactly one child control, which is usually a layout panel such as a `Grid`, `StackPanel`, or `Canvas` object that contains additional content as desired.

How It Works

`ScrollViewer` is a control that has scrollbars so that you can scroll its contents vertically as well as horizontally. `ScrollViewer` can contain exactly one control. A `StackPanel` or a `Grid` is the best candidate; you can place multiple controls in the scrolling view by containing the controls within the `StackPanel` or `Grid`.

The `ScrollViewer` control has properties to control whether the scrollbars are visible, disabled, or automatically visible as needed: `HorizontalScrollBarVisibility` and `VerticalScrollBarVisibility`. If you set both to `Auto`, the horizontal and vertical scrollbars appear only when needed, based on the size and amount of content in the control. Other options are `Disabled`, `Hidden`, and `Visible`.

The Code

The sample code includes a `TextBox`, a `Button`, and a `ScrollViewer` control that initially contains a `StackPanel`. Type text into the `TextBox`, and click the Click to Add Text button. When the `Button` event fires, it dynamically adds a `TextBlock` to the `StackPanel` in the `ScrollViewer`. Perform this step a few times; when the `StackPanel` fills with `TextBlock` controls, the vertical scrollbar appears. If the entered text is long enough, the horizontal scrollbar appears. Figure 3-36 shows the results.

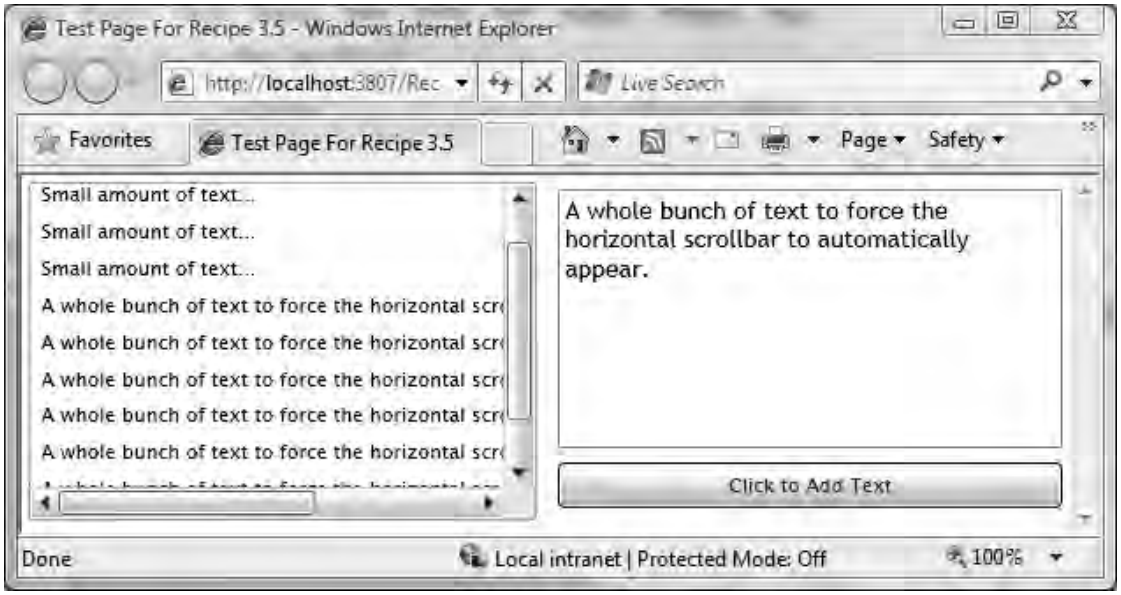


Figure 3-36. *The ScrollViewer in action*

Built-in controls like `ListBox` encapsulate a `ScrollViewer` as part of their default internal Visual Tree. It is handy that this functionality is readily available to developers when they need to display a large amount of data as part of the layout. Listings 3-4 and 3-5 show the code for this recipe.

Listing 3-4. *Recipe 3.5 MainPage.xaml File*

```
<UserControl x:Class="Ch03_DevelopingUX.Recipe3_5.MainPage"
```

```
xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
xmlns:mc="http://schemas.openxmlformats.org/markup-compatibility/2006"
d:DesignHeight="300" d:DesignWidth="400"  <Grid x:Name="LayoutRoot" Background="White">
<Grid.RowDefinitions>
<RowDefinition Height="*"/>
</Grid.RowDefinitions>
<Grid.ColumnDefinitions>
<ColumnDefinition Width="0.495*"/>
<ColumnDefinition Width="0.505*"/>
</Grid.ColumnDefinitions>
<ScrollViewer Margin="4,4.135,4,4" HorizontalScrollBarVisibility="Auto"
VerticalScrollBarVisibility="Auto">
<StackPanel x:Name="spText" Margin="4,4,4,4"></StackPanel>
</ScrollViewer>
<StackPanel Margin="4,4.135,4,114.865" Grid.Column="1">
<TextBox x:Name="typedText" Height="96" Text="TextBox"
TextWrapping="Wrap" FontSize="14" Margin="4,4,4,4" BorderThickness="0"/>
<Button x:Name="AddText" Content="Click to Add Text" Margin="4,4,4,4"
Click="AddText_Click"/>
</StackPanel>
</Grid>
</UserControl>
```

Listing 3-5. *Recipe 3.5 MainPage.xaml.cs Class File*

```
using System.Windows;
using System.Windows.Controls;

namespace Ch03_DesigningUX.Recipe3_5
{
public partial class MainPage : UserControl
  {
public MainPage()
    {
InitializeComponent();
    }

private void AddText_Click(object sender, RoutedEventArgs e)
    {
TextBlock text = new TextBlock();
text.Text = typedText.Text;
text.Margin = new Thickness(2, 2, 2, 2);
spText.Children.Add(text);
}
  }
}
```

3-6. Applying a Border to Elements

Problem

You want to apply rounded corners to controls like the Image control that normally don't support them as well as provide a border and background to elements, to enhance visual appeal.

Solution

Put content in the `Border` control, and configure properties such as `Background` and `CornerRadius` to enhance visual appeal.

How It Works

The `Border` control inherits from `FrameworkElement` and is a container control. It can contain exactly one child element. However, the child element can be a `Panel` such as a `Grid`, `StackPanel`, or `Canvas`, which can contain additional controls.

When you add a `Border` to an application, the `Background` property is `Transparent` by default. You can apply a solid color or gradient brush to provide a background for the `Border`. You can also set the `CornerRadius` property to provide rounded corners, as shown in Figure 3-37, which has a `CornerRadius` of 20 for all four corners.

Figure 3-37. *Laying out a Border control*

Many controls, such as `Image`, `TextBox`, `TextBlock`, and so on, do not contain a `CornerRadius` property and have square corners. The `Border` property can apply rounded corners to contained objects. In Figure 3-37, the `Border` contains a `Grid` and applies rounded corners to its layout.

If you drop a `TextBox` onto the `Border` containing the `Grid` shown in Figure 3-37, the background of the `TextBox` is `White` by default. If you set it to `Transparent`, the `Border`'s `Background` shows through.

You next want to apply a Border to a Textbox. Figure 3-38 shows how a plain TextBox appears on the gradient.

Figure 3-38. *Plain TextBoxes in the UI*

The TextBox controls are each placed in the Border. To make the Border control wrap the TextBox, clear the Height and Width properties of the Border and the TextBox controls so that they default to Auto; this shrinks the Border around the TextBox.

The size for the TextBox/Border combination is determined by the size of the font for the text in the TextBox as well as the Alignment and Margin settings of the Border and TextBox controls. Figure 3-39 shows the finished product for this recipe.

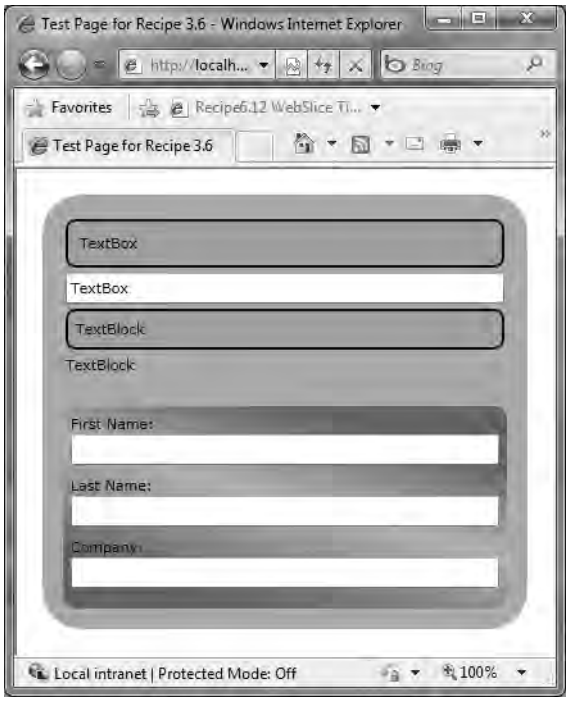


Figure 3-39. *Rounded corners for a TextBox control*

Here is the XAML markup for one of the `Border`/`TextBox` combinations:

```
<Border VerticalAlignment="Top" Margin="21,119,19,0"
CornerRadius="12,12,12,12">
<Border.Background>
<RadialGradientBrush>
<GradientStop Color="#FF003A74"/>
<GradientStop Color="#FF636E95" Offset="1"/>
</RadialGradientBrush>
</Border.Background>
<TextBox Background="{x:Null}" Text="TextBox" TextWrapping="Wrap"
BorderBrush="{x:Null}" FontSize="16" Margin="5,5,5,5"/>
</Border>
```

You want the `TextBox` to "disappear" into the `Border` while retaining all of its functionality. Notice in Figure 3-39 that you cannot see the outline of the `TextBox`. This is because you set the `Background` and `BorderBrush` to `Transparent` or `Null`. Also, setting `Border Background` to a `RadialGradient` highlights the rounding effect of the `CornerRadius` of 12 all around.

To place the `TextBox` inside the `Border` so that it appears to be fully encapsulated, set a `Margin` of 5 all around the `TextBox`. This ensures nice spacing between the content and the `Border` edge.

The Code

The code in this recipe takes everything covered earlier and applies it to TextBox controls to provide a rounded appearance. You also use a Border to highlight an editing region with plain TextBox controls. Figure 3-40 shows the output.

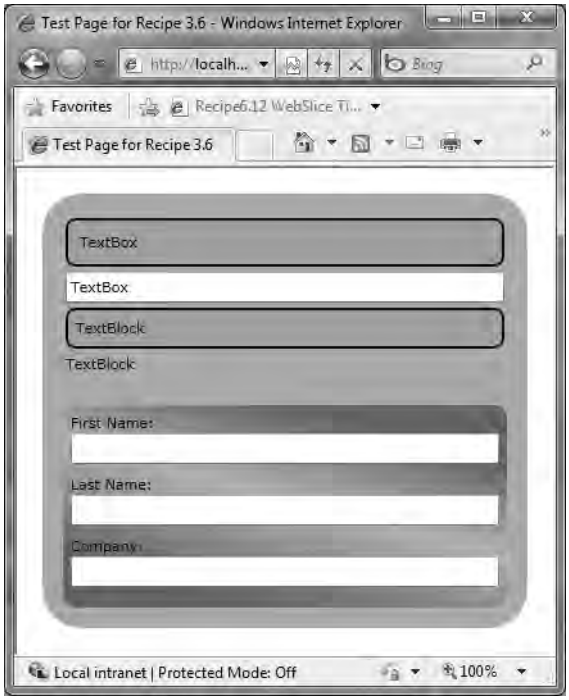


Figure 3-40. *Recipe 3-6 Sample code output*

Figure 3-40 shows two TextBox controls and two TextBlock controls, one inside a Border control and a plain version of each control. The bottom portion of the UI uses a Border control to highlight an area of the application. Listing 3-6 has the full XAML for the source code.

Listing 3-6. *Recipe 3.6 MainPage.xaml File*

```
<UserControl x:Class="Ch03_DevelopingUX.Recipe3_6.MainPage"
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
mc:Ignorable="d"
d:DesignHeight="341" d:DesignWidth="400"
<Border CornerRadius="30" Margin="20"  Background="#FFA9A9A9" >
<Grid x:Name="LayoutRoot" MinWidth="350"  Background="#FFA9A9A9"
```

```
Height=”322” Margin=”8,8,8,8”>
<Grid.RowDefinitions>
<RowDefinition Height=”0.46*”/>
<RowDefinition Height=”0.54*”/>
</Grid.RowDefinitions>
<Grid.ColumnDefinitions>
<ColumnDefinition Width=”*”/>
</Grid.ColumnDefinitions>
<StackPanel Margin=”8,8,8,4”>
<Border Padding=”4,4,4,4”  BorderThickness=”2” Margin=”2,2,2,2”
Height=”Auto” Width=”Auto” CornerRadius=”7,7,7,7”
BorderBrush=”#FF000080” Background=”#726CB167”>
<TextBox Height=”Auto” Width=”Auto” Text=”TextBox” TextWrapping=”Wrap”
Foreground=”#FF000000” Background=”#00FFFFFF” BorderBrush=”{x:Null}”
BorderThickness=”2,2,2,2”/>
</Border>
<TextBox Height=”Auto” Width=”Auto” Text=”TextBox” TextWrapping=”Wrap”
Margin=”2,2,2,2” Opacity=”1”/>
<Border Padding=”4,4,4,4” BorderThickness=”2” Margin=”2,2,2,2”
Height=”Auto” Width=”Auto” CornerRadius=”7,7,7,7”
BorderBrush=”#FF000080” Background=”#726CB167”>
<TextBlock Height=”Auto” Width=”Auto” Text=”TextBlock”
TextWrapping=”Wrap” Foreground=”#FF000000” Margin=”2,2,2,2”/>
</Border>
<TextBlock Height=”Auto” Width=”Auto” Text=”TextBlock”
TextWrapping=”Wrap” Margin=”2,2,2,2”/>
</StackPanel>
<Border Grid.Column=”0” CornerRadius=”10,10,10,10”
Margin=”8,8,8,8” Grid.Row=”1”>
<Border.Background>
<LinearGradientBrush EndPoint=”0.560000002384186,0.003000000002607703”
StartPoint=”0.439999997615814,0.996999979019165”>
<GradientStop Color=”#FF586C57”/>
<GradientStop Color=”#FFA3BDA3” Offset=”0.536”/>
<GradientStop Color=”#FF586C57” Offset=”0.968999981880188”/>
</LinearGradientBrush>
</Border.Background>
<StackPanel Margin=”4,4,4,4”  x:Name=”FormData”>
<TextBlock Height=”Auto” Width=”Auto” Text=”First Name:”
TextWrapping=”Wrap” Margin=”2,2,2,0”/>
<TextBox Height=”Auto” Width=”Auto” Text=”” TextWrapping=”Wrap”
x:Name=”Field1” Margin=”2,0,2,4”/>
<TextBlock Height=”Auto” Width=”Auto” Text=”Last Name:”
TextWrapping=”Wrap” Margin=”2,4,2,0”/>
<TextBox Height=”Auto” x:Name=”Field2” Width=”Auto”
```

```
TextWrapping="Wrap" Margin="2,0,2,4"/>
<TextBlock Height="Auto" Width="Auto" Text="Company:"
TextWrapping="Wrap" Margin="2,4,2,0"/>
<TextBox Height="Auto" x:Name="Field3" Width="Auto"
TextWrapping="Wrap" Margin="2,0,2,2"/>
</StackPanel>
</Border>
</Grid>
</Border>
</UserControl>
```

3-7. Using Simple Animations with Objects

Problem

You need to create dynamic UIs in Silverlight with animation.

Solution

Take advantage of the built-in animation features available in Silverlight 4.

How It Works

Silverlight has powerful animation capabilities that allow the designer or developer to animate any property value of type `Double`, `Color`, or `Point`. Animation lets you vary a property between two values over a specified period of time, thus providing the illusion of motion or transformation.

In Silverlight , the animation engine is left to interpret how to change the value over the specified period of time between the configured values for the property that is being animated.

To apply an animation to a UI element, create a `Storyboard in XAML`, and set `TargetName` and `TargetProperty` to specify the element and the property of the element to animate. Nest the animation within the `Storyboard` element in XAML like this:

```
<Storyboard x:Name="Rect1MouseMove">
<DoubleAnimation BeginTime="00:00:00.5" From="1" To="7"
AutoReverse="True" Duration="00:00:00.5"
Storyboard.TargetName="Rect1"
Storyboard.TargetProperty="(Shape.StrokeThickness)"/>
</Storyboard>
```

The `TargetName` and `TargetProperty` attributes are attached properties for the `Storyboard` class. `Storyboard` objects are usually created as resources within either the `Application.Resources` or `UserControl.Resources` element, making it easy to interact with the `Storyboard` by referencing it by the `x:Name` value. The above XAML contains a `DoubleAnimation` object, which can animate a value of type `Double` between the values configured in the `From` and `To` properties. An additional property configured above is `AutoReverse`, which indicates whether the animation should automatically reverse itself and animate in the opposite direction starting at the `To` value and ending at the `From` value. `BeginTime`

indicates how long after starting the storyboard should the animation actually begin. `Duration` specifies how long the animation should take to animate between the `From` and `To` values for the property of type `Double`. Also, a `Storyboard` can contain more than one animation, allowing one `Storyboard` to animate multiple objects and properties.

The `Storyboard` class provides `Begin`, `Pause`, `Stop`, and `Resume` methods you can use to control the `Storyboard` programmatically. For a `Button` `Click` event, the following code starts the animation:

```
private void Rect1_MouseEnter(object sender, MouseEventArgs e)
{
Rect1MouseMove.Begin();
}
```

`Triggers` provide an elegant way of firing an animation. Silverlight 4 supports `Triggers` like WPF, where an animation is kicked off via XAML code only; but currently, the only supported event that can be associated with a trigger is `Loaded`. Here is an example:

```
<Rectangle.Triggers>
<EventTrigger RoutedEvent="Rectangle.Loaded">
<BeginStoryboard>
<Storyboard>
<DoubleAnimation Storyboard.TargetName="Rect1"
BeginTime="00:00:00.1"
Storyboard.TargetProperty="(UIElement.Opacity)"
From="0.0" To="1.0" Duration="0:0:1" />
</Storyboard>
</BeginStoryboard>
</EventTrigger>
</Rectangle.Triggers>
```

■ **Note** Keyframe animations provide greater control over animations, as we cover in Recipe 3-8.

The Code

The sample code uses a `Rectangle`, an `Ellipse`, and a copy of the `StackPanel` from Recipe 3-6 with a few `TextBoxes` with a `Border`. The goal is to liven up the interface. The first property you animate is the `Opacity` for all three objects in the `Load` event, which will make them fade in when the application starts. You first declare a `DoubleAnimation` (that is, animate a value of type `Double`) for the `Rectangle` named `Rect1`:

```
<DoubleAnimation Storyboard.TargetName="Rect1"
BeginTime="00:00:00.1"
Storyboard.TargetProperty="(UIElement.Opacity)"
From="0.0" To="1.0" Duration="0:0:1" />
```

To make the objects appear at different times after the application loads for a more dramatic effect, configure BeginTime to 0.1 seconds for the Rectangle, 0.4 seconds for the Ellipse, and 0.8 seconds for the StackPanel. Set the TargetProperty to the common base class UIElement.Opacity to simplify the copying and pasting when you duplicate the animation for all three objects. Animate the Opacity property from 0 to 1 for all three objects so that they magically appear in sequence upon load.

The Loaded event is the only RoutedEvent supported in a Trigger for Silverlight . You can read more about RoutedEvents in the Silverlight documentation:

```
http://msdn.microsoft.com/en-us/library/system.windows.routedevent(VS.96).aspx
```

Silverlight lets you configure a Trigger in XAML for the Loaded event so that when the event fires, you play a Storyboard that animates the Opacity for each object without having to write any code:

```
<Rectangle.Triggers>
<EventTrigger RoutedEvent="Rectangle.Loaded">
<BeginStoryboard>
<Storyboard>
<DoubleAnimation Storyboard.TargetName="Rect1"
BeginTime="00:00:00.1"
Storyboard.TargetProperty="(UIElement.Opacity)"
From="0.0" To="1.0" Duration="0:0:1" />
</Storyboard>
</BeginStoryboard>
</EventTrigger>
</Rectangle.Triggers>
```

You may wonder why the Storyboard is embedded in the Rectangle declaration and not configured as a Resource on the UserControl. The reason is that Silverlight does not support loading a value for Storyboard using the StaticResource markup extension, which we covered in Recipe 2-9. Similar XAML configures a trigger for the Ellipse and StackPanel as well. A screenshot doesn't make a lot of sense for an animation, so just run the code to see how the three objects appear sequentially in the browser.

Next, add MouseEnter and MouseLeave animations for the Rectangle and Ellipse. You create one animation for the Rectangle and use it for both MouseEnter and MouseLeave, but you create two separate animations for MouseEnter and MouseLeave for the Ellipse.

Because MouseEnter and MouseLeave are not RoutedEvents, create the three Storyboard objects as resources on the UserControl; doing so keeps things tidy and provides a unique name for the x:Key attribute so that you can reference the Storyboard objects by name. The Rectangle Storyboard changes StrokeThickness from 1 to 7 over 0.5 seconds. Set AutoReverse to True so that it automatically reverts back to 1, which lets you avoid creating a separate animation for MouseEnter and MouseLeave. If you wanted the StrokeThickness to stay at 7 until the MouseLeave event fires, you would have two separate animations and leave AutoReverse at the default value of False.

To cause the animation to take place for the desired event, add MouseEnter and MouseLeave event handlers that call this single line of code:

```
Rect1MouseMove.Begin();
```

For the Ellipse, you animate using a ColorAnimation, but it is just as easy to create as the DoubleAnimation:

```
<ColorAnimation BeginTime="00:00:00" Duration="00:00:00.3"
From="#FFC18125" To="#FF2DBD43"
Storyboard.TargetName="Ellipse1"
```

```
Storyboard.TargetProperty=
"(Shape.Fill).(SolidColorBrush.Color)"/>
```

Instead of the `From` and `To` values being a `Double` value, they are a `SolidColorBrush.Color` value configured on the `Shape.Fill` property. We cover `Brush` objects in Recipe 3-2.

The last item to discuss is the `PointAnimation` used to animate a `PathGeometry` consisting of an `ArcSegment` object. `PointAnimation` is no more difficult than the previous two types of animation. Here is the code:

```
<Storyboard x:Name="PathClick">
<PointAnimation AutoReverse="True"
Storyboard.TargetProperty="Point"
Storyboard.TargetName="animatedArcSegment"
Duration="0:0:2" To="200,200"/>
</Storyboard>
```

This code animates the `Point` property on the `ArcSegment` to provide an interesting effect.

To see the animations, run the Recipe 3-7 test page, and the load animations fire. Move the mouse over the `Rectangle` and then move the mouse outside it, to see the `DoubleAnimation` alter the `StrokeThickness`. Move the mouse into the `Ellipse` and then move the mouse outside it, to see how the shorter duration changes the effect for the `Ellipse`'s `Fill` animation. Finally, click the blue `ArcSegment` to see the `PointAnimation` take effect and then autoreverse. The code appears in Listings 3-7 and 3-8.

Listing 3-7. *Recipe 3.7 MainPage.xaml File*

```
<UserControl x:Class="Ch03_DevelopingUX.Recipe3_7.MainPage"
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"
mc:Ignorable="d"
d:DesignHeight="300" d:DesignWidth="400">
<UserControl.Resources>
<Storyboard x:Name="Rect1MouseMove">
<DoubleAnimation BeginTime="00:00:00.5" From="1" To="7"
AutoReverse="True" Storyboard.TargetName="Rect1"
Storyboard.TargetProperty="(Shape.StrokeThickness)"
Duration="00:00:00.5"/>
</Storyboard>
<Storyboard x:Name="EllipseMouseEnter">
<ColorAnimation BeginTime="00:00:00" Duration="00:00:00.3"
From="#FFC18125" To="#FF2DBD43"
Storyboard.TargetName="Ellipse1"
Storyboard.TargetProperty=
"(Shape.Fill).(SolidColorBrush.Color)"/>
</Storyboard>
<Storyboard x:Name="EllipseMouseLeave">
```

```
<ColorAnimation BeginTime="00:00:00" Duration="00:00:00.3" To="#FFC18125"
Storyboard.TargetName="Ellipse1"
Storyboard.TargetProperty="(Shape.Fill).(SolidColorBrush.Color)"/>
</Storyboard>
<Storyboard x:Name="PathClick">
<PointAnimation AutoReverse="True"
Storyboard.TargetProperty="Point"
Storyboard.TargetName="animatedArcSegment"
Duration="0:0:2" To="200,200"/>
</Storyboard>
</UserControl.Resources>
<Grid x:Name="LayoutRoot" Background="White">
<Grid.RowDefinitions>
<RowDefinition Height="0.432*"/>
<RowDefinition Height="0.568*"/>
</Grid.RowDefinitions>
<Grid.ColumnDefinitions>
<ColumnDefinition Width="0.467*"/>
<ColumnDefinition Width="0.533*"/>
</Grid.ColumnDefinitions>
<Rectangle x:Name="Rect1" RadiusX="12" RadiusY="8" Opacity="0"
HorizontalAlignment="Stretch" Margin="66,30,85,49"
VerticalAlignment="Stretch" Width="129.2" Fill="#FF4863AF"
Stroke="#FF000000" d:LayoutOverrides="Width"
MouseEnter="Rect1_MouseEnter" MouseLeave="Rect1_MouseLeave">
<Rectangle.Triggers>
<EventTrigger RoutedEvent="Rectangle.Loaded">
<BeginStoryboard>
<Storyboard>
<DoubleAnimation Storyboard.TargetName="Rect1"
BeginTime="00:00:00.1"
Storyboard.TargetProperty="(UIElement.Opacity)"
From="0.0" To="1.0" Duration="0:0:1" />
</Storyboard>
</BeginStoryboard>
</EventTrigger>
</Rectangle.Triggers>
</Rectangle>
<Ellipse x:Name="Ellipse1" HorizontalAlignment="Stretch"
Margin="81,30,125,40" Opacity="0" VerticalAlignment="Stretch"
Grid.Column="1" Fill="#FFC18125" Stroke="#FF000000"
MouseEnter="Ellipse1_MouseEnter" MouseLeave="Ellipse1_MouseLeave">
<Ellipse.Triggers>
<EventTrigger RoutedEvent="Ellipse.Loaded">
<BeginStoryboard>
```

```
<Storyboard>
<DoubleAnimation Storyboard.TargetName=”Ellipse1”
BeginTime=”00:00:00.4”
Storyboard.TargetProperty=”(UIElement.Opacity)”
From=”0.0” To=”1.0” Duration=”0:0:1” />
</Storyboard>
</BeginStoryboard>
</EventTrigger>
</Ellipse.Triggers>
</Ellipse>
<StackPanel Margin=”4,4,4,4” Grid.Row=”1” Grid.Column=”0”
x:Name=”stackPanel” Opacity=”0”>
<StackPanel.Triggers>
<EventTrigger RoutedEvent=”StackPanel.Loaded” >
<BeginStoryboard>
<Storyboard>
<DoubleAnimation Storyboard.TargetName=”stackPanel”
BeginTime=”00:00:00.8” From=”0.0” To=”1.0” Duration=”0:0:1”
Storyboard.TargetProperty=”(UIElement.Opacity)”/>
</Storyboard>
</BeginStoryboard>
</EventTrigger>
</StackPanel.Triggers>
<Border Padding=”4,4,4,4”  BorderThickness=”2” Margin=”2,2,2,2”
Height=”Auto” Width=”Auto” CornerRadius=”7,7,7,7”
BorderBrush=”#FF000080” Background=”#726CB167”>
<TextBox Height=”Auto” Width=”Auto” Text=”TextBox”
TextWrapping=”Wrap” Foreground=”#FF000000”
Background=”#00FFFFFF” BorderBrush=”{x:Null}”/>
</Border>
<Border Padding=”4,4,4,4”  BorderThickness=”2” Margin=”2,2,2,2”
Height=”Auto” Width=”Auto” CornerRadius=”7,7,7,7”
BorderBrush=”#FF000080” Background=”#726CB167”>
<TextBox Height=”Auto” Width=”Auto” Text=”TextBox”
TextWrapping=”Wrap” Foreground=”#FF000000”
Background=”#00FFFFFF” BorderBrush=”{x:Null}”/>
</Border>
<Border Padding=”4,4,4,4”  BorderThickness=”2” Margin=”2,2,2,2”
Height=”Auto” Width=”Auto” CornerRadius=”7,7,7,7”
BorderBrush=”#FF000080” Background=”#726CB167”>
<TextBox Height=”Auto” Width=”Auto” Text=”TextBox”
TextWrapping=”Wrap” Foreground=”#FF000000”
Background=”#00FFFFFF” BorderBrush=”{x:Null}”/>
</Border>
<Border Padding=”4,4,4,4”  BorderThickness=”2” Margin=”2,2,2,2”
```

```
Height="Auto" Width="Auto" CornerRadius="7,7,7,7"
BorderBrush="#FF000080" Background="#726CB167">
<TextBox Height="Auto" Width="Auto" Text="TextBox"
TextWrapping="Wrap" Foreground="#FF000000"
Background="#00FFFFFF" BorderBrush="{x:Null}"/>
</Border>
</StackPanel>
<Path Fill="Blue" Grid.Column="2" Grid.Row="2" Margin="10,10,10,10"
MouseLeftButtonDown="Path_MouseLeftButtonDown">
<Path.Data>
<PathGeometry>
<PathFigure>
<ArcSegment x:Name="animatedArcSegment" Point="50,50" Size="50,150"
RotationAngle="-20" IsLargeArc="False"
SweepDirection="Clockwise"/>
</PathFigure>
</PathGeometry>
</Path.Data>
</Path>
</Grid>
</UserControl>
```

Listing 3-8. *Recipe 3.7 MainPage.xXaml.cs Class File*

```
using System.Windows.Controls;
using System.Windows.Input;
namespace Ch03_DevelopingUX.Recipe3_7
{
public partial class MainPage : UserControl
  {
public MainPage()
    {
InitializeComponent();
    }

private void Rect1_MouseEnter(object sender, MouseEventArgs e)
    {
Rect1MouseMove.Begin();
    }

private void Rect1_MouseLeave(object sender, MouseEventArgs e)
    {
Rect1MouseMove.Begin();
    }
```

```
private void Ellipse1_MouseEnter(object sender, MouseEventArgs e)
    {
EllipseMouseEnter.Begin();
    }

private void Ellipse1_MouseLeave(object sender, MouseEventArgs e)
    {
EllipseMouseLeave.Begin();
    }

private void Path_MouseLeftButtonDown(object sender,
MouseButtonEventArgs e)
    {
PathClick.Begin();
}
  }
}
```

3-8. Animating UI Elements with Keyframes

Problem

You need to animate UI objects using techniques to control how an animation interpolates over time, so that you can achieve more realistic effects like acceleration and deceleration.

Solution

Use the animation objects that support keyframes—such as the `ColorAnimationUsingKeyFrames`, `DoubleAnimationUsingKeyFrames`, `PointAnimationUsingKeyFrames`, and `ObjectAnimationUsingKeyFrames` classes—to create more realistic effects.

How It Works

We covered the basics of animation in Recipe 3-7. In Chapter 1, Recipe 1-5, we explained how to create keyframe animations as part of the Expression Blend walkthrough. In this recipe, we dive deeper into keyframe animations and explore animating multiple controls and properties in the same `Storyboard`, configuring the interpolation type for the animation, and easing in, easing out, or accelerating portions of the overall animation for fine-tuned control.

Just as in Recipe 3-7, keyframe animations work on certain types, including `Color`, `Double`, `Point`, and `Object` with the corresponding keyframe class of `ColorAnimationUsingKeyFrames`, `DoubleAnimationUsingKeyFrames`, `PointAnimationUsingKeyFrames`, and `ObjectAnimationUsingKeyFrames`.

Each of these classes includes a `KeyFrames` collection containing keyframe objects that correspond to the type being animated, with an additional wrinkle of the algorithm used to interpolate between keyframes.

The available interpolation options are linear, discrete, and splined. Linear interpolation animates at a constant rate for the duration of the segment. Discrete interpolation animates at discrete intervals without interpolation over time.

Splined interpolation is more similar to linear than discrete but provides the ability to accelerate or decelerate the animation within the duration of a segment. The spline-interpolation method has an additional property called `KeySpline` that defines a Bezier curve to create more realistic effects. The `KeySpline` property defines a Bezier curve with two control points that go from (0,0) to (1,1). The first control point defines the curve factor of the first half of the curve, and the second control point defines the curve factor for the second half of the curve; the curve factor defines the rate of change or acceleration for the spline keyframe.

When you create an animation as demonstrated in Recipe 1-5, each keyframe in the time line has a Common Properties section, which lists the values that are animated, as well as an Easing section, which shows the Bezier curve for the `KeySpline`. Figure 3-41 shows Expression Blend animating a ball falling to the ground and then bouncing.

When you play the animation, the ball falls with a linear speed and then bounces up and down a few times. The bouncing action is simulated by a bunch of keyframes toward the end of the animation time line; the keyframes move the ball up and down in smaller segments until it comes to rest. The linear speed is a result of the default `KeySpline` Bezier curve (shown in the Easing Configuration section of the properties window) that is applied to the second keyframe highlighted in the Objects and Timeline window shown in Figure 3-41.

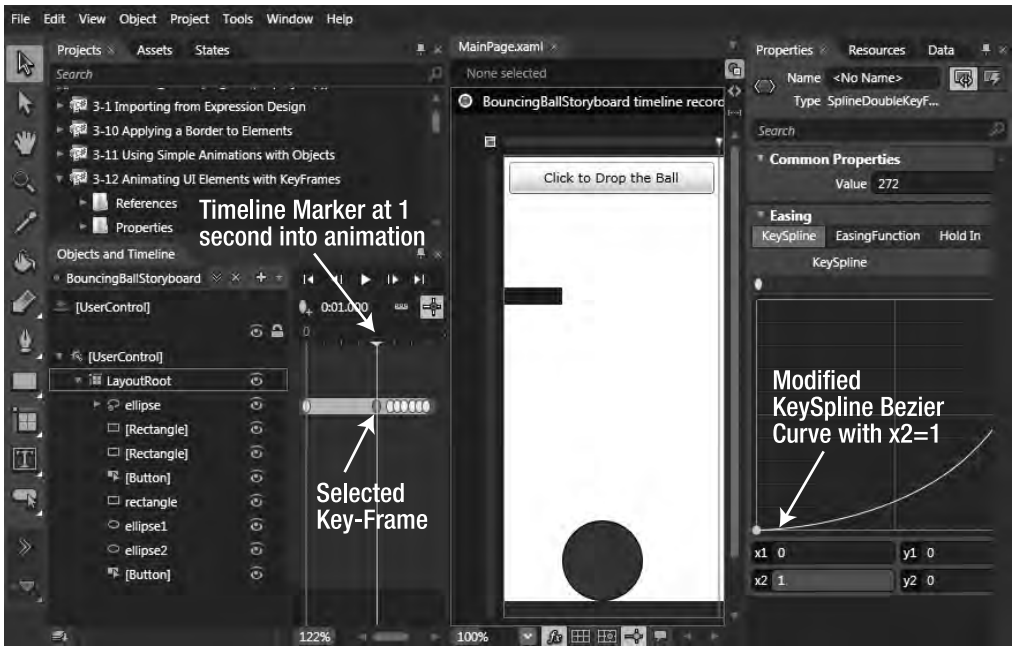


Figure 3-41. *Animating a ball falling to the ground and bouncing*

In general, the segment of the animation where the easing applies corresponds to the time line before the currently selected keyframe point in the Objects and Timeline window. In this case, any easing that is applied to the properties of the highlighted keyframe (the second keyframe in Figure 3-41) is for the segment between the first and second keyframe, or between 0 and 1 seconds in the

animation time line shown in the Objects and Timeline window. Figure 3-42 shows a zoomed-in view of the easing configuration section for this animation.

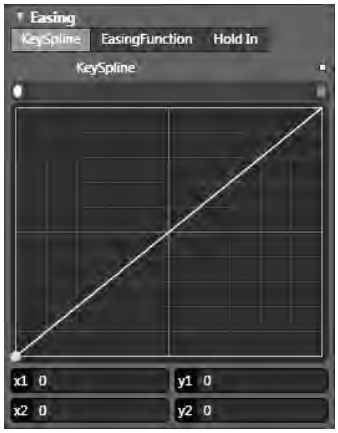


Figure 3-42. *Default KeySpline Bezier curve*

Notice the values set to 0 for x1, x2 and y1, y2, which corresponds to the value for the Bezier curve control points. Valid values are `Double` values between 0 and 1. The x1 and y1 values represent the beginning of the segment, or earlier in the time line. The x2 and y2 values represent the end of the segment, or later in the time line, bounded by the selected keyframe on the right and the previous keyframe (if there is one) on the left in the Objects and Timeline window. We cover custom easing functions available in Silverlight 4in Recipe 3-20.

We mentioned earlier that the ball falls at a linear speed from top to bottom over a period of 1 second between the first and second keyframe. Thinking of the chart as time along the X axis and speed along the Y axis with an origin at the lower-left corner can help you understand how to change the values. To simulate acceleration as the ball moves from top to bottom, increase the value of x2 to the maximum value of 1, yielding the curve shown in Figure 3-43.

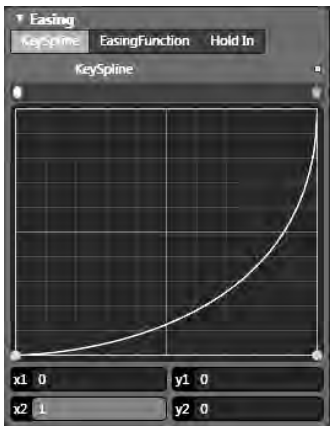


Figure 3-43. *Modified KeySpline Bezier curve with acceleration toward the end*

Keeping in mind that time is along the X axis and speed is along the Y axis, changing x2 to 1 pulls the curve down or slows the speed, gently increasing the speed until about two thirds of the way through, at which point the speed increases toward infinity at the end. Increasing speed over time is the definition of acceleration, and with this curve the falling ball looks more real. After the initial fall, you leave the default curve for the bounce up but use the curve shown in Figure 3-43 for the remaining shorter falls until the ball comes to rest. As you can see, splined interpolation is the most flexible algorithm and can provide the closest approximation of complex movement in the real world.

The Code

To test the falling ball, run the Recipe 3-8 application shown in Figure 3-44 and click the button above the blue `Ellipse` to drop it.

Figure 3-44. *Falling ball UI*

In addition to fine-tuning the animation, keyframes allow you to animate multiple values for multiple objects for the same `Storyboard`. To demonstrate, add a `Rectangle` and two `Ellipses` to the Artboard, as shown in Figure 3-45.

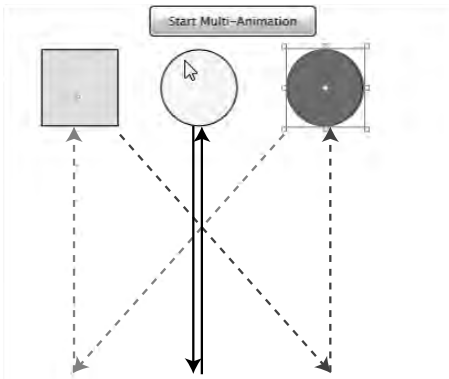


Figure 3-45. *Multianimation UI*

Next, create a `Storyboard` named `MultipleAnimations` following the steps in Recipe 1-5. Include an initial keyframe for each object. You want the two objects on the end to switch spots while the yellow `Ellipse` in the middle drops to the bottom and then returns to the top. The `Rectangle` and `Ellipse` on the ends move diagonally, switching locations back at the top, as shown by the arrows in Figure 3-45.

When the `Storyboard` is in recording mode, it is a matter of creating keyframes for each object either by selecting the object in the Visual Tree and clicking the New Keyframe button or by changing a setting on an object either via the properties window or by repositioning the object. The new keyframe is created wherever the vertical yellow cursor is located in the Objects and Timeline window. Figure 3-46 shows the `Storyboard` in edit mode with the yellow time line cursor at 0 seconds, when all three objects are animated.

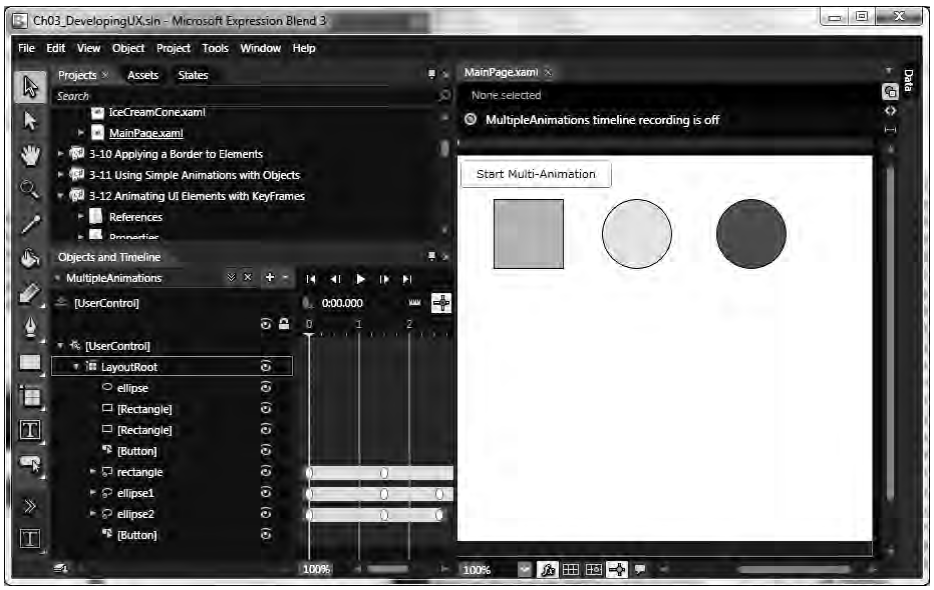


Figure 3-46. *Creating the multi-animation Storyboard*

You can grab individual keyframes and drag left or right in the time line for an object to fine-tune positioning in the time line. You can see the time line by changing or dragging the zoom percentage at lower left in the time line editor. You can also multiselect keyframes and drag them left or right in unison. Finally, if you are in Timeline recording mode and make a mistake, Edit ❜ Undo and Ctrl+Z are your best friends and have a deep undo queue.

Run the code, and click the Start Multi-Animation button. Play with the time line keyframes, dragging them left or right to test things out. Just remember to enter Timeline recording by clicking Timeline Recording Is Off on the Artboard to turn on recording. If you are finished editing a `Storyboard` and do not want to make any changes, you can close the `Storyboard` by clicking the Close Timeline button, as shown in Figure 3-47.

Figure 3-47. *Closing and zooming a Storyboard*

Although you generally work with animations in XAML, the animation classes are fully programmable in .NET managed code. For a walkthrough on how to work with animation classes in code, check out this link in the Silverlight 4 MSDN documentation:

`http://msdn.microsoft.com/en-us/library/cc189069(VS.96).aspx`

The entire XAML markup was generated using Expression Blend so we do not show the full listing of the XAML file because it all generated code. The only code in the code-behind kicks off the animation by calling Storyboard.`Begin()`.

3-9. Transforming an Object

Problem

You need to rotate, move, scale, or skew UI elements to produce a visual effect.

Solution

Apply a `RotateTransform`, `ScaleTransform`, `SkewTransform`, or `TranslateTransform` to alter a UI element's appearance.

How It Works

Silverlight supports two-dimensional `Transform` classes to rotate, scale, skew, and move objects. All transformations are performed by multiplying the coordinate space of an object by a transformation matrix. The matrix is made up of nine values in a three-by-three grid; the third column is constant, making it an affine transformation, which in the simplest terms means that anything that was a straight line continues to be straight after the transformation. For more information about the format of the transformation matrix in Silverlight, see

`http://msdn.microsoft.com/en-us/library/cc189037(VS.96).aspx`

Silverlight provides several high-level classes to make it easy to apply the most common types of transforms to an object. These classes are listed in Table 3-2.

Table 3-2. *Available Transforms in Silverlight*

Class Name	Description
`MatrixTransform`	Allows the designer or developer to create custom transformations that are not available through the other classes in this table. The transformation matrix is modified directly.
`RotateTransform`	Rotates an object by the configured `Angle`.
`ScaleTransform`	Scales an object by the configured amounts in the X and Y direction.
`SkewTransform`	Skews an object by the configured angles in the X and Y direction.
`TranslateTransform`	Moves an object by the configured amount in the X and Y direction.
`TransformGroup`	Lets the designer or developer apply multiple `Transform` operations to a single object. Note that the order of transforms listed in the group matters. Changing the order can alter the effect.

For `RotateTransform`, `ScaleTransform`, and `SkewTransform`, the effect is applied in reference to the upper-left corner or coordinate (0,0) for the object by default. You can alter the reference point by providing values for `CenterX` and `CenterY`.

We cover `MatrixTransform` because it provides the greatest flexibility to aid in understanding how transforms work. `MatrixTransform` explicitly sets the matrix described earlier to transform the object. Here is a `MatrixTransform` with the default values for the matrix:

```
<TextBox Height="Auto" Text="TextBox" TextWrapping="Wrap">
<TextBox.RenderTransform>
<MatrixTransform>
<MatrixTransform.Matrix>
```

```
<Matrix  M11= »1 » M12= »0 » M21= »0 » M22= »1 » OffsetX= »0 » OffsetY= »0 »  />
</MatrixTransform.Matrix>
</MatrixTransform>
</TextBox.RenderTransform>
</TextBox>
```

The M11, M12, M21, and M22 values represent the locations in the matrix described at the URL listed earlier. OffsetX and OffsetY change the position of the object by the specified number of pixels in either the X (right) and/or Y (down) direction.

■ **Note** Positive and negative floating-point values are valid for M11, M12, M21, M22, OffsetX, and OffsetY. Start by setting individual values with small numbers when you test it, to get a feel for how the matrix affects the object.

A shorthand notation for the preceding format is available on the MatrixTransform markup in the form M11,M12,M21,M22,OffsetX,OffsetY, which means the previous value can also be written

```
<MatrixTransform Matrix="1,0,0,1,0,0"/>
```

The sample code creates a MatrixTransform test bench that demonstrates how altering the values for M11, M12, M21, M22, OffsetX, and OffsetY alter the appearance of the object. When you run the sample, enter small values (between 0 and 2 for the M values) as well as positive and negative values to see the generated effect. If you enter a value that seems to make the TextBox disappear, click the Reset button.

As you alter values for M11, M12, M21, M22, OffsetX, and OffsetY, you can see how the changes affect the rendering for the TextBox, which indicates how the RotateTransform, ScaleTransform, SkewTransform, and TranslateTransform classes perform their work under the covers. These four classes provide a valuable service: they make the matrix math easier to work with by configuring the various properties available on those classes to perform the desired transformation.

Just as you can apply multiple effects with MatrixTransform by changing multiple values in the Matrix value, you can apply multiple effects with the RotateTransform, ScaleTransform, SkewTransform, and TranslateTransform classes by grouping them within a TransformGroup object.

In addition, these four classes are much easier to animate than MatrixTransform. With MatrixTransform, you have to do the math yourself to perform the animation, which may be nontrivial if you're applying multiple effects. On the other hand, the four transform classes have specific double properties like Angle, ScaleX, and ScaleY, depending on the transform applied, that can be animated with a DoubleAnimation or DoubleKeyframeAnimation. Recipe 3-14 covers how to animate these transform classes.

The Code

In general, MatrixTransform should be your choice of last resort for the reasons we've listed. Essentially, if you are unable to achieve the desired effect with a combination of the four higher-level transforms, then that is the time to use MatrixTransform.

However, this sample code creates a UI that lets you exercise MatrixTransform to understand how modifying the transform affects the UI element. Figure 3-48 shows the UI.

Enter numbers that are small, such as 0.2, to see the effect; otherwise, the transform may move the TextBox off the visible screen. As you change different values, you skew, rotate, and otherwise move the object, providing insight into how the RotateTransform, ScaleTransform, SkewTransform, and

TranslateTransform classes work. Listing 3-9 contains the XAML for the UI, and Listing 3-10 shows the MainPage.xaml.cs class file.

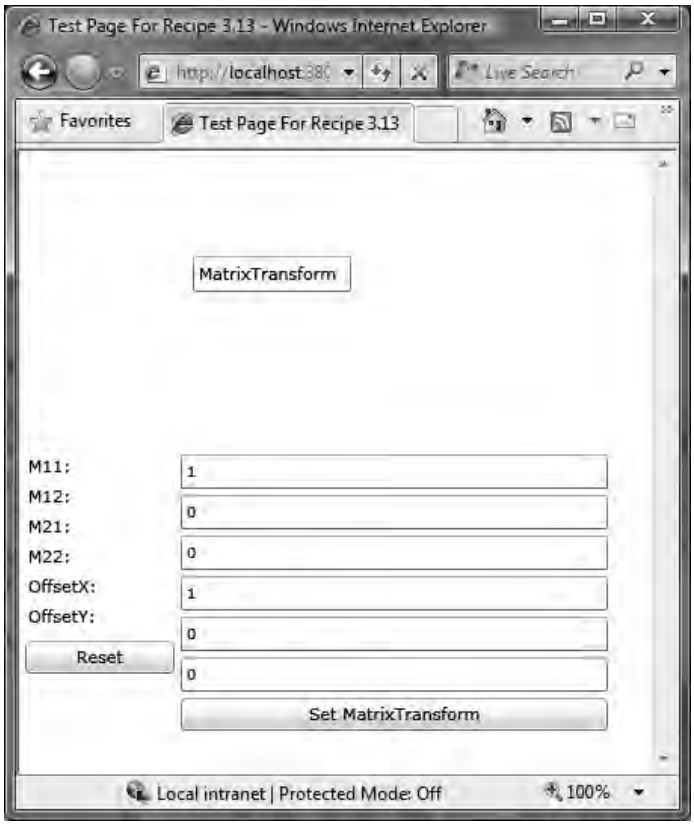


Figure 3-48. *Fun with a matrix*

Listing 3-9. *Recipe 3.9 MainPage.xaml*

```
<UserControl x:Class="Ch03_DesigningUX.Recipe3_9.MainPage"
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"
mc:Ignorable="d"
d:DesignHeight="400" d:DesignWidth="400">
<Grid x:Name="LayoutRoot" Background="White">
<Grid.RowDefinitions>
<RowDefinition Height="0.49*"/>
<RowDefinition Height="0.51*"/>
```

```
</Grid.RowDefinitions>
<Grid.ColumnDefinitions>
<ColumnDefinition Width="*"/>
</Grid.ColumnDefinitions>
<TextBox x:Name="txtMatrixTransform" Height="Auto" Margin="115,70,187,0"
VerticalAlignment="Top" Text="MatrixTransform" TextWrapping="Wrap"
HorizontalAlignment="Stretch" d:LayoutOverrides="Height">
<TextBox.RenderTransform>
<MatrixTransform>
<MatrixTransform.Matrix>
<Matrix  M11= »1 » M12= »0 » M21= »0 » M22= »1 » OffsetX= »0 » OffsetY= »0 »/>
</MatrixTransform.Matrix>
</MatrixTransform>
</TextBox.RenderTransform>
</TextBox>
<StackPanel Margin= »4,4,0,4 » HorizontalAlignment= »Left »
VerticalAlignment= »Stretch » Width= »99.4 » Grid.Row= »1 »>
<TextBlock Text="M11:" TextWrapping="Wrap" Margin="2,2,2,2"/>
<TextBlock Text="M12:" TextWrapping="Wrap" Margin="2,2,2,2"/>
<TextBlock Text="M21:" TextWrapping="Wrap" Margin="2,2,2,2"/>
<TextBlock Text="M22:" TextWrapping="Wrap" Margin="2,2,2,2"/>
<TextBlock Text="OffsetX:" TextWrapping="Wrap" Margin="2,2,2,2"/>
<TextBlock Text="OffsetY:" TextWrapping="Wrap" Margin="2,2,2,2"/>
<Button Height="Auto" Width="Auto" Content="Reset" Margin="0,6,0,0"
Click="ResetMatrix"/>
</StackPanel>
<StackPanel Grid.Row="1" Margin="0,4,8,4" HorizontalAlignment="Right"
VerticalAlignment="Stretch" Width="286.6" d:LayoutOverrides="Width">
<TextBox x:Name="txtM11" Text="1" TextWrapping="Wrap" Margin="2,2,2,2"
FontSize="10" FontFamily="Portable User Interface"/>
<TextBox x:Name="txtM12" Text="0" TextWrapping="Wrap" Margin="2,2,2,2"
FontSize="10" FontFamily="Portable User Interface"/>
<TextBox x:Name="txtM21" Text="0" TextWrapping="Wrap" Margin="2,2,2,2"
FontSize="10" FontFamily="Portable User Interface"/>
<TextBox x:Name="txtM22" Text="1" TextWrapping="Wrap" Margin="2,2,2,2"
FontSize="10" FontFamily="Portable User Interface"/>
<TextBox x:Name="txtOffsetX" Text="0" TextWrapping="Wrap" Margin="2,2,2,2"
FontSize="10" FontFamily="Portable User Interface"/>
<TextBox x:Name="txtOffsetY" Text="0" TextWrapping="Wrap" Margin="2,2,2,2"
FontSize="10" FontFamily="Portable User Interface"/>
<Button Height="Auto" Width="Auto" Content="Set MatrixTransform"
Margin="2,2,2,2" Click="ApplyMatrix"/>
</StackPanel>
</Grid>
</UserControl>
```

Listing 3-10. *Recipe 3.9 MainPage.xaml.cs Class File*

```
using System;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Media;

namespace Ch03_DesigningUX.Recipe3_9
{
public partial class MainPage : UserControl
  {
public MainPage()
    {
InitializeComponent();
    }

private void ApplyMatrix(object sender, RoutedEventArgs e)
    {
MatrixTransform mt = (MatrixTransform)txtMatrixTransform.RenderTransform;
try
      {
Matrix m = new Matrix(Convert.ToDouble(txtM11.Text),
Convert.ToDouble(txtM12.Text), Convert.ToDouble(txtM21.Text),
Convert.ToDouble(txtM22.Text), Convert.ToDouble(txtOffsetX.Text),
Convert.ToDouble(txtOffsetY.Text));
mt.Matrix = m;
      }
catch
      {
txtMatrixTransform.Text = "Invalid-retry:-)";
ResetMatrix(sender, e);
      }
    }

private void ResetMatrix(object sender, RoutedEventArgs e)
    {
txtM11.Text = "1";
txtM12.Text = "0";
txtM21.Text = "0";
txtM22.Text = "1";
txtOffsetX.Text = "0";
txtOffsetY.Text = "0";
MatrixTransform mt = (MatrixTransform)txtMatrixTransform.RenderTransform;
Matrix m = new Matrix(1, 0, 0, 1, 0, 0);
mt.Matrix = m;
}
  }
}
```

3-10. Creating a Simple Cartoon Scene

Problem

You need to create an animated scene for a cartoon or game in Silverlight.

Solution

First, create a static display of the cartoon scene. Next, create an animation `Storyboard` that alters the appropriate values for the `RotateTransform`, `ScaleTransform`, and `SkewTransform` classes over a period of time using the Objects and Timeline editing tool in Expression Blend.

How It Works

When you apply a transform in Expression Blend or create a transform via code, it is static in nature after it is applied. For example, here is a transform applied to a `Rectangle`:

```
<Rectangle Width=”50” Height=”50” Fill=”Navy”>
<Rectangle.RenderTransform>
<RotateTransform x:Name=”RotateTransform” Angle=”30”
CenterX=”25” CenterY=”25” />
</Rectangle.RenderTransform>
</Rectangle>
```

Figure 3-49 shows the `Rectangle` tilted 30 degrees.

Figure 3-49. *Rectangle with transform at design time*

The transform is static in that when the code runs, the `Rectangle` appears exactly the same.

The Code

Recall from Recipes 3-7 and 3-8 that the animation classes can animate the types `Double`, `Color`, and `Point`. Animating a transform is a matter of creating a `Storyboard` object, picking animation class like `DoubleAnimation` to animate a type of `Double`, and setting the key properties:

- `TargetName`
- `TargetProperty`
- `From`
- `To`
- `Duration`

As an example, create a Storyboard that continuously rotates a Rectangle as shown in Figure 3-49, animating a RotateTransform to perform a full 360-degree rotation every 5 seconds with this Storyboard:

```
<Storyboard x:Name="RotateStoryboard">
<DoubleAnimation
Storyboard.TargetName="RotateTransform"
Storyboard.TargetProperty="Angle"
From="0" To="360" Duration="0:0:5"
RepeatBehavior="Forever" />
</Storyboard>
```

As you can see, it is straightforward to combine transforms with animation by editing XAML code. However, with the Objects and Timeline editor in Expression Blend, you can record a dynamic Storyboard to create a simple cartoon. For example, you can animate the Angle property for the RotateTransform to simulate a rolling boulder.

The application for this recipe is a cartoon-like boulder that rolls off an edge and tumbles down a hill with a couple of rocky bumps. First, draw the static scene in Figure 3-50 resulting in the key frames shown in Figure 3-51.

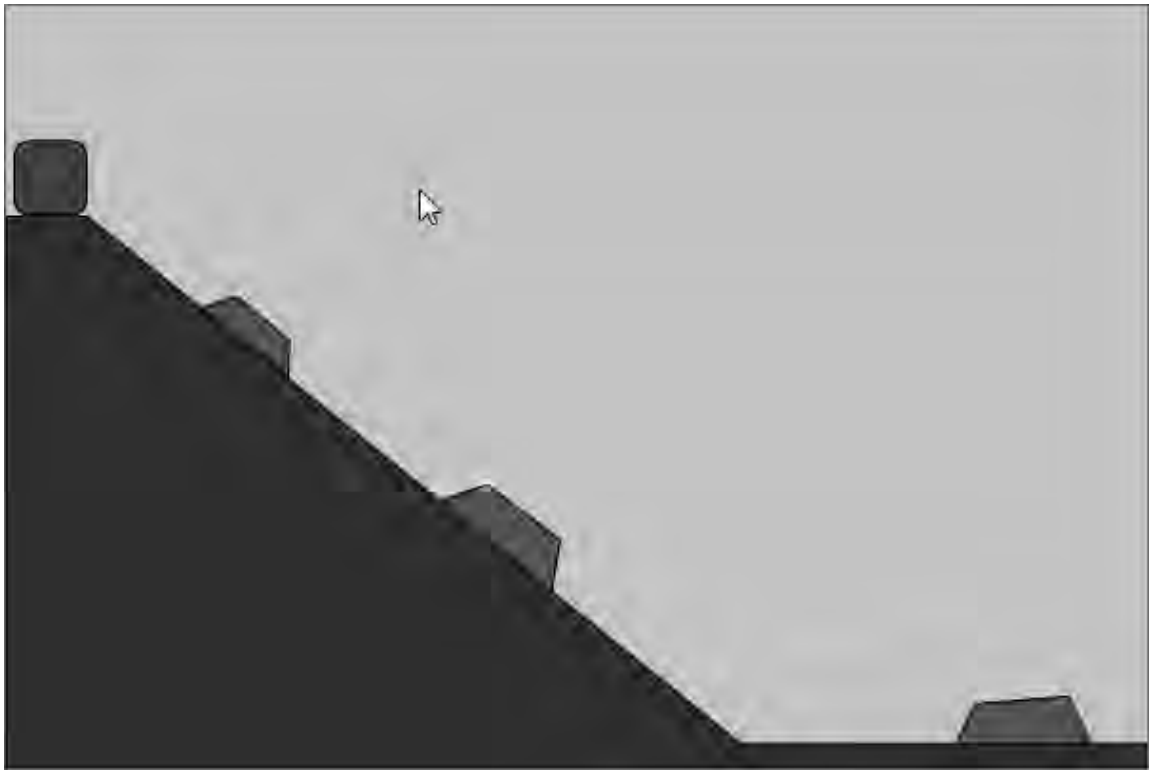


Figure 3-50. *The static cartoon scene*

Figure 3-51. *The boulder rolling over the edge*

You next add two keyframes to simulate the boulder sliding down the side of the cliff. At the point at which the boulder hits the first bump, apply a scale transform of 1.1 to simulate the boulder hitting the edge. About 0.1 seconds later, scale it back to 1.0 so that the boulder appears to have a violent collision. Figure 3-52 shows the sequence; you can see that the boulder is slightly larger in the middle scene.

Figure 3-52. *The boulder striking the bump*

Continue to add keyframes by visualizing the spinning and falling action with a few smudges on the LCD screen; this helps line up the next point to animate, which includes another bump into a rock on the slope.

An important aid in visualizing the action of the animation is the trail left by the keyframes: bright bluish spots with smaller bluish spots in between, marking the animation flow. Change the Canvas Background color from sky blue to black to help highlight the animation path, as shown in Figure 3-53.

Figure 3-53. *The animation trail*

Change the canvas back to a sky blue color, and continue with the animation. After bouncing off the second bump, the boulder goes through a long spinning fall and finally comes to rest after colliding with the bump at the bottom of the slope. The final cartoon scene is shown in Figure 3-54.

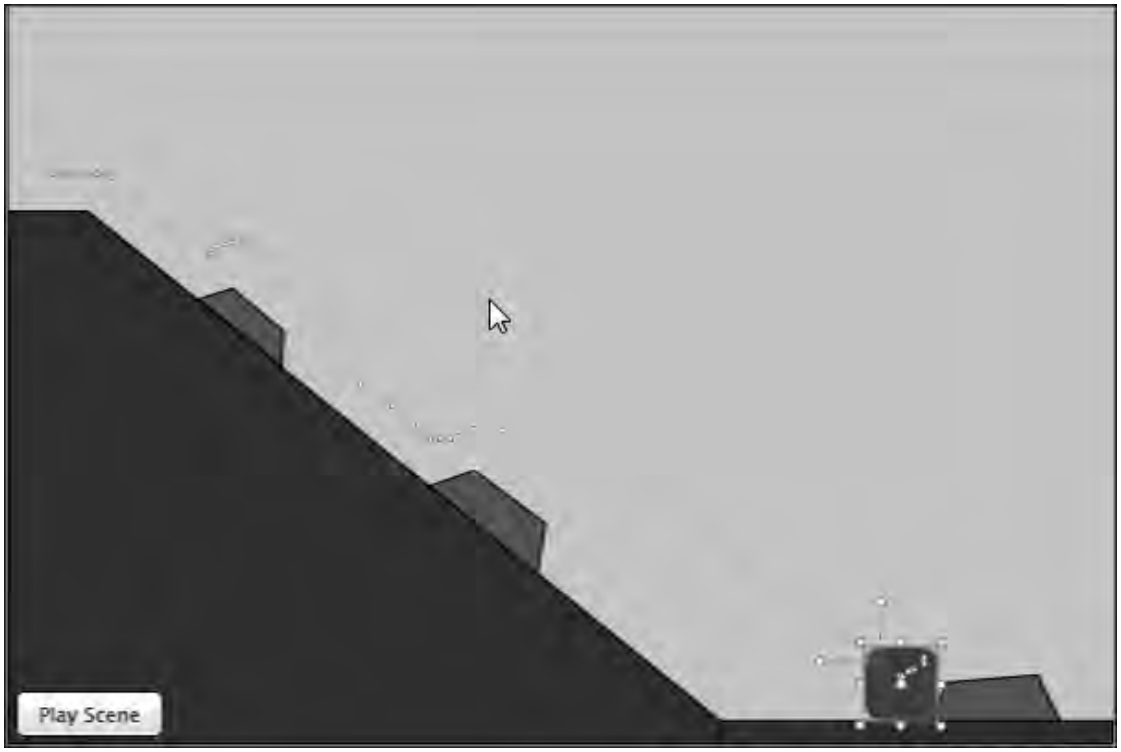


Figure 3-54. *The final cartoon scene*

The `FallingBoulderStoryboard` object includes a total of 41 keyframes. It would be extremely tedious and take up many pages to go through each change in every keyframe. Instead, we encourage you to open the project from the book's download, open the `FallingBoulderStoryboard` animation in the Objects and Timeline tool window, and step through the animation visually.

Keep an eye on the rotation transform throughout the animation to see what changes are made in addition to the location transform. The other transform that comes into play is the scale transform, which expands and then contracts the boulder when it gets close to the bumps on the slope.

Try sliding keyframes later or earlier in the time line, either individually or as a group, to see the effect on the cartoon scene. Also, be sure to zoom in and out for both the time line and the Artboard to get a good view of what is happening as you slide the yellow cursor back and forth in the time line.

The cartoon probably runs a bit slowly, but this helps you see what is going on with the animation. One area to improve would be to smooth out the rotation for the boulder. You could, for example, calculate a rotation velocity in degrees per second and try to maintain that speed between keyframes.

All the code is automatically generated by Expression Blend (except the button-click event attached to the button added at the end to let you kick off the animation) so we do not list out all of the XAML. Please review the source code download to get an understanding of the amount of generated code. The only hand-written code is a call to `FallingBoulderStoryboard.Begin()` in a button click event to kick off the animation.

3-11. Handling Keyboard Input

Problem

You need to capture keyboard input as part of an application UI, such as detecting when an arrow key is pressed in an online game.

Solution

Hook into the `KeyDown` and `KeyUp` event handlers so that code can detect when a key is pressed as well as released.

How It Works

Keyboard event-handler functions can be attached to any Silverlight 4 object that inherits either directly or indirectly from the `UIElement` class. The events that are available are `KeyDown` and `KeyUp`. `KeyDown` fires when a key is pressed *and* the Silverlight plug-in has focus in the web browser. `KeyUp` fires when a pressed key is released *and* the Silverlight plug-in has focus in the web browser. Note that keyboard events do not fire in Full Screen mode.

■ **Note** Refer to Chapter 6 to learn how to set focus on the Silverlight control from JavaScript in the browser.

Event handlers for `KeyUp` and `KeyDown` include the ubiquitous `sender` parameter as well as an instance of `KeyEventArgs`, like this:

```
void OnKeyUp(object sender, KeyEventArgs e)
```

The object `KeyEventArgs` contains the following:

- `Key`: Returns an instance of an enumerations type of `Key` so that you can check for `Key.Up`, `Key.Down`, and so on. `Key` represents portable key codes common across platforms.
- `PlatformKeyCode`: For `Key` values that equal `Key.Unknown`, represents an integer that corresponds to the platform-specific key code.
- `Handled`: Set to `true` to stop the event from bubbling up to parent objects up the Visual Tree.
- `Source`: Indicates which object in the UI originally had focus when a key was pressed.

For Windows-specific platform key codes, see

```
http://msdn.microsoft.com/en-us/library/ms645540(VS.85).aspx
```

For Macintosh-specific key codes, refer to

```
http://go.microsoft.com/fwlink/?LinkId=97928
```

You can press modifier keys, such as Ctrl and Alt, together with other keys and generate their own keyboard events.

■ **Note** Shift and Ctrl are common to Windows and Macintosh, but others are unique.

You check modifier keys by accessing the `Keyboard.Modifiers` property using bitwise operations, because multiple modifiers can be pressed simultaneously. This code checks to see if the modifier key Ctrl was pushed:

```
if ((Keyboard.Modifiers & ModifierKeys.Control) == ModifierKeys.Control)
```

The keyboard events `KeyDown` and `KeyUp` are routed events that bubble up from child to parent via the ownership chain in the Visual Tree. This means you can have a single handler for each event at the top of the ownership chain if you intend to handle keyboard events globally.

If a specific object in the UI needs to respond to a keyboard event, the object should implement its own `KeyDown` and `KeyUp` events. Within the events, the object should set the value of `e.Handled` to `True` for the instance of `KeyEventArgs` that is passed into the handler. This stops the bubbling of the event because it is not necessary to do so in this case.

■ **Note** Keyboard events are prevented from being passed to keyboard event handlers in the application as a security feature. This prevents a Silverlight application from impersonating another application (or the entire desktop) and collecting keyboard-entered personal or private data.

The Code

The code starts by changing the root element from a `Grid` to a `Canvas` object because you do not need layout and you want to use coordinate positioning. Lay out a simple game UI using gradients and `Path` objects to create an ice cave.

The idea of the game is to have a radioactive ball bouncing around in the cave; you try to control the ball using the arrow keys. If the ball sits on a wall for too long, it melts the ice, and the cave collapses. This recipe doesn't implement the entire game, but you lay out the basic UI and set up the beginnings of the game to receive keyboard input.

You have two options to use with the `KeyDown` and `KeyUp` events. Which one to use depends on the type of game you are creating. The focus is using the arrow keys to provide input. If you are building a game where the player is in complete control of the movement—say, a flying game—you may want to use `KeyDown` to kick off a `Storyboard` or thread to keep the object moving while the key is held down. You can use the `KeyUp` event to signal that the movement should end by stopping the `Storyboard` or background thread.

For games where an object moves independently via some sort of artificial intelligence, if you want to provide input to counteract the movement (in this case, to keep the radioactive ball from touching a wall), it may be better game play to use the `KeyUp` event to apply discrete amounts of movement so that the user has to click faster or slower to maintain control. This game uses this approach first to see how it plays.

As mentioned earlier, you build a game board using gradients and Path objects to create an ice cave environment, as shown in Figure 3-55.

Figure 3-55. *Ice cave static UI*

Figure 3-55 is at design time in Expression Blend. Also create a simple `Storyboard` that animates a rotate transform to make the `RadioactiveBall` object more dynamic. In addition, set the `RadioactiveBall.Visibility` to `Visibility.Collapsed` so that it doesn't show up when the game is initially run.

Put a couple of messages in `TextBlocks`, including Click to Play; this receives a `Click` event to ensure the Silverlight control has focus before kicking off the game. The `Click` event sets `Visibility` to `Visibility.Collapsed` for the two `TextBlocks` and sets `Visibility` to `Visibility.Visible` for the `RadioactiveBall` object. You also kick off the rotation `Storyboard` named `SpinGameBallStoryboard`. Here is the `Click` event, and Figure 3-56 shows the application at runtime:

```
private void TextBlock_MouseLeftButtonDown(object sender, MouseButtonEventArgs e)
{
ClickToPlay.Visibility = Visibility.Collapsed ;
WelcomeMessage.Visibility = Visibility.Collapsed ;
RadioactiveBall.Visibility = Visibility.Visible;
SpinGameBallStoryboard.Begin();
}
```

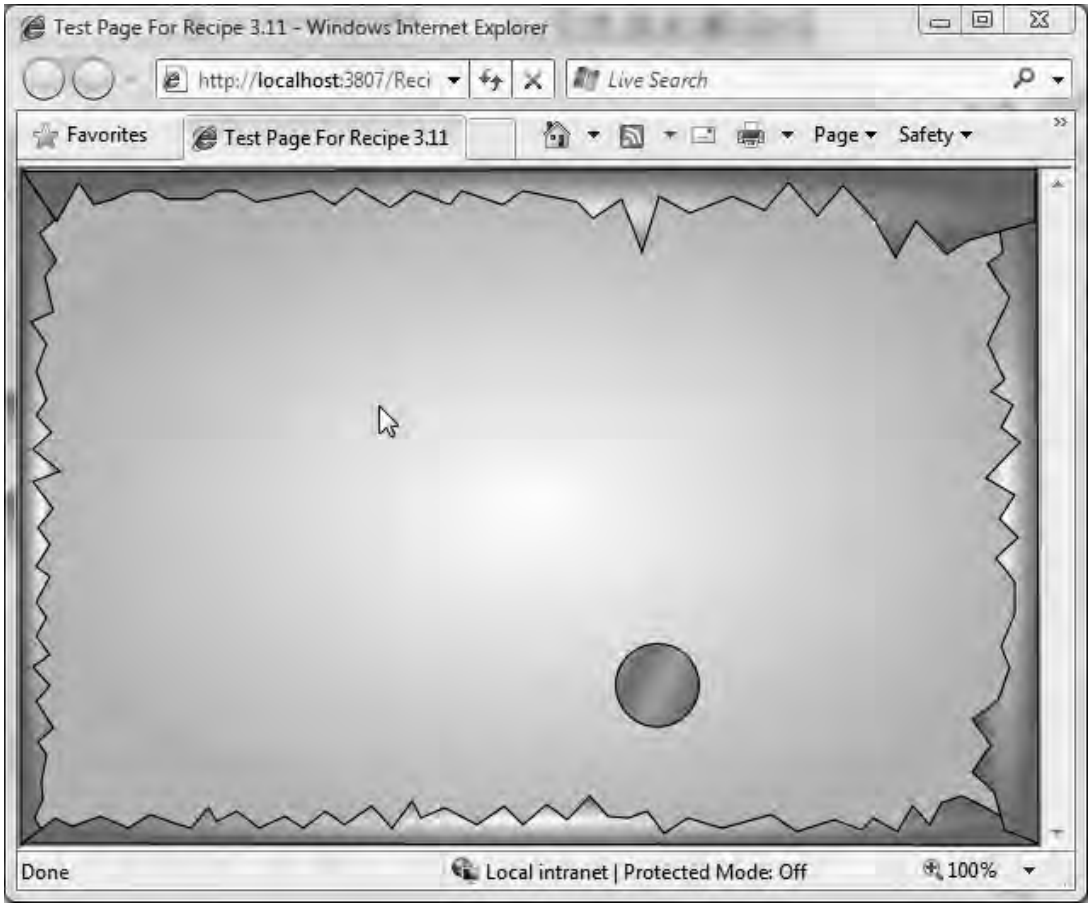


Figure 3-56. *Ice cave running in the browser*

When you run the game, it seems tedious and time consuming to move the radioactive ball around the scene, but that's because the radioactive ball does not have any artificial intelligence and doesn't move on its own. Imagine the ball flying around at different speeds while you push the arrow keys faster or slower to redirect the ball, keeping it off the walls for an ever-increasing period of time as you advance through levels. Each level could have a smaller cave through the use of a scale transform to make the four sides smaller.

Control over the `RadioactiveBall` object is broken into two separate handlers. One is the `GameCanvas_KeyUp` event handler that receives the `KeyUp` event, evaluates the `Key`, and performs some basic collision detection with the edges:

```
private void GameCanvas_KeyUp(object sender, KeyEventArgs e)
{
switch (e.Key)
  {
case Key.Right: if ((leftPosition) <= (this.ActualWidth –
```

```
(RadioactiveBall.Width*1.25)))
leftPosition += moveSpeed;
break;
case Key.Left: if (leftPosition >= (RadioactiveBall.Width * .25))
leftPosition -= moveSpeed;
break;
case Key.Up: if (topPosition >= (RadioactiveBall.Height * .25))
topPosition -= moveSpeed;
break;
case Key.Down: if (topPosition <= (this.ActualHeight - (RadioactiveBall.Height*1.25)))
topPosition += moveSpeed;
break;
  }
Draw();
}
```

The other method, `Draw`, repositions the `RadioactiveBall` object to the new positions, which may be the current position due to collision detection. The only other interesting code is in the `MainPage` constructor; it wires up the `KeyUp` event handler and gets the initial position of the `RadioactiveBall` object:

```
this.KeyUp += new KeyEventHandler(GameCanvas_KeyUp);
//Get initial position
leftPosition = (double)RadioactiveBall.GetValue(Canvas.LeftProperty);
topPosition = (double)RadioactiveBall.GetValue(Canvas.TopProperty);
```

That's it for the code in the code-behind file. The rest of the application is the resulting markup, which we do not show because it is all generated from the work in Expression Blend.

3-12. Working with Ink

Problem

You want to letusers draw directly on your Silverlight application in the web browser to allow image or video markup and handwriting recognition.

Solution

Use the `InkPresenter` control and associated events in your Silverlight application to collect and process strokes. For handwriting recognition, use a Windows Communication Foundation (WCF) service to perform the handwriting recognition on the server side of the application and return the results to a Silverlight application.

How It Works

The term *stroke* when talking about ink refers to the process of putting a pen or stylus to a touch screen, moving it across the screen by either writing or making annotations, and then lifting it off the screen. Each stylus-down, move-across-the-screen, stylus-up cycle is an ink stroke. For computers that do not have a touch screen, clicking the mouse button, holding the mouse button down, moving across the screen, and then releasing the mouse button creates an ink stroke.

■ **Note** Note that using a stylus on a tablet computer or digitizer results in much higher resolution than what a user achieves using a mouse, allowing for additional detail. Be sure to test your applications on a tablet PC as well as with a mouse on a desktop computer.

The `InkPresenter` object makes inking possible in an application. Ink strokes are stored as a collection that is part of the `InkPresenter`. If you drop an `InkPresenter` onto an application, run it, and try inking, nothing happens, because strokes are collected via the `InkPresenter`'s events and methods.

Since .NET Framework 3.0, WPF provides great support for ink in desktop applications. Silverlight is a cross-browser, cross-platform programmatic subset of WPF, but one thing that WPF has that Silverlight does not is handwriting recognition. This is not a major limitation, because Silverlight is a web technology. Strokes can be sent back to the server for processing within a WCF service that makes the appropriate calls into the .NET Framework WPF assemblies to perform recognition and return the text to the Silverlight application. This MSDN article provides an example of sending strokes to a server for handwriting-recognition processing:

```
http://msdn.microsoft.com/en-us/magazine/cc721604.aspx
```

`InkPresenter` is based on a `Canvas` object, but it is transparent by default and does not have a configurable `Fill` property. Therefore, `InkPresenter` is used in conjunction with other objects like `Image`, `MediaElement`, `Canvas`, and `Border` to provide a visible UI.

The Code

This recipe's sample code starts by expanding the size of the default Silverlight application to 800 by 600 pixels and dividing the `Grid` into two rows and two columns. In `Grid.Column` 0 and `Grid.Row` 0, you place a `Border` with a simple gradient; place an `InkPresenter` inside the `Border` to provide an appearance of a drawing or writing surface.

As we mentioned earlier, you must use the events and methods of `InkPresenter` to process and collect strokes. The important events are `MouseLeftButtonDown`, `MouseMove`, and `MouseLeftButtonUp`. Here are the steps:

1. In `MouseLeftButtonDown`, create a new stroke, and add it to the `InkPresenter`'s `StrokeCollection`.
2. In `MouseMove`, add `StylusPoints` to the newly added stroke as the mouse moves around.
3. In `MouseLeftButtonUp`, complete the newly added stroke.

Name the `InkPresenter` object `InkEssentials` and wire up handlers for the three events to the XAML in Visual Studio 2010:

```
<InkPresenter x:Name="InkEssentials" Background="Transparent"
```

```
MouseLeftButtonDown=”InkEssentials_MouseLeftButtonDown”
MouseMove=”InkEssentials_MouseMove” Height=”Auto” Width=”Auto”
MouseLeftButtonUp=”InkEssentials_MouseLeftButtonUp” />
```

■ **Note** You *must* set the `Background` property on the `InkPresenter` to a value, any value, for the `InkPresenter` to receive mouse events and the ink functionality to work.

In the `MainPage.xaml.cs` file, you implement the code to perform the three steps. In the `MouseLeftButtonDown` event, the sender is passed in as well as an event argument object of type `MouseButtonEventArgs`. The `MouseButtonEventArgs` object provides access to a copy of the stylus or mouse points generated as the mouse or stylus is moved across the screen via the `e.StylusDevice.GetStylusPoints` method.

The first step is to have the `InkPresenter` attempt to capture the mouse by calling `CaptureMouse`. That lets you respond to the `MouseMove` event and capture the generated stylus or mouse points as the mouse or stylus is moved across the screen:

```
private void InkEssentials_MouseLeftButtonDown(object sender,
MouseButtonEventArgs e)
{
InkEssentials.CaptureMouse();
_currentStroke = new System.Windows.Ink.Stroke();
//Change color of the stroke and stroke outline
_currentStroke.DrawingAttributes.Color = Colors.Orange;
_currentStroke.DrawingAttributes.OutlineColor = Colors.Black;
_currentStroke.StylusPoints.Add(
e.StylusDevice.GetStylusPoints(InkEssentials));
InkEssentials.Strokes.Add(_currentStroke);
}
```

In the `MouseLeftButtonDown` event, you copy the collected mouse or stylus points and add them to the current `Stroke` so that the `Stroke` can be drawn at the same points where the mouse or stylus moves, creating the effect of inking. As the mouse moves, you collect additional points in the `MouseMove` event:

```
private void InkEssentials_MouseMove(object sender, MouseEventArgs e)
{
if (null != _currentStroke)
  {
_currentStroke.StylusPoints.Add(
e.StylusDevice.GetStylusPoints(InkEssentials));
  }
}

private void InkEssentials_MouseLeftButtonUp(object sender, MouseButtonEventArgs e)
```

```
{
_currentStroke = null;
InkEssentials.ReleaseMouseCapture();
}
```

When the user has finished inking or writing on the screen, they release the left mouse button, causing the `MouseLeftButtonUp` event to fire. When this event fires, you set the `currentStroke` variable to `null` because you have finished with that stroke. Because you are finished, you call `ReleaseMouseCapture` to stop collecting mouse or stylus point locations.

When you run the application, you can ink on the browser surface, as shown in Figure 3-57.

Figure 3-57. *Basic ink functionality in Silverlight 4*

Notice the orange ink with the black outline. The default is black ink, but when you create the stroke, you modify the `DrawingAttributes` in this code:

```
_currentStroke.DrawingAttributes.Color = Colors.Orange;
_currentStroke.DrawingAttributes.OutlineColor = Colors.Black;
```

Next, add another `InkPresenter` with an `Image` object behind it to provide a background. Write similar code to handle the `MouseLeftButtonDown`, `MouseMove`, and `MouseLeftButtonUp` events. Listings 3-11 and 3-12 show the code, and Figure 3-58 shows the output.

Figure 3-58. *InkPresenter with Image background*

Listing 3-11. *Recipe 3.12 MainPage.xaml File*

```
<UserControl x:Class="Ch03_DesigningUX.Recipe3_12.MainPage"
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"
d:DesignHeight="800" d:DesignWidth="600"
```

```
mc:Ignorable="d">
<Grid x:Name="LayoutRoot" Background="White">
<Grid.RowDefinitions>
<RowDefinition Height="0.502*"/>
<RowDefinition Height="0.498*"/>
</Grid.RowDefinitions>
<Grid.ColumnDefinitions>
<ColumnDefinition Width="0.5*"/>
<ColumnDefinition Width="0.5*"/>
</Grid.ColumnDefinitions>
<Border Margin="4,4,4,4" CornerRadius="10,10,10,10" Padding="0,0,0,0" >
<Border.Background>
<LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
<GradientStop Color="#FF767373" Offset="0.004"/>
<GradientStop Color="#FF1A1818" Offset="1"/>
<GradientStop Color="#FF888686" Offset="0.473"/>
</LinearGradientBrush>
</Border.Background>
<InkPresenter x:Name="InkEssentials" Background="Transparent"
MouseLeftButtonDown="InkEssentials_MouseLeftButtonDown"
MouseMove="InkEssentials_MouseMove" Height="Auto" Width="Auto"
MouseLeftButtonUp="InkEssentials_MouseLeftButtonUp" />
</Border>
<Image Margin="4,4,4,4" Grid.Column="1" x:Name="Picture"
Source="/img/VerticalLandscape.jpg"/>
<InkPresenter Margin="4,4,4,4" Grid.Column="1" x:Name="InkPicture"
MouseLeftButtonDown="InkPicture_MouseLeftButtonDown"
MouseMove="InkPicture_MouseMove" Background="Transparent"
MouseLeftButtonUp="InkPicture_MouseLeftButtonUp"/>
</Grid>
</UserControl>
```

Listing 3-12. *Recipe 3.12 MainPage.xaml.cs Class File*

```
using System.IO.IsolatedStorage;
using System.Windows.Controls;
using System.Windows.Input;
using System.Windows.Media;
namespace Ch03_DesigningUX.Recipe3_12
{
public partial class MainPage : UserControl
  {
private System.Windows.Ink.Stroke _currentStroke;
private System.Windows.Ink.Stroke _currentImageStroke;
private IsolatedStorageSettings settings =
```

```
IsolatedStorageSettings.ApplicationSettings;
private string setting = “Ink”;
private string FormDataFileName = “ImageInk.data”;
private string FormDataDirectory = “InkData”;

public MainPage()
    {
InitializeComponent();
    }
private void InkEssentials_MouseLeftButtonDown(object sender,
MouseButtonEventArgs e)
    {
InkEssentials.CaptureMouse();
_currentStroke = new System.Windows.Ink.Stroke();
//Change color of the stroke and stroke outline
_currentStroke.DrawingAttributes.Color = Colors.Orange;
_currentStroke.DrawingAttributes.OutlineColor = Colors.Black;
_currentStroke.StylusPoints.Add(
e.StylusDevice.GetStylusPoints(InkEssentials));
InkEssentials.Strokes.Add(_currentStroke);
    }

private void InkEssentials_MouseMove(object sender, MouseEventArgs e)
    {
if (null != _currentStroke)
      {
_currentStroke.StylusPoints.Add(
e.StylusDevice.GetStylusPoints(InkEssentials));
      }
    }

private void InkEssentials_MouseLeftButtonUp(object sender,
MouseButtonEventArgs e)
    {
_currentStroke = null;
InkEssentials.ReleaseMouseCapture();
    }

private void InkPicture_MouseLeftButtonDown(object sender,
MouseButtonEventArgs e)
    {
InkPicture.CaptureMouse();
_currentImageStroke = new System.Windows.Ink.Stroke();
_currentImageStroke.StylusPoints.Add(
e.StylusDevice.GetStylusPoints(InkPicture));
InkPicture.Strokes.Add(_currentImageStroke);
    }
```

```
private void InkPicture_MouseMove(object sender, MouseEventArgs e)
    {
if (null != _currentImageStroke)
      {
_currentImageStroke.StylusPoints.Add(
e.StylusDevice.GetStylusPoints(InkPicture));
      }
    }

private void InkPicture_MouseLeftButtonUp(object sender, MouseButtonEventArgs e)
{
_currentImageStroke = null;
InkPicture.ReleaseMouseCapture();
    }
  }
}
```

3-13. Adding 3-D Effects to UI Elements

Problem

You want to add three-dimensional effects to UI elements in your Silverlight application.

Solution

Use the new perspective transforms feature in Silverlight to simulate displaying and moving UI elements in 3-D space.

How It Works

WPF has full support for 3-D graphics as well as perspective transforms to simulate 3-D effects. Silverlight 3 added support for perspective transforms, which more easily let Silverlight developers simulate moving objects in 3-D effects.

■ **Note** Silverlight does not support true 3-D graphics like WPF or DirectX. However, with perspective transforms, you can achieve some very interesting effects.

The `UIElement` base class adds a property named `Projection` that is of type `System.Windows.MediaProjection`, which is an abstract base class. This property sets the perspective projection to apply when rendering the `UIElement` or descendent object. The `Projection` base class has two descendents that can be assigned to the `UIElement.Projection` property: `Matrix3DProjection` and `PlaneProjection`.

`Matrix3DProjection` is a wrapper class around a `Matrix3D` class. The `Matrix3D` class represents a 4 x 4 matrix. It can be used to create a standard Translate, Scale, Rotate, or Perspective matrix for transformations in 3-D space and should be familiar to game developers or anyone who programs software in 3-D space.

For more information about creating and working with 3-D matrixes, please refer to the DirectX documentation or a book that covers 3-D development:

```
http://msdn.microsoft.com/en-us/directx/default.aspx
```

The `Matrix3DProjection` class provides a way to apply an arbitrary 3-D matrix to a `UIElement`, allowing you to create highly customized transformations. The `Matrix3DProjection` has a minimal API, so you must write the code that correctly creates the necessary 3D transforms to achieve the desired affect.

If you do not need to support customized 3-D matrices, you can still easily apply 3-D effects via the `PlaneProjection` class. With the `PlaneProjection` class, you can create the illusion that an object is rotating toward or away from the user. The `PlaneProjection` object can be used to apply a static transformation to skew an object in 3-D. You can use this method to create a UI where objects appear to be stacked in 3-D space by applying unique `PlaneProjection` values. Combining the `PlaneProjection` class with `Storyboard` object lets you animate properties of the `PlaneProjection` class to create the illusion that a `UIElement` is moving through 3-D space.

The Code

In this recipe, you take advantage of the new Silverlight Navigation Application template to create a couple of examples to help you better understand how to work with projections and perspective transforms.

The first example, shown in Figure 3-59, allows the user to apply rotation to the picture with a slider for the X, Y, and Z planes.

Notice that the values displayed for the amount of rotation in the X, Y, and Z planes are three-digit integers. Originally, the values were a one, two, or three-digit number on the left side of the decimal and a large number of digits to the right of the decimal point. Because the decimal values are not important, we wrote a simple value converter for Silverlight 3 to truncate the decimal values and force it to display a three-digit integer. In Silverlight 4, we take advantage of the `StringFormat` property for the `Binding` markup extension. This allows us to change this line of code:

```
{Binding Value, ElementName=YaxisSlider,
Converter={StaticResource DecimalFormatConverter}}">
```

to this line of code:

```
{Binding Value, ElementName=YaxisSlider,
StringFormat=000}">
```

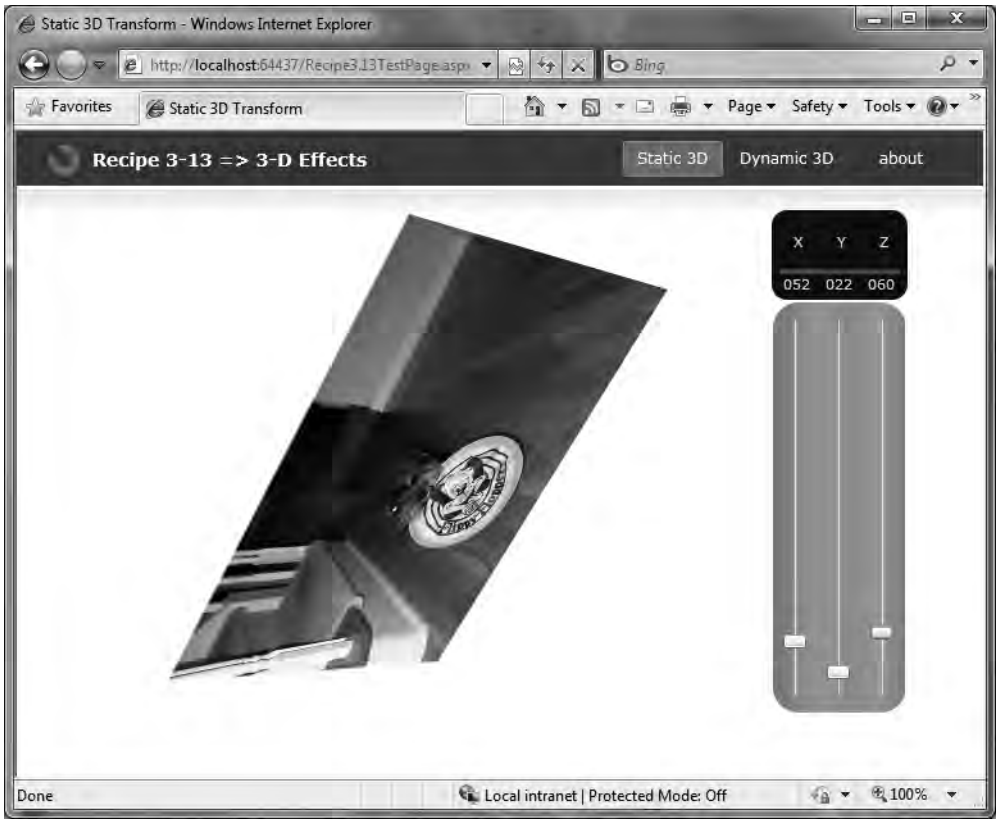


Figure 3-59. *Static 3-D transform test page*

You apply the slider values programmatically in the code-behind file because it is not possible to databind elements directly with the `PlaneProjection`'s `RotationX`, `RotationY`, and `RotationZ` properties. The reason is that these are not `DependencyProperties` but are instead simple .NET properties. Listing 3-13 shows the `Static3DTransform` XAML file.

Listing 3-13. *Recipe 3.13 Static3DTransform.xaml File*

```
<navigation:Page
x:Class="Ch03_DevelopingUX.Recipe3_13.Static3DTransform"
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:navigation=
"clr-namespace:System.Windows.Controls;assembly=
System.Windows.Controls.Navigation"
mc:Ignorable="d" d:DesignWidth="640" d:DesignHeight="480"
```

```
Title=”Static 3D Transform”
Style=”{StaticResource PageStyle}”>
<navigation:Page.Resources>
<Color x:Key=”CustomGreen”>#FFADFA97</Color>

</navigation:Page.Resources>
<Grid x:Name=”LayoutRoot”>
<Grid.ColumnDefinitions>
<ColumnDefinition Width=”0.831*”/>
<ColumnDefinition Width=”0.169*”/>
</Grid.ColumnDefinitions>
<Image HorizontalAlignment=”Left”
VerticalAlignment=”Top” Margin=”60”
Source=”/Ch03_DevelopingUX.Recipe3_13Component/Assets/image.jpg”
MaxWidth=”452” MaxHeight=”339” Width=”400”>
<Image.Projection>
<PlaneProjection x:Name=”ImageRotation”/>
</Image.Projection>
</Image>
<StackPanel Grid.Column=”1”  Orientation=”Vertical”>
<Border Background=”#FF1A1A1A” CornerRadius=”12” Width=”106”>
<StackPanel Margin=”4” >
<StackPanel Orientation=”Horizontal”>
<TextBlock Text=”X” Margin=”13”>
<TextBlock.Foreground>
<SolidColorBrush Color=
“{StaticResource CustomGreen}”/>
</TextBlock.Foreground>
</TextBlock>
<TextBlock Text=”Y” Margin=”13”>
<TextBlock.Foreground>
<SolidColorBrush Color=”
{StaticResource CustomGreen}”/>
</TextBlock.Foreground>
</TextBlock>
<TextBlock Text=”Z” Margin=”13”>
<TextBlock.Foreground>
<SolidColorBrush Color=
“{StaticResource CustomGreen}”/>
</TextBlock.Foreground>
</TextBlock>
</StackPanel>
<Rectangle Height=”4” Fill=”#FFD21416” Margin=”2,0”></Rectangle>
<StackPanel Orientation=”Horizontal”>
<TextBlock Margin=”5,0,5,0” Text=
```

```
“{Binding Value, ElementName=XaxisSlider,
Converter={StaticResource DecimalFormatConverter}}”>
<TextBlock.Foreground>
<SolidColorBrush Color=
“{StaticResource CustomGreen}”/>
</TextBlock.Foreground>
</TextBlock>
<TextBlock Margin=”7,0,5,0” Text=
“{Binding Value, ElementName=YaxisSlider,
Converter={StaticResource DecimalFormatConverter}}”>
<TextBlock.Foreground>
<SolidColorBrush Color=
“{StaticResource CustomGreen}”/>
</TextBlock.Foreground>
</TextBlock>
<TextBlock Margin=”7,0,5,0” Text=
“{Binding Value, ElementName=ZaxisSlider, Converter=
{StaticResource DecimalFormatConverter}}”>
<TextBlock.Foreground>
<SolidColorBrush Color=
“{StaticResource CustomGreen}”/>
</TextBlock.Foreground>
</TextBlock>
</StackPanel>
</StackPanel>
</Border>
<Border CornerRadius=”20” Margin=”2” MinHeight=”320” Width=”104”>
<Border.Background>
<LinearGradientBrush EndPoint=”-1.038,0.5”
StartPoint=”2.038,0.5”>
<GradientStop Color=”#FF7AC367” Offset=”0.403”/>
<GradientStop Color=”#FF7AC367” Offset=”0.562”/>
<GradientStop Color=”#FF44B324” Offset=”0.313”/>
<GradientStop Offset=”0.665” Color=”#FF44B324”>
</GradientStop>
<GradientStop Color=”#FF73B962” Offset=”0.472”/>
</LinearGradientBrush>
</Border.Background>
<StackPanel Orientation=”Horizontal” >
<Slider x:Name=”XaxisSlider” HorizontalAlignment=”Left”
Margin=”8”
Orientation=”Vertical” Maximum=”360” LargeChange=”18”
ValueChanged=”XaxisSlider_ValueChanged” SmallChange=”1” />
<Slider x:Name=”YaxisSlider” HorizontalAlignment=”Left”
Margin=”8”
```

```
Orientation="Vertical" Maximum="360" LargeChange="18"
ValueChanged="YaxisSlider_ValueChanged" SmallChange="1"/>
<Slider x:Name="ZaxisSlider" HorizontalAlignment="Left"
Margin="8"
Orientation="Vertical" Maximum="360" LargeChange="18"
ValueChanged="ZaxisSlider_ValueChanged" SmallChange="1"/>
</StackPanel>
</Border>
</StackPanel>
</Grid>
</navigation:Page>
```

Listing 3-14 contains the `Static3DTransform` XAML code file.

Listing 3-14. *Recipe 3.13 Static3DTransform.xaml.cs Code File*

```
using System.Windows;
using System.Windows.Controls;
using System.Windows.Navigation;

namespace Ch03_DevelopingUX.Recipe3.Views_13
{
public partial class Static3DTransform : Page
  {
public Static3DTransform()
    {
InitializeComponent();
    }
// Executes when the user navigates to this page.
protected override void OnNavigatedTo(NavigationEventArgs e)
    {
    }
private void XaxisSlider_ValueChanged(object sender,
RoutedPropertyChangedEventArgs<double> e)
    {
ImageRotation.RotationX = e.NewValue;
    }
private void YaxisSlider_ValueChanged(object sender,
RoutedPropertyChangedEventArgs<double> e)
    {
ImageRotation.RotationY = e.NewValue;
    }
private void ZaxisSlider_ValueChanged(object sender,
RoutedPropertyChangedEventArgs<double> e)
    {
ImageRotation.RotationZ = e.NewValue;
```

```
    }
  }
}
```

The other example in this recipe demonstrates dynamic 3-D transformations using a `Storyboard` that projects two images rotating in 3-D space. Figure 3-60 shows the UI that lets you start an animation that rotates two images in 3-D space.

Figure 3-60. *Dynamic 3D transform test page*

The only code is for the buttons to control the storyboard. All the movement is contained in a `Storyboard` that animates over the `RotationY`, `RotationZ`, and Global Offset X and Y values.

The first example demonstrated how `RotationY` and `RotationZ` parameters. The Global Offset X and Y values control how the object appears as it is offset along the X, Y, and Z axes in 3-D space.

■ **Note** X values increase from left to right. Y values increase from top to bottom. Z axis values increase toward the user and decrease as an object moves further away.

To create the Storyboard in Expression Blend, orient the pictures opposite each other with a slight decline, using the RotationY and RotationZ properties to make the objects appear to face each other. The objects are not visible initially because they have a (+/-) 90-degree RotationY value, depending on the object.

Create the Storyboard time line with four keyframes 1 second apart, for a total of 4 seconds of rotation. The first and last keyframes have the same values to force the picture back to its original position. The other three keyframes change RotationY in 90-degree increments to give the appearance of revolving around a center point but always facing the center. RotationZ changes from 10 to 0 to emphasize the object either being closer or further away on the Z axis.

The other properties animated are the Global Offset X and Z values, because you want the pictures to move along a constant Y value (rotate left and right) while appearing closer when at the front and further away when at the back. You wrap the whole animation in a 3-D–looking room and use gradients to simulate depth. We do not show the XAML file because it is auto-generated. We also do not show the code file because it is simple Storyboard start and stop code. Please review the code in the source code archive that accompanies this book to see the details.

We do not cover MainPage.xaml or MainPage.xaml.cs because they wire up the navigation application template, which we cover in Chapter 6.

3-14. Dynamically Creating Bitmaps

Problem

You need to create bitmap images directly at runtime in your Silverlight application.

Solution

Use the new WriteableBitmap object in Silverlight to create bitmap images at runtime.

How It Works

Silverlight 2 does not have the ability to create bitmaps at runtime. With Silverlight 4, you can use the WriteableBitmap class to create a new bitmap image in custom code or from other elements in the UI. To use the WriteableBitmap class, include the System.Windows.Media.Imaging namespace.

To create a custom bitmap from an element in the UI, you can use this constructor:

```
WriteableBitmap bmp = new WriteableBitmap(LayoutRoot, null);
```

LayoutRoot is the default name of the root Grid control in a new Silverlight application, so any UI elements contained in LayoutRoot are included in the created bitmap image. You specify null for the Transform to be applied to the image; however, you can specify a Transform that is applied as the last part of the operation, meaning the bitmap is created and then the Transform is applied. As an example, you can apply a transform that creates a reflection of the UI element from which the bitmap is created.

The other constructors available for WriteableBitmap take either a BitmapSource object or height and width values as a place holder for content that is created. The BitmapSource class is an abstract class, so the object to work with is the BitmapImage class. You can load a JPEG or PNG image into a BitmapImage by URI or using a stream.

The other WriteableBitmap constructor takes a height and width, which are used to generate the appropriate-sized Pixels property that points to an array of integers representing the image. With this constructor, you have a blank slate of pixels on which you can set values to create an image for more direct image control.

The Code

The example for this recipe imports a PNG or JPEG image into the application. It gives the user an option to add a watermark to the image and then save the image in a custom format. The user can clear the image and then reload the saved image with the watermark. Figure 3-61 shows the UI after importing an image.

Figure 3-61. *The sample UI after importing an image*

Figure 3-62 shows the UI after adding a watermark to the image; it says, "Silverlight 4 Rocks!!!"

Figure 3-62. *The sample UI after importing an image*

Listing 3-15 shows the XAML file.

Listing 3-15. *Recipe 3.14 MainPage.xaml File*

```
<UserControl x:Class="Ch03_DevelopingUX.Recipe3_14.MainPage"
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"
mc:Ignorable="d"
<Grid x:Name="LayoutRoot">
<Grid.Background>
```

```
<LinearGradientBrush EndPoint="-0.131,-0.123" StartPoint="1.215,1.232">
<GradientStop Color="#FF000000"/>
<GradientStop Color="#FFFFFFFF" Offset="1"/>
</LinearGradientBrush>
</Grid.Background>
<Grid.RowDefinitions>
<RowDefinition Height="0.075*"/>
<RowDefinition Height="0.832*"/>
<RowDefinition Height="0.093*"/>
</Grid.RowDefinitions>
<Grid.ColumnDefinitions>
<ColumnDefinition Width="0.059*"/>
<ColumnDefinition Width="0.890*"/>
<ColumnDefinition Width="0.051*"/>
</Grid.ColumnDefinitions>
<TextBlock Margin="8,4" Grid.Column="1" Grid.Row="2" Text="Status"
TextWrapping="Wrap" x:Name="StatusLabel" VerticalAlignment="Center"/>
<Border Grid.Column="1" Grid.Row="1" Margin="8" CornerRadius="12"
x:Name="ImageContainer" Width="600" Height="600">
<Border.Background>
<LinearGradientBrush EndPoint="0.035,-0.031" StartPoint="1.649,2.131">
<GradientStop Color="#FF1D351E"/>
<GradientStop Color="#FF1D351E" Offset="1"/>
<GradientStop Color="#FFB7D8BA" Offset="0.50900000333786011"/>
</LinearGradientBrush>
</Border.Background>
<Grid>
<Image x:Name="ImageContent" Stretch="UniformToFill"  Margin="12"/>
<TextBlock TextWrapping="Wrap" Margin="8" RenderTransformOrigin="0.5,0.5"
FontSize="16" FontWeight="Bold" Foreground="#FF000BFF"
x:Name="txtBlockWatermark" Text="Silverlight 4 Rocks!!!!"
TextAlignment="Center" d:LayoutOverrides="GridBox"
VerticalAlignment="Bottom" Visibility="Collapsed"/>
</Grid>
</Border>
<StackPanel Margin="8,4" Grid.Column="1" Orientation="Horizontal">
<Button Margin="2,2,6,2" Content="Import File" x:Name="ButtonImportFiles"
Click="ButtonImportFile_Click"/>
<Button x:Name="btnSaveCustomFile"  Click="btnSaveCustomFile_Click"
Content="Save File" Margin="8,2,2,2"/>
<Button x:Name="btnOpenCustomFile"  Click="btnOpenCustomFile_Click"
Content="Open File" Margin="2"/>
<Button x:Name="btnClearImage"
Content="Clear Image" Margin="16,2,2,2" Click="btnClearImage_Click"/>
<Button x:Name="btnAddWatermark"
```

```
Content=”Add Watermark” Margin=”2” Click=”btnAddWatermark_Click”/>
<TextBox x:Name=”textWatermark” Margin=”2” Width=”202”
HorizontalContentAlignment=”Left” Height=”24”/>
</StackPanel>
</Grid>
</UserControl>
```

Listing 3-16 shows the code-behind, which we cover next.

Listing 3-16. *Recipe 3.14 MainPage.xaml.cs File*

```
using System;
using System.IO;
using System.Linq;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Media;
using System.Windows.Media.Imaging;

namespace Ch03_DevelopingUX.Recipe3_14
{
public partial class MainPage : UserControl
  {
public MainPage()
    {
InitializeComponent();
    }

private void ButtonImportFile_Click(object sender, RoutedEventArgs e)
    {
txtBlockWatermark.Visibility = Visibility.Collapsed;
//Create dialog
OpenFileDialog fileDlg = new OpenFileDialog();
//Set file filter as desired
fileDlg.Filter = “Png Files (*.png)|*.png|Jpeg Files (*.jpg)|*.jpg”;
fileDlg.FilterIndex = 1;
//Allow multiple files to be selected (false by default)
fileDlg.Multiselect = false;

//Show Open File Dialog
BitmapImage img = new BitmapImage();
if (true == fileDlg.ShowDialog())
      {
StatusLabel.Text =
fileDlg.File.Name + “  selected”;
```

```
using (FileStream reader = fileDlg.File.OpenRead())
        {
img.SetSource(reader);
        }
ImageContent.Source = img;
      }
    }

private void btnSaveCustomFile_Click(object sender, RoutedEventArgs e)
    {
SaveFileDialog sfd = new SaveFileDialog();
sfd.Filter = "sl3 Files (*.sl3)|*.sl3";
sfd.FilterIndex = 1;

WriteableBitmap bmp = new WriteableBitmap(ImageContainer, null);
if (true == sfd.ShowDialog())
      {
byte[] flattend = null;
flattend = bmp.Pixels.SelectMany((p)=>BitConverter.GetBytes(p)).ToArray();
using (Stream fs = sfd.OpenFile())
        {
fs.Write(flattend, 0, flattend.Length);
fs.Flush();
fs.Close();
        }
      }
    }

private void btnOpenCustomFile_Click(object sender, RoutedEventArgs e)
    {
txtBlockWatermark.Visibility = Visibility.Collapsed;
OpenFileDialog fileDlg = new OpenFileDialog();
fileDlg.Filter = "sl4 Files (*.sl4)|*.sl4";
fileDlg.FilterIndex = 1;
fileDlg.Multiselect = false;

if (true == fileDlg.ShowDialog())
      {
StatusLabel.Text =
fileDlg.File.Name + "  selected";
using (FileStream reader = fileDlg.File.OpenRead())
        {
WriteableBitmap wrtBmp = null;
wrtBmp = new WriteableBitmap(ImageContainer, null);
byte[] fourBytes = new byte[4];
```

```
int byteCounter = 0;
int intCounter = 0;

while (byteCounter < reader.Length - 1)
          {
reader.Read(fourBytes,0, 4);
wrtBmp.Pixels[intCounter] = BitConverter.ToInt32(fourBytes, 0);
intCounter++;
byteCounter += 4;
          }
ImageContent.Source = wrtBmp;
        }
      }
    }
private void btnClearImage_Click(object sender, RoutedEventArgs e)
    {
txtBlockWatermark.Visibility = Visibility.Collapsed;
txtBlockWatermark.Text = "";
ImageContent.Source = null;
    }

private void btnAddWatermark_Click(object sender, RoutedEventArgs e)
    {
txtBlockWatermark.Visibility = Visibility.Visible;
txtBlockWatermark.Text = textWatermark.Text;
    }
  }
}
```

The `ButtonImportFile_Click` event handler that imports an image uses the `OpenFileDialog` to let a user browse to a file. After a file is chosen, it is loaded into an image using a `FileStream` object with this code:

```
img.SetSource(reader);
```

The `btnSaveCustomFile_Click` event handler uses the new `SaveFileDialog` to allow the user to save the file outside of isolated storage in their file system. We cover the `SaveFileDialog` in Recipe 2-18. When you have a location to save the file, you can use a stream to save the bitmap bits stored in the `WritableBitmap.Pixels` property. The `Pixels` property is an array of integers, so you convert the `int` array to a `byte` array using the `BitConverter` with LINQ:

```
flattend = bmp.Pixels.SelectMany(
(p)=>BitConverter.GetBytes(p)).ToArray();
```

The `btnOpenCustomFile_Click` event handler does the opposite by reading bytes four at a time and using the `BitConverter` to convert the four `bytes` to an `int`. Each `int` is then set in order in the `Pixels int` array:

```
using (FileStream reader = fileDlg.File.OpenRead())
{
WriteableBitmap wrtBmp = null;
wrtBmp = new WriteableBitmap(ImageContainer, new TranslateTransform());
byte[] fourBytes = new byte[4];
int byteCounter = 0;
int intCounter = 0;

while (byteCounter < reader.Length - 1)
  {
reader.Read(fourBytes,0, 4);
wrtBmp.Pixels[intCounter] = BitConverter.ToInt32(fourBytes, 0);
intCounter++;
byteCounter += 4;
  }
```

When all of the bytes have been processed, the `WriteableBitmap` is set as the `Source` on the `Image` element. Note that the file format is not compatible with any of the standardized file formats. This can be remedied by implementing an encoder/decoder for a standard file format and obtaining raw bitmap data from the `WriteableBitmap.Pixels` property.

For simplicity, the code assumes a fixed size for the image based on the `ImageContainer` UI element. For a resizable UI, you also have to save the height and width of the image when saving and then use those values to instantiate a `WritableBitmap` object with the correct dimensions in its constructor. You can add the dimensions to the stream as the first two bytes; with a little additional coding, you can have a more flexible custom format for internal use in an application.

3-15. Improving Graphic Animation and Video Performance

Problem

You want to maximize performance for graphic animations and video streaming.

Solution

Take advantage of the support for hardware acceleration and bitmap caching available in Silverlight 4

How It Works

Silverlight 2 did not take advantage of hardware acceleration available in today's video display adapters. Silverlight 3 and later lets you take advantage of the available display hardware, processor, and video memory, to improve performance of Silverlight applications.

To enable GPU acceleration, configure the Silverlight 4 plug-in by adding this parameter to the standard `<OBJECT>` declaration:

```
<param name="enableGPUAcceleration" value="true" />
```

To take advantage of GPU acceleration, configure the `UIElement.CacheMode` property by configuring it to `BitmapCache`, which is the only valid option:

```
CacheMode="BitmapCache"
```

This setting caches visual elements as bitmaps after the first time they render. After an object is cached as a bitmap, it no longer goes through the rendering phase; the cached version on the GPU is displayed instead, potentially yielding significant performance improvements.

A related option that you can configure on the Silverlight plug-in is the `enableCacheVisualation` parameter. When set to `True`, it tints non-accelerated parts of the UI red.

The Code

To demonstrate how to configure an application as well as the potential performance improvements, you create a simple application that animates some sample XAML from Expression Design. Figure 3-63 shows the UI.

When you run the application without enabling GPU acceleration, a check in Windows Task Manager shows CPU utilization between 20% and 40%, mostly hovering around 25% to 30%.

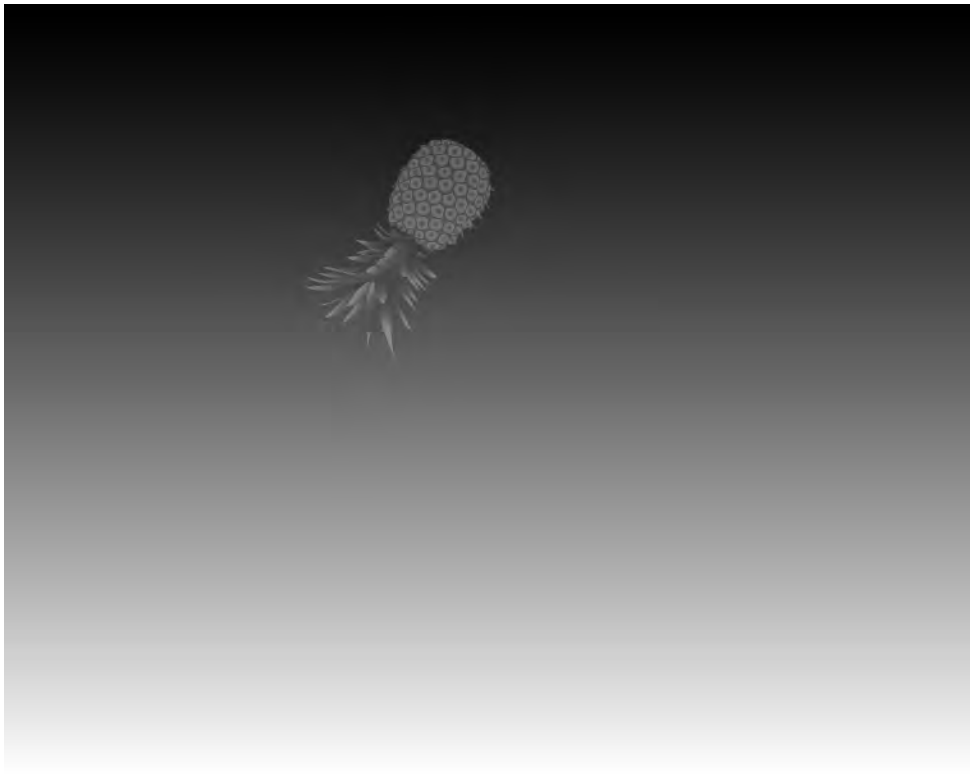


Figure 3-63. *The sample UI*

Configure `enableGPUAcceleration` to `True`, and test again. The results are the same, as expected. Next, set `CacheMode="BitmapCache"` on `LayoutRoot` (the root `Grid` control) to try enabling bitmap caching for the entire application, which consists of a gradient configured on `LayoutRoot` and a `Canvas` that contains the pineapple. Also enable the visualization parameter to observe what parts of the UI are accelerated:

```
<param name="enableCacheVisualization" value="true" />
```

When you run the UI, it looks exactly like Figure 3-63 without any red tint, because the entire UI is accelerated; however, you do not see any noticeable performance improvement. Next, move the `CacheMode="BitmapCache"` attribute to the `Canvas` object that contains the XAML for the pineapple. Figure 3-64 shows the UI with the background tinted red because it is not accelerated—only the pineapple is accelerated.

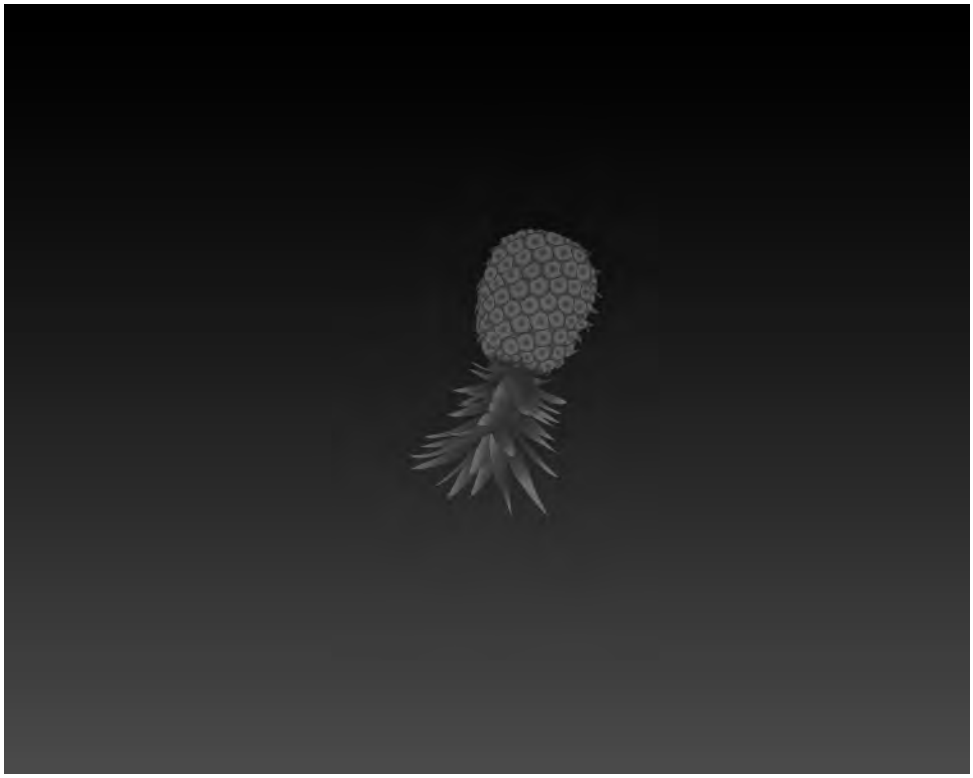


Figure 3-64. *The GPU accelerated pineapple*

In this test run, you see a very noticeable performance improvement: CPU utilization drops to just a few percentage points, trending between 0% and 2%, which is much improved over the non-accelerated test. This goes to show that you should not apply the `BitmapCache` without validating the resulting performance improvements using the visualization parameter. Be sure to set the visualization parameter to `false` to remove the red tint for non-accelerated UI elements.

Note that if you run the same test by applying the `BitmapCache` attribute to a `MediaElement` when playing video, you will also see a fairly large reduction in CPU utilization.

The XAML code is straight forward, with much of the XAML in the `Storyboard` for the animation and the pineapple. Listing 3-27 shows the abbreviated XAML.

Listing 3-27. *Recipe 3.15 Abbrevidated MainPage.Xaml File*

```
<UserControl x:Class="Ch03_DevelopingUX.Recipe3_15.MainPage"
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"
mc:Ignorable="d" d:DesignWidth="800" d:DesignHeight="600">
<UserControl.Resources>
<Storyboard x:Name="AnimatePineappleStoryboard"
AutoReverse="true" RepeatBehavior="Forever" >
<DoubleAnimationUsingKeyFrames
BeginTime="00:00:00" Storyboard.TargetName="Pineapple"
Storyboard.TargetProperty=
"(UIElement.RenderTransform).(TransformGroup.Children)[3].
(TranslateTransform.X)">
<!--- Removed storyboard code--->
</Storyboard>
</UserControl.Resources>
<Grid x:Name="LayoutRoot">
<Grid.Background>
<LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
<GradientStop Color="Black" Offset="0"/>
<GradientStop Color="White" Offset="1"/>
</LinearGradientBrush>
</Grid.Background>
<Canvas x:Name="Pineapple" Opacity="0.5" Margin="-81,-162,0,0" CacheMode="BitmapCache"
HorizontalAlignment="Left" Width="201" RenderTransformOrigin="0.5,0.5" Height="378"
VerticalAlignment="Top">
<Canvas.RenderTransform>
<TransformGroup>
<ScaleTransform ScaleX= »0.1 » ScaleY= »0.1 »/>
<SkewTransform/>
<RotateTransform/>
<TranslateTransform/>
</TransformGroup>
</Canvas.RenderTransform>
<!--- removed markup for pineapple --->    </Canvas>
</Grid>
</UserControl>
```

The code-behind has a single line of code in `Initialize()`:

```
AnimatePineappleStoryboard.Begin();
```

3-16. Improve Animation with Custom Easing Functions

Problem

You want to customize how animations appear so that they look more realistic.

Solution

Take advantage of one or more of the 11 new built-in easing functions, or create a custom easing function that implements the `IEasingFunction` interface or inherits from `EasingFunctionBase`.

How It Works

In Silverlight 2, you could visually create an animation that appeared more realistic by increasing distance over time in a time line—you could add an acceleration and adjust the `KeySpline` values as covered in Recipe 3-8. Although this approach worked for many scenarios, developers sometimes hand-coded animations to achieve a desired affect.

Silverlight 3 and later tries to make this much easier by adding support for custom easing functions as well as providing 11 built-in easing functions that can go a long way toward helping animations appear more realistic. Table 3-3 lists these functions.

Table 3-3. *Built-in Easing Functions*

Function Name	Description
`BackEase`	Adds inertia before an animation begins by retracting slightly in the opposite direction of the intended motion
`BounceEase`	Adds a bouncing effect to an animation
`CircleEase`	Adds acceleration or deceleration based on a circular function
`CubicEase`	Adds acceleration or deceleration using the formula $f(t)=t^3$
`ElasticEase`	Creates an animation that simulates an oscillating spring that eventually comes to rest
`ExponentialEase`	Adds acceleration or deceleration using an exponential formula
`PowerEase`	Adds acceleration or deceleration using the formula $f(t)=t^P$ where p is equal to the `Power` property
`QuadraticEase`	Adds acceleration or deceleration using the formula $f(t)=t^2$

`QuarticEase`	Adds acceleration or deceleration using the formula $f(t)=t^4$
`QuinticEase`	Adds acceleration or deceleration using the formula $f(t)=t^5$
`SineEase`	Adds acceleration or deceleration using a sine formula

You can apply a custom easing function or one of the built-in easing functions to an individual keyframe visually in Expression Blend by selecting the EasingFunction tab in the Easing section, as shown in Figure 3-65.

Figure 3-65. *Select an easing function to apply to a keyframe*

Notice at the bottom in Figure 3-65 that you can select a custom easing function that resides in the chapter's namespace or one of the built-in easing functions. You can also choose whether the easing function applies on the way in to the keyframe, on the way out, or to both.

Of course, it is possible to create an instance of an easing function class and apply it programmatically as well. But Expression Blend 4 provides a very visual way of applying easing functions and lets you see the results immediately by playing the animation at design-time.

The Code

For this recipe, you build a teeter-totter that rolls a ball back and forth at an even pace by default. Figure 3-66 shows an image from Expression Blend.

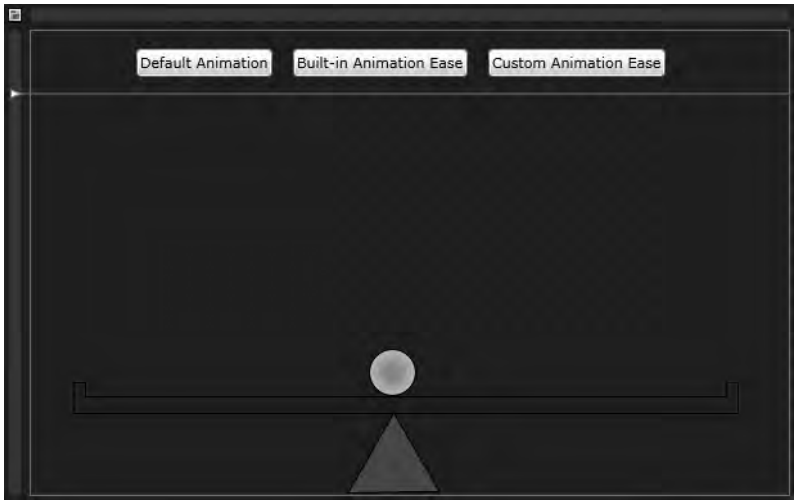


Figure 3-66. *The teeter-totter*

In Expression Blend, you select keyframes in the time line and apply one of the built-in easing functions to experiment with different appearances. Use a `SineEase` for both in and out when the ball is at the far right or far left. Also add a `PowerEase` with a `Power` of 2 for both in and out.

Now that you have visually designed which built-in ease functions you want to apply when the second button is clicked in the UI, assign names to the keyframes in Visual Studio so that you can programmatically apply the ease. Also remove the easing functions from the XAML so that when the Default Animation button in the UI is clicked, no easing is applied.

Listing 3-18 and 3-19 show the `.xaml` and `.xaml.cs` files, respectively.

Listing 3-18. *Recipe 3.16 MainPage.xaml File*

```
<UserControl x:Class="Ch03_DevelopingUX.Recipe3_16.MainPage"
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"
Width="590" Height="362" mc:Ignorable="d">
<UserControl.Resources>
<Storyboard x:Name="RollingBallStoryboard" RepeatBehavior="Forever">
<DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
Storyboard.TargetName="rectangle" Storyboard.TargetProperty=
"(UIElement.RenderTransform).(TransformGroup.Children)[2].(RotateTransform.Angle)">
<EasingDoubleKeyFrame KeyTime="00:00:00" Value="0"/>
<EasingDoubleKeyFrame KeyTime="00:00:01" Value="-12.655"/>
<SplineDoubleKeyFrame KeyTime="00:00:02" Value="0"/>
<EasingDoubleKeyFrame KeyTime="00:00:03" Value="13.557"/>
<EasingDoubleKeyFrame KeyTime="00:00:04" Value="0"/>
</DoubleAnimationUsingKeyFrames>
```

```
<DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
Storyboard.TargetName="ball" Storyboard.TargetProperty=
"(UIElement.RenderTransform).(TransformGroup.Children)[3].(TranslateTransform.X)">
<EasingDoubleKeyFrame x:Name="PowerEase1" KeyTime="00:00:00" Value="0">
</EasingDoubleKeyFrame>
<EasingDoubleKeyFrame x:Name="SineEase1" KeyTime="00:00:01" Value="-223">
</EasingDoubleKeyFrame>
<EasingDoubleKeyFrame KeyTime="00:00:01.5000000" Value="-112.5"/>
<EasingDoubleKeyFrame x:Name="PowerEase2" KeyTime="00:00:02" Value="0">
</EasingDoubleKeyFrame>
<EasingDoubleKeyFrame x:Name="SineEase2" KeyTime="00:00:03" Value="244">
</EasingDoubleKeyFrame>
<EasingDoubleKeyFrame KeyTime="00:00:03.5000000" Value="123"/>
<EasingDoubleKeyFrame x:Name="PowerEase3" KeyTime="00:00:04" Value="0">
</EasingDoubleKeyFrame>
</DoubleAnimationUsingKeyFrames>
<DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
Storyboard.TargetName="ball" Storyboard.TargetProperty=
"(UIElement.RenderTransform).(TransformGroup.Children)[3].(TranslateTransform.Y)">
<EasingDoubleKeyFrame x:Name="PowerEase4" KeyTime="00:00:00" Value="0">
</EasingDoubleKeyFrame>
<EasingDoubleKeyFrame KeyTime="00:00:00.5000000" Value="14.5"/>
<EasingDoubleKeyFrame x:Name="SineEase3" KeyTime="00:00:01" Value="51">
</EasingDoubleKeyFrame>
<EasingDoubleKeyFrame KeyTime="00:00:01.5000000" Value="14.5"/>
<EasingDoubleKeyFrame x:Name="PowerEase5" KeyTime="00:00:02" Value="0">
</EasingDoubleKeyFrame>
<EasingDoubleKeyFrame KeyTime="00:00:02.5000000" Value="14.5"/>
<EasingDoubleKeyFrame x:Name="SineEase4" KeyTime="00:00:03" Value="55">
</EasingDoubleKeyFrame>
<EasingDoubleKeyFrame KeyTime="00:00:03.5000000" Value="13.5"/>
<EasingDoubleKeyFrame x:Name="PowerEase6" KeyTime="00:00:04" Value="0">
</EasingDoubleKeyFrame>
</DoubleAnimationUsingKeyFrames>
</Storyboard>
</UserControl.Resources>
<Grid x:Name="LayoutRoot">
<Grid.RowDefinitions>
<RowDefinition Height="0.135*"/>
<RowDefinition Height="0.865*"/>
</Grid.RowDefinitions>
<StackPanel Orientation="Horizontal" Margin="2">
<Button x:Name="btnDefaultAnimation" HorizontalAlignment="Center"
Margin="80,8,8,8" Content="Default Animation"
Click="btnDefaultAnimation_Click" VerticalAlignment="Center"/>
```

```
<Button x:Name="btnBuiltInAnimation" HorizontalAlignment="Center" Margin="8"
Content="Built-in Animation Ease" Click="btnBuiltInAnimation_Click"
VerticalAlignment="Center"/>
<Button x:Name="btnCustomAnimation" HorizontalAlignment="Center" Margin="8"
Content="Custom Animation Ease" Click="btnCustomAnimation_Click"
VerticalAlignment="Center"/>
</StackPanel>
<Path x:Name="rectangle" Fill="#FF002E7E" Stretch="Fill" Stroke="Black"
Height="25" Margin="33,0,38.909,63" VerticalAlignment="Bottom"
RenderTransformOrigin="0.499912530183792,0.719995724607971" Grid.Row="1"
UseLayoutRounding="False" Data="M0.5,0.5 L9.5000019,0.5 L9.5000019,11.499801
L508.53659,11.499801 L508.59113,0.76702565 L517.591,0.81274098 L517.50037,18.655201
L517.50037,24.500023 L0.5,24.500023 L0.5,22.499994 L0.5,11.499801 z" >
<Path.RenderTransform>
<TransformGroup>
<ScaleTransform/>
<SkewTransform/>
<RotateTransform/>
<TranslateTransform/>
</TransformGroup>
</Path.RenderTransform>
</Path>
<Path x:Name="path" Fill="#FF267E00" Stretch="Fill" Stroke="Black" Height="63.5"
Margin="246.5,0,271.5,1" VerticalAlignment="Bottom" UseLayoutRounding="False"
Data="M390,537 L355,594 L425,593 z" Grid.Row="1"/>
<Ellipse x:Name="ball" Stroke="Black" Height="37" Margin="263,0,290,77"
VerticalAlignment="Bottom" RenderTransformOrigin="0.5,0.5" Grid.Row="1">
<Ellipse.RenderTransform>
<TransformGroup>
<ScaleTransform/>
<SkewTransform/>
<RotateTransform/>
<TranslateTransform/>
</TransformGroup>
</Ellipse.RenderTransform>
<Ellipse.Fill>
<RadialGradientBrush RadiusX="0.539" RadiusY="0.539"
GradientOrigin="0.28,0.287">
<GradientStop Color="#FFA5A3A3" Offset="0.991"/>
<GradientStop Color="#FFC9C5C5"/>
<GradientStop Color="#FF969292" Offset="0.905"/>
</RadialGradientBrush>
</Ellipse.Fill>
</Ellipse>
</Grid>
</UserControl>
```

Listing 3-19. *Recipe 3.16 MainPage.xaml.cs File*

```
using System.Windows;
using System.Windows.Controls;
using System.Windows.Media.Animation;

namespace Ch03_DevelopingUX.Recipe3_16
{
public partial class MainPage : UserControl
  {
public MainPage()
    {
InitializeComponent();
    }

private void btnDefaultAnimation_Click(object sender, RoutedEventArgs e)
    {
EasingDoubleKeyFrame EasingKF = null;
for (int i = 1; i < 7; i++)
      {
EasingKF = LayoutRoot.FindName("PowerEase" + i.ToString())
as EasingDoubleKeyFrame;
EasingKF.EasingFunction = null;
      }

for (int i = 1; i < 5; i++)
      {
EasingKF = LayoutRoot.FindName("SineEase" + i.ToString())
as EasingDoubleKeyFrame;
EasingKF.EasingFunction = null;
      }
RollingBallStoryboard.Begin();
    }

private void btnBuiltInAnimation_Click(object sender, RoutedEventArgs e)
    {
PowerEase pe = new PowerEase();
pe.Power = 2;
pe.EasingMode = EasingMode.EaseInOut;
SineEase se = new SineEase();
se.EasingMode = EasingMode.EaseInOut;
EasingDoubleKeyFrame EasingKF = null ;

for (int i = 1; i < 7; i++)
      {
```

```
EasingKF = LayoutRoot.FindName("PowerEase" + i.ToString())
as EasingDoubleKeyFrame;
EasingKF.EasingFunction = pe;
      }

for (int i = 1; i < 5; i++)
      {
EasingKF = LayoutRoot.FindName("SineEase" + i.ToString())
as EasingDoubleKeyFrame;
EasingKF.EasingFunction = se;
      }
RollingBallStoryboard.Begin();
    }

private void btnCustomAnimation_Click(object sender, RoutedEventArgs e)
    {
PowerEase pe = new PowerEase();
pe.Power = 2;
pe.EasingMode = EasingMode.EaseInOut;
SineEase se = new SineEase();
se.EasingMode = EasingMode.EaseInOut;
EasingDoubleKeyFrame EasingKF = null;

MyCustomEasingFunction mce = new MyCustomEasingFunction();
for (int i = 1; i < 7; i++)
      {
EasingKF = LayoutRoot.FindName("PowerEase" + i.ToString())
as EasingDoubleKeyFrame;
EasingKF.EasingFunction = null ;
      }

for (int i = 1; i < 5; i++)
      {
EasingKF = LayoutRoot.FindName("SineEase" + i.ToString())
as EasingDoubleKeyFrame;
EasingKF.EasingFunction = mce;
      }
RollingBallStoryboard.Begin();
    }
   }
}
```

The last button in the UI enables a custom easing function for the animation that uses the `Math.Sqrt` function to apply easing. When this button is clicked, you apply the custom ease when the ball rolls to either the left or right side. It gives the effect of accelerating into the stop and decelerating

out of the stop. You can try whatever math function makes sense for your scenario with little effort. Listing 3-20 shows the code for the custom easing function.

Listing 3-20. *Recipe 3.16 MyCustomEasingFunction.cs File*

```
using System;
using System.Windows.Media.Animation;

namespace Ch03_DevelopingUX.Recipe3_16
{
public class MyCustomEasingFunction : EasingFunctionBase
  {
public MyCustomEasingFunction()
: base()
    {

    }
protected override double EaseInCore(double normalizedTime)
    {
return Math.Sqrt(normalizedTime);
    }
  }
}
```

We do not show additional screenshots because static images do not represent the animations well. Check out the sample to see the differences and try some other variations.

3-17. Adding Pixel Shader Visual Effects

Problem

You want to add visual special effects to your Silverlight application, such as making a photo black and white or applying a distortion to an image.

Solution

Take advantage of the support for both built-in and custom pixel shaders in Silverlight.

How It Works

Pixel shaders have long been used in game development to provide the spectacular visual effects available in major console and computer game video game releases. Silverlight 3 introduced support for pixel shaders, including two built-in effects: drop shadows and motion blur. It also includes support for incorporating custom pixel shaders for even more compelling content.

Pixel-shader effects in Silverlight are rendered in software—they are not GPU accelerated. Applying effects to large portions of a UI or animating properties of effects can affect performance. Therefore, you need to thoroughly test applied effects to ensure good performance.

To apply an effect, you configure the `Effect` property on descendents of the `UIElement` base class. To manipulate effects programmatically, add this namespace to your code-behind:

```
System.Windows.Media.Effects
```

Only one effect can be applied at a time directly on a `UIElement`. One way to apply multiple effects is to apply one effect directly on the `UIElement` and other effect on a parent object. Effects applied to parent `UIElements` are also applied to child `UIElements`. Note that applying multiple pixel-shader effects can affect performance.

Pixel-shader effects are written in High Level Shading Language (HLSL) for DirectX. This link has more information about HLSL:

```
http://msdn.microsoft.com/en-us/library/bb509561(VS.85).aspx
```

Many books cover HLSL development, as does the documentation for the DirectX SDK. In addition, the DirectX Sample Browser that is installed when you install the DirectX SDK has links to training on pixel-shader authoring.

HLSL pixel shaders are compiled using the DirectX SDK into a format that can be used programmatically in WPF and Silverlight. Tools in the WPF Futures CodePlex project can help you integrate pixel-shader compilation in a WPF solution. The tools have been modified to work with Silverlight projects as well, now that Silverlight 3 and later supports pixel shaders. You can download the tool and instructions here:

```
http://www.codeplex.com/wpf/Release/ProjectReleases.aspx?ReleaseId=14962
```

■ **Note** You need to install the DirectX SDK to access compile-time support, in order to build the `.ps` files. It is available at `downloads.microsoft.com`. The SDK is updated frequently so please use the search functionality to obtain the latest version.

For a collection of sample pixel-shader effects, download the WPF library, which also works with Silverlight:

```
http://wpffx.codeplex.com/
```

You use these samples as part of the custom pixel effect example. You apply custom pixel-shader effects the same way you apply the built-in pixel shader effects.

The Code

This recipe uses the Silverlight Navigation Application with two view pages: one view to demonstrate the built-in pixel-shader effects, and the other view to demonstrate applying custom pixel-shader effects. We do not cover `MainPage.xaml` and `MainPage.xaml.cs` because they wire up the application. The first application page is shown in Figure 3-67.

Figure 3-67. *The built-in pixel-shader demo page*

Two built-in pixel shaders are available in Silverlight 3 and later `BlurEffect` and `DropShadowEffect`. You can build a quick sample application that applies both affects to an `Image` object. You apply the `DropShadowEffect` directly to the `Image`, because only one pixel-shader effect can be applied to a `UIElement`. To apply the `BlurEffect`, you wrap the `Image` in a `Grid` object and apply the effect there. You can manipulate the sliders to see the effect of the various parameters available on the two effects. Here is the XAML for applying an effect to the `Grid` and `Image` objects:

```
<Grid x:Name="DogImageGrid" Margin="0,0,8,0">
<Grid.Effect>
<BlurEffect Radius="1" />
</Grid.Effect>
<Image x:Name="DogImage" Margin="8"
Source="/Ch03_DevelopingUX.Recipe3_17Component/Assets/image.jpg"
HorizontalAlignment="Center" VerticalAlignment="Top">
<Image.Effect>
<DropShadowEffect/>
</Image.Effect>
</Image>
</Grid>
```

You configure the `Radius` property to 1 for the `BlurEffect` applied to the `Grid` so that it doesn't alter the settings on the `DropShadowEffect` effect applied to the `Image`. Leave the default settings applied to the `DropShadowEffect`; the effect controls are also configured with the defaults.

The other application page in the UI demonstrates custom pixel-shader effects. Be sure to follow the steps in the "How Do I" section of this recipe to configure your development environment as well

as download and install the necessary tools. You should also download the sample Pixel Shader Effects library available here, because it provides many useful sample effects:

```
http://wpffx.codeplex.com/
```

Demonstration videos are also available at this link. Extract the WPFSLFx folder to a directory of your choice. You can find the HLSL source code (.fx) files for the compiled pixel shaders in the WPF version of the ShaderEffectLibrary project. When you open the WPF project and select a .fx file, you se that its Build Action is set to Effect, taking advantage of the Visual Studio tools to integrate compiling the effect. To use it in Silverlight, copy the .ps output and add it to a Silverlight project.

Under the WPFSLFx folder in the SL folder are three projects. The SLShaderEffectLibrary and SLTransitionEffects projects contain the sample pixel-shader effects. Open the SLShaderEffectLibrary to find 23 compiled pixel-shader effects (.ps) in the ShaderSource folder; they were compiled using the DirectX SDK from .fx files. The .ps files are configured as a resource in the Silverlight project in the ShaderSource folder.

Each .ps file has a corresponding .cs class file in the EffectFiles folder. Look at the BandedSwirlEffect.cs file to see how to integrate the .ps compiled pixel shader. The class BandedSwirlEffect inherits from the ShaderEffect base class. In the constructor's code region, a static constructor creates an instance of the PixelShader class, setting the UriSource to the .ps file stored as a resource in the assembly.

The WPF project includes a nonstatic constructor to instantiate the effect as well as dependency properties that represent the properties declared in the BandedSwirl.fx HLSL source code file:

```
float2 center : register(C0);
float spiralStrength : register(C1);
float distanceThreshold : register(C2);
```

In the Silverlight project, the BandedSwirlEffect.cs code file contains three dependency properties that are linked to the corresponding pixel-shader registry like this:

```
public static readonly DependencyProperty CenterProperty =
DependencyProperty.Register("Center", typeof(Point),
typeof(BandedSwirlEffect),
new UIPropertyMetadata(new Point(0.5, 0.5),
PixelShaderConstantCallback(0)));
```

The method PixelShaderConstantCallback is a helper function available in Silverlight. It associates a dependency property value with a pixel shader's float constant register. Now that we have provided an overview of the process to integrate pixel shaders in Silverlight, you can copy the compiled output from the SLShaderEffectLibrary included with the WPF pixel-shader library provided by Microsoft on CodePlex to the sample code and apply custom effects to the same photograph used in the first example.

Drop a copy of SLShaderEffectLibrary.dll into the Recipe3.21 folder, and add a reference to it in the Recipe 3-21 project. Next, copy the UI from the first example; but remove the blur and drop shadow effects in Expression Blend by clicking the Advanced Options button for the Effect property and clicking Reset as well as the related controls for manipulating the pixel-shader settings.

Build the project, and switch to Expression Blend to apply a custom pixel-shader effect. Select the DogImage Image control, and click New next to the Effect property. Figure 3-68 shows that the SLShaderEffectLibrary is now available in the visual tools; you can see all the newly available pixel shaders you can test, including the BandedSwirlEffect we covered earlier.

Select BandedSwirlEffect as the test custom effect, and click OK. Figure 3-69 shows the immediate effect of the pixel shader on the image in the Expression Blend design surface.

Figure 3-68. *The newly available pixel-shader effects in Expression Blend*

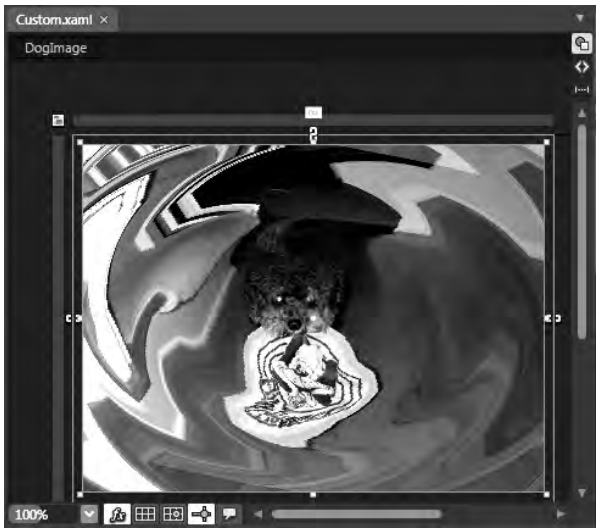


Figure 3-69. *The BandedSwirlEffect applied in Expression Blend*

The effect has a fish-eye appearance that would be interesting to animate as a way to bring a picture into view. To demonstrate animating the effect, first set the image to an `Opacity` of 0 as the starting point.

Next, create a new `Storyboard` in Expression Blend, and call it `DogImageStoryboard`. Create a keyframe at the starting point, and move the yellow time line to 1.5 seconds; set `Opacity` back to 100%, because you want the image to take 1.5 seconds to come into view. Expand `DogImage` in the Objects and Timeline window, and select the `BandedSwirl` property.

Here you can create keyframes between 0 and 1.5 seconds in the time line to animate the banded swirl. Add a couple of keyframes and adjust the `SwirlStrength` property on the `BandedSwirlEffect`, eventually setting it to 0 at 1.5 seconds so the image looks normal. Create a few more keyframes, experimenting with various settings and playing the animation in Expression Blend to see the results.

Finally, add a button to the UI to kick off the `Storyboard`. Run the sample code to see the results. We do not show the sample code for this recipe because most of the code is generated in Expression Blend from the earlier steps, and the code-behind contains minimal code. We recommend opening the `Custom.xaml` page in Expression Blend and playing around with the time line to see how you can improve the animation, or select a different pixel shader in the `SLShaderEffectLibrary` for a different approach.

3-18. Create and Work with Design-Time Data in Expression Blend

Problem

You want to create a data-driven UI without having to run the application in order to see the results.

Solution

Take advantage of the support in Expression Blend 3 and later for design-time datasources.

How It Works

With Expression Blend 3 and later you have access to the Data panel shown in Figure 3-70. Its features are listed in Table 3-4.

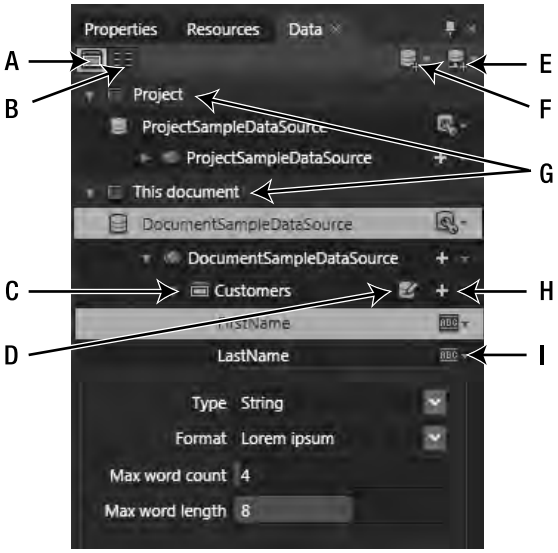


Figure 3-70. *The Data panel in Expression Blend 4*

Table 3-4. *Expression Blend 4 Data Panel Features*

Annotation	Description
A	Selected by default, list mode for the Data panel lets you drag the `Customers` collection shown in Figure 3-71 onto the Artboard and generates a `ListBox` data-bound to the `Customers` design-time datasource.
B	Details mode lets you drag a collection item like `FirstName` to the Artboard to create a control data-bound to the collection item. This action also configures the `DataContext` property of the parent container to the collection, in this case `Customers`.
C	This is a document-level datasource collection named `Customers`. In addition, a datasource named `ProjectSampleDataSource` is defined at the Project level.
D	Click this button to edit and further customize the collection. You can specify the type of value (`String`, `Number`, `Boolean`, or `Image`) as well as the format (for `String`, how many words; for `Number`, how many digits; and for `Image`, a folder location).
E	The "Create data source" button allows you to add a live or real datasource to the application to display at runtime.
F	The "Create sample data" button allows you to create a design-time datasource to help working with UI elements that display data.
G	You can define datasources at the document and project levels of an application.

Annotation	Description
H	Click the plus sign to add a simple property to a datasource collection, or click the down-arrow next to the plus sign to choose whether to add a simple property, a complex property, or a collection property to the design-time datasource.
I	Click the down-arrow for an individual property to edit the attributes for the property, such as its type and format, depending on the type of the property.

When you click the "Add sample data source" button shown as item F in Figure 3-70, it displays the dialog shown in Figure 3-71. You have the option of enabling the sample datasource at runtime as well, which is great for demonstrating the data-driven UI.

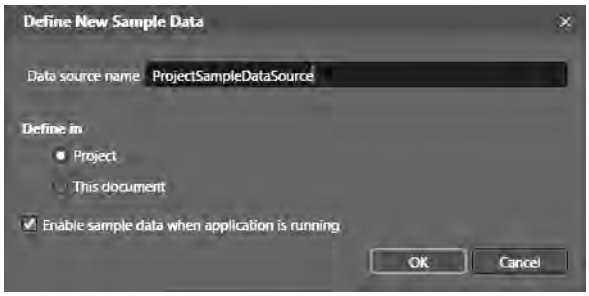


Figure 3-71. *The Define New Sample Data Dialog*

This allows you to work with the design-time data in Expression Blend while also displaying the design-time data at runtime for testing and demonstration purposes. You can also add a live datasource to the UI that pulls data from a live datasource for display at runtime, by clicking item E in Figure 3-70. As long as your schema is compatible between the design-time datasource and the live datasource, you can use both in an application. Let's say you start working with a design-time datasource to build your application. You add a live datasource to the Data panel in Expression Blend to make it available. Drag items from the live datasource, and drop them onto the control displaying the corresponding sample data.

■ **Note** Clear the Enable When Running Application check box in the datasource properties to allow the live datasource to display data at runtime.

As long as the data schemas match, the sample data displays on the Artboard in Expression Blend and the live data displays when the application executes. This is because the sample datasource bindings are still available in the design-time properties.

The Code

This recipe borrows the `ApressBooks` class from Recipe 2-9 to serve as the live datasource. This class reads an XML file called `ApressBooks.xml` that is included as content within the project and that has the following structure:

```
<ApressBooks>
<ApressBook>
<ID/>
<ISBN/>
<Author/>
<Title/>
<Description/>
<DatePublished/>
<NumPages/>
<Price/>
</ApressBook>
  …
</ApressBooks>
```

Listing 3-21 shows the `ApressBooks.cs` class file that reads the XML file to produce a C# `List` object of type `ApressBooks`.

Listing 3-21. *Recipe 3.18 ApressBooks Class File*

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Xml;
using System.Xml.Linq;

namespace Ch03_DevelopingUX.Recipe3_18
{
public class ApressBooks
  {
private List<ApressBook> _apressBookList;
public List<ApressBook> ApressBookList
    {
get
      {
if (null == _apressBookList)
RetrieveData();
return _apressBookList;
      }
    }
```

```
private void RetrieveData()
    {
XmlReaderSettings XmlRdrSettings = new XmlReaderSettings();
XmlRdrSettings.XmlResolver = new XmlXapResolver();
XmlReader reader = XmlReader.Create("ApressBooks.xml", XmlRdrSettings);
XDocument xDoc = XDocument.Load(reader);
_apressBookList =
(from b in xDoc.Descendants("ApressBook")
select new ApressBook()
         {
Author = b.Element("Author").Value,
Title = b.Element("Title").Value,
ISBN = b.Element("ISBN").Value,
Description = b.Element("Description").Value,
PublishedDate = Convert.ToDateTime(b.Element("DatePublished").Value),
NumberOfPages = b.Element("NumPages").Value,
Price = b.Element("Price").Value,
ID = b.Element("ID").Value
}).ToList();
    }
  }

public class ApressBook
  {
public string Author { get; set; }
public string Title { get; set; }
public string ISBN { get; set; }
public string Description { get; set; }
public DateTime PublishedDate { get; set; }
public string NumberOfPages { get; set; }
public string Price { get; set; }
public string ID { get; set; }
  }
}
```

After adding a reference to `System.Xml.Linq`, everything compiles, and you are ready to experiment with the new data panel features.

Start by clicking the "Create sample data" button on the Expression Blend 4 Data panel and select "New Sample Data…"to bring up the dialog shown in Figure 3-71. Name the datasource `ApressBooksSampleData`, and click `OK`. Also enable sample data when the application is running. Doing so sets the `DataContext` for the parent `Grid` named `LayoutRoot` to the sample datasource. If you unselect the option to display sample data at runtime, the sample datasource is configured on `d:DataContext`, not to the `DataContext` attribute. The `d:` namespace specifies that the property is valid only at design-time in Expression Blend 3 or later and is ignored at runtime.

This generates a new project-level sample datasource with two properties named `Property1` and `Property2`. Double-click the property names to edit then: change `Property1` to `ISBN` and `Property2` to

`Title`, and change the default generated type for `Property2` to `String` instead of `Boolean`. Add a new property of type `String`, and name it `Description`. Also change the maximum word count to 20 from the default of 4 for the `Description` property, because it may contain many words. Finally, change the default name of `Collection` to `ApressBookCollection`.

Drag the `ApressBookCollection` item located under the `ApressBooksSampleData` item in the Data panel to the Artboard, to generate a `ListBox` control data bound to the sample data. Resize the `ListBox` to fill the available area. Figure 3-72 shows the sample data displayed in Expression Blend 4 at design-time.

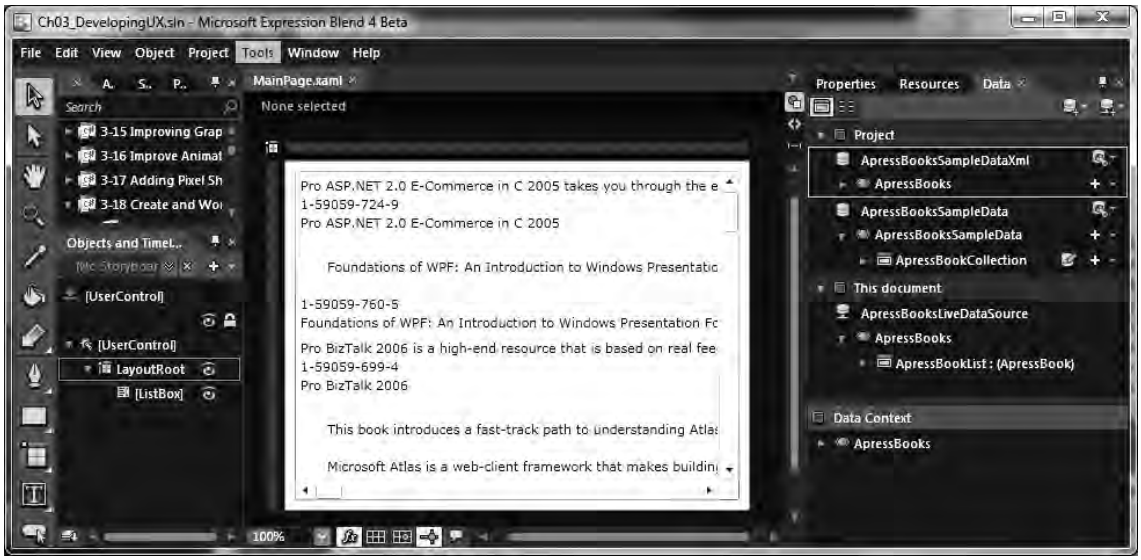


Figure 3-72. *Sample data displayed at design-time*

You can now edit the template by selecting the `ListBox`'s `ItemTemplate` property and selecting Edit Resource from the advanced property menu. Rearrange the generated `ItemTemplate` so that `ISBN` is at the top followed by `Title` and then `Description`.

The text generated by the sample data is the generic Latin you may have seen in PowerPoint or elsewhere. You can edit the sample data manually by clicking the Edit Sample Values button for the collection, which results in the dialog shown in Figure 3-73.

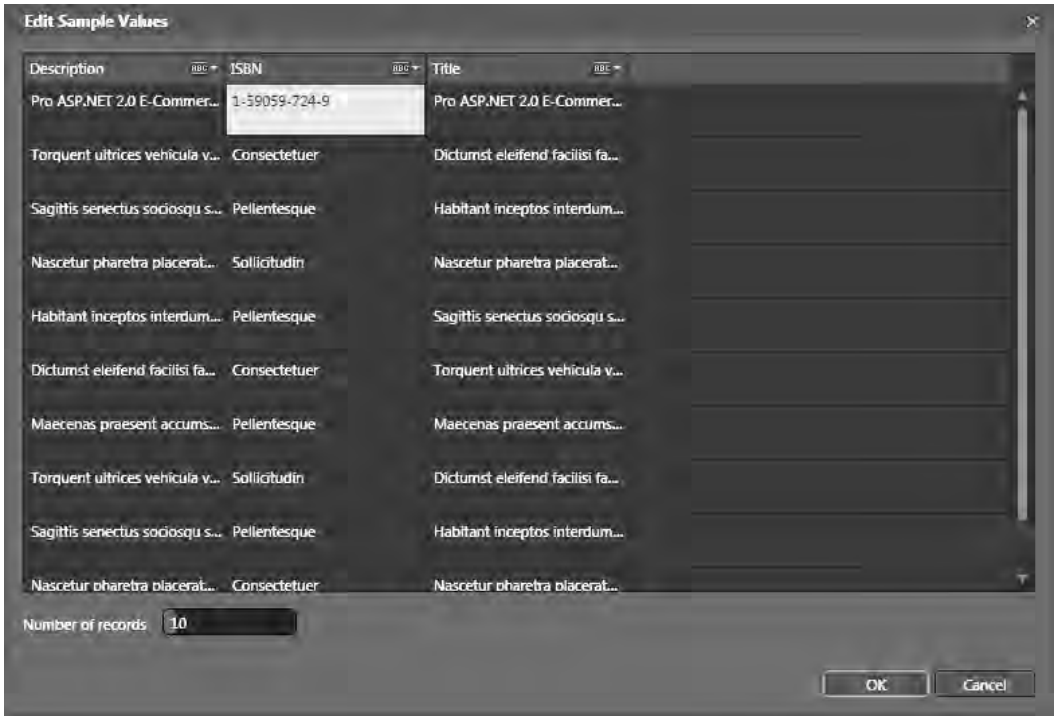


Figure 3-73. *Edit Sample Values dialog*

Manually editing a small amount of data for a simple UI may be acceptable, but it can get old for a large, complex datasource. This is when the Import Sample Data from XML menu option comes in handy. Select this option by clicking the Create Sample Data button and point it to the `ApressBooks.xml` file, name it ApressBookSampleDataXml to generate the datasource shown in Figure 3-74.

All the fields are added by default when you import sample data from an XML file. Next, modify the fields to just the three you are currently working with as part of the manually created sample data: `ISBN`, `Title`, and `Description`. As before, you can drag the new XML datasource onto the `ListBox` to update the design-time datasource so that real data is displayed; see Figure 3-75.

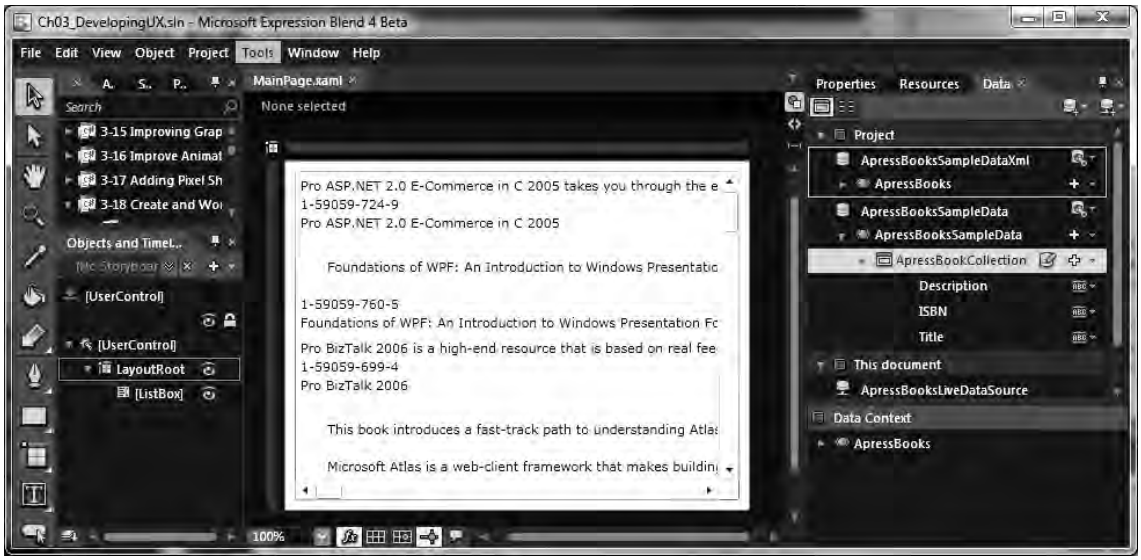


Figure 3-74. *XML-based sample datasource in the Data panel*

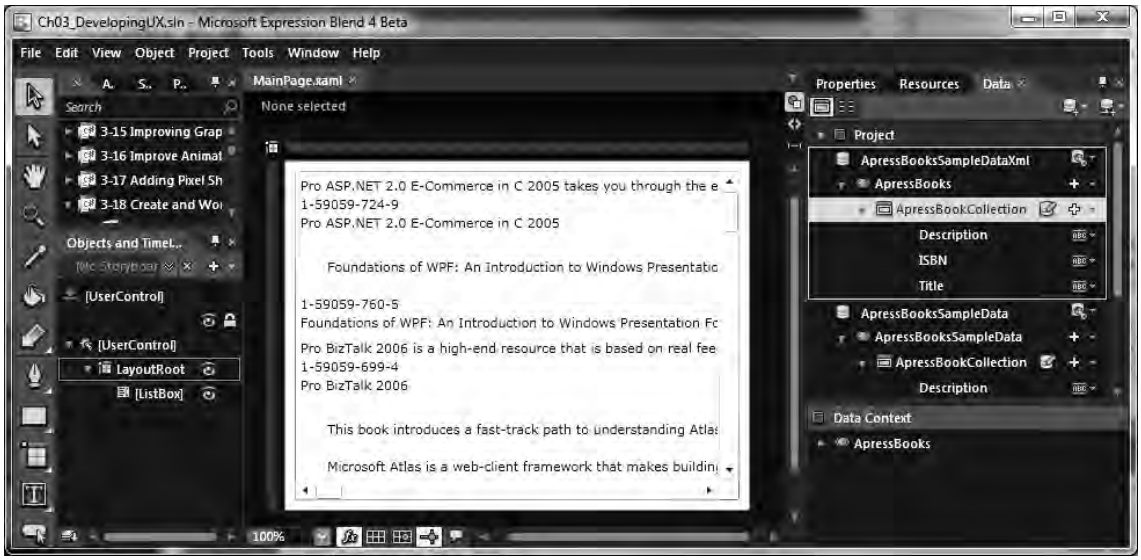


Figure 3-75. *Real data imported via XML*

To display live data at runtime, click the "Create data source" button and select Create Object Data Source… in the Data panel to display the dialog box shown in Figure 3-76. Choose the ApressBooks object.

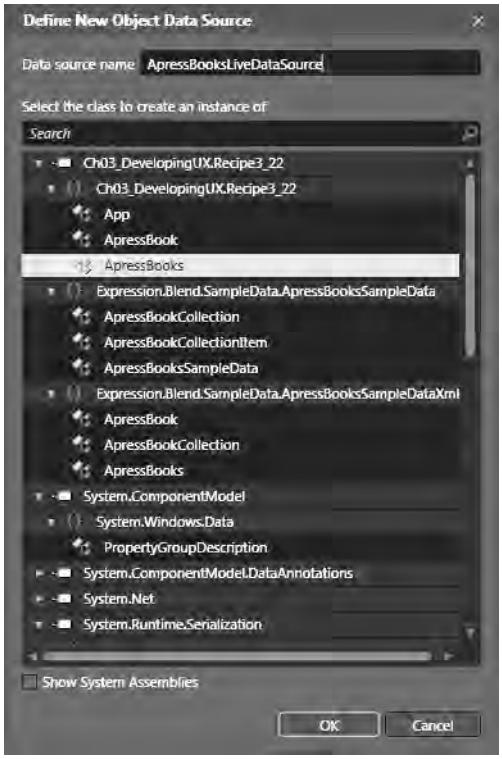


Figure 3-76. *Displaying real data imported via XML*

Switch the design-time datasource back to the manually created datasource by dragging it onto the `ListBox` in Expression Blend 4. Doing so demonstrates that the different datasources are automatically displayed depending on whether you are at design-time or runtime: the live datasource is displayed at runtime.

When you run the application with the manually created datasource, the first record is the edited record with the manually typed-in data, but the rest of the items are generated Latin data. At design-time, uncheck the Enable When Running the Application option for the manually created datasource. When you run the recipe sample in this state, no data is displayed at runtime.

To enable the live datasource on the `ListBox`, drag the ApressBookList: (`ApressBook`) item (under the `ApressBooksLiveDataSource | ApressBooks` item in the hierarchy) to the UI, dropping it onto `LayoutRoot` so that the mouse cursor says Bind LayoutRoot.DataContext to ApressBooksLiveDataSource. This action assigns the live datasource you just created to the `DataContext` property. Listing 3-22 shows the `MainPage.xaml` file.

Listing 3-22. *Recipe 3.18 MainPage.xaml File*

```
<UserControl
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"
```

```
x:Class="Ch03_DevelopingUX.Recipe3_18.MainPage"
mc:Ignorable="d"
d:DesignHeight="300" d:DesignWidth="400">
<UserControl.Resources>

<DataTemplate x:Key="ApressBookCollectionItemTemplate">
<StackPanel>
<TextBlock Text="{Binding Description}"/>
<TextBlock Text="{Binding ISBN}"/>
<TextBlock Text="{Binding Title}"/>
</StackPanel>
</DataTemplate>
</UserControl.Resources>
<Grid x:Name="LayoutRoot" Background="White"
d:DataContext="{Binding Source={StaticResource ApressBooksSampleData}}"
DataContext="{Binding Source={StaticResource ApressBooksLiveDataSource}}">
<ListBox Margin="8"
ItemTemplate="{StaticResource ApressBookCollectionItemTemplate}"
ItemsSource="{Binding ApressBookList}" />
</Grid>
</UserControl>
```

You can see in Listing 3-22 the `DataContext` and `d:DataContext` properties configured on the `LayoutRoot Grid` control to the design-time and runtime datasources. Initially, when you run the code, no data is displayed, because the design-time datasource collection name is `ApressBookCollection`. However, on the live datasource, the name is `ApressBookList`. In order to have the design-time and runtime datasources work properly, the collection names must be the same. When this is corrected, the datasources work as expected.

We do not show any of the code-behind files because there is no custom code to discuss. The only other code we show here in Listing 3-23 is `App.xaml`, where the three project-level datasources are created.

Listing 3-23. *Recipe 3.18 App.xaml File*

```
<Application 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:SampleData1="clr-namespace:Expression.Blend.SampleData.ApressBooksSampleData"
mc:Ignorable="d" xmlns:local="clr-namespace:Ch03_DevelopingUX.Recipe3_18"
xmlns:SampleData="clr-namespace:Expression.Blend.SampleData.ApressBooksSampleDataXml"
x:Class="Ch03_DevelopingUX.Recipe3_18.App">
<Application.Resources>
<local:ApressBooks x:Key="ApressBooksLiveDataSource" d:IsDataSource="True"/>
<SampleData:ApressBooks x:Key="ApressBooksSampleDataXml"
d:IsDataSource="True"/>
<SampleData1:ApressBooksSampleData x:Key="ApressBooksSampleData"
```

```
d:IsDataSource="True"/>
</Application.Resources>
</Application>
```

Design-time datasources exist in generated classes created in a project folder named `SampleData`, which is added by Expression Blend when the datasources are created. In this folder is a subfolder that corresponds to each design-time datasource. Figure 3-77 shows the generated folders and code files.

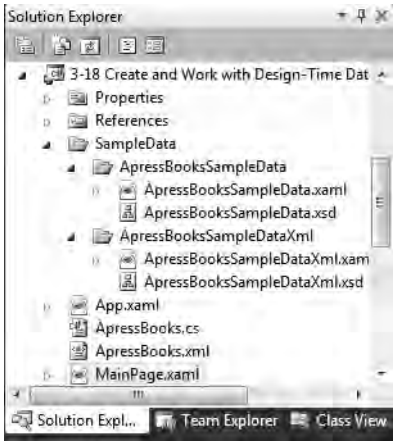


Figure 3-77. *The sample data's generated classes and schema*

3-19. Reuse Application Interactivity with Behaviors

Problem

You want to reuse designed interactivity across UI elements and applications.

Solution

Take advantage of the support for Expression Blend behaviors and triggers that is available via the Expression Blend SDK, in the samples that ship with Expression Blend, and in examples available online.

How It Works

An Expression Blend 3 or later *behavior* is a reusable piece of interactivity that can be applied directly to UI elements in Expression Blend. Using the Expression Blend 4 SDK, you can create reusable libraries of behaviors that can be shared within a team, allowing interactivity to be applied in a consistent manner across a project.

Behaviors can be as simple as playing and stopping an animation; or they can be more complex, such as applying a realistic physics effect to an object. Figure 3-78 shows the Assets library filtered on Behaviors in Expression Blend 4.

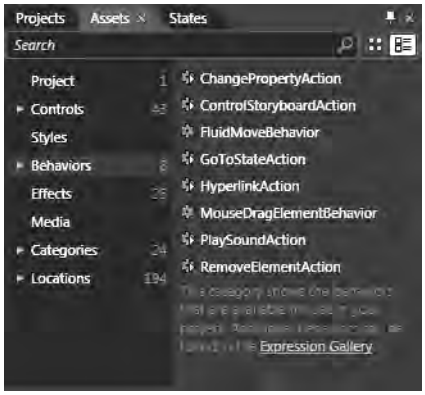


Figure 3-78. *Behaviors that ship with Expression Blend 4*

To apply a behavior, drag it onto an element and configure its properties. We go through this process in the next section.

The Code

To try using a behavior, add a `Rectangle` element to the Artboard. You want to play one sound when the user moves the mouse over the `Rectangle` and then play another sound when the user moves the mouse outside of the `Rectangle` element.

In Silverlight 2, you would have had to write code to play the sound in the `MouseEnter` and `MouseLeave` event handlers, which seems like overkill when you consider that for a complex UI, many event handlers perform relatively simple tasks. That is the beauty of behaviors and triggers: they encapsulate simple to complex actions into markup, allowing for reuse.

For this example, drag a `PlaySoundAction` behavior from the Assets panel, drop it onto the `Rectangle`, and name it `EnterSound`. Do this step a second time, but name the second `PlaySoundAction` behavior `LeaveSound`. The `PlaySoundAction` behavior is added as a child object in the object tree, as shown in Figure 3-79.

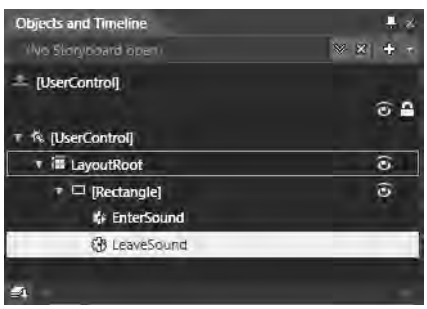


Figure 3-79. *Newly added behaviors nested under a target element*

The next step is to configure the properties for the behaviors to play a sound on the appropriate event. We recorded two sounds called Enter Rectangle and Leave Rectangle so you have some

copyright-free (albeit cheesy) sounds to work with. Add both `.wma` files to the project with Build Action set to `Content` in Visual Studio 2010.

Moving back to Expression Blend 4, select the `EnterSound` behavior, and configure its properties by dragging the target symbol next to the `SourceName` property and dropping it on the `Rectangle` UI element. This step adds a default name of `rectangle` to the element and configures it as the `SourceName` element. Change `EventName` to `MouseEnter` as the trigger, and configure the `Source` property by browsing to the sound file in the project folder. Expression Blend is smart enough to change the file path to a relative path because the sound files are part of the project. Figure 3-80 shows the configuration for the `EnterSound PlaySoundAction` behavior.

Figure 3-80. `EnterSound PlaySoundAction` *configuration*

When you run the sample, there is a slight delay between the action and the sound, which is a result of us pausing about a second when we edited the sound—the sound plays immediately, but the recording includes about a second of dead space.

With respect to creating your own behaviors, many example behaviors are available for review online. The Expression Blend 4 Community Site has several behaviors available for download:

```
http://gallery.expression.microsoft.com/en-
us/site/search?f%5B0%5D.Type=RootCategory&f%5B0%5D.
Value=behaviors
```

Several additional example Expression Blend behaviors and triggers are available for download at `http://expressionblend.codeplex.com/`. The examples from CodePlex install into this directory: `C:\Program Files (x86)\Microsoft Expression\Blend 4 Samples`.

3-20. Customizing the Right-Click Context Menu

Problem

You want to improve user experience by taking advantage of the context menu to provide a more familiar experience.

How it Works

In Silverlight, when you right click on the Silverlight control you get the default menu as shown in Figure 3-81 that displays "Silverilght."

Figure 3-81. *Right-click on a Silverlight application*

This seems like a lost opportunity to add more interactivity to an application. In Silverlight 4 Microsoft adds the ability to customize the context menu to display any XAML you would like via the `Popup` control. This is enabled by the new `MouseRightUp` and `MouseRightDown` events.

You can place XAML within a `Popup` control that you can show and hide by setting `Popup.IsOpen` to either `true` or `false`.

To position the `Popup` near where the mouse right-click occurs you can get the click position and set the `Popup.HorizontalOffset` and `Popup. VerticalOffset` to near the click position.

The Code

For this recipe, we create a simple example that loads an image and allows a user to right-click on the image to adjust a blur and drowshadow effect applied to the image. Figure 3-82 shows the initial UI.

Figure 3-82. *Recipe 3-20 Initial UI*

Now that we have the initial UI, we add a Popup item to the designer in Expression Blend and proceed to add a few TextBlock and slider objects to create a UI that manipulates the applied shader effects as shown in Figure 3-83.

Figure 3-83. *The Popup at design-time in Expression Blend*

To add the UI items, we select the PopUp object and double click on the items we want to add in the Asset Bar. Expression Blend won't let you select children in the `Popup` object on the ArtBoard so we then proceed to edit properties for each object to position them as desired in the Properties tool window.

We now switch to Visual Studio to add the code in the slider `ValueChanged` event handlers to adjust the shader effects. We don't go into detail on adjusting the shader effects because we cover that in Recipe 3-17 but we do want to cover how to react to right-clicks to open, position, and close the `Popup` right-context menu.

In the `MouseRightButtonDown` event, we set `e.Handled = true` to prevent the Silverlight menu from appearing. If the user clicks outside of the `Popup` menu it should automatically close so we set `Popup.IsOpen` equal to false in the `MouseLeftButtonDown` event.

In order to position the `Popup` object near the menu click, we put the following code in the `MouseRightButtonUp` event:

```
pop.HorizontalOffset = e.GetPosition(null).X + 2;
pop.VerticalOffset = e.GetPosition(null).Y + 2;
pop.IsOpen = true;
```

Listing 3-24 has the full code-behind listing.

Listing 3-24. *Recipe 3.19 MainPage.xaml.cs File*

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Net;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Input;
using System.Windows.Media.Effects;
namespace Ch03_DevelopingUX.Recipe3_20
{
public partial class MainPage : UserControl
  {
public MainPage()
    {
InitializeComponent();
    }

private void ImageEdit_MouseRightButtonDown(object sender, MouseButtonEventArgs e)
    {
e.Handled = true;
    }

private void ImageEdit_MouseRightButtonUp(object sender, MouseButtonEventArgs e)
    {
pop.HorizontalOffset = e.GetPosition(null).X + 2;
pop.VerticalOffset = e.GetPosition(null).Y + 2;
```

```
pop.IsOpen = true;
    }

private void SliderDropShadowBlur_ValueChanged(object sender,
RoutedPropertyChangedEventArgs<double> e)
    {
if (null != ImageEdit)
((DropShadowEffect)ImageEdit.Effect).BlurRadius = e.NewValue;
    }

private void SliderBlur_ValueChanged(object sender, RoutedPropertyChangedEventArgs<double>
e)
    {
if (null != ContainerGrid)
((BlurEffect)ContainerGrid.Effect).Radius = e.NewValue;
    }

private void ImageEdit_MouseLeftButtonDown(object sender, MouseButtonEventArgs e)
    {
pop.IsOpen = false;
    }

private void SliderDropShadowDepth_ValueChanged(object sender,
RoutedPropertyChangedEventArgs<double> e)
    {
if (null != ImageEdit)
((DropShadowEffect)ImageEdit.Effect).ShadowDepth = e.NewValue;
    }
  }
}
```

Figure 3-84 shows the application in action.

Figure 3-84. *Final output with shader effects adjusted*

3-21. Accessing the Clipboard

Problem

You need to allow users to cut, copy, and paste text via the Clipboard.

How it Works

Silverlight 4 added a new `Clipboard` class to the `System.Windows` namepace. It has three static methods available to work with clipboard data:

- `SetText` – Places text on the clipboard
- `ContainsText` – Checks whether the clipboard contains text
- `GetText` – Retrieves text from the clipboard

When a `Clipboard` method is called in an event handler, the user is prompted on whether to allow access to the clipboard as shown in Figure 3-85

Figure 3-85. Security prompt for clipboard access

if the application is a trusted out-of-browser application you are not prompted and the clipboard access works just like in any other .NET program. In general, whether in browser or out-o-browser, the clipboard access works only for text. There isn't support for items like images, etc.

The Code

The code for this recipe is fairly simple. We have three buttons labled Cut, Copy, and Paste with two TextBox controls with the TextBox on the left containing Lorem ipsum text as shown in Figure 3-86.

Figure 3-86. Initial Test UI

Select text in the left TextBox and then click cut or copy to place the text on the clipboard. Click paste and the text is added to the TextBox on the right. Listing 3-25 has the XAML and Listing 3-26 has the .cs file for MainPage.

Listing 3-25. *Recipe 3.21 MainPage.xaml File*

```
<UserControl x:Class="Ch03_DevelopingUX.Recipe3_21.MainPage"
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:Ch03_DevelopingUX.Recipe3_21"
mc:Ignorable="d"
d:DesignHeight="300" d:DesignWidth="400">

<Grid x:Name="LayoutRoot" >
<Grid.Background>
<LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
<GradientStop Color="#FF2D2D2D" Offset="0"/>
<GradientStop Color="#FF858484" Offset="1"/>
</LinearGradientBrush>
</Grid.Background>
<TextBlock Height="19" Margin="130,8,130,0" TextWrapping="Wrap"
Text="Clipboard Demonstration" VerticalAlignment="Top"
Foreground="White"/>
<TextBox Margin="8,45,0,92" TextWrapping="Wrap" Foreground="White"
Text="Lorem ipsum dolor sit amet, consectetur
Background="{x:Null}" HorizontalAlignment="Left" Width="173"
x:Name="SourceText" />
<TextBox Margin="0,45,8,92" TextWrapping="Wrap" Background="{x:Null}"
Foreground="White" HorizontalAlignment="Right" Width="173"
x:Name="DestinationText" />
<Button x:Name="btnCopy" Content="Copy" HorizontalAlignment="Left"
VerticalAlignment="Bottom" Width="75" Margin="106,0,0,45"
Click="btnCopy_Click" />
<Button x:Name="btnCut" Content="Cut" HorizontalAlignment="Left"
VerticalAlignment="Bottom" Width="75" Margin="8,0,0,45"
Click="btnCut_Click" />
<Button x:Name="btnPaste" Content="Paste" HorizontalAlignment="Right"
VerticalAlignment="Bottom" Width="75" Margin="0,0,57,45"
Click="btnPaste_Click" />
</Grid>
</UserControl>
```

Listing 3-26. *Recipe 3.21 MainPage.xaml.cs File*

```
using System.Linq;
using System.Windows;
using System.Windows.Controls;

namespace Ch03_DevelopingUX.Recipe3_21
{
public partial class MainPage : UserControl
  {
public MainPage()
    {
InitializeComponent();
    }

private void btnCut_Click(object sender, RoutedEventArgs e)
    {
Clipboard.SetText(SourceText.SelectedText);
SourceText.Text = SourceText.Text.Remove(
SourceText.Text.IndexOf(SourceText.SelectedText),
SourceText.SelectedText.Count());
    }

private void btnCopy_Click(object sender, RoutedEventArgs e)
    {
Clipboard.SetText(SourceText.SelectedText);
    }

private void btnPaste_Click(object sender, RoutedEventArgs e)
    {
DestinationText.Text += Clipboard.GetText();
}
  }
}
```

3-22. Using Right-to-Left Text

Problem

You need to display text right-to-left for languages that naturally flow right-to-left such as Arabic.

How it Works

Silverlight 4 adds a `FlowDirection` property to the `FrameworkElement` base class that lets developers configure whether text flows left-to-right (default) or right-to-left.

The Code

The code for this recipe is very simple with two TextBox controls that are configured to display their text in a different flow direction. Figure 3-87 shows the UI.

Figure 3-87. `Security prompt for clipboard access`

The flow for right to left makes much more sense if you have a language that is designed for it but it is good to see the improved localization support available in Silverlight 4. Listing 3-27 and 3-28 has the code.

Listing 3-27. *Recipe 3.22 MainPage.xaml File*

```
<UserControl x:Class="Ch03_DevelopingUX.Recipe3_22.MainPage"
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"
mc:Ignorable="d"
d:DesignHeight="300" d:DesignWidth="400" >

<Grid x:Name="LayoutRoot" Background="White">
<TextBox Height="115" HorizontalAlignment="Left" Margin="12,30,0,0"
```

```
Name=”textLeftToRight” VerticalAlignment=”Top” Width=”376” Text=””
TextWrapping=”Wrap” />
<TextBox Height=”115” HorizontalAlignment=”Left” Margin=”12,173,0,0”
Name=”textRightToLeft” VerticalAlignment=”Top” Width=”376” Text=””
TextWrapping=”Wrap” FlowDirection=”RightToLeft” />
<TextBlock Height=”17” HorizontalAlignment=”Left” Margin=”12,7,0,0”
Name=”textBlock1” Text=”Left to Right” VerticalAlignment=”Top”
Width=”376” />
<TextBlock Height=”17” HorizontalAlignment=”Left” Margin=”12,151,0,0”
Name=”textBlock2” Text=”Right to Left” VerticalAlignment=”Top”
Width=”376” FlowDirection=”RightToLeft” />
</Grid>
</UserControl>
```

Listing 3-28. *Recipe 3.22 MainPage.xaml.cs File*

```
using System.Windows.Controls;

namespace Ch03_DevelopingUX.Recipe3_22
{
public partial class MainPage : UserControl
  {
public MainPage()
    {
InitializeComponent();
textLeftToRight.Text =
“Lorem ipsum dolor sit amet, consectetur adipisicing \n”+
“elit, sed do eiusmod tempor incididunt ut labore et \n”+
“dolore magna aliqua. Ut enim ad minim veniam, quis \n”+
“nostrud exercitation ullamco”;
textRightToLeft.Text =
“Lorem ipsum dolor sit amet, consectetur adipisicing \n” +
“elit, sed do eiusmod tempor incididunt ut labore et \n” +
“dolore magna aliqua. Ut enim ad minim veniam, quis \n” +
“nostrud exercitation ullamco”;
}
  }
}
```

3-23. Prototype Application Design

Problem

You want to prototype an application design in a flexible, dynamic way using tools that support the designer/developer process.

Solution

Take advantage of Expression Blend 4 and SketchFlow to create rich, dynamic design prototypes that let designers manage the design process while providing solid integration with developers.

How It Works

In the early stages of the creative process, designers often start with pen and paper along with a stack of sticky pads and use arrows to simulate interactivity. SketchFlow provides a designer-focused toolset that supports the creative process while attempting to stay out of the way of free-flowing creativity.

SketchFlow lets designers sketch out ideas and then turn those ideas into working prototypes that are as rough or as real as the designer wants. When a designer is satisfied, the prototype can be demonstrated for review and comment using the SketchFlow player. An entire book could be dedicated to just Expression Blend 4 and SketchFlow; we provide just a quick overview to cover the highlights so that you are sufficiently aware of the capabilities to get started.

The Code

In Expression Blend 4+SketchFlow, choose File ❥ New to open the New Project dialog shown in Figure 3-88.

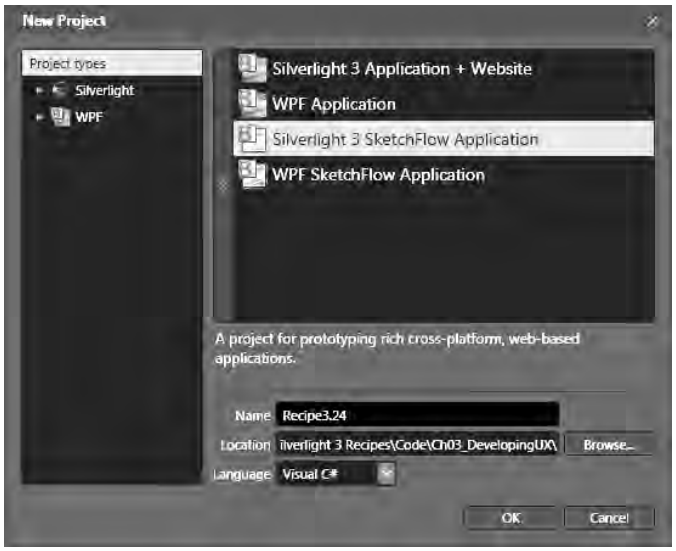


Figure 3-88. *Expression Blend 4+SketchFlow New Project dialog*

Clicking OK in Figure 3-88 generates two projects: one for the application and the other for the prototype screens that are stored in a resource dictionary. In this case, we made the project names and namespaces match the naming standards for the book's source code, resulting in two projects:

- 3-23 Prototype Application Design (the prototype application)
- 3-23 Prototype Application Design – Screens (the resource dictionary project)

Sketch a quick UI for a scuba shop named Scuba Adventures, creating a Welcome pane and a Confirm and Pay pane as shown in Figure 3-89.

Expression Blend 4+SketchFlow includes custom SketchFlow styles that are more visually conducive to the design process, providing a sketchy appearance. The controls are available in the Assets panel under Styles, as shown in Figure 3-82. Under the hood, the controls are the same ones you normally use, but with a custom look.

A more streamlined but similar animation tool is located above the Artboard in Figure 3-89 It is easy to create additional screens in the SketchFlow Map shown below the Artboard in Figure 3-89.

Under the File menu is the Package SketchFlow Project menu item, which you can use to package up the SketchFlow application for deployment on a web server for demonstration purposes. You can also build and run the project in Expression Blend to display the prototype in the SketchFlow player.

This recipe provides a quick overview of the capabilities in SketchFlow. For more information, check out the SketchFlow site:

```
http://expression.microsoft.com/en-us/ee215229.aspx
```

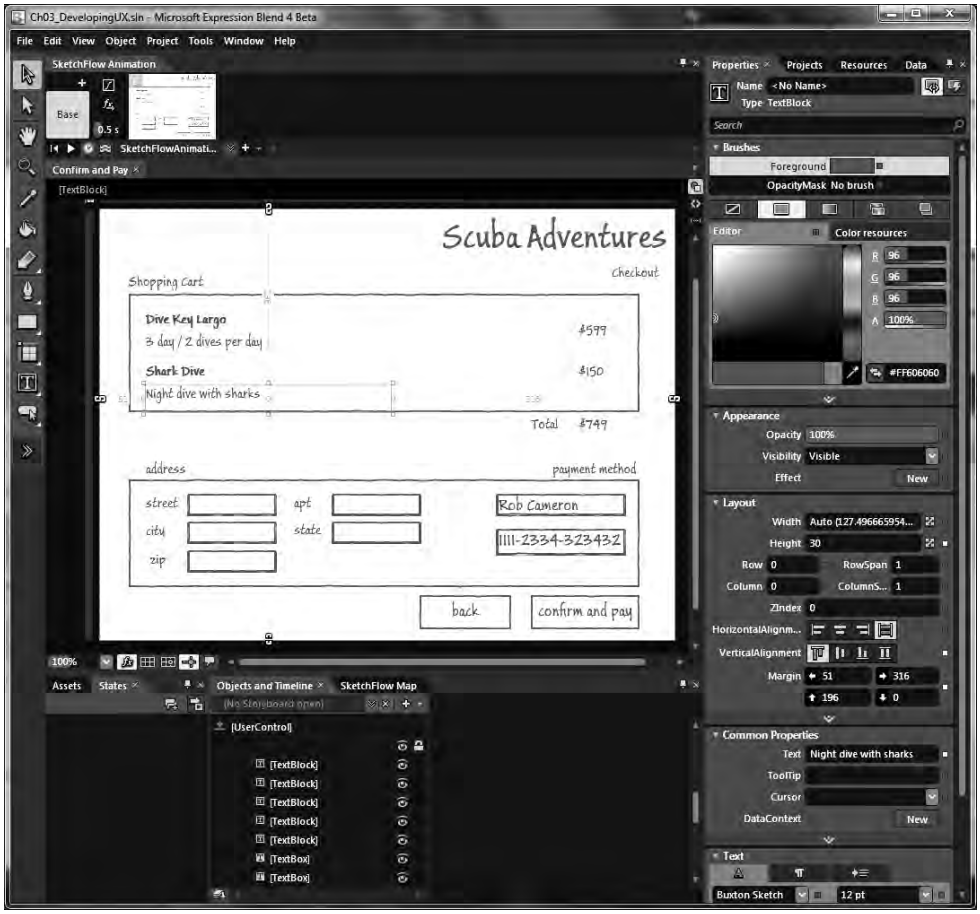


Figure 3-89. *Expression Blend 4+SketchFlow in action*

CHAPTER 4

Data Binding

All applications deal with information in some form or another. A slick user interface (UI) powered by a rich drawing and control framework can be pretty useless if there is no meaningful data to be displayed through it.

Application developers using UI frameworks like Silverlight need a powerful yet easy way of tying the application data to the UI they design. Data binding is a feature that enables just that.

Through data binding, developers can associate properties of application-level data classes to properties of UI elements. This association is evaluated at runtime, and data is automatically transferred back and forth between the UI and the business logic layer of the application (subject to additional parameters stipulated by the specific association). Such an association, called a *binding*, is implemented through the `System.Windows.Data.Binding` type.

Let's look at the recipes to see `Binding` and its associated properties in action.

4-1. Binding Application Data to the UI

Problem

You need to bind various properties on UI objects in Silverlight to application data available in managed code.

Solution

Use the `Binding` markup extension to specify the appropriate data bindings in XAML or use the `FrameworkElement.SetBinding()` method to do the same in the codebehind.

How It Works

The `Binding` markup extension or the `FrameworkElement.SetBinding()` method can be used to bind properties on instances of application data types to dependency properties defined on any type inheriting from `FrameworkElement`. The application data type properties are called the *source* properties for the binding, and the dependency properties are called the *target* properties.

Binding Expression

XAML exposes several markup extensions, one of which is `Binding`. A markup extension provides an extension to the default XAML namespaces and is used as a keyword within a set of curly braces in

your XAML document. The syntax for using the Binding extension to bind some data to a property is as follows:

```
<object targetPropertyname =
  "{Binding sourcePropertyPath, oneOrMoreBindingProperties}" .../>
```

The entire Binding statement within the curly braces, including all the property settings, is collectively called a binding expression.

The targetPropertyName points to a dependency property on the XAML element. The sourcePropertyPath is the complete, qualified path to a property in the data source object hierarchy. The dot notation can be used to indicate properties belonging to type instances that are nested within other instances. The Binding extension also exposes several properties that can be set to impact various behaviors of the binding, such as the direction of the data flow, input validation behavior, or conversion of values. We will discuss most of the properties in subsequent recipes.

Dependency Properties

Dependency properties are unique to the Silverlight runtime and have some differences compared with standard .NET properties. One of the major differences is that a target property needs to be a dependency property to allow data binding. We introduced dependency properties in Chapter 2 and provide additional background on the Silverlight dependency property system in Chapter 5. You can also read about dependency properties in the Silverlight SDK documentation.

Associating the Data Source

The data source is a CLR object, and the source properties are public properties with at least public get accessors defined. The data source can be set as the DataContext on the element at the level where the binding is being set or on a containing element, thus making it automatically available as the DataContext to all children elements. The following is an example of using the DataContext, where a CLR type declared as a resource named CLRDS_Company is being used as the data source on the Grid and the Text property on a contained TextBlock is being bound to the Street property on the data source object:

```
<Grid x:Name="LayoutRoot" Background="White"
    DataContext="{StaticResource CLRDS_Company}">
  <TextBlock Text="{Binding Street}"/>
</Grid>
```

The data source can also be set as the Source property on the binding itself. This may be necessary if the data for the elements in your UI came from different data sources and just providing a higher-level DataContext was not enough. A sample of the syntax for that would look like the following, where the Source can be set to a different data source than the one defined in the data context:

```
<TextBlock Text="{Binding Name,Source={StaticResource SomeOtherDS}}"/>
```

In either case, you can define the data source by referencing a CLR type as a resource in your XAML, as shown here:

```
<UserControl.Resources>
  <local:Company x:Key="CLRDS_Company" />
</UserControl.Resources>
```

The `local:` prefix is a custom namespace defined to bring in the `Company` type. Both custom namespace mapping and the `StaticResource` extension used to reference such resources in XAML were covered in detail in Chapter 2.

The Code

The CLR object model shown in Listing 4-1 is being used as the application data source for this sample.

Listing 4-1. *Application Data Classes*

```
using System.Collections.Generic;

namespace Recipe4_1
{
  public class Employee
  {
    public string FirstName { get; set; }
    public string LastName { get; set; }
    public long PhoneNum { get; set; }
  }
  public class Company
  {
    public string Name { get; set; }
    public string Street { get; set; }
    public string City { get; set; }
    public string State { get; set; }
    public int ZipCode { get; set; }
    public List<Employee> Employees { get; set; }

    public Company()
    {
      this.Name = "Woodgrove Bank";
      this.Street = "555 Wall Street";
      this.City = "New York";
      this.State = "NY";
      this.ZipCode = 10005;
      this.Employees = new List<Employee>();

      this.Employees.Add(
          new Employee
          {
            FirstName = "Joe",
            LastName = "Duffin",
            PhoneNum = 2125551212
          });
      this.Employees.Add(
          new Employee
```

```
            {
              FirstName = "Alex",
              LastName = "Bleeker",
              PhoneNum = 7185551212
            });

        //rest of the initialization code omitted for brevity
        this.Employees.Add(new Employee
        {
          FirstName = "Nelly",
          LastName = "Myers",
          PhoneNum = 7325551212
        });
        this.Employees.Add(new Employee
        {
          FirstName = "Marcus",
          LastName = "Bernard",
          PhoneNum = 7325551414
        });
        this.Employees.Add(new Employee
        {
          FirstName = "Juliette",
          LastName = "Bernard",
          PhoneNum = 7325551414
        });
        this.Employees.Add(new Employee
        {
          FirstName = "Cory",
          LastName = "Winston",
          PhoneNum = 9085551414
        });
this.Employees.Add(new Employee
        {
          FirstName = "Randall",
          LastName = "Valetta",
          PhoneNum = 2015551414
        });

        this.Employees.Add(new Employee
        {
          FirstName = "Maurice",
          LastName = "Dutronc",
          PhoneNum = 3635551414
        });
        this.Employees.Add(new Employee
        {
```

```
        FirstName = "Nathan",
        LastName = "Adams",
        PhoneNum = 3635551414
      });
      this.Employees.Add(new Employee
      {
        FirstName = "Harold",
        LastName = "Anthony",
        PhoneNum = 3745551414
      });
      this.Employees.Add(new Employee
      {
        FirstName = "Paul",
        LastName = "Gomez",
        PhoneNum = 3415551414
      });

      this.Employees.Add(new Employee
      {
        FirstName = "Martha",
        LastName = "Willard",
        PhoneNum = 4795551414
      });
      this.Employees.Add(new Employee
      {
        FirstName = "Barry",
        LastName = "Driver",
        PhoneNum = 4165551414
      });
this.Employees.Add(new Employee
      {
        FirstName = "Peter",
        LastName = "Martinson",
        PhoneNum = 4165551414
      });
      this.Employees.Add(new Employee
      {
        FirstName = "Mike",
        LastName = "Dempsey",
        PhoneNum = 4165551656
      });
    }
  }
}
```

The XAML page shown in Listing 4-2 declares an instance of the Company class to use as a data source.

Listing 4-2. *XAML for the Page*

```
<UserControl x:Class="Recipe4_1.MainPage"
  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"
  mc:Ignorable="d"
  xmlns:local="clr-namespace:Recipe4_1"
  Width="400" Height="300" >

  <UserControl.Resources>
    <local:Company x:Key="CLRDS_Company" />
  </UserControl.Resources>

  <Grid x:Name="LayoutRoot" Background="White"
        DataContext="{StaticResource CLRDS_Company}" Margin="8,8,8,8">

    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.38*"/>
      <ColumnDefinition Width="0.032*"/>
      <ColumnDefinition Width="0.238*"/>
      <ColumnDefinition Width="0.028*"/>
      <ColumnDefinition Width="0.322*"/>
    </Grid.ColumnDefinitions>
<Grid.RowDefinitions>
      <RowDefinition Height="0.103*"/>
      <RowDefinition Height="0.114*"/>
      <RowDefinition Height="0.783*"/>
    </Grid.RowDefinitions>
    <TextBlock  Grid.ColumnSpan="5" x:Name="tbxCompanyName"/>
    <TextBlock Text="{Binding Street}" Grid.ColumnSpan="1" Grid.Row="1" />
    <TextBlock Text="," Grid.Column="1" Grid.Row="1"  />
    <TextBlock Text="{Binding City}" Grid.Column="2"
               Grid.ColumnSpan="1" Grid.Row="1" />
    <TextBlock Text="," Grid.Column="3" Grid.ColumnSpan="1"
               Grid.Row="1" Grid.RowSpan="1"/>
    <StackPanel Margin="0,0,0,8" Orientation="Horizontal"
                Grid.Column="4" Grid.ColumnSpan="1"
           Grid.Row="1" Grid.RowSpan="1">
      <TextBlock Margin="0,0,5,0" Text="{Binding State}" />
      <TextBlock Text="{Binding Zip}"/>
    </StackPanel>
```

```
    <ListBox x:Name="lbxEmployees" Grid.RowSpan="1" Grid.Row="2"
             Grid.ColumnSpan="5" ItemsSource="{Binding Employees}">
      <ListBox.ItemTemplate>
        <DataTemplate>
          <Grid>
            <Grid.ColumnDefinitions>
              <ColumnDefinition Width="Auto"/>
              <ColumnDefinition Width="Auto"/>
              <ColumnDefinition Width="Auto"/>
            </Grid.ColumnDefinitions>
            <TextBlock Grid.Column="0" Text="{Binding FirstName}"
                       Margin="0,0,5,0" />
            <TextBlock Grid.Column="1" Text="{Binding LastName}"
                       Margin="0,0,5,0"/>
            <TextBlock Grid.Column="2" Text="{Binding PhoneNum}"/>
          </Grid>
        </DataTemplate>
      </ListBox.ItemTemplate>
    </ListBox>
  </Grid>

</UserControl>
```

To bind the data to the UI, you set the `DataContext` property on the top-level grid named `LayoutRoot`. As discussed earlier, the `DataContext` is made available to all contained controls inside the grid so that any binding expression automatically uses it as the binding source, thus negating the need to specify the source explicitly in the binding statement. So for each of the binding expressions in the UI for the controls contained immediately within the grid, you simply specify the name of the property in the `Company` type to which you want to bind the control's property.

You use a `ListBox` to display the `Employees` collection in the `Company` instance. You set the `ItemTemplate` for the `ListBox` to a `DataTemplate` that defines how each item in the `ListBox` is displayed. The `DataTemplate` is discussed in greater detail later in this chapter, but for now, think of it as a way to package the UI representation of a specific data type. By binding the `ItemsSource` property of the `ListBox` to the `Employees` property on the `Company` instance, you effectively provide an instance of the `Employee` class as the data source for each item in the `ListBox`. In the `DataTemplate`, you can then bind properties of individual elements to properties on the `Employee` class to display employee data. The page output for the application is shown in Figure 4-1.

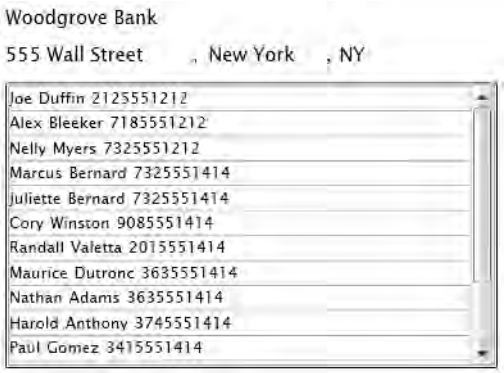


Figure 4-1. *The data-bound page*

Note that the `Company` type being referenced as the `CLRDS_Company` resource will also need to have a default constructor defined to be referenced in XAML this way. If you do not have a default constructor, you can instantiate the type and set the `DataContext` in code like so:

```
LayoutRoot.DataContext = new Company(SomeParameter);
```

You can also create and set bindings in code if you need to. To do so, create and initialize an instance of the `Binding` type, and then use the `SetBinding()` method on the `FrameworkElement` type to associate it with a specific `DependencyProperty`, as shown in Listing 4-3.

Listing 4-3. *Creating a Binding in Code*

```
using System.Windows.Controls;
using System.Windows.Data;

namespace Recipe4_1
{
  public partial class MainPage : UserControl
  {
    public MainPage()
    {
      InitializeComponent();
      //In case you want to set the datacontext in code...
      //LayoutRoot.DataContext = new Company();
      //create a new Binding
      Binding CompanyNameBinding = new Binding("Name");
      //set properties on the Binding as needed
      CompanyNameBinding.Mode = BindingMode.OneWay;
      //apply the Binding to the DependencyProperty of
      //choice on the appropriate object
      tbxCompanyName.SetBinding(TextBlock.TextProperty,
        CompanyNameBinding);
```

```
    }
  }
}
```

Before you apply the `Binding`, you can also set various properties on the `Binding` to control its behavior. The `BindingMode` setting in Listing 4-3 is one such property. `BindingMode` controls the direction of data flow in the `Binding`, and the `OneWay` setting stipulates that data only flow from the source to the target in this case. The `BindingMode` is discussed in greater detail in Recipe 4-3 later in the chapter.

To utilize the code in Listing 4-3, you will need to name the element that is targeted by the binding in XAML appropriately so that it becomes accessible to you in code. In the following snippet, you see how to name the `TextBlock` `tbxCompanyName` in Listing 4-2 so that you can refer to it in code.

```
<Grid x:Name="LayoutRoot" Background="White"
DataContext="{StaticResource CLRDS_Company}">
  <!-- markup omitted for brevity -->
  <TextBlock  Grid.ColumnSpan="5" x:Name="tbxCompanyName"/>
</Grid>
```

4-2. Binding Using a DataTemplate

Problem

You need to apply a custom UI to data and specify how various parts of a complex data structure are bound to various parts of your complex UI. You also need this representation encapsulated so that it can be reused across your application wherever the related data structure is employed.

Solution

Define a `DataTemplate` and specify appropriate bindings to bind parts of the backing data structure to elements of the data template. Apply the `DataTemplate` where possible to apply a consistent UI to the bound data.

How It Works

A `DataTemplate` offers a way to provide a repeatable and consistent visual representation for a portion or all of a specific application data source within your UI. It encapsulates a portion of your UI and can be defined in terms of any of the standard drawing primitives and controls available, as well any custom controls you might write. Appropriate bindings applied to various properties of the constituent elements ties the `DataTemplate` to the backend application data source that it aims to provide the UI for.

Declaring a DataTemplate

Listing 4-4 shows a simple `DataTemplate` that binds the `Text` properties of several `TextBlock` controls to properties in a CLR type.

Listing 4-4. *A Simple DataTemplate*

```
<DataTemplate x:Key="dtAddress">
  <Grid >
    <Grid.RowDefinitions>
      <RowDefinition Height="Auto"/>
      <RowDefinition Height="Auto"/>
    </Grid.RowDefinitions>
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="Auto" />
    </Grid.ColumnDefinitions>
    <TextBlock x:Name="tblkStreet" HorizontalAlignment="Stretch"
               VerticalAlignment="Stretch" Text="{Binding Street}"
               TextWrapping="Wrap" Foreground="White" FontSize="12"
               FontWeight="Bold"/>
    <StackPanel  Grid.RowSpan="1" Orientation="Horizontal" Grid.Row="1"
                 VerticalAlignment="Stretch">
      <TextBlock  x:Name="tblkCity" Text="{Binding City}"
                  TextWrapping="Wrap" FontSize="12"
                  FontWeight="Bold" Foreground="White"/>
      <TextBlock  x:Name="tblkComma" Text="," TextWrapping="Wrap"
                  Margin="2,0,2,0" FontSize="12" FontWeight="Bold"
                  Foreground="White"/>
      <TextBlock  x:Name="tblkState" Text="{Binding State}"
                  TextWrapping="Wrap" FontSize="12"
                  FontWeight="Bold" Foreground="White"/>
      <TextBlock  x:Name="tblkZip" Text="{Binding ZipCode}"
                  TextWrapping="Wrap" Margin="3,0,0,0" FontSize="12"
                  FontWeight="Bold" Foreground="White"/>
    </StackPanel>
  </Grid>
</DataTemplate>
```

Note that a `DataTemplate` can be declared either as a resource that can be referenced using its `x:Key` value, as shown in Listing 4-4, or in place, as Listing 4-5 shows.

Listing 4-5. *A DataTemplate Declared and Used in Place*

```
<ContentControl x:Name="cntctrlEmployee" HorizontalAlignment="Stretch"
                VerticalAlignment="Stretch"
                Grid.Column="0" Background="Yellow" Margin="5,5,5,5"
                Height="200">
  <ContentControl.ContentTemplate>
    <DataTemplate>
      <TextBlock x:Name="tblkFirstName" Text="{Binding FirstName}"
```

```
                TextWrapping="Wrap" FontSize="14" FontWeight="Bold"
                Foreground="White" Margin="3,0,0,0"/>
    </DataTemplate>
  </ContentControl.ContentTemplate>
</ContentControl>
```

In Listing 4-5, you define and associate a `DataTemplate` to the `ContentControl.ContentTemplate` property in place. For in-place use, the `DataTemplate` is scoped to the containing element (in this case, the `ContentControl.ContentTemplate`) and is not available for use outside that scope.

You can also define a `DataTemplate` as a resource either in the resource section of the page or that of the application. In the former case, the `DataTemplate` is control scoped—that is, it is available for use anywhere on the `MainPage` (which is a `UserControl`). In the latter case, it is available for use anywhere in the entire application. In keeping with the rules, anything stored as a resource in `ResourceDictionaries`, such a `DataTemplate`, needs an `x:Key` defined so that it can be referenced for use via the `StaticResource` extension. Resource usage and `ResourceDictionaries` were covered in detail in Chapter 2.

Using a DataTemplate

So how do you use a `DataTemplate`? You can apply one to either a `ContentControl` (or a derived control, like `Button`) or an `ItemsControl` (or a derived control, like `ListBox`). To apply the `DataTemplate`, you set the `ContentControl.ContentTemplate` property or the `ItemsControl.ItemTemplate` property to the `DataTemplate`, as shown here:

```
<ContentControl  ContentTemplate="{StaticResource dtAddress}" />
<ListBox  ItemTemplate="{StaticResource dtAddress}" />
```

At runtime, the data bound to the `ContentControl.Content` property, or each data item in the data collection bound to the `ItemsControl.ItemsSource` property, is used to provide data for the bound properties in the `DataTemplate`.

■ **Note** The recipes in Chapter 5 will show you how to write custom controls so that DataTemplates can be used to customize the look and feel of data bound to your control.

The Code

Listing 4-6 shows code for the classes that provide the data for this sample.

Listing 4-6. *Data Classes*

```
namespace Recipe4_2
{
  public class Employee
  {
    public string FirstName { get; set; }
```

```
    public string LastName { get; set; }
    public long PhoneNum { get; set; }
    public string ImageUri
    {
      get
      {
        return "/" + FirstName + ".png";
      }
    }
    public Address Address { get; set; }
  }

  public class Address
  {
    public string Street { get; set; }
    public string City { get; set; }
    public string State { get; set; }
    public int ZipCode { get; set; }
  }
}
```

Listing 4-7 shows the code to initialize the data, defined in the constructor of the `MainPage` class, in the codebehind file for the `MainPage`.

Listing 4-7. *Data Initialization*

```
using System.Collections.Generic;
using System.Windows.Controls;

namespace Recipe4_2
{
  public partial class MainPage : UserControl
  {
    public MainPage()
    {
      InitializeComponent();

      List<Employee> EmployeeList = new List<Employee>();

      EmployeeList.Add(new Employee
          {
            FirstName = "Joe",
            LastName = "Duffin",
            PhoneNum = 2125551212,
            Address = new Address { Street = "2000 Mott Street",
```

```
            City = "New York", State = "NY", ZipCode = 10006 }
        });

    EmployeeList.Add(new Employee
        {
          FirstName = "Alex",
          LastName = "Bleeker",
          PhoneNum = 7185551212,
          Address = new Address { Street = "11000 Clover Street",
            City = "New York", State = "NY", ZipCode = 10007 }
        });

    EmployeeList.Add(new Employee
        {
          FirstName = "Nelly",
          LastName = "Myers",
          PhoneNum = 7325551212,
          Address = new Address { Street = "12000 Fay Road",
            City = "New York", State = "NY", ZipCode = 10016 }
        });

    cntctrlEmployee.Content = EmployeeList[0];
    itmctrlEmployees.ItemsSource = EmployeeList;
  }
 }
}
```

You define two data templates, one each for the `Address` type and the `Employee` type in the `MainPage.xaml` file,

as shown in Listing 4-8.

Listing 4-8. *DataTemplates for the Address and Employee Data Types*

```
<UserControl.Resources>
  <DataTemplate x:Key="dtAddress">
    <Grid >
      <Grid.RowDefinitions>
        <RowDefinition Height="Auto"/>
        <RowDefinition Height="Auto"/>
      </Grid.RowDefinitions>
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="Auto" />
      </Grid.ColumnDefinitions>
      <TextBlock x:Name="tblkStreet" HorizontalAlignment="Stretch"
```

```
                VerticalAlignment="Stretch" Text="{Binding Street}"
                TextWrapping="Wrap" Foreground="White" FontSize="12"
                FontWeight="Bold"/>
    <StackPanel  Grid.RowSpan="1" Orientation="Horizontal" Grid.Row="1"
                 VerticalAlignment="Stretch">
      <TextBlock  x:Name="tblkCity" Text="{Binding City}"
                  TextWrapping="Wrap" FontSize="12"
                  FontWeight="Bold" Foreground="White"/>
      <TextBlock  x:Name="tblkComma" Text="," TextWrapping="Wrap"
                  Margin="2,0,2,0" FontSize="12" FontWeight="Bold"
                  Foreground="White"/>
      <TextBlock  x:Name="tblkState" Text="{Binding State}"
                  TextWrapping="Wrap" FontSize="12"
                  FontWeight="Bold" Foreground="White"/>

      <TextBlock  x:Name="tblkZip" Text="{Binding ZipCode}"
                  TextWrapping="Wrap" Margin="3,0,0,0" FontSize="12"
                  FontWeight="Bold" Foreground="White"/>
    </StackPanel>
  </Grid>
</DataTemplate>
<DataTemplate x:Key="dtEmployee">
  <Grid Height="Auto" Width="300" Margin="5,5,5,5">
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.508*"/>
      <ColumnDefinition Width="0.492*"/>
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
      <RowDefinition Height="0.801*" />
      <RowDefinition Height="0.199*"/>
    </Grid.RowDefinitions>
    <Rectangle HorizontalAlignment="Stretch" Margin="0,-74.9660034179688,0,0"
               Stroke="#FF000000" Grid.Row="1" Grid.RowSpan="1" RadiusX="3"
               RadiusY="3" StrokeThickness="0" Fill="#FF9FA8E4"/>
    <Rectangle HorizontalAlignment="Stretch" Margin="0,0,0,0"
               Grid.ColumnSpan="2" Grid.RowSpan="1" RadiusX="3"
               RadiusY="3" Stroke="#FF686868" StrokeThickness="0"
               Width="Auto">
      <Rectangle.Fill>
        <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
          <GradientStop Color="#FF000000"/>
          <GradientStop Color="#FF9FA8E4" Offset="1"/>
        </LinearGradientBrush>
      </Rectangle.Fill>
    </Rectangle>
```

```
      <Rectangle HorizontalAlignment="Stretch" Margin="3,3,3,3"
                 Stroke="#FF0A28EE" Grid.RowSpan="1"
                 StrokeThickness="5" VerticalAlignment="Stretch"/>
      <Image Margin="8,8,8,8" x:Name="imgEmployee"
             Source="{Binding ImageUri}"
             Stretch="Fill"
             HorizontalAlignment="Stretch" VerticalAlignment="Stretch"
             Grid.RowSpan="1"/>
      <StackPanel Margin="0,-0.1140000000059605,0,0"  Orientation="Horizontal"
                  Grid.Row="1" Grid.ColumnSpan="1" VerticalAlignment="Stretch"
                  Grid.RowSpan="1">
        <TextBlock x:Name="tblkFirstName" Text="{Binding FirstName}"
                   TextWrapping="Wrap" FontSize="14" FontWeight="Bold"
                   Foreground="White" Margin="3,0,0,0"/>
        <TextBlock x:Name="tblkLastName" Text="{Binding LastName}"
                   TextWrapping="Wrap" FontSize="14" FontWeight="Bold"
                   Margin="3,0,0,0" Foreground="White"/>
      </StackPanel>
      <StackPanel Margin="0,0,0,0" Grid.Column="1">
        <ContentControl ContentTemplate="{StaticResource dtAddress}"
                        Content="{Binding Address}" Foreground="#FF0A28EE" />
        <TextBlock x:Name="tblkPhoneNum" Text="{Binding PhoneNum}"
                   TextWrapping="Wrap" FontSize="12" FontWeight="Bold"
                   Margin="0,5,0,0" Foreground="White"/>
      </StackPanel>
    </Grid>
  </DataTemplate>
</UserControl.Resources>
```

You can see that a `DataTemplate` can, in turn, use another `DataTemplate` in a nested fashion. In `dtEmployee` earlier, you use a `ContentControl` to display an employee's address, and you reuse `dtAddress` as the `ContentTemplate`. This kind of reuse helps facilitate the consistency in UI representation of data, keeping in line with the promise of `DataTemplates`.

Applying the `DataTemplate` is simple. Let's apply it to a `ContentControl` like so

```
<ContentControl x:Name="cntctrlEmployee" HorizontalAlignment="Stretch"
                VerticalAlignment="Stretch"
                Grid.Column="0" Background="Yellow" Margin="5,5,5,5"
                ContentTemplate="{StaticResource dtEmployee}" Height="200"/>
```

and bind it to the first `Employee` in the `EmployeeList` collection, as shown in the `MainPage`'s constructor code in Listing 4-7, like so

```
cntctrlEmployee.Content = EmployeeList[0];
```

Figure 4-2 shows the `DataTemplate` in action.

Figure 4-2. *DataTemplate in action in a ContentControl*

Let's also apply the same `DataTemplate` to a `ListBox`, like so:

```
<ListBox x:Name="itmctrlEmployees"
         HorizontalAlignment="Stretch" VerticalAlignment="Stretch"
         Grid.Column="1"
         Width="325"
         ItemTemplate="{StaticResource dtEmployee}"
         Height="400"/>
```

Them, you bind it to the entire `EmployeeList` collection, as shown in the `MainPage`'s constructor code in Listing 4-7, like so:

```
itmctrlEmployees.ItemsSource = EmployeeList;
```

This time, you see the `DataTemplate` being applied to each item in the `ListBox` but producing a consistent UI, as shown in Figure 4-3.

Figure 4-3. *DataTemplate applied to ItemTemplate of a ListBox*

4-3. Receiving Change Notifications for Bound Data

Problem

You have data-bound elements in your UI, and you want to enable change notifications and automatic refresh of the UI when the bound application data changes.

Solution

You implement the `System.ComponentModel.INotifyPropertyChanged` interface in your data types and the `System.Collections.Specialized.INotifyCollectionChanged` interface in your collection types. You then raise the events defined in these interfaces from the implementing types to provide change notifications. You also ensure that the `Mode` property for each data binding is set to either `BindingMode.OneWay` or `BindingMode.TwoWay` to enable automatic UI refresh.

How It Works

The Silverlight binding infrastructure is aware of these two special interfaces and automatically subscribes to change notification events defined in the interfaces when implemented by the data source types.

Change Notification for Noncollection Types

The `INotifyPropertyChanged` interface has a single event named `PropertyChanged`. The event parameter is of type `PropertyChangedEventArgs`, which accepts the name of the changing property as a string parameter to the constructor and exposes it through the `PropertyName` property. The `PropertyChangedEvntArgs` class is shown here:

```
public class PropertyChangedEventArgs : EventArgs
{
    // Fields
    private readonly string propertyName;

    // Methods
    public PropertyChangedEventArgs(string propertyName);

    // Properties
    public string PropertyName { get; }
}
```

Once you implement the `INotifyPropertyChanged` interface in your data source type, you raise `PropertyChanged` whenever you need to raise change notifications for any of the bound source properties. You pass in the name of the property being changed through an instance of `PropertyChangedEventArgs`. Listing 4-9 shows a small but standard sample implementation.

Listing 4-9. *Sample Implementation of INotifyPropertyChanged*

```
public class Notifier : INotifyPropertyChanged
{
  //implementing INotifyPropertyChanged
  public event PropertyChangedEventHandler PropertyChanged;
  //utility method to raise PropertyChanged
  private void RaisePropertyChanged(PropertyChangedEventArgs e)
  {
    if (PropertyChanged != null)
      PropertyChanged(this, e);
  }

  private string _SomeBoundProperty;
  public string SomeBoundProperty
  {
    get { return _SomeBoundProperty; }
    set
    {
      //save old value
      string OldVal = _SomeBoundProperty;
      //compare with new value
      if (OldVal != value)
      {
        //if different, set property
        _SomeBoundProperty = value;
        //and raise PropertyChanged
        RaisePropertyChanged(new
          PropertyChangedEventArgs("SomeBoundProperty"));
      }

    }
  }
}
```

Change Notification for Collection Types

The `INotifyCollectionChanged` interface also has a single event, named `CollectionChanged`, which can be raised by implementing collection types to provide change notifications. The change information that can be gained for collections is richer in comparison to `INotifyPropertyChanged`, as you can see in the `NotifyCollectionChangedEventArgs` type listed here:

```
public sealed class NotifyCollectionChangedEventArgs : EventArgs
{
  // Other members omitted for brevity
```

```
  public NotifyCollectionChangedEventArgs(NotifyCollectionChangedAction action,
  object newItem, object oldItem, int index);

  public NotifyCollectionChangedAction Action { get; }

  public IList NewItems { get; }

  public int NewStartingIndex { get; }

  public IList OldItems { get; }

  public int OldStartingIndex { get; }
}
```

The code sample in the next section shows a custom collection that implements `INotifyCollectionChanged`.

The Code

The sample code for this recipe builds a simple data entry form over the data struc tures in Listing 4-10.

Listing 4-10. *Application Data Classes*

```
using System.Collections.Generic;
using System.Collections.Specialized;
using System.ComponentModel;

namespace Recipe4_3
{
  public class Employee : INotifyPropertyChanged
  {

    public event PropertyChangedEventHandler PropertyChanged;
    private void RaisePropertyChanged(PropertyChangedEventArgs e)
    {
      if (PropertyChanged != null)
        PropertyChanged(this, e);
    }

    public Employee()
    {
    }
```

```
private string _FirstName;
public string FirstName
{
  get { return _FirstName; }
  set
  {
    string OldVal = _FirstName;
    if (OldVal != value)
    {
      _FirstName = value;
      RaisePropertyChanged(new PropertyChangedEventArgs("FirstName"));
    }
  }
}
private string _LastName;
public string LastName
{
  get { return _LastName; }
  set
  {
    string OldVal = _LastName;
    if (OldVal != value)
    {
      _LastName = value;
      RaisePropertyChanged(new PropertyChangedEventArgs("LastName"));
    }
  }
}

private long _PhoneNum;
public long PhoneNum
{
  get { return _PhoneNum; }
  set
  {
    long OldVal = _PhoneNum;
    if (OldVal != value)
    {
      _PhoneNum = value;
      RaisePropertyChanged(new PropertyChangedEventArgs("PhoneNum"));
    }
  }
}

private Address _Address;
```

```
  public Address Address
  {
    get { return _Address; }
    set
    {
      Address OldVal = _Address;
      if (OldVal != value)
      {
        _Address = value;
        RaisePropertyChanged(new PropertyChangedEventArgs("Address"));
      }
    }
  }
}
public class Address : INotifyPropertyChanged
{
  public event PropertyChangedEventHandler PropertyChanged;
  private void RaisePropertyChanged(PropertyChangedEventArgs e)
  {
    if (PropertyChanged != null)
      PropertyChanged(this, e);
  }

  private string _Street;
  public string Street
  {
    get { return _Street; }
    set
    {
      string OldVal = _Street;
      if (OldVal != value)
      {
        _Street = value;
        RaisePropertyChanged(new PropertyChangedEventArgs("Street"));
      }
    }
  }

  private string _City;
  public string City
  {
    get { return _City; }
    set
    {
      string OldVal = _City;
```

```
        if (OldVal != value)
        {
          _City = value;
          RaisePropertyChanged(new PropertyChangedEventArgs("City"));
        }
      }
    }

    private string _State;
    public string State
    {
      get { return _State; }
      set
      {
        string OldVal = _State;
        if (OldVal != value)
        {
          _State = value;
          RaisePropertyChanged(new PropertyChangedEventArgs("State"));
        }
      }
    }

    private int _ZipCode;
    public int ZipCode
    {
      get { return _ZipCode; }
      set
      {
        int OldVal = _ZipCode;
        if (OldVal != value)
        {
          _ZipCode = value;
          RaisePropertyChanged(new PropertyChangedEventArgs("ZipCode"));
        }
      }
    }
  }

  public class EmployeeCollection : ICollection<Employee>,
    IList<Employee>,
    INotifyCollectionChanged
  {
    private List<Employee> _internalList;
```

```
public EmployeeCollection()
{
  _internalList = new List<Employee>();
}

public event NotifyCollectionChangedEventHandler CollectionChanged;

private void RaiseCollectionChanged(NotifyCollectionChangedEventArgs e)
{
  if (CollectionChanged != null)
  {
    CollectionChanged(this, e);
  }
}
//Methods/Properties that would possibly change the collection and its content
//need to raise the CollectionChanged event
public void Add(Employee item)
{
  _internalList.Add(item);
  RaiseCollectionChanged(
    new NotifyCollectionChangedEventArgs(NotifyCollectionChangedAction.Add,
      item, _internalList.Count - 1));
}
public void Clear()
{
  _internalList.Clear();
  RaiseCollectionChanged(
    new NotifyCollectionChangedEventArgs(NotifyCollectionChangedAction.Reset));
}
public bool Remove(Employee item)
{
  int idx = _internalList.IndexOf(item);
  bool RetVal = _internalList.Remove(item);
  if (RetVal)
    RaiseCollectionChanged(
      new NotifyCollectionChangedEventArgs(
        NotifyCollectionChangedAction.Remove, item, idx));
  return RetVal;
}
public void RemoveAt(int index)
{
  Employee item = null;
  if (index < _internalList.Count)
    item = _internalList[index];
  _internalList.RemoveAt(index);
```

```
    if (index < _internalList.Count)
      RaiseCollectionChanged(
        new NotifyCollectionChangedEventArgs(
          NotifyCollectionChangedAction.Remove, item, index));

  }
  public void Insert(int index, Employee item)
  {
    _internalList.Insert(index, item);
    RaiseCollectionChanged(
      new NotifyCollectionChangedEventArgs(
        NotifyCollectionChangedAction.Add, item, index));
  }
  public Employee this[int index]
  {
    get { return _internalList[index]; }
    set
    {
      _internalList[index] = value;
      RaiseCollectionChanged(
        new NotifyCollectionChangedEventArgs(
          NotifyCollectionChangedAction.Replace, value, index));

    }
  }

  public bool Contains(Employee item)
  {
    return _internalList.Contains(item);
  }
  public void CopyTo(Employee[] array, int arrayIndex)
  {
    _internalList.CopyTo(array, arrayIndex);
  }
  public int Count
  {
    get { return _internalList.Count; }
  }
  public bool IsReadOnly
  {
    get { return ((IList<Employee>)_internalList).IsReadOnly; }
  }
  public IEnumerator<Employee> GetEnumerator()
  {
    return _internalList.GetEnumerator();
```

```
    }
    System.Collections.IEnumerator System.Collections.IEnumerable.GetEnumerator()
    {
      return (System.Collections.IEnumerator)_internalList.GetEnumerator();
    }
    public int IndexOf(Employee item)
    {
      return _internalList.IndexOf(item);
    }
  }

}
```

As shown in Listing 4-10, both the `Employee` and the `Address` types implement `INotifyPropertyChanged` to provide change notification. You also define a custom collection named `EmployeeCollection` for `Employee` instances and implement `INotifyCollectionChanged` on the collection type.

You can see the additional change information that can be accessed through the `NotifyCollectionChangedEventArgs`. Using the `NotifyCollectionChangedAction` enumeration, you can specify the type of change (`Add`, `Remove`, `Replace`, or `Reset`). You can also specify the item that changed and its index in the collection. This detail allows the binding infrastructure to optimize the binding so that the entire UI bound to the collection need not be refreshed for each change in the collection.

Also note that the `System.Collections.ObjectModel` contains a generic type named `ObservableCollection<T>` that already implements `INotifyCollectionChanged`. For all data binding scenarios, unless you have a specific reason to implement your own collection type, `ObservableCollection<T>` should meet your needs, as it does ours in the rest of this book.

However, `ObservableCollection<T>` simply extends `Collection<T>`, which is a base collection class in the framework. If you choose to have change notification enabled for some of the other, more advanced, collections in the framework, such as `List<T>` or `LinkedList<T>`, or if you have implemented your own custom collection types with custom business logic, implementing `INotifyCollectionChanged` is the way to go.

Another scenario where you might choose to implement a custom collection is if you want to declare the collection as a resource in your XAML. This would necessitate creating a nongeneric collection class with a default constructor, and you would possibly want to initialize such a collection in the constructor. You can, however, extend `ObservableCollection` directly in such cases and do away with the need to implement any of the collection manipulation methods shown in the previous sample.

Listing 4-11 shows the simple data entry UI that you build on top of this collection.

Listing 4-11. *Data Entry UI XAML*

```
<UserControl x:Class="Recipe4_3.MainPage"
             xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
             xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
             xmlns:local="clr-namespace:Recipe4_3"
             xmlns:d="http://schemas.microsoft.com/expression/blend/2008"
             xmlns:mc="http://schemas.openxmlformats.org/markup-compatibility/2006"
             Width="400"
             Height="441">
```

```
<UserControl.Resources>
    <!-- Employee collection Data source -->
    <local:EmployeeCollection x:Key="REF_EmployeeCollection" />
    <!-- Data template to be used for the Employee type -->
    <DataTemplate x:Key="dtEmployee">
        <StackPanel Orientation="Horizontal">
            <TextBlock Text="{Binding FirstName}" />
            <TextBlock Text="{Binding LastName}"
                       Margin="5,0,0,0" />
        </StackPanel>
    </DataTemplate>
</UserControl.Resources>
<Grid x:Name="LayoutRoot"
      Background="White"
      Margin="10,10,10,10">
    <Grid.RowDefinitions>
        <RowDefinition Height="*" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
    </Grid.RowDefinitions>
    <ListBox Grid.Row="0"
             x:Name="lbx_Employees"
             ItemsSource="{StaticResource REF_EmployeeCollection}"
             ItemTemplate="{StaticResource dtEmployee}"
             SelectionChanged="lbx_Employees_SelectionChanged" />
    <Grid x:Name="grid_NewButton"
          Margin="0,2,0,0"
          Grid.Row="1"
          HorizontalAlignment="Right">
        <Button  x:Name="btn_New"
                 Click="btn_New_Click"
                 Content="New Employee" />
    </Grid>
    <Border Grid.Row="2"
            Visibility="Collapsed"
            x:Name="border_EmployeeForm"
            Margin="0,2,0,0"
            BorderBrush="Black"
            BorderThickness="1"
            Padding="1,1,1,1">
        <Grid x:Name="grid_EmployeeForm">
            <Grid.ColumnDefinitions>
                <ColumnDefinition Width="0.142*" />
```

```
    <ColumnDefinition Width="0.379*" />
    <ColumnDefinition Width="0.1*" />
    <ColumnDefinition Width="0.097*" />
    <ColumnDefinition Width="0.082*" />
    <ColumnDefinition Width="0.2*" />
</Grid.ColumnDefinitions>
<Grid.RowDefinitions>
    <RowDefinition Height="0.10*" />
    <RowDefinition Height="0.15*" />
    <RowDefinition Height="0.15*" />
    <RowDefinition Height="0.15*" />
    <RowDefinition Height="0.45*" />
</Grid.RowDefinitions>

<TextBox HorizontalAlignment="Stretch"
         Margin="1,1,1,1"
         x:Name="tbxFName"
         VerticalAlignment="Stretch"
         Text="{Binding FirstName, Mode=TwoWay}"
         Grid.Row="1"
         Width="Auto"
         Grid.RowSpan="1"
         Grid.ColumnSpan="2"
         Grid.Column="1" />
<TextBox HorizontalAlignment="Stretch"
         Margin="1,1,1,1"
         x:Name="tbxLName"
         VerticalAlignment="Stretch"
         Text="{Binding LastName, Mode=TwoWay}"
         Grid.Row="1"
         Grid.Column="3"
         Width="Auto"
         Grid.RowSpan="1"
         Grid.ColumnSpan="3" />
<TextBlock HorizontalAlignment="Stretch"
           Margin="1,1,1,1"
           VerticalAlignment="Stretch"
           Text="Last"
           TextWrapping="Wrap"
           Grid.RowSpan="1"
           Grid.Column="4"
           Grid.ColumnSpan="2"
           Height="Auto"
           Width="Auto" />
<TextBlock HorizontalAlignment="Center"
```

```
                Margin="1,1,1,1"
                VerticalAlignment="Center"
                Text="First"
                TextWrapping="Wrap"
                Grid.RowSpan="1"
                Grid.Column="1"
                Width="Auto"
                Height="Auto" />
    <TextBlock HorizontalAlignment="Center"
                Margin="1,1,1,1"
                VerticalAlignment="Stretch"
                Text="Name"
                TextWrapping="Wrap"
                Grid.RowSpan="1"
                Grid.Row="1"
                Height="Auto"
                Width="Auto" />
    <TextBlock HorizontalAlignment="Center"
                Margin="1,1,1,1"
                VerticalAlignment="Stretch"
                Text="Street"
                TextWrapping="Wrap"
                Grid.Row="2"
                Width="Auto" />
    <TextBox HorizontalAlignment="Stretch"
             x:Name="tbxStreet"
             VerticalAlignment="Stretch"
             Text="{Binding Address.Street, Mode=TwoWay}"
             Grid.Row="2"
             Margin="1,1,1,1"
             Grid.Column="1"
             Grid.ColumnSpan="5"
             Width="Auto" />
    <TextBlock HorizontalAlignment="Center"
                VerticalAlignment="Stretch"
                Text="City"
                TextWrapping="Wrap"
                Margin="1,1,1,1"
                Grid.Row="3" />
<TextBlock Text="State"
                Margin="1,1,1,1"
                TextWrapping="Wrap"
                Grid.Column="2"
                Grid.Row="3"
                HorizontalAlignment="Center" />
```

```
<TextBlock Text="Zip"
           Margin="1,1,1,1"
           TextWrapping="Wrap"
           Grid.Column="4"
           Grid.Row="3"
           HorizontalAlignment="Center" />
<TextBox HorizontalAlignment="Stretch"
         x:Name="tbxCity"
         Margin="1,1,1,1"
         VerticalAlignment="Stretch"
         Text="{Binding Address.City, Mode=TwoWay}"
         Grid.Row="3"
         Grid.Column="1" />
<TextBox Background="Transparent"
         Grid.Column="3"
         Margin="1,1,1,1"
         Grid.Row="3"
         Text="{Binding Address.State, Mode=TwoWay }"
         x:Name="tbxState">
</TextBox>
<TextBox Background="Transparent"
         Grid.Column="5"
         Grid.Row="3"
         Margin="1,1,1,1"
         Text="{Binding Address.ZipCode, Mode=TwoWay }"
         x:Name="tbxZipCode" />
<TextBlock HorizontalAlignment="Center"
           VerticalAlignment="Stretch"
           Text="Phone"
           Margin="1,1,1,1"
           TextWrapping="Wrap"
           Grid.Row="4" />
<TextBox Grid.Column="1"
         Grid.Row="4"
         Margin="1,1,1,1"
         Text="{Binding PhoneNum, Mode=TwoWay }"
         x:Name="tbxPhoneNum" />
<Button  Grid.Column="5"
         Margin="1,1,1,1"
         Grid.Row="4"
         Height="30.911"
         VerticalAlignment="Top"
         Content="Close"
         x:Name="btnClose"
         Click="btnClose_Click" />
```

```
            </Grid>
        </Border>
    </Grid>
</UserControl>
```

You can see that, for the editable controls, you set the `Mode` property of the binding to `BindingMode.TwoWay`. The `Mode` property can be set to one of three values:

- `BindingMode.OneTime` binds the value coming from the data source only once, when the element is initially displayed, and never again during the lifetime of the application. This is useful for static data that does not change for the lifetime of the application.
- `BindingMode.OneWay` refreshes the bound value with any changes that happens to the data source but does not propagate changes made in the UI to the bound data source. This is useful for data that is read only to the user but that can change through other means in the application. This is the default setting for `Binding.Mode` if you do not specify any setting in your XAML or code.
- `BindingMode.TwoWay` enables bidirectional propagation of changes and is the suitable mode for data-editing scenarios.

Running the sample produces the output shown in Figure 4-4.

Figure 4-4. *Initial output from the application*

Listing 4-12 shows the codebehind for the `MainPage`. As shown in the constructor, you initialize the bound `EmployeeCollection` instance with some initial `Employee` data. If you selected one of the records, you would see the output in Figure 4-5.

Listing 4-12. *Codebehind for the Page*

```
using System.Windows;
using System.Windows.Controls;
using System.Collections.ObjectModel;

namespace Recipe4_3
{
  public partial class MainPage : UserControl
  {
    public MainPage()
    {
      InitializeComponent();

      //initialize the employee collection with some sample data
      EmployeeCollection empColl = (EmployeeCollection)lbx_Employees.ItemsSource;

      empColl.Add(new Employee
      {
        FirstName = "Joe",
        LastName = "Duffin",
        PhoneNum = 2125551212,
        Address = new Address
        {
          Street = "2000 Mott Street",
          City = "New York",
          State = "NY",
          ZipCode = 10006
        }
      });

      empColl.Add(new Employee
      {
        FirstName = "Alex",
        LastName = "Bleeker",
        PhoneNum = 7185551212,
        Address = new Address
        {
          Street = "11000 Clover Street",
          City = "New York",
          State = "NY",
          ZipCode = 10007
        }
      });
```

```
    empColl.Add(new Employee
    {
      FirstName = "Nelly",
      LastName = "Myers",
      PhoneNum = 7325551212,
      Address = new Address
      {
        Street = "12000 Fay Road",
        City = "New York",
        State = "NY",
        ZipCode = 10016
      }
    });
  }

  private void btn_New_Click(object sender, RoutedEventArgs e)
  {
    //get the bound collection
    EmployeeCollection empColl = (EmployeeCollection)lbx_Employees.ItemsSource;
    //create and initialize a new Employee
    Employee newEmp = new Employee();
    newEmp.Address = new Address();
    //add it to the collection
    empColl.Add(newEmp);
    //set the current selection to the newly added employee.
    //This will cause selection change to fire, and set
    //the datacontext for the form appropriately
    lbx_Employees.SelectedItem = newEmp;

  }

  private void lbx_Employees_SelectionChanged(object sender,
    SelectionChangedEventArgs e)
  {
    //set the datacontext of the form to the selected Employee
    grid_EmployeeForm.DataContext = (Employee)lbx_Employees.SelectedItem;
    //show the form
    border_EmployeeForm.Visibility = Visibility.Visible;
    grid_NewButton.Visibility = Visibility.Collapsed;
  }

  private void btnClose_Click(object sender, RoutedEventArgs e)
  {
    //hide the form
    border_EmployeeForm.Visibility = Visibility.Collapsed;
```

```
      grid_NewButton.Visibility = Visibility.Visible;
    }
  }
}
```

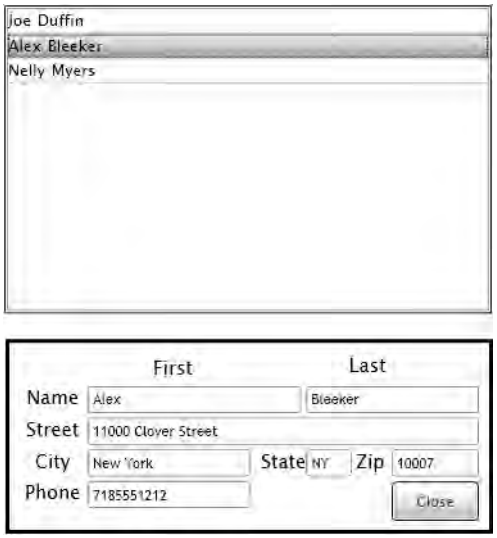


Figure 4-5. *Edit form for an existing employee*

In the `SelectionChanged` handler for `lbxEmployees`, named `lbx_Employees_SelectionChanged()` in Listing 4-12, you set the `DataContext` of the containing `Grid` named `grid_EmployeeForm` to the selected `Employee` data item. This populates the contained fields with various properties of the `Employee` instance based on the bindings defined in Listing 4-11. You then make the `Grid` visible.

If you try editing the First Name field, you should see it changing in the selected item in the `ListBox` once you tab out of the field after the edit. As the data entry form propagates the change back to the appropriate `Employee` item in the collection as a result of the `TwoWay` binding, this action, in turn, causes the `ListBox`'s binding to the collection to refresh the selected item.

If you click the New Employee button, you should get a blank data entry form, as shown in Figure 4-6, and see a blank item added to the `ListBox`. To achieve this, you handle the `Click` event of the button in `btn_New_Click()` shown in Listing 4-12. You create a new instance of the `Employee` type, initialize it, and add it to the collection. This takes care of displaying the blank item in the `ListBox` through the change notification mechanism of `INotifyCollectionChanged`. You also programmatically make that item the selected item in the `ListBox`, which in turns fires the `SelectionChanged` handler of the `ListBox`, and the data entry form is displayed again, as described in the previous paragraph.

Filling the fields in the data entry form should again cause change notifications to be propagated to the `ListBox`, as you tab out of fields.

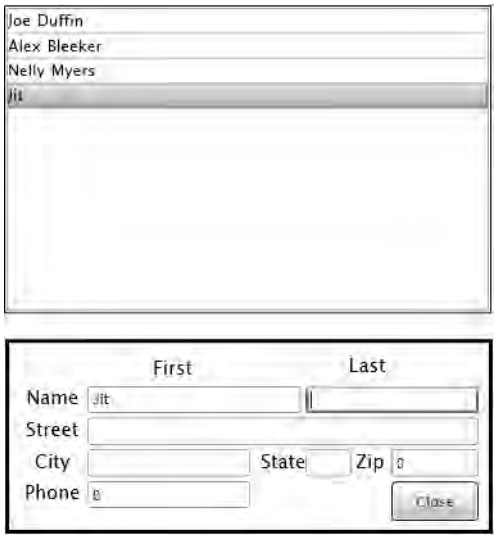


Figure 4-6. *Entering a new employee*

4-4. Converting Values During Data Binding

Problem

You are trying to bind to a data source and need to convert the source value to either a different type or a different value suitable for display in the UI.

Solution

Implement `System.Windows.Data.IValueConverter` to create a value converter type, and associate it to the binding to appropriately convert the value.

How It Works

Often, you will come across scenarios where the source value that you are trying to bind to is either a data type that needs to be converted before it can be bound or has the same data type as the target but needs some logical or contextual transformation before it can be meaningful to the UI.

As an example, imagine the `Visibility` property of a control. It is natural to think of `Visibility` as a Boolean, and thus express it in code as a `bool`. However, trying to bind a `bool` to the `Visibility` property of a Silverlight control will pose a challenge: in Silverlight, `Visibility` is expressed in terms of the `Visibility` enumeration, which has two values, `Visible` and `Collapsed`. In this case, you will need to convert from a source type (`bool`) to a target type (`Visibility`).

Imagine another scenario where you have the monthly spending of a family broken into categories as a data source, and you need to visually represent each expenditure as a percentage of the total. In this case, the data types of both the source and the target can be the same (say a `double`), but there is a logical transformation required between them—from an absolute value to a percentage.

Implementing Value Conversion

To use value conversion, you implement the `System.Windows.Data.IValueConverter` interface. The `IValueConverter` interface accommodates both source-to-target conversion through the `Convert()` method and target-to-source conversion through the `ConvertBack()` method.

Listing 4-13 shows a sample converter implementation that converts `bool` to `Visibility` and back.

Listing 4-13. *Value Converter from bool to Visibility*

```
public class BoolToVisibilityConverter : IValueConverter
{
  public object Convert(object value, Type targetType,
    object parameter, System.Globalization.CultureInfo culture)
  {
    //check to see that the parameter types are conformant
    if (value.GetType() != typeof(bool) || targetType != typeof(Visibility))
      return null;
    bool src = (bool)value;
    //translate
    return (src == true) ? Visibility.Visible : Visibility.Collapsed;
  }

  public object ConvertBack(object value, Type targetType,
    object parameter, System.Globalization.CultureInfo culture)
  {
    //check to see that the parameter types are conformant
    if (value.GetType() != typeof(Visibility) || targetType != typeof(bool))
      return null;
    Visibility src = (Visibility)value;
    //translate
    return (src == Visibility.Visible) ? true : false;
  }
}
```

In both methods, the first parameter named `value` is the source value and the second parameter named `targetType` is the data type of the target to which the value needs to be converted. The `ConvertBack()` method will need to be fully implemented if you have a two-way binding, where an edit on the UI would require the change to be sent back to the source. If you do not update the data through your UI, you can simply either return `null` or throw a suitable exception from the `ConvertBack()` method.

Also note that each method accepts a parameter, aptly named `parameter`, where you can pass additional information as may be required by the conversion logic, as well as the target culture as the last parameter, in case you need to take into account a difference in the culture between source and target.

To use the value converter, you first declare it as a resource in your XAML, with an appropriate custom namespace mapping to bring in the assembly, in this case `local`:

```
<local:BoolToVisibilityConverter x:Name="REF_BoolToVisibilityConverter" />
```

After the converter resource has been declared as shown here, you can associate it to a `Binding` by using its `Converter` property. Once the converter is associated, every piece of data flowing through the `Binding` either way is passed through the converter methods—`Convert()` if the data is flowing from the source to the target property, and `ConvertBack()` if it is the other way. A sample usage is shown here

```
<ContentControl Visibility="{Binding IsControlVisible,
  Converter={StaticResource REF_BoolToVisibilityConverter}}"/>
```

where `IsControlVisible` is a Boolean property on a data source CLR type bound to the control.

The Code

The code sample builds a simple spending analysis application for a family, where the expenditure for different categories are maintained in a `DataGrid` and also graphed in a bar graph as a percentage of the total. The application allows you to change the spending in each category to different values and watch the graph change accordingly. It also allows you to drag any bar in the graph using your mouse and watch the corresponding value change in the `DataGrid`, maintaining the same total. Figure 4-7 shows the application output.

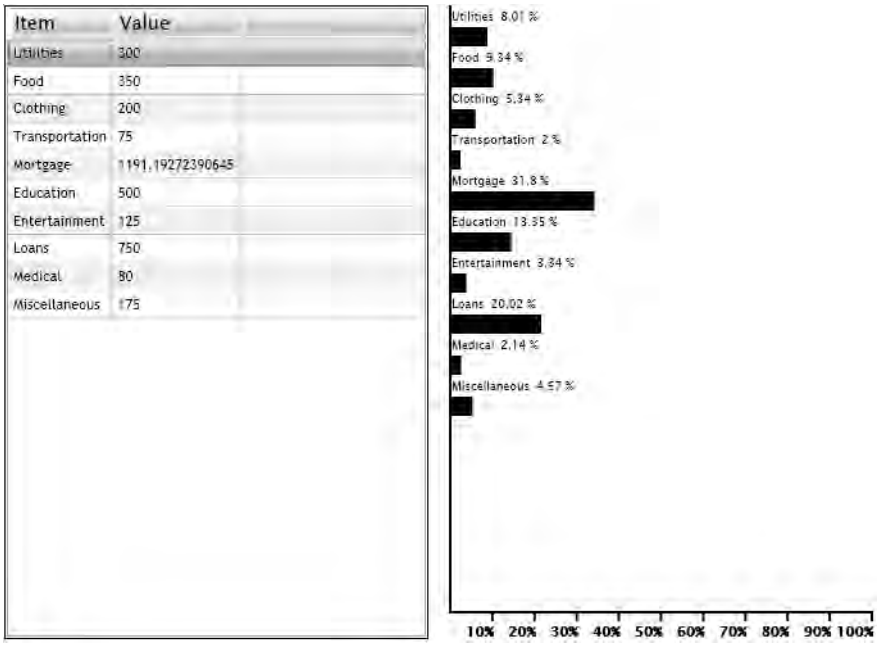


Figure 4-7. *Family spending chart*

Listing 4-14 shows the data classes used for this sample. The `Spending` class represents a specific expenditure, while the `SpendingCollection` extends `ObservableCollection<Spending>` to add some initialization code in a default constructor.

Listing 4-14. *Application Data Classes*

```
using System.Collections.ObjectModel;
using System.ComponentModel;
using System.Linq;

namespace Recipe4_4
{
  public class SpendingCollection : ObservableCollection<Spending>,
    INotifyPropertyChanged
  {
    public SpendingCollection()
    {
      this.Add(new Spending
      {
        ParentCollection = this,
        Item = "Utilities",
        Amount = 300
      });
      this.Add(new Spending
      {
        ParentCollection = this,
        Item = "Food",
        Amount = 350
      });
      this.Add(new Spending
      {
        ParentCollection = this,
        Item = "Clothing",
        Amount = 200
      });
      this.Add(new Spending
      {
        ParentCollection = this,
        Item = "Transportation",
        Amount = 75
      });
      this.Add(new Spending
      {
        ParentCollection = this,
        Item = "Mortgage",
        Amount = 3000
      });
      this.Add(new Spending
      {
```

```
        ParentCollection = this,
        Item = "Education",
        Amount = 500
      });
      this.Add(new Spending
      {
        ParentCollection = this,
        Item = "Entertainment",
        Amount = 125
      });
      this.Add(new Spending
      {
        ParentCollection = this,
        Item = "Loans",
        Amount = 750
      });
      this.Add(new Spending
      {
        ParentCollection = this,
        Item = "Medical",
        Amount = 80
      });
      this.Add(new Spending
      {
        ParentCollection = this,
        Item = "Miscellaneous",
        Amount = 175
      });
    }

    public double Total
    {
      get
      {
        return this.Sum(spending => spending.Amount);
      }
    }
  }

  public class Spending : INotifyPropertyChanged
  {

    public event PropertyChangedEventHandler PropertyChanged;
    internal void RaisePropertyChanged(PropertyChangedEventArgs e)
    {
```

```
  if (PropertyChanged != null)
  {
    PropertyChanged(this, e);
  }
}


SpendingCollection _ParentCollection = null;

public SpendingCollection ParentCollection
{
  get { return _ParentCollection; }
  set { _ParentCollection = value; }
}

private string _Item;
public string Item
{
  get { return _Item; }
  set
  {
    string OldVal = _Item;
    if (OldVal != value)
    {
      _Item = value;
      RaisePropertyChanged(new PropertyChangedEventArgs("Item"));

    }
  }
}

private double _Amount;
public double Amount
{
  get { return _Amount; }
  set
  {
    double OldVal = _Amount;
    if (OldVal != value)
    {
      _Amount = value;


      foreach (Spending sp in ParentCollection)
        sp.RaisePropertyChanged(new PropertyChangedEventArgs("Amount"));
```

```
        }
      }
    }
  }
}
```

Listing 4-15 shows the XAML for the page. If you look at the resources section, you will notice two value converters. `SpendingToBarWidthConverter` converts a `double` value representing `Spending` to another `double` value representing a corresponding bar width, and vice versa. `SpendingToPercentageStringConverter` converts a `Spending` value to a percentage of the total spending, and vice versa. These converter implementations will be discussed in more detail momentarily.

Listing 4-15. *XAML for the Page*

```
<UserControl x:Class="Recipe4_4.MainPage"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    xmlns:data=
    "clr-namespace:System.Windows.Controls;assembly=System.Windows.Controls.Data"
    xmlns:local="clr-namespace:Recipe4_4"
    Width="800" Height="510">

  <UserControl.Resources>
    <local:SpendingCollection x:Key="REF_SpendingList" />
    <local:SpendingToBarWidthConverter x:Key="REF_SpendingToBarWidthConverter" />
    <local:SpendingToPercentageStringConverter
      x:Key="REF_SpendingToPercentageStringConverter" />
    <DataTemplate x:Key="dtBarTemplate">
      <Grid HorizontalAlignment="Left" VerticalAlignment="Stretch"
            Height="30"  Margin="0,2,0,0" >
        <Grid.RowDefinitions>
          <RowDefinition Height="0.5*" />
          <RowDefinition Height="0.5*" />
        </Grid.RowDefinitions>
        <Rectangle Grid.Row="1" VerticalAlignment="Stretch"
                   Fill="Black" HorizontalAlignment="Left"
                   Width="{Binding Amount,Mode=TwoWay,
                    Converter={StaticResource REF_SpendingToBarWidthConverter},
                    ConverterParameter={StaticResource REF_SpendingList}}"
                   MouseMove="Rectangle_MouseMove"
                   MouseLeftButtonDown="Rectangle_MouseLeftButtonDown"
                   MouseLeftButtonUp="Rectangle_MouseLeftButtonUp"/>
        <StackPanel Orientation="Horizontal" Grid.Row="0">
          <TextBlock Text="{Binding Item}" FontSize="9" />
          <TextBlock Text="{Binding Amount,
            Converter={StaticResource REF_SpendingToPercentageStringConverter},
```

```
          ConverterParameter={StaticResource REF_SpendingList}}"
                   Margin="5,0,0,0"
                   FontSize="9"/>
      </StackPanel>
    </Grid>
  </DataTemplate>
</UserControl.Resources>

<Grid x:Name="LayoutRoot" Background="White" Width="694">
  <Grid.ColumnDefinitions>
    <ColumnDefinition Width="*"/>
    <ColumnDefinition Width="*"/>
  </Grid.ColumnDefinitions>
  <data:DataGrid HorizontalAlignment="Stretch" Margin="8,8,8,8"
                 VerticalAlignment="Stretch"
                 HeadersVisibility="Column" x:Name="dgSpending"
                 ItemsSource="{StaticResource REF_SpendingList}"
                 AutoGenerateColumns="False">
    <data:DataGrid.Columns>
      <data:DataGridTextColumn Header="Item"
                          Binding="{Binding Item,Mode=TwoWay}"/>
      <data:DataGridTextColumn Header="Value" Width="100"
                          Binding="{Binding Amount,Mode=TwoWay}"/>
    </data:DataGrid.Columns>
  </data:DataGrid>
  <Grid HorizontalAlignment="Stretch" VerticalAlignment="Stretch"
        Grid.Column="1" Margin="8,8,8,8" x:Name="GraphRoot"
        DataContext="{StaticResource REF_SpendingList}">
    <Grid.RowDefinitions>
      <RowDefinition Height="*"/>
      <RowDefinition Height="20"/>
    </Grid.RowDefinitions>
    <Rectangle Height="Auto" HorizontalAlignment="Left"
               VerticalAlignment="Stretch" Width="2"
               Stroke="#FF000000" StrokeThickness="0"
               Fill="#FF000000" x:Name="rectYAxis" Margin="0,0,0,0"/>
    <Rectangle Height="2" HorizontalAlignment="Stretch"
               VerticalAlignment="Bottom" Fill="#FF000000"
               Stroke="#FF000000" StrokeThickness="0"
               Stretch="Fill" x:Name="rectXAxis" Margin="0,0,0,0"
               Width="350" />
    <Grid HorizontalAlignment="Stretch" VerticalAlignment="Stretch"
          Width="Auto" Grid.Row="1" Margin="2,0,0,0"
          x:Name="gridMarkers">
      <Grid.ColumnDefinitions>
```

```
    <ColumnDefinition Width="0.1*" />
    <ColumnDefinition Width="0.1*" />
    <ColumnDefinition Width="0.1*" />
    <ColumnDefinition Width="0.1*" />
    <ColumnDefinition Width="0.1*" />
    <ColumnDefinition Width="0.1*" />
    <ColumnDefinition Width="0.1*" />
    <ColumnDefinition Width="0.1*" />
    <ColumnDefinition Width="0.1*" />
    <ColumnDefinition Width="0.1*" />
  </Grid.ColumnDefinitions>
  <Grid.RowDefinitions>
    <RowDefinition Height="0.3*" />
    <RowDefinition Height="0.7*" />
  </Grid.RowDefinitions>
  <Rectangle Width="2" Fill="Black" VerticalAlignment="Stretch"
             HorizontalAlignment="Right" Grid.Column="0" />
  <Rectangle Width="2" Fill="Black" VerticalAlignment="Stretch"
             HorizontalAlignment="Right" Grid.Column="1" />
  <Rectangle Width="2" Fill="Black" VerticalAlignment="Stretch"
             HorizontalAlignment="Right" Grid.Column="2" />
  <Rectangle Width="2" Fill="Black" VerticalAlignment="Stretch"
             HorizontalAlignment="Right" Grid.Column="3" />
  <Rectangle Width="2" Fill="Black" VerticalAlignment="Stretch"
             HorizontalAlignment="Right" Grid.Column="4" />
  <Rectangle Width="2" Fill="Black" VerticalAlignment="Stretch"
             HorizontalAlignment="Right" Grid.Column="5" />
  <Rectangle Width="2" Fill="Black" VerticalAlignment="Stretch"
             HorizontalAlignment="Right" Grid.Column="6" />
  <Rectangle Width="2" Fill="Black" VerticalAlignment="Stretch"
             HorizontalAlignment="Right" Grid.Column="7" />
  <Rectangle Width="2" Fill="Black" VerticalAlignment="Stretch"
             HorizontalAlignment="Right" Grid.Column="8" />
  <Rectangle Width="2" Fill="Black" VerticalAlignment="Stretch"
             HorizontalAlignment="Right" Grid.Column="9" />
  <TextBlock HorizontalAlignment="Right" VerticalAlignment="Stretch"
             Grid.Row="1" Grid.Column="0" Text="10%" FontSize="11"
             FontWeight="Bold" />
  <TextBlock HorizontalAlignment="Right" VerticalAlignment="Stretch"
             Grid.Row="1" Grid.Column="1" Text="20%" FontSize="11"
             FontWeight="Bold" />
  <TextBlock HorizontalAlignment="Right" VerticalAlignment="Stretch"
             Grid.Row="1" Grid.Column="2" Text="30%" FontSize="11"
             FontWeight="Bold" />
  <TextBlock HorizontalAlignment="Right" VerticalAlignment="Stretch"
```

```
                Grid.Row="1" Grid.Column="3" Text="40%" FontSize="11"
                FontWeight="Bold" />
      <TextBlock HorizontalAlignment="Right" VerticalAlignment="Stretch"
                Grid.Row="1" Grid.Column="4" Text="50%" FontSize="11"
                FontWeight="Bold" />
      <TextBlock HorizontalAlignment="Right" VerticalAlignment="Stretch"
                Grid.Row="1" Grid.Column="5" Text="60%" FontSize="11"
                FontWeight="Bold" />
      <TextBlock HorizontalAlignment="Right" VerticalAlignment="Stretch"
                Grid.Row="1" Grid.Column="6" Text="70%" FontSize="11"
                FontWeight="Bold" />
      <TextBlock HorizontalAlignment="Right" VerticalAlignment="Stretch"
                Grid.Row="1" Grid.Column="7" Text="80%" FontSize="11"
                FontWeight="Bold" />
      <TextBlock HorizontalAlignment="Right" VerticalAlignment="Stretch"
                Grid.Row="1" Grid.Column="8" Text="90%" FontSize="11"
                FontWeight="Bold" />
      <TextBlock HorizontalAlignment="Right" VerticalAlignment="Stretch"
                Grid.Row="1" Grid.Column="9" Text="100%" FontSize="11"
                FontWeight="Bold" />
    </Grid>
    <Grid Height="Auto" HorizontalAlignment="Stretch" Margin="2,0,0,2"
          VerticalAlignment="Stretch" Width="Auto" x:Name="gridBars"
          ShowGridLines="True">
      <ItemsControl ItemsSource="{StaticResource REF_SpendingList}"
                    ItemTemplate="{StaticResource dtBarTemplate}" />
    </Grid>
  </Grid>
 </Grid>
</UserControl>
```

The rest of the XAML is pretty simple. The `SpendingCollection`, through a resource reference named `REF_SpendingList`, is bound to a `DataGrid` named `dgSpending`. The bar graph is implemented as an `ItemsControl`, once again bound to the same `SpendingCollection` instance, using a `DataTemplate` named `dtBarTemplate` for each bar.

Note how you use the converters inside `dtBarTemplate`. You bind the `Width` of a `Rectangle` directly to the `Amount` property on the bound `Spending` instance and then use the `Converter` property of the `Binding` to associate the `SpendingToBarWidthConverter`. You also bind the `Text` property of a `TextBlock` similarly, using the `SpendingToPercentageStringConverter` instead. On both occasions, you also pass in the entire `SpendingCollection` instance through the `ConverterParameter` property of the `Binding`. The `ConverterParameter` property value maps to the method parameter named `parameter` in both the `Convert()` and `ConvertBack()` methods on the value converter. This makes the collection available inside the converter code.

`SpendingToBarWidthConverter`, shown in Listing 4-16, is used to convert a spending value to the length of the corresponding bar in the bar graph; both data types are `double`.

Listing 4-16. *Value Converter Converting Spending to Bar Width*

```
using System;
using System.Windows;
using System.Windows.Data;
using System.Windows.Shapes;

namespace Recipe4_4
{
  public class SpendingToBarWidthConverter : IValueConverter
  {
    public object Convert(object value, Type targetType,
      object parameter, System.Globalization.CultureInfo culture)
    {
      //verify validity of all the parameters
      if (value.GetType() != typeof(double) || targetType != typeof(double)
        || parameter == null
        || parameter.GetType() != typeof(SpendingCollection))
        return null;
      //cast appropriately
      double Spending = (double)value;
      double Total = ((SpendingCollection)parameter).Total;
      //find the xAxis
      Rectangle rectXAxis = (Rectangle)((MainPage)Application.Current.RootVisual)
        .FindName("rectXAxis");
      //calculate bar width in proportion to the xAxis width
      return (Spending / Total) * rectXAxis.Width;
    }

    public object ConvertBack(object value, Type targetType,
      object parameter, System.Globalization.CultureInfo culture)
    {
      //verify validity of all the parameters
      if (value.GetType() != typeof(double) || targetType != typeof(double)
        || parameter == null
        || parameter.GetType() != typeof(SpendingCollection))
        return null;
      //cast appropriately
      double BarWidth = (double)value;
      double Total = ((SpendingCollection)parameter).Total;
      //find the xAxis
      Rectangle rectXAxis = (Rectangle)((MainPage)Application.Current.RootVisual)
        .FindName("rectXAxis");
      //calculate new spending keeping total spending constant based on
```

```
      //new bar width to xAxis width ratio
      return (BarWidth / rectXAxis.Width) * Total;
    }
  }
}
```

To convert the spending value into bar width in `SpendingToBarWidthConverter.Convert()`, you calculate the ratio of the spending value in question to the total spending evaluated from the `SpendingCollection` passed in as `parameter`. You then calculate the bar width as the same ratio applied to the total width of the X axis of the graph, also defined as a `Rectangle` named `rectXAxis` in XAML. In `SpendingToBarWidthConverter.ConvertBack()`, you reverse that calculation.

Listing 4-17 shows the `SpendingToPercentageStringConverter` code. The calculation of the percentage value in `Convert()` is again based off the spending total derived from the `SpendingCollection` instance and then formatted appropriately to a string. Since you never do the reverse conversion, you do not implement `ConvertBack()` in this case.

Listing 4-17. *Value Converter Converting Spending to a Percentage String*

```
using System;
using System.Windows.Data;

namespace Recipe4_4
{
  public class SpendingToPercentageStringConverter : IValueConverter
  {
    public object Convert(object value, Type targetType,
      object parameter, System.Globalization.CultureInfo culture)
    {
      //verify validity of all the parameters
      if (value.GetType() != typeof(double) || targetType != typeof(string)
        || parameter == null
        || parameter.GetType() != typeof(SpendingCollection))
        return null;
      //cast appropriately
      double Spending = (double)value;
      double Total = ((SpendingCollection)parameter).Total;
      //calculate the spending percentage and format as string
      return ((Spending / Total) * 100).ToString("###.##") + " %";
    }

    public object ConvertBack(object value, Type targetType,
      object parameter, System.Globalization.CultureInfo culture)
    {
      throw new NotImplementedException();
    }
  }
}
```

■ **Note** There is no requirement that a value converter also perform a type conversion. In the code sample for SpendingToBarWidthConverter, for example, you convert values of the same data type double, where the conversion is one of context—that is, from one kind of measure (Spending) to another (Width). Therefore, it is called a value conversion. There is another concept known as a TypeConverter, which is discussed in more detail in Chapter 5.

Listing 4-18 shows the codebehind for the `MainPage`. Of note is the `MouseMove` handler `Rectangle_MouseMove()` for each `Rectangle` representing a bar in the `ItemsControl`. In the handler, you calculate the distance moved as the difference of the current mouse position and its previous position and change the `Width` of the bar accordingly. You then store the current position as the previous position for the next move.

Listing 4-18. *Codebehind for the Page*

```
using System.Windows;
using System.Windows.Controls;
using System.Windows.Input;
using System.Windows.Shapes;
namespace Recipe4_4
{
  public partial class MainPage : UserControl
  {
    private bool MouseLeftBtnDown = false;
    Point PreviousPos;
    public MainPage()
    {
      InitializeComponent();
    }

    private void Rectangle_MouseMove(object sender, MouseEventArgs e)
    {
      if (MouseLeftBtnDown)
      {
        Rectangle rect = (Rectangle)sender;
        Point CurrentPos = e.GetPosition(sender as Rectangle);
        double Moved = CurrentPos.X - PreviousPos.X;
        if (rect.Width + Moved >= 0)
        {
          rect.Width += Moved;
        }
        PreviousPos = CurrentPos;
      }
```

```
    }

    private void Rectangle_MouseLeftButtonDown(object sender,
      MouseButtonEventArgs e)
    {
      MouseLeftBtnDown = true;
      PreviousPos = e.GetPosition(sender as Rectangle);
    }

    private void Rectangle_MouseLeftButtonUp(object sender,
      MouseButtonEventArgs e)
    {
      MouseLeftBtnDown = false;
    }
  }
}
```

4-5. Binding Across Elements

Problem

You would like to data bind some property of a XAML element to a property on another element on the page or to a different property on the source element itself.

Solution

To bind to a property on another element, name the source element, and then use the `ElementName` property on the binding. To bind to a property on the same element, use the `RelativeSource` property on the binding.

How It Works

In earlier recipes in this chapter, you have walked through binding a property (target) of a XAML element to a property (source) on a CLR object. This is one possible scenario. You may encounter situations where the binding scenarios are slightly different in terms of the binding source.

Binding to Another Element

In this scenario, a property on an element on a page is data bound to a property on another element on the same page. You can achieve this by setting the `Binding.ElementName` property on the binding declaration to the name of the source element and the `Binding.Path` property to the name of the property on the element. Note that this feature was introduced in Silverlight 3.

For an example, consider a `Slider` control on a page, with a `TextBox` on the same page displaying the current value of the `Slider`. This snippet illustrates such a binding arrangement:

```
<TextBox Text="{Binding Path=Value,ElementName=sliderSource, Mode=OneWay}" />
<Slider x:Name="sliderSource"
        Minimum="0"
        Maximum="100" />
```

Note that the `Binding.ElementName` on the `TextBox.Text` property points to the `Slider` on the page. The rest of the binding declaration follows the usual binding rules; for instance, if you were to set the `Binding.Mode` value to `TwoWay`, editing the `TextBox.Text` to a permissible value within the `Slider`'s range would actually reset the `Slider` thumb to that value.

Binding to Self

In this scenario, a property on an element is data bound to another property on the same element. This is made possible by using the `Binding.RelativeSource` property. The `Binding.RelativeSource` property can be set to one of the two values specified in the `System.Windows.Data.RelativeSourceMode` enumeration: `Self` and `TemplatedParent`. Using the `RelativeSourceMode.Self` value allows the binding to use the element itself as a source for the binding.

In the following code snippet, you bind the `ForeGround` property of a `TextBox` to the `Text` property of the same `TextBox`. The intent is that if the user types in a valid color name in the `TextBox`, the edited text is displayed in that color. Since there is no conversion from string to a brush, you rely on a value converter to do the conversion for you:

```
<TextBox
  Foreground="{Binding Path=Text,RelativeSource={RelativeSource Self},
  Converter={StaticResource REF_ColorStringToBrushConverter}" />
```

Note the syntax of the `RelativeSource` attribute setting in the preceding binding expression. The format `RelativeSource={RelativeSource <RelativeSourceMode>}` is the required syntax.

Binding to the TemplatedParent

An instance of a control to which a control template is applied is the `TemplatedParent` to any element within the control template definition. The following snippet shows a possible binding where a `TextBox` within a control template is binding its `Foreground` property to the `TemplatedParent`'s `Foreground` property:

```
<ControlTemplate TargetType="MyControl">
  …
  <TextBox
      Foreground=
    "{Binding Path=Foreground,RelativeSource={RelativeSource TemplatedParent}}" />
  …

</ControlTemplate>
```

This will cause the `TextBox` to inherit the same `Foreground` brush that the developer decides to set on any particular instance of the control named `MyControl`.

This scenario is only useful within the context of control templating. Controls and control templates are discussed in Chapter 5, and we will cover this scenario in more detail there. This recipe does not elaborate on this scenario any more.

The Code

The code sample for this recipe illustrates the element binding and self binding techniques discussed above. The sample uses the new 3-D capabilities in Silverlight to rotate a simple visual along the X, Y, and Z axes of a 3-D plane. The visual contains a `Grid` with the current angle values for each rotation axis displayed within a `Border`, and three separate `Sliders` are used to control the rotation angles. For more on the Silverlight 3-D capabilities please refer to Chapter 3 in this book.

Figure 4-8 shows the sample in action.

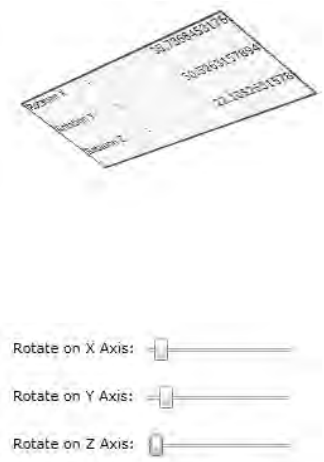


Figure 4-8. *Element and Self Binding sample*

The majority of the code is encapsulated in a user control named `RotatorDemoControl`. Listing 4-19 shows the complete XAML for `RotatorDemoControl`.

Listing 4-19. *XAML for RotatorDemoControl*

```
<UserControl x:Class="Recipe4_5.RotatorDemoControl"
             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"
             mc:Ignorable="d"
             xmlns:local="clr-namespace:Recipe4_5"
             >

  <Grid x:Name="LayoutRoot">
```

```
<Grid.RowDefinitions>
  <RowDefinition Height="0.75*" />
  <RowDefinition Height="0.25*" />
</Grid.RowDefinitions>
<Grid x:Name="target"
      Width="275"
      Height="100">
  <Grid.ColumnDefinitions>
    <ColumnDefinition />
    <ColumnDefinition />
    <ColumnDefinition />
  </Grid.ColumnDefinitions>
  <Grid.RowDefinitions>
    <RowDefinition />
    <RowDefinition />
    <RowDefinition />
  </Grid.RowDefinitions>
  <Border BorderThickness="2"
          Grid.RowSpan="3"
          Grid.ColumnSpan="3"
          BorderBrush="Red"
          Background="AliceBlue"></Border>
  <TextBlock Text="Rotation X"
             Margin="3,0,0,0" />
  <TextBlock Text=":"
             Grid.Column="1" />
  <TextBlock Text="{Binding Xangle}"
             Grid.Column="2"
             Margin="0,0,0,3" />
  <TextBlock Text="Rotation Y"
             Grid.Row="1"
             Margin="3,0,0,0" />
  <TextBlock Text=":"
             Grid.Column="1"
             Grid.Row="1" />
  <TextBlock Text="{Binding Yangle}"
             Grid.Column="2"
             Grid.Row="1"
             Margin="0,0,0,3" />
  <TextBlock Text="Rotation Z"
             Grid.Row="2"
             Margin="3,0,0,0" />
  <TextBlock Text=":"
             Grid.Column="1"
             Grid.Row="2" />
```

```
      <TextBlock Text="{Binding Zangle}"
                 Grid.Column="2"
                 Grid.Row="2"
                 Margin="0,0,0,3" />
      <Grid.Projection>
        <PlaneProjection x:Name="gridProjection" />
      </Grid.Projection>
    </Grid>
    <StackPanel Orientation="Vertical" HorizontalAlignment="Center"
                Grid.Row="1">
      <StackPanel Orientation="Horizontal"
                  Margin="0,10,0,10">
        <TextBlock Text="Rotate on X Axis: " />
        <Slider Minimum="0"
                Maximum="360"
                x:Name="sliderX"
                Value=
               "{Binding ElementName=gridProjection, Mode=TwoWay, Path=RotationX}"
                Width="125" />
      </StackPanel>
      <StackPanel Orientation="Horizontal"
                  Margin="0,10,0,10">
        <TextBlock Text="Rotate on Y Axis: " />
        <Slider Minimum="0"
                Maximum="360"
                x:Name="sliderY"
                Value=
               "{Binding ElementName=gridProjection, Mode=TwoWay, Path=RotationY}"
                Width="125" />
      </StackPanel>
      <StackPanel Orientation="Horizontal"
                  Margin="0,10,0,10">
        <TextBlock Text="Rotate on Z Axis: " />
        <Slider Minimum="0"
                Maximum="360"
                x:Name="sliderZ"
                Value=
               "{Binding ElementName=gridProjection, Mode=TwoWay, Path=RotationZ}"
                Width="125" />
      </StackPanel>
    </StackPanel>
  </Grid>
</UserControl>
```

As shown in Listing 4-19, the PlaneProjection named gridProjection projects the Grid to a 3-D plane. The PlaneProjection type exposes three properties, namely RotationX, RotationY and RotationZ, each of which can be independently set to an angle value between 0 and 360 degrees to rotate the Grid along that axis.

If you note the binding expression for the Value property of the Slider named sliderX, you will see that it is bound directly in a TwoWay mode to the RotationX property of gridProjection, utilizing the ElementName binding attribute. The range for sliderX is set to vary between 0 and 360, and changing this value will cause gridProjection to rotate along the X axis by that amount. The other two Sliders, sliderY and sliderZ, follow a similar arrangement to affect the RotationY and RotationZ properties of the gridProjection element.

Listing 4-20 shows the codebehind for the RotatorDemoControl.

Listing 4-20. *Codebehind for RotatorDemoControl*

```
using System.ComponentModel;
using System.Windows;
using System.Windows.Controls;

namespace Recipe4_5
{
  public partial class RotatorDemoControl : UserControl, INotifyPropertyChanged
  {
    public event PropertyChangedEventHandler PropertyChanged;

    public RotatorDemoControl()
    {
      InitializeComponent();

      sliderX.ValueChanged +=
        new RoutedPropertyChangedEventHandler<double>((s, e) =>
      {
        Xangle = sliderX.Value;
      });
      sliderY.ValueChanged +=
        new RoutedPropertyChangedEventHandler<double>((s, e) =>
      {
        Yangle = sliderY.Value;
      });
      sliderZ.ValueChanged +=
        new RoutedPropertyChangedEventHandler<double>((s, e) =>
      {
        Zangle = sliderZ.Value;
      });
    }

    private double _Xangle = default(double);
```

```
public double Xangle
{
  get
  {
    return _Xangle;
  }
  set
  {
    if (value != _Xangle)
    {
      _Xangle = value;
      if (PropertyChanged != null)
        PropertyChanged(this, new PropertyChangedEventArgs("Xangle"));
    }

  }
}

private double _Yangle = default(double);

public double Yangle
{
  get
  {
    return _Yangle;
  }

  set
  {
    if (value != _Yangle)
    {
      _Yangle = value;
      if (PropertyChanged != null)
        PropertyChanged(this, new PropertyChangedEventArgs("Yangle"));
    }

  }
}

private double _Zangle = default(double);
public double Zangle
{
  get
  {
    return _Zangle;
```

```
      }
      set
      {
        if (value != _Zangle)
        {
          _Zangle = value;
          if (PropertyChanged != null)
            PropertyChanged(this, new PropertyChangedEventArgs("Zangle"));
        }

      }
    }
  }

}
```

As Listing 4-20 shows, the `RotatorDemoControl` control class exposes three properties named `Xangle`, `Yangle`, and `Zangle` with property change notification enabled. These values are updated when the corresponding slider values are changed, as shown in the event handlers of the `ValueChanged` events of the `Sliders`, in the constructor of the `RotatorDemoControl` class.

If you refer to the `RotatorDemoControl` XAML in Listing 4-19, you will note that there are three `TextBlocks` inside the rotated `Grid` that are respectively bound to these properties. The intention is to display the angle values as the `Grid` is rotated. Looking at the binding statements for these `TextBlocks`, you will note that they simply provide the `Binding.Path` values pointing to the properties on `RotatorDemoControl`. But how do the bindings know to use the control class as its data source? Take a look at Listing 4-21 that shows the XAML for the `MainPage`, which actually declares the `RotatorDemoControl` user control.

Listing 4-21. *XAML for MainPage*

```
<UserControl x:Class="Recipe4_5.MainPage"
             xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
             xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
             xmlns:local="clr-namespace:Recipe4_5"
             Width="640"
             Height="480">
  <Grid x:Name="LayoutRoot"
        Background="White">
    <local:RotatorDemoControl
        DataContext="{Binding RelativeSource={RelativeSource Self}}" />
  </Grid>
</UserControl>
```

Listing 4-21 shows that the `DataContext` for the `RotatorDemoControl` is bound to itself because the `RelativeSource` attribute is set to `Self`. This then sets the `RotatorDemoControl` instance as the data source for the `TextBlock` bindings referred to earlier and helps display the angle values as notified through the corresponding properties on the `RotatorDemoControl` class.

4-6. Validating Input for Bound Data

Problem

You need to capture data validation errors in your application code and provide visual indications of such errors if needed.

Solution

Attach handlers to the `BindingValidationError` event of the control in question, and ensure that the binding is set to raise the event on validation exceptions.

How It Works

As you create UIs that are data bound to various controls in a `TwoWay` binding so that users of your application can edit the data, you often have the need for those edits to pass validation checks. And in the event one or more of those validations fail, you may want to capture the errors and display them to your users in a meaningful way.

Validation Error Notification

There is built-in support for notification of validation errors in the data binding subsystem within Silverlight. To enable this support, the `Binding.ValidatesOnExceptions` property needs to be set to `true` on the binding. This allows the framework to capture any exceptions raised during the setting of a property on a data source or during a type conversion and propagate them to your code as validation errors. This prevents the otherwise normal flow of your application suffering a crash from the exception being unhandled.

Most of the controls in the base class library that may typically be used in two-way bindings provide a built-in user interface to display the binding validation error to the user. The built-in user interface usually provides a small error icon overlaid on the control, hovering on which displays the error message in a tooltip beside the control. The error message displayed is the `Exception.Message` property value of the raised exception. Once the error is corrected, the control logic automatically removes the error user interface.

Figure 4-9 shows a `TextBox` control displaying a validation error with the default error user interface.

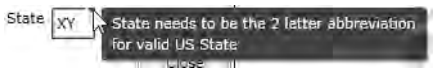


Figure 4-9. *TextBox control displaying validation error using default error UI*

Getting Error Information

In some cases, it may not be enough to simply display the error message. You may want programmatic access to the error information, for additional reasons like logging or some other custom handling of the error beyond the display of the standard error user interface.

To enable this, the `FrameworkElement` class (and, by inheritance, every control) can raise the `BindingValidationError` event whenever an exception gets propagated as a validation error or an

existing validation error is removed. To instruct the binding subsystem to raise this event, you need to set the `Binding.NotifyOnValidationError` property to true on the binding.

If you handle the `BindingValidationError` event, you can access detailed error information through the event argument of type `ValidationErrorEventArgs`. The `ValidationErrorEventArgs.Action` property, of type `ValidationErrorEventAction`, has two possible values—`ValidationErrorEventAction.Added` (indicating that a validation error has occurred) and `ValidationErrorEventAction.Removed` (indicating that an error was corrected). The `ValidationErrorEventArgs.Exception` property gives you access to the actual exception that caused the validation error.

Getting a Validation Error Summary

In many applications, it is common to show a summary of all the errors that a user might have made in performing the necessary data input. Typically, a summary display such as that will point out the fields where the errors were made, the nature of the error, and in some cases, will also include automatic navigation (click the entry in the summary to navigate to the field). This feature is also built into the Silverlight binding validation mechanism now and is enabled through the `System.Windows.Controls.ValidationSummary` control and its related classes in the `System.Windows.Controls.Data.Input` assembly.

Once you place a `ValidationSummary` control in your page, the binding subsystem automatically knows to populate it with the error entries and then binding errors occur. There is no additional wiring up that you have to perform. The following snippet shows a sample declaration:

```
<input:ValidationSummary />
```

Also note that validation errors are bubbled up the visual tree by the binding subsystem. This means that the `ValidationSummary` control can be placed anywhere in your page, as long as it is higher in the visual tree than the control(s) whose validation errors it is supposed to display.

Note that the default error and validation summary user interfaces can be customized using control templating. Please see Chapter 5 for more information on this.

Let's take a look at how all of this might work.

The Code

You'll modify Recipe 4-3 to add input validation. You remove the custom collection class in favor of using a simple `ObservableCollection`. To add the validation on the data source, you adjust some of the property setters to throw exceptions if certain validation rules are not met. You also change the types of `Employee.PhoneNum` and `Address.ZipCode` properties to string to simply the validation logic. The application data classes with some of these modified property setters are shown in Listing 4-22.

Listing 4-22. *Application Data Classes*

```
using System;
using System.Collections.Generic;
using System.Collections.Specialized;
using System.ComponentModel;
using System.Linq;
namespace Recipe4_6
{
  public class Employee : INotifyPropertyChanged
```

```
{
  //InotifyPropertyChanged implementation
  public event PropertyChangedEventHandler PropertyChanged;
  private void RaisePropertyChanged(PropertyChangedEventArgs e)
  {
    if (PropertyChanged != null)
      PropertyChanged(this, e);
  }

  public Employee()
  {
  }

  private string _FirstName;
  public string FirstName
  {
    get { return _FirstName; }
    set
    {
      string OldVal = _FirstName;
      if (OldVal != value)
      {
        _FirstName = value;
        RaisePropertyChanged(new PropertyChangedEventArgs("FirstName"));
      }
    }
  }
  private string _LastName;
  public string LastName
  {
    get { return _LastName; }
    set
    {
      string OldVal = _LastName;
      if (OldVal != value)
      {
        _LastName = value;
        RaisePropertyChanged(new PropertyChangedEventArgs("LastName"));
      }
    }
  }
  private string _PhoneNum;
  public string PhoneNum
  {
    get { return _PhoneNum; }
```

```
    set
    {
      string OldVal = _PhoneNum;

      if (value.Length != 10)
        throw new Exception("Phone Number has to be exactly 10 digits");
      try
      {
        Convert.ToInt64(value);
      }
      catch
      {
        throw new Exception("Phone Number has to be exactly 10 digits");
      }

      if (OldVal != value)
      {
        _PhoneNum = value;
        RaisePropertyChanged(new PropertyChangedEventArgs("PhoneNum"));
      }
    }
  }
  private Address _Address;
  public Address Address
  {
    get { return _Address; }
    set
    {
      Address OldVal = _Address;
      if (OldVal != value)
      {
        _Address = value;
        RaisePropertyChanged(new PropertyChangedEventArgs("Address"));
      }
    }
  }
  private bool _InError = default(bool);

  public bool InError
  {
    get
    {
      return _InError;
    }
```

```
      set
      {
        if (value != _InError)
        {
          _InError = value;
          if (PropertyChanged != null)
            PropertyChanged(this, new PropertyChangedEventArgs("InError"));
        }

      }
    }
  }

  public class Address : InotifyPropertyChanged
  {

    private static List<string> StateList =
      new List<string>(){ "AL","AK","AS","AZ","AR","CA","CO","CT","DE","DC","FM",
        "FL","GA","GU","HI","ID","IL","IN","IA","KS","KY","LA","ME","MH","MD","MA",
        "MI","MN","MS","MO","MT","NE","NV","NH","NJ","NM","NY","NC","ND","MP","OH",

« OK », »OR », »PW », »PA », »PR », »RI », »SC », »SD », »TN », »TX », »UT », »VT », »VI »,
»VA », »WA »,
        "WV","WI","WY" };

    public event PropertyChangedEventHandler PropertyChanged;
    private void RaisePropertyChanged(PropertyChangedEventArgs e)
    {
      if (PropertyChanged != null)
        PropertyChanged(this, e);
    }

    private string _Street;
    public string Street
    {
      get { return _Street; }
      set
      {
        string OldVal = _Street;
        if (OldVal != value)
        {
          _Street = value;
          RaisePropertyChanged(new PropertyChangedEventArgs("Street"));
        }
      }
```

```
}
private string _City;
public string City
{
  get { return _City; }
  set
  {
    string OldVal = _City;

    if (OldVal != value)
    {
      _City = value;
      RaisePropertyChanged(new PropertyChangedEventArgs("City"));
    }
  }
}
private string _State;
public string State
{
  get { return _State; }
  set
  {
    string OldVal = _State;
    //length needs to be 2 characters
    if (StateList.Contains(value) == false)
      throw new Exception(
        "State needs to be the 2 letter abbreviation for valid US State"
        );
          if (OldVal != value)
    {
      _State = value;
      RaisePropertyChanged(new PropertyChangedEventArgs("State"));
    }
  }
}
private string _ZipCode;
public string ZipCode
{
  get { return _ZipCode; }
  set
  {
    string OldVal = _ZipCode;
    //length needs to be 5 characters
    if (value.Length != 5)
      throw new Exception("Zipcode needs to be exactly 5 digits");
```

```
        try
        {
          Convert.ToInt32(value);
        }
        catch
        {
          throw new Exception("Zipcode needs to be exactly 5 digits");
        }

        if (OldVal != value)
        {
          _ZipCode = value;
          RaisePropertyChanged(new PropertyChangedEventArgs("ZipCode"));
        }
      }
    }
  }

}
```

As Listing 4-22 shows, `Employee.PhoneNum` validates a phone number if it has exactly ten digits in its setter and raises an `Exception` otherwise. Similarly, `Address.State` and `Address.ZipCode` check for a two-letter state abbreviation and a five-digit ZIP code, respectively, and raise `Exceptions` if those criteria are not met. Also note the new `InError` property on the `Employee` class; we will address its use in a little bit.

Listing 4-23 shows the complete XAML for the page.

Listing 4-23. *XAML for the Page*

```
<UserControl x:Class="Recipe4_6.MainPage"
             xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
             xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
             xmlns:local="clr-namespace:Recipe4_6"
             xmlns:d="http://schemas.microsoft.com/expression/blend/2008"
             xmlns:mc="http://schemas.openxmlformats.org/markup-compatibility/2006"
             xmlns:input=
"clr-namespace:System.Windows.Controls;assembly=System.Windows.Controls.Data.Input"
             mc:Ignorable="d"
             Width="400"
             Height="450">

  <UserControl.Resources>

    <local:BoolToVisibilityConverter x:Key="REF_BoolToVisibilityConverter" />

    <DataTemplate x:Key="dtEmployee">
```

```
    <Grid>
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="Auto" />
      </Grid.ColumnDefinitions>
      <TextBlock Text="{Binding FirstName}"/>
      <TextBlock Text="{Binding LastName}"
                 Grid.Column="1"
                 Grid.Row="0"
                 Margin="5,0,0,0" />
      <TextBlock Text=" -> Error!!" Foreground="Red"
                 Visibility=
    "{Binding InError, Converter={StaticResource REF_BoolToVisibilityConverter}}"
                 Grid.Column="2" />

    </Grid>
  </DataTemplate>
</UserControl.Resources>

<Grid x:Name="LayoutRoot"
      Background="White"
      Margin="10,10,10,10">
  <Grid.RowDefinitions>
    <RowDefinition Height="*" />
    <RowDefinition Height="Auto" />
    <RowDefinition Height="Auto" />
    <RowDefinition Height="Auto" />
  </Grid.RowDefinitions>

  <ListBox Grid.Row="0"
           x:Name="lbx_Employees"
           ItemTemplate="{StaticResource dtEmployee}"
           SelectionChanged="lbx_Employees_SelectionChanged" />

  <Grid x:Name="grid_NewButton"
        Margin="0,2,0,0"
        Grid.Row="1"
        HorizontalAlignment="Right">
    <Button  x:Name="btn_New"
             Click="btn_New_Click"
             Content="New Employee" />
  </Grid>

  <input:ValidationSummary Grid.Row="2" Margin="0,10,0,5"/>
```

```
<Border Grid.Row="3"
        Visibility="Collapsed"
        x:Name="border_EmployeeForm"
        Margin="0,2,0,0"
        BorderBrush="Black"
        BorderThickness="1"
        Padding="1,1,1,1">
  <Grid x:Name="grid_EmployeeForm">

    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.142*" />
      <ColumnDefinition Width="0.379*" />
      <ColumnDefinition Width="0.1*" />
      <ColumnDefinition Width="0.097*" />
      <ColumnDefinition Width="0.082*" />
      <ColumnDefinition Width="0.2*" />
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
      <RowDefinition Height="0.10*" />
      <RowDefinition Height="0.15*" />
      <RowDefinition Height="0.15*" />
      <RowDefinition Height="0.15*" />
      <RowDefinition Height="0.45*" />
    </Grid.RowDefinitions>

    <TextBox HorizontalAlignment="Stretch"
             Margin="1,1,1,1"
             x:Name="tbxFName"
             VerticalAlignment="Stretch"
             Text="{Binding FirstName, Mode=TwoWay}"
             Grid.Row="1"
             Width="Auto"
             Grid.RowSpan="1"
             Grid.ColumnSpan="2"
             Grid.Column="1" />
    <TextBox HorizontalAlignment="Stretch"
             Margin="1,1,1,1"
             x:Name="tbxLName"
             VerticalAlignment="Stretch"
             Text="{Binding LastName, Mode=TwoWay}"
             Grid.Row="1"
             Grid.Column="3"
             Width="Auto"
             Grid.RowSpan="1"
             Grid.ColumnSpan="3" />
```

```
<TextBlock HorizontalAlignment=”Stretch”
           Margin=”1,1,1,1”
           VerticalAlignment=”Stretch”
           Text=”Last”
           TextWrapping=”Wrap”
           Grid.RowSpan=”1”
           Grid.Column=”4”
           Grid.ColumnSpan=”2”
           Height=”Auto”
           Width=”Auto” />
<TextBlock HorizontalAlignment=”Center”
           Margin=”1,1,1,1”
           VerticalAlignment=”Center”
           Text=”First”
           TextWrapping=”Wrap”
           Grid.RowSpan=”1”
           Grid.Column=”1”
           Width=”Auto”
           Height=”Auto” />
<TextBlock HorizontalAlignment=”Center”
           Margin=”1,1,1,1”
           VerticalAlignment=”Stretch”
           Text=”Name”
           TextWrapping=”Wrap”
           Grid.RowSpan=”1”
           Grid.Row=”1”
           Height=”Auto”
           Width=”Auto” />
<TextBlock HorizontalAlignment=”Center”
           Margin=”1,1,1,1”
           VerticalAlignment=”Stretch”
           Text=”Street”
           TextWrapping=”Wrap”
           Grid.Row=”2”
           Width=”Auto” />
<TextBox HorizontalAlignment=”Stretch”
         x:Name=”tbxStreet”
         VerticalAlignment=”Stretch”
         Text=”{Binding Address.Street, Mode=TwoWay}”
         Grid.Row=”2”
         Margin=”1,1,1,1”
         Grid.Column=”1”
         Grid.ColumnSpan=”5”
         Width=”Auto” />
<TextBlock HorizontalAlignment=”Center”
           VerticalAlignment=”Stretch”
```

```
            Text="City"
            TextWrapping="Wrap"
            Margin="1,1,1,1"
            Grid.Row="3" />
<TextBlock Text="State"
            Margin="1,1,1,1"
            TextWrapping="Wrap"
            Grid.Column="2"
            Grid.Row="3"
            HorizontalAlignment="Center" />
<TextBlock Text="Zip"
            Margin="1,1,1,1"
            TextWrapping="Wrap"
            Grid.Column="4"
            Grid.Row="3"
            HorizontalAlignment="Center" />
<TextBox HorizontalAlignment="Stretch"
          x:Name="tbxCity"
          Margin="1,1,1,1"
          VerticalAlignment="Stretch"
          Text="{Binding Address.City, Mode=TwoWay}"
          Grid.Row="3"
          Grid.Column="1" />
<TextBox Background="Transparent"
          Grid.Column="3"
          Margin="1,1,1,1"
          Grid.Row="3"
          Text="{Binding Address.State, Mode=TwoWay,
         ValidatesOnExceptions=True,NotifyOnValidationError=True}"
          x:Name="tbxState">
</TextBox>
<TextBox Background="Transparent"
          Grid.Column="5"
          Grid.Row="3"
          Margin="1,1,1,1"
          Text="{Binding Address.ZipCode, Mode=TwoWay ,
           ValidatesOnExceptions=True,NotifyOnValidationError=True}"
          x:Name="tbxZipCode" />

<TextBlock HorizontalAlignment="Center"
            VerticalAlignment="Stretch"
            Text="Phone"
            Margin="1,1,1,1"
            TextWrapping="Wrap"
            Grid.Row="4" />
<TextBox Grid.Column="1"
```

```
                Grid.Row="4"
                Margin="1,1,1,1"
                Text="{Binding PhoneNum, Mode=TwoWay ,
          ValidatesOnExceptions=True,NotifyOnValidationError=True}"
                x:Name="tbxPhoneNum" />
        <Button  Grid.Column="5"
                Margin="1,1,1,1"
                Grid.Row="4"
                Height="30.911"
                VerticalAlignment="Top"
                Content="Close"
                x:Name="btnClose"
                Click="btnClose_Click" />
      </Grid>
    </Border>
  </Grid>
</UserControl>
```

Note the binding expression for the `TextBox`. Text for displaying and editing a state, a ZIP code, and a phone number sets both `ValidatesOnExceptions` and `NotifyOnValidationError` to `true`. Also note that the `dtEmployee` data template now includes an extra `TextBlock` with its `Visibility` property bound to the `InError` property of the bound `Employee` instance. This `TextBlock` then displays an error string in red beside the `Employee` name when `Employee.InError` is set to `true` for the currently selected `Employee` instance in the `lbx_Employees` and hides it when not. Since the `InError` property is `Boolean` in type, you use a value converter to convert it to type `Visibility` for the binding to work. Value converters were covered in more detail in Recipe 4-4. For the source code of the converter used here, you can look at the `BoolToVisibilityConverter` class in the sample code for this recipe.

And last, note the `ValidationSummary` control in the second row of the top level `Grid`. As validation errors are made, the `ValidationSummary` control gets populated with entries describing the error, and clicking one of the items positions you in the control in error.

Listing 4-24 shows the complete codebehind for the page.

Listing 4-24. *MainPage Codebehind*

```
using System.Windows;
using System.Windows.Controls;
using System.Windows.Media;
using System.Collections.ObjectModel;
using System.Collections.Generic;

namespace Recipe4_6
{
  public partial class MainPage : UserControl
  {
    public MainPage()
    {
      InitializeComponent();
```

```
//initialize the employee collection with some sample data
ObservableCollection<Employee> empColl = new ObservableCollection<Employee>();

empColl.Add(new Employee
{
  FirstName = “Joe”,
  LastName = “Duffin”,
  PhoneNum = “2125551212”,
  Address = new Address
  {
    Street = “2000 Mott Street”,
    City = “New York”,
    State = “NY”,
    ZipCode = “10006”
  }
});

empColl.Add(new Employee
{
  FirstName = “Alex”,
  LastName = “Bleeker”,
  PhoneNum = “7185551212”,
  Address = new Address
  {
    Street = “11000 Clover Street”,
    City = “New York”,
    State = “NY”,
    ZipCode = “10007”
  }
});

empColl.Add(new Employee
{
  FirstName = “Nelly”,
  LastName = “Myers”,
  PhoneNum = “7325551212”,
  Address = new Address
  {
    Street = “12000 Fay Road”,
    City = “New York”,
    State = “NY”,
    ZipCode = “10016”
  }
});
```

```
    lbx_Employees.ItemsSource = empColl;

    this.BindingValidationError +=
      new System.EventHandler<ValidationErrorEventArgs>((s, e) =>
    {

      if (lbx_Employees.SelectedItem == null) return;
      //change the InError property of the currently selected Employee
      if(e.Action == ValidationErrorEventAction.Added)
        (lbx_Employees.SelectedItem as Employee).InError = true;
      else
        (lbx_Employees.SelectedItem as Employee).InError = false;

    });

  }

  private void btn_New_Click(object sender, RoutedEventArgs e)
  {
    //get the bound collection
    ObservableCollection<Employee> empColl =
      (ObservableCollection<Employee>)lbx_Employees.ItemsSource;
    //create and initialize a new Employee
    Employee newEmp = new Employee();
    newEmp.Address = new Address();
    //add it to the collection
    empColl.Add(newEmp);
    //set the current selection to the newly added employee.
    //This will cause selection change to fire, and set the
    //datacontext for the form appropriately
    lbx_Employees.SelectedItem = newEmp;

  }

  private void lbx_Employees_SelectionChanged(object sender,
    SelectionChangedEventArgs e)
  {
    //set the datacontext of the form to the selected Employee
    grid_EmployeeForm.DataContext = (Employee)lbx_Employees.SelectedItem;
    //show the form
    border_EmployeeForm.Visibility = Visibility.Visible;
    grid_NewButton.Visibility = Visibility.Collapsed;
  }
```

```
    private void btnClose_Click(object sender, RoutedEventArgs e)
    {
      //hide the form
      if (lbx_Employees.SelectedItem != null)
        (lbx_Employees.SelectedItem as Employee).InError = false;
      border_EmployeeForm.Visibility = Visibility.Collapsed;
      grid_NewButton.Visibility = Visibility.Visible;
    }
  }
}
```

As you can see in the C# codebehind, you don't need to do anything special for the binding subsystem to display validation errors. If you refer to the `BindingValidationError` event handler on the page, you will see that you handle the event to update the `InError` property of the currently selected `Employee` in the `lbx_Employees`. If a validation error has occurred, you set it to `true`, and to `false` otherwise. If you refer to the XAML in Listing 4-23, this is the property change that notifies the data template `dtEmployee` to change the visibility of the error indicator `TextBlock`.

Also note that you are able to handle the `BindingValidationError` event on the page, even though the validation error happens at controls that are contained further down in the visual tree. As mentioned before, `BindingValidationError` events are bubbled all the way up to the highest level container in the XAML, so you are free to handle them anywhere in the visual tree, including in and higher than the control where it happened.

■ **Note** If you are in debug mode in Visual Studio, the debugger will break at the exceptions raised in the property setters for the data classes. This is normal, and if you continue with processing, you will see the application behave the way it should. The Silverlight runtime absorbs the unhandled exceptions because of the error handling property settings on the Binding and translates them to notifications. However, the Visual Studio debugger has no notion of this, so it breaks on the exception if you are in debug mode.

Figure 4-10 illustrates the UI used to display a binding validation error, errors displayed in the `ValidationSummary`, a summary item selected, and the tooltip UI displaying the actual error message in the focused control that's in error.

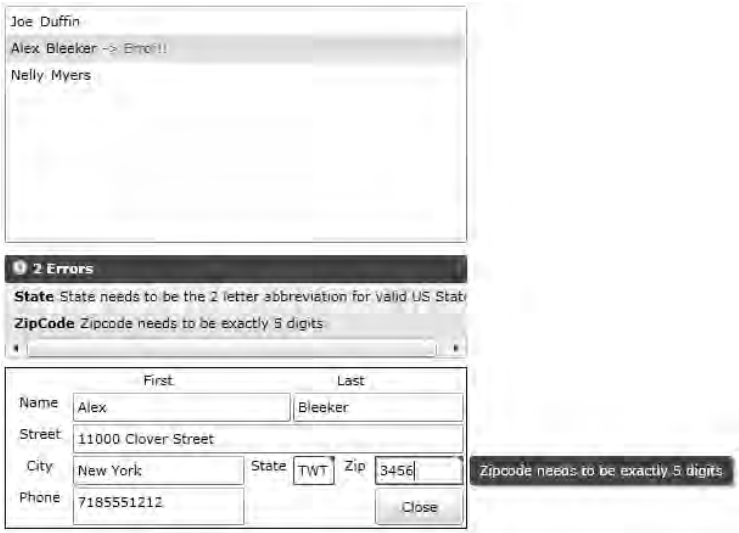


Figure 4-10. *Input validation error display with validation summary*

4-7. Controlling Updates

Problem

You would like to have explicit programmatic control on when property updates happen in a `TwoWay` data binding scenario.

Solution

Set the `UpdateSourceTrigger` attribute to `Explicit` in the binding declaration and programmatically invoke `BindingExpression.UpdateSource()`.

How It Works

The default behavior of most Silverlight controls is to send the updates occurring as a result of user edits directly to the bound property as soon as they occur. For instance, when you change the text in a `TextBox`, whose `Text` property is data bound in a `TwoWay` mode, the bound property is updated as soon as the user tabs out or focus is shifted somewhere else through some other means.

Often, it may be desirable to hold the updates and batch them at the end of an edit session through some explicit user-driven mechanism like a Save button. A multitude of reasons could drive a decision like that: computed fields that can only be calculated when multiple other fields are populated, validation logic that involves dependencies across multiple fields, some preprocessing of the edited data before updates are applied, and so on.

Silverlight offers you this control through the `Binding.UpdateSourceTrigger` property. Setting this property to `UpdateSourceTrigger.Explicit` causes the runtime to hold all property updates in the anticipation that you will perform the updates explicitly in code. The following code snippet shows a

binding declaration for the `Text` property on a `TextBox` with the `UpdateSourceTrigger` attribute set to `Explicit`:

```
<TextBox HorizontalAlignment="Stretch"
 Margin="1,1,1,1"
 x:Name="tbxLName"
 VerticalAlignment="Stretch"
 Text=
"{Binding LastName, Mode=TwoWay,UpdateSourceTrigger=Explicit}"
 Grid.Row="1"
 Grid.Column="3"
 Width="Auto"
 Grid.RowSpan="1"
 Grid.ColumnSpan="3" />
```

To actually perform the updates, you need to access the `BindingExpression` instance supporting the binding in question and invoke the `BindingExpression.UpdateSource()` method on it. You can acquire the `BindingExpression` instance in question by using the `FrameworkElement.GetBindingExpression()` method and passing in the property whose related `BindingExpression` you may need. This code snippet shows an example:

```
BindingExpression beLastName = tbxLName.GetBindingExpression(TextBox.TextProperty);
beLastName.UpdateSource();
```

Note that any validation logic that you have built into the property setters will execute only when `UpdateSource()` is invoked for that specific binding. So if you are batching the calls to `UpdateSource()`, it will cause all validation logic to be batched as well.

The Code

The code sample for this recipe extends the sample from Recipe 4-6 to add explicit update support. A Save button is added to the employee edit user interface and any updates made are propagated back when that button is clicked.

Figure 4-11 shows the state of the edit user interface before and after the Save button is clicked. Note that while you have potentially incorrect data in the `state`, `zipcode` and `phone` number fields, the validation check results only show up once the updates are attempted.

Figure 4-11. *Employee edit user interface before and after batched update attempt*

Listing 4-25 shows the XAML for the main page.

Listing 4-25. *XAML for MainPage*

```
<UserControl x:Class="Recipe4_7.MainPage"
             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:local="clr-namespace:Recipe4_7"
             xmlns:mc="http://schemas.openxmlformats.org/markup-compatibility/2006"
             xmlns:input="clr-
namespace:System.Windows.Controls;assembly=System.Windows.Controls.Data.Input"
             Width="400"
             Height="450">
    <UserControl.Resources>

    <local:BoolToVisibilityConverter x:Key="REF_BoolToVisibilityConverter" />

    <DataTemplate x:Key="dtEmployee">
      <Grid>
        <Grid.ColumnDefinitions>
          <ColumnDefinition Width="Auto" />
          <ColumnDefinition Width="Auto" />
          <ColumnDefinition Width="Auto" />
        </Grid.ColumnDefinitions>
```

```
      <TextBlock Text="{Binding FirstName}" />
      <TextBlock Text="{Binding LastName}"
                 Grid.Column="1"
                 Grid.Row="0"
                 Margin="5,0,0,0" />
      <TextBlock Text=" -> Error!!"
                 Foreground="Red"
                 Visibility=
    "{Binding InError, Converter={StaticResource REF_BoolToVisibilityConverter}}"
                 Grid.Column="2" />

    </Grid>
  </DataTemplate>

</UserControl.Resources>
  <Grid x:Name="LayoutRoot"
        Background="White"
        Margin="10,10,10,10">
      <Grid.RowDefinitions>
         <RowDefinition Height="*" />
         <RowDefinition Height="Auto" />
         <RowDefinition Height="Auto" />
         <RowDefinition Height="Auto" />
      </Grid.RowDefinitions>
      <ListBox Grid.Row="0"
               x:Name="lbx_Employees"
               ItemTemplate="{StaticResource dtEmployee}"
               SelectionChanged="lbx_Employees_SelectionChanged" />
      <Grid x:Name="grid_NewButton"
            Margin="0,2,0,0"
            Grid.Row="1"
            HorizontalAlignment="Right">
          <Button  x:Name="btn_New"
                   Click="btn_New_Click"
                   Content="New Employee" />
      </Grid>
  <input:ValidationSummary Grid.Row="2"
                           Margin="0,10,0,5" />
  <Border Grid.Row="3"
              Visibility="Collapsed"
              x:Name="border_EmployeeForm"
              Margin="0,2,0,0"
              BorderBrush="Black"
              BorderThickness="1"
              Padding="1,1,1,1">
```

```
<Grid x:Name="grid_EmployeeForm">

    <Grid.ColumnDefinitions>
        <ColumnDefinition Width="0.142*" />
        <ColumnDefinition Width="0.379*" />
        <ColumnDefinition Width="0.1*" />
        <ColumnDefinition Width="0.097*" />
        <ColumnDefinition Width="0.082*" />
        <ColumnDefinition Width="0.2*" />
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
        <RowDefinition Height="0.10*" />
        <RowDefinition Height="0.15*" />
        <RowDefinition Height="0.15*" />
        <RowDefinition Height="0.15*" />
        <RowDefinition Height="0.45*" />
    </Grid.RowDefinitions>
    <TextBox HorizontalAlignment="Stretch"
             Margin="1,1,1,1"
             x:Name="tbxFName"
             VerticalAlignment="Stretch"
             Text=
      "{Binding FirstName, Mode=TwoWay, UpdateSourceTrigger=Explicit}"
             Grid.Row="1"
             Width="Auto"
             Grid.RowSpan="1"
             Grid.ColumnSpan="2"
             Grid.Column="1" />
    <TextBox HorizontalAlignment="Stretch"
             Margin="1,1,1,1"
             x:Name="tbxLName"
             VerticalAlignment="Stretch"
             Text=
        "{Binding LastName, Mode=TwoWay,UpdateSourceTrigger=Explicit}"
             Grid.Row="1"
             Grid.Column="3"
             Width="Auto"
             Grid.RowSpan="1"
             Grid.ColumnSpan="3" />
    <TextBlock HorizontalAlignment="Stretch"
               Margin="1,1,1,1"
               VerticalAlignment="Stretch"
               Text="Last"
               TextWrapping="Wrap"
               Grid.RowSpan="1"
```

```
            Grid.Column="4"
            Grid.ColumnSpan="2"
            Height="Auto"
            Width="Auto" />
  <TextBlock HorizontalAlignment="Center"
            Margin="1,1,1,1"
            VerticalAlignment="Center"
            Text="First"
            TextWrapping="Wrap"
            Grid.RowSpan="1"
            Grid.Column="1"
            Width="Auto"
            Height="Auto" />
  <TextBlock HorizontalAlignment="Center"
            Margin="1,1,1,1"
            VerticalAlignment="Stretch"
            Text="Name"
            TextWrapping="Wrap"
            Grid.RowSpan="1"
            Grid.Row="1"
            Height="Auto"
            Width="Auto" />
  <TextBlock HorizontalAlignment="Center"
            Margin="1,1,1,1"
            VerticalAlignment="Stretch"
            Text="Street"
            TextWrapping="Wrap"
            Grid.Row="2"
            Width="Auto" />
  <TextBox HorizontalAlignment="Stretch"
           x:Name="tbxStreet"
           VerticalAlignment="Stretch"
           Text=
"{Binding Address.Street, Mode=TwoWay, UpdateSourceTrigger=Explicit}"
           Grid.Row="2"
           Margin="1,1,1,1"
           Grid.Column="1"
           Grid.ColumnSpan="5"
           Width="Auto" />
  <TextBlock HorizontalAlignment="Center"
             VerticalAlignment="Stretch"
             Text="City"
             TextWrapping="Wrap"
             Margin="1,1,1,1"
             Grid.Row="3" />
```

```
  <TextBlock Text="State"
             Margin="1,1,1,1"
             TextWrapping="Wrap"
             Grid.Column="2"
             Grid.Row="3"
             HorizontalAlignment="Center" />
  <TextBlock Text="Zip"
             Margin="1,1,1,1"
             TextWrapping="Wrap"
             Grid.Column="4"
             Grid.Row="3"
             HorizontalAlignment="Center" />
  <TextBox HorizontalAlignment="Stretch"
           x:Name="tbxCity"
           Margin="1,1,1,1"
           VerticalAlignment="Stretch"
           Text=
  "{Binding Address.City, Mode=TwoWay, UpdateSourceTrigger=Explicit}"
           Grid.Row="3"
           Grid.Column="1" />

  <TextBox Background="Transparent"
           Grid.Column="3"
           Margin="1,1,1,1"
           Grid.Row="3"
           Text=
  "{Binding Address.State, Mode=TwoWay,UpdateSourceTrigger=Explicit,
  ValidatesOnExceptions=True,NotifyOnValidationError=True}"
           x:Name="tbxState">
  </TextBox>


  <TextBox Background="Transparent"
           Grid.Column="5"
           Grid.Row="3"
           Margin="1,1,1,1"
           Text=
"{Binding Address.ZipCode, Mode=TwoWay, UpdateSourceTrigger=Explicit,
    ValidatesOnExceptions=True,NotifyOnValidationError=True}"
           x:Name="tbxZipCode" />

  <TextBlock HorizontalAlignment="Center"
             VerticalAlignment="Stretch"
             Text="Phone"
             Margin="1,1,1,1"
```

```
                        TextWrapping="Wrap"
                        Grid.Row="4" />
                <TextBox Grid.Column="1"
                         Grid.Row="4"
                         Margin="1,1,1,1"
                         Text=
                    "{Binding PhoneNum, Mode=TwoWay, UpdateSourceTrigger=Explicit,
            ValidatesOnExceptions=True,NotifyOnValidationError=True}"
                         x:Name="tbxPhoneNum" />
                <StackPanel Orientation="Horizontal"
                            Grid.Column="4"
                            Margin="1,1,1,1"
                            Grid.ColumnSpan="2"
                            Grid.Row="4">
                    <Button Height="30.911"
                            Margin="2,2,2,0"
                            VerticalAlignment="Top"
                            Content="Save"
                            x:Name="btnSave"
                            Click="btnSave_Click" />
                    <Button Height="30.911"
                            Margin="2,2,2,0"
                            VerticalAlignment="Top"
                            Content="Close"
                            x:Name="btnClose"
                            Click="btnClose_Click" />
                </StackPanel>

            </Grid>
        </Border>
    </Grid>
</UserControl>
```

Note the changes in XAML to the `Binding` declarations to set the `UpdateSourceTrigger` to `Explicit`. Listing 4-26 shows the codebehind.

Listing 4-26. *Codebehind to MainPage*

```
using System.Collections.ObjectModel;
using System.Linq;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Data;
namespace Recipe4_7
{
```

```
  public partial class MainPage : UserControl
  {
    public MainPage()
    {
      InitializeComponent();

      //initialize the employee collection with some sample data
      ObservableCollection<Employee> empColl =
        new ObservableCollection<Employee>();

      empColl.Add(new Employee
      {
        FirstName = "Joe",
        LastName = "Duffin",
        PhoneNum = "2125551212",
        Address = new Address
        {
          Street = "2000 Mott Street",
          City = "New York",
          State = "NY",
          ZipCode = "10006"
        }
      });

      empColl.Add(new Employee
      {
        FirstName = "Alex",
        LastName = "Bleeker",
        PhoneNum = "7185551212",
        Address = new Address
        {
          Street = "11000 Clover Street",
          City = "New York",
          State = "NY",
          ZipCode = "10007"
        }
      });

empColl.Add(new Employee
      {
        FirstName = "Nelly",
        LastName = "Myers",
        PhoneNum = "7325551212",
        Address = new Address
        {
```

```
          Street = "12000 Fay Road",
          City = "New York",
          State = "NY",
          ZipCode = "10016"
        }
      });

      lbx_Employees.ItemsSource = empColl;

      this.BindingValidationError +=
        new System.EventHandler<ValidationErrorEventArgs>((s, e) =>
        {

          if (lbx_Employees.SelectedItem == null) return;
          //change the InError property of the currently selected Employee
          if (e.Action == ValidationErrorEventAction.Added)
            (lbx_Employees.SelectedItem as Employee).InError = true;
          else
            (lbx_Employees.SelectedItem as Employee).InError = false;

        });
    }

    private void btn_New_Click(object sender, RoutedEventArgs e)
    {
      //get the bound collection
      ObservableCollection<Employee> empColl =
        (ObservableCollection<Employee>)lbx_Employees.ItemsSource;
      //create and initialize a new Employee
      Employee newEmp = new Employee();
      newEmp.Address = new Address();
      //add it to the collection
      empColl.Add(newEmp);
//set the current selection to the newly added employee.
      //This will cause selection change to fire, and set the
      //datacontext for the form appropriately
      lbx_Employees.SelectedItem = newEmp;

    }

    private void lbx_Employees_SelectionChanged(object sender,
      SelectionChangedEventArgs e)
    {
      //set the datacontext of the form to the selected Employee
      grid_EmployeeForm.DataContext = (Employee)lbx_Employees.SelectedItem;
```

```
      //show the form
      border_EmployeeForm.Visibility = Visibility.Visible;
      grid_NewButton.Visibility = Visibility.Collapsed;
    }

    private void btnClose_Click(object sender, RoutedEventArgs e)
    {
      //hide the form
      border_EmployeeForm.Visibility = Visibility.Collapsed;
      grid_NewButton.Visibility = Visibility.Visible;
    }

    private void btnSave_Click(object sender, RoutedEventArgs e)
    {

      var bindingExpressions =
        grid_EmployeeForm.Children.OfType<TextBox>().
        Select((tbx)=>tbx.GetBindingExpression(TextBox.TextProperty));
      foreach (BindingExpression be in bindingExpressions) be.UpdateSource();
    }
  }
}
```

Note the code in the `Click` event handler for `btnSave`. You perform a quick LINQ query on `grid_EmployeeForm.Children` collection to get access to the `BindingExpressions` for the `Text` property of all the children of type `TextBox`. You then proceed to iterate through the collection of `BindingExpressions` and call `UpdateSource()` on each of them.

4-8. Providing reasonable defaults for bound data

Problem

You want to provide some default binding behavior for data bound fields—such as formatting, null value replacements, or fallback values in case of input validation failure.

Solution

Use the string format, null value replacement, and fallback value features of the Binding type.

How It Works

Silverlight 4 adds support for null value replacement, fallback values, and string formatting to data binding.

Null Value Replacement

Data fields or properties in backing business objects often have differing connotations for what represents a null value within that application's context. For example a null CLR string may not be acceptable by a business logic layer whereas an empty string or the string "null" may indicate that a database null value needs to be stored in the bound data field. Another example could be a business data type of nullable<int> bound to a TextBox, where an empty string entered in the UI cannot be automatically converted to a nullable<int>. Similarly, on the UI side of things, a null value of type such as nullable<int> coming from the business logic layer may need a specific visual representation, such as an empty string.

Typically, developers have employed value converters to perform these types of conversions. The Binding element in Silverlight 4 exposes a property named TargetNullValue (defined in the BindingBase class) that allows this problem to be solved much more elegantly. TargetNullValue is of type object, and when set to a specific value does the following:

- On transfer of data from the data source to the target property, the binding displays the value specified in the TargetNullValue, whenever the source data is a CLR null value.
- On transfer of data from the target to the data source, the binding transfers a CLR null value whenever it encounters the value specified in TargetNullValue.

As an example, look at this snippet:

```
<TextBox Text="{Binding Path=WeddingAnniversaryDate, TargetNullValue=``}"/>
```

If the WeddningAnniversaryDate source property was of type nullable<DateTime> (or DateTime? In C# terms), then a CLR null value from the property will displayed as an empty string in the UI. Conversely, if an unmarried user applies an empty string in the UI, the value transferred to the underlying business object's WeddingAnniversaryDate property will be a CLR null.

Fallback value

There can be several reasons why an error might occur in transferring a value from a source property to a target through a binding: an invalid property path specification in the binding declaration in XAML, errors in value conversion, a specific ValueConverter throwing an exception, string formatting errors, etc.

To avoid an application exception during such scenarios, it would be handy to be able to provide some sort of fallback value that the UI can display in face of such exceptions without causing the application to fail. Silverlight 4 introduces a FallbackValue property (again through the BindingBase class) that allows you to do exactly that. This snippet shows an example:

```
<TextBox Text="{Binding Path=Salary, FallbackValue=0}"/>
```

In this snippet, if there was any kind of error in trying to transfer the value of the Salary data field to the bound Text property of the TextBox, the value 0 specified in the FallbackValue attribute will be displayed. Note that FallbackValue only applies to the transfer of data from source to target and not vice versa.

String Formatting

Silverlight 4 also adds a StringFormat property to the Binding type. Setting the StringFormat type to an appropriate format allows you to apply a formatting to a value when displayed as text on the UI. This snippet shows an example:

```
<TextBox Text="{Binding Path=PhoneNum, StringFormat=(###) ###-####}"/>
```

Let's assume that the PhoneNum field in the backing class is a long value. With the applied StringFormat, a PhoneNum value of 7325551212 will display as (732) 555-1212. Any valid string format as allowed by the String.Format() method is an acceptable value. For the various string formatting options, a good reference is the documentation for the String.Format() method.

You can also use the standard parameter substitution mechanism in the format. The snippet below shows an example where a positioned parameter specifies the formatting of the phone number:

```
<TextBox Text="{Binding Path=PhoneNum,
    StringFormat='Phone No: \{0:(###) ###-####\}' }"/>
```

In this case, a source value of 7325551212 will be formatted as Phone No: (732) 555-1212. Note that since bindings in Silverlight always bind a single value to a single property, using more than one parameter substitution value (i.e. more than the 0^{th} placeholder in the above format) is an error. Also note that the "{" and the "}" tokens are escaped with a "\" to prevent the XAML parser from considering them as part of the binding expression rather than the format string.

The Code

To demonstrate the above features, you adapt the code sample from Recipe 4-6. For more details about that sample, please refer back to Recipe 4-6, as we will only discuss the changes we make for this recipe.

Listing 4-27 shows the relevant changes to the data source classes in the dataclasses.cs file.

Listing 4-27. *Changes to the data source classes*

```
public class Employee : INotifyPropertyChanged
{
  ...

  private long _PhoneNum = 9999999999;
  public long PhoneNum
  {
      get { return _PhoneNum; }
      set
      {
          long OldVal = _PhoneNum;

          if (_PhoneNum.ToString().Trim().Length != 10)
              throw new Exception("Phone Number has to be exactly 10 digits");
```

```
            if (OldVal != value)
            {
                _PhoneNum = value;
                RaisePropertyChanged(new PropertyChangedEventArgs("PhoneNum"));
            }
        }
    }

  ...
}

public class Address : INotifyPropertyChanged
{

  ...

    private string _ZipCode = null;
    public string ZipCode
    {
        get
        {
            if (_ZipCode == null)
                throw new Exception();
            else
                return _ZipCode;
        }
        set
        {
            string OldVal = _ZipCode;
            //length needs to be 5 characters
            if (value.Length != 5)
                throw new Exception("Zipcode needs to be exactly 5 digits");
            try
            {
                Convert.ToInt32(value);
            }
            catch
            {
                throw new Exception("Zipcode needs to be exactly 5 digits");
            }

            if (OldVal != value)
            {
                _ZipCode = value;
                RaisePropertyChanged(new PropertyChangedEventArgs("ZipCode"));
```

```
            }
        }
    }
}
```

You change the PhoneNum property to be of type long and initialize it to a default value. You also change the ZipCode property to of type string and throw an exception in the property getter if the current value is null. We will explain the motivation behind the changes as we examine the corresponding changes in the XAML in the next listing. Listing 4-28 shows the relevant changes made to the bindings in MainPage.xaml highlighted in bold.

Listing 4-28. *Changes to bindings in MainPage.xaml*

```
<Grid x:Name="grid_EmployeeForm">
    ...
    <TextBox Background="Transparent"
         Grid.Column="3"
         Margin="1,1,1,1"
         Grid.Row="3"
         Text="{Binding Address.State, Mode=TwoWay, TargetNullValue='NJ',
        ValidatesOnExceptions=True,NotifyOnValidationError=True}"
         x:Name="tbxState">
    </TextBox>
    <TextBox Background="Transparent"
         Grid.Column="5"
         Grid.Row="3"
         Margin="1,1,1,1"
         Text="{Binding Address.ZipCode, Mode=TwoWay ,FallbackValue='08820',
          ValidatesOnExceptions=True,NotifyOnValidationError=True}"
         x:Name="tbxZipCode" />


    <TextBox Grid.Column="1"
         Grid.Row="4"
         Margin="1,1,1,1"
         Text="{Binding PhoneNum, Mode=TwoWay ,StringFormat=(###) ###-####,
  ValidatesOnExceptions=True,NotifyOnValidationError=True}"
         x:Name="tbxPhoneNum" />

    ...
</Grid>
```

The first change to note in Listing 4-28 is the addition of the TargetNullValue attribute to the binding to the Text property on the tbxState TextBox. Since the initial value of the bound property State on the Address class is a CLR null, the binding populates the Text property with the initial value of 'NJ' when the new employee form is initially displayed.

The second change to note is the use of the FallbackValue attribute on the binding for the tbxZipCode TextBox. If you refer back to Listing 4-27, you will note that you changed the bound property Address.ZipCode to throw an exception in the property getter when the property value is null. Since this is the case when a new instance of the data class is initially created, this causes the binding to result in an error, and consequently the FallbackValue to be used to populate the Text property.

The last change to note is the use of the StringFormat attribute on the binding for the tbxPhoneNum property. You may have noticed in Listing 4-27 that you changed the backing property PhoneNum to a long. The application of the specified StringFormat causes a long value of 7325551212 to be displayed as (732) 555-1212 whereas without the format applied, it would have been converted to the string 7325551212 and displayed as is.

Figure 4-12 shows the New Employee form open with no data entered.

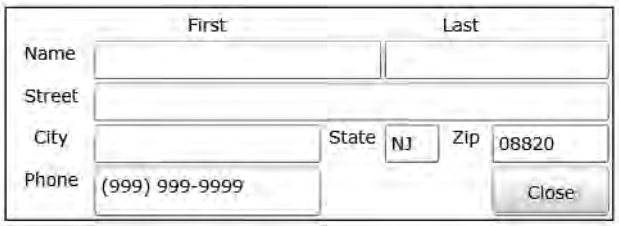


Figure 4-12. *New Employee form with the binding enhancements applied.*

CHAPTER 5

Controls

If you are a presentation layer developer or designer, we do not need to tell you how important controls can be in building quality user interfaces efficiently with a modular approach. To that end, any good UI development framework comes with a comprehensive library of controls, and Silverlight is no exception. From basic controls like `Button`, `RadioButton`, and `CheckBox` to more advanced controls like `Calendar` and `DataGrid`, Silverlight offers a fairly wide set to choose from. Most of the Silverlight controls distributed as a part of the core runtime are found in the `System.Windows.Controls` and `System.Windows.Controls.Primitives` namespaces in the `System.Windows` assembly. Additional controls are distributed as a part of the Silverlight SDK and are found in the `System.Windows.Controls.dll` and `System.Windows.Controls.Data.dll` assemblies. The core runtime control assembly is added to all Silverlight projects created using Visual Studio, with references to the other two assemblies and appropriate namespace mappings for XAML usage added as necessary.

Controls do not always meet the developer's needs right out of the box. More often than not, their default UI must be adapted for a specific application's needs. All Silverlight controls expose rich APIs consisting of various properties and methods that can be used to further customize the control's UI. Silverlight also incorporates the concept of styles. Styles allow you to collect specific settings for a control type and reapply them across many control instances, helping you achieve reuse as well UI standardization. And lastly, for those scenarios where the control developer's intent simply does not satisfy your UI needs, Silverlight also incorporates control templates, a feature that allows you to completely replace a control's default UI with your own while leaving the control's behavior intact.

Silverlight also allows you to write your own controls. You can write user controls (alternatively called composite controls) that are more application or domain specific and are usually crafted by composing a UI out of other existing controls. Or you can write custom controls, a more advanced control implementation strategy resulting in more general-purpose usage and allowing you to benefit from features like control templates.

Although this chapter is on controls, we will not to cover in detail the usage and API for each control that Silverlight comes with. That information is easily found in the Silverlight documentation at `msdn.microsoft.com/en-us/library/cc189048(VS.95).aspx` and in other books on Silverlight like Matthew MacDonald's *Pro Silverlight 4 in C#* (Apress, 2010). Instead, we will focus more on the following:

- Various extensibility mechanisms in the Silverlight control framework
- Common control customization scenarios
- Control authoring

Our hope is that once you get familiar with using the controls with help from the sources we've mentioned, these recipes will give you that additional knowledge to make you truly productive in using and authoring controls.

A Word About the Samples

Most of the control recipes in this chapter need to use some form of application data. To make it easier to structure the sample code, and to avoid having to repetitively explain the data source logic, we include a common Windows Communication Foundation (WCF) web service and use it as the data source for the recipes wherever applicable. The WCF service defines a set of service operations that expose various data elements from the `Production` schema in the `AdventureWorks` Online Transaction Processing (OLTP) sample database. LINQ to SQL is used to generate the data model and corresponding data classes for the tables in the schema that we use in the various samples. Once you download the sample code, the WCF service is in the `AdventureWorksDataService` project in the `Ch05_Controls` Visual Studio solution.

We use SQL Server 2008 Express version, which you can download for free from `www.microsoft.com/express/sql/download/default.aspx`. When you install the product, take care to name the server `SQLEXPRESS`. This is the server name that the code samples expect. If you must change it, visit the `Web.config` files for the web service project, and change the database connection strings to reflect your chosen server name.

You will also need to install the `AdventureWorks` OLTP database sample for SQL Server 2008, which you can download at `msftdbprodsamples.codeplex.com/releases/view/4004`. Note that you can get this database in two flavors: one that uses the new SQL Server 2008 data types and schema and one that continues to use the SQL Server 2005 versions. We chose to use the 2005 schema version to attain a larger reach for those who might already have `AdventureWorks` installed, so keep that in mind while downloading. The installer packages will most likely be named `AdventureWorksDB.msi` or `AdventureWorksDB_x64.msi`, depending on your choice of the 32-bit or 64-bit architecture.

We do not discuss the WCF service code in this chapter, and we hope you will navigate to the sample code to take a look as needed. To learn more about using a WCF service with Silverlight, check out Chapter 7. Recipe 7-4 uses LINQ to SQL in a similar approach as used here in the `AdventureWorks` service and will provide you with a good background for the related techniques.

5-1. Customizing a Control's Basic Appearance

Problem

You want to customize the look and feel of a control by setting various properties. Furthermore, you want to create an artifact that can be used repeatedly to apply these property values to multiple controls of the same type.

Solution

Create a style in XAML containing the necessary property settings. Then, apply the style to all controls of that type to get a consistent look and feel.

How It Works

A style is a collection of property value settings targeted to a control of a specific type. Styles are typically defined in XAML as a resource in a `ResourceDictionary`. The `TargetType` property for a style determines what control type the `Style` can be applied to. Once defined, the style can be accessed in XAML using the `StaticResource` markup extension.

Property settings in style definitions are defined using the <Setter> element, where Setter.Property is set to the name of the property on the target that you want the style to influence and Setter.Value contains the value that you want to apply. The following code shows a simple style definition for a Button, where the Foreground and the FontSize properties of the Button will be set to the values specified in the style definition:

```
<Style TargetType="Button"
       x:Key="STYLE_Button">
  <Setter Property="Foreground"
          Value="#FFE41414" />
  <Setter Property="FontSize"
          Value="18" />
</Style>
```

The FrameworkElement base class, and as such every control in the Silverlight Control Framework, exposes a Style dependency property. This property can be set on any control on a page, either in XAML or in the codebehind, to apply a style to that control. The following code shows the application of a style to a Button control:

```
<Button Style="{StaticResource STYLE_Button}" />
```

Starting with Silverlight 3, styles also support inheritance (i.e., you can define a new style based on an existing style). In the new style definition, you can choose to redefine existing property settings to new values, as well as add new property settings. The BasedOn attribute on a style definition needs to be set to the base style from which you are inheriting the current style. This code shows an inherited style definition:

```
<Style TargetType="Button"
       x:Key="STYLE_InheritedButton"
       BasedOn="{StaticResource STYLE_Button}">
  <Setter Property="Width"
          Value="225" />
  <Setter Property="FontFamily"
          Value="Trebuchet" />
</Style>
```

Style Scoping

Also recall that styles are declared as resources. Consequently, in XAML markup, styles are scoped by the resource dictionary to which they belong. For example, a style defined in the Resources section of a page can be applied to any element in that page at any level of the hierarchy, whereas a style defined in the Resources section of a Grid can only be applied to elements within that Grid. To have a style be universally available to an application, you can define the style in the Application.Resources section in your App.xaml file. You can also use a MergedResourceDictionary to bring in styles defined in external resource dictionaries. For more on ResourceDictionary and MergedResourceDictionary, please refer to related recipes in Chapter 2.

The Code

The code sample in Listing 5-1 demonstrates how to define styles and apply them to controls. The XAML page contains three instances each of a `Button`. Two of the `Button` instances have styles applied to them to illustrate the resulting changes in look and feel.

Listing 5-1. *MainPage.xaml with a sample style targeting a button*

```
<UserControl x:Class="Recipe5_1.MainPage"
             xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
             xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
             Width="400"
             Height="300">
  <UserControl.Resources>
    <Style TargetType="Button"
           x:Key="STYLE_Button">
      <Setter Property="Width"
              Value="100" />
      <Setter Property="Height"
              Value="30" />
      <Setter Property="Foreground"
              Value="#FFE41414" />
      <Setter Property="Background">
        <Setter.Value>
          <LinearGradientBrush EndPoint="0.5,1"
                               StartPoint="0.5,0">
            <GradientStop Color="#FFE26F56" />
            <GradientStop Color="#FFDA390B"
                          Offset="1" />
          </LinearGradientBrush>
        </Setter.Value>
      </Setter>
      <Setter Property="FontSize"
              Value="18" />
      <Setter Property="FontFamily"
              Value="Georgia" />
    </Style>

    <Style TargetType="Button"
           x:Key="STYLE_InheritedButton" BasedOn="{StaticResource STYLE_Button}">
      <Setter Property="Width"
              Value="225" />
      <Setter Property="FontFamily"
              Value="Trebuchet" />
      <Setter Property="Cursor"
              Value="Hand" />
```

```
      <Setter Property="Margin"
              Value="0,10,0,10" />
    </Style>

  </UserControl.Resources>

  <StackPanel x:Name="LayoutRoot"
              Background="White">
    <Button Content="Not Styled"
            Margin="0,0,0,20" />

    <Button Content="Styled" x:Name="Styled"
            Style="{StaticResource STYLE_Button}" />
    <Button Content="Inherited Style" x:Name="Inherited"
            Style="{StaticResource STYLE_InheritedButton}" />
  </StackPanel>

</UserControl>
```

The style named `STYLE_Button` is being applied to the `Button` named `Styled`, setting several properties including its `Height`, `Width`, `Foreground`, and `Background` brushes, as well as some of the font-related properties.

The style named `STYLE_InheritedButton` inherits from `STYLE_Button`. You override the `Width` property to change its value to 225 from the original 100, and you override the `FontFamily` property to change it to the `Trebuchet` font. You also add two new property settings in the inherited style: a `Margin` property value setting and a `Cursor` property value setting. `STYLE_InheritedButton` is then applied to the `Button` named `Inherited`.

■ **Note** Note the property element syntax for defining the `Background` property. The property element syntax allows setting the property value as a child element to the `<Setter>` element, instead of the inline string literal using the `Value` attribute. This can be used when the values being set are complex enough that they cannot be represented as a simple string literal.

Figure 5-1 shows the result of applying the style.

Figure 5-1. *Styled buttons versus the default look and feel*

Also note the `Content` property setting of the `Button` in Listing 5-1. A control's content model is discussed more in Recipe 5-2. For now, it is sufficient to think of it as a way of placing additional content such as a text label inside the control.

5-2. Replacing the Default UI of a Control

Problem

Every control has an out-of-the-box user interface. You want to replace this default UI with a custom one without having to write a new control.

Solution

Design a custom control template to express the new UI for the control, and apply it to the control using the `Template` property or through a `Style` in your application's XAML.

How It Works

Every Silverlight control that renders itself visually at runtime needs its UI defined as a part of the control writing process. The preferred mode of defining this UI is by designing a self-contained block of XAML and associating it with the control so that it can be loaded and rendered by the control code. This block of XAML is what forms the default control template for that control. Recipe 5-10 shows you how to specify the default control template when writing a custom control. The next few sections focus on the mechanics of the control template itself and explore things you need to be aware of in modifying or replacing the control template for an existing control.

Control Template Syntax

A control template always starts with the XAML element `<ControlTemplate>`. The `TargetType` attribute must supply the CLR type of the control to which the template can be applied. Here is a sample declaration:

```
<UserControl.Resources>
  <ControlTemplate x:Key="ctCustomRadioButton" TargetType="RadioButton">
  <!--Template Definition Here -->
  </ControlTemplate>
</UserControl.Resources>
```

Inside the `<ControlTemplate>` tag, you can have any XAML as long as it is renderable. The template is typically defined as a stand-alone resource in a resource dictionary, where the `x:Key` attribute specifies the unique key for the template by which it can be referenced when applied to the control. For more on declaring resources, refer to Chapter 2.

Setting the Template

The `Control` base class exposes a `Template` property that can be set on any control to replace its template, as shown here:

```
<RadioButton Template="{StaticResource ctCustomRadioButton}"/>
```

You can also use a style to apply a template to a control, like so:

```
<Style TargetType="RadioButton" x:Name="styleGelRadioButton">
  <Setter Property="Template" Value="{StaticResource ctCustomRadioButton}"/>
  <!--Other setters here -->
</Style>
<!--apply the Style and hence the template-->
<RadioButton Style="{StaticResource styleGelRadioButton}"/>
```

In the previous examples, you define the control templates as stand-alone resources; then, you reference them in a style or apply them using the `Template` property. Note that control templates can also be defined inline without having to declare them as a separate resource. The following XAML code demonstrates this:

```
<!-- defined in place in a Style -->
<Style TargetType="RadioButton" x:Name="styleGelRadioButton">
  <Setter Property="Template">
      <Setter.Value>
          <ControlTemplate TargetType="RadioButton">
              <!-- rest of the template -->
          </ControlTemplate>
      </Setter.Value>
  </Setter>
  <!-- rest of the setters -->
</Style>

<!-- defined in place in a control declaration -->
<RadioButton>
  <RadioButton.Template>
      <ControlTemplate TargetType="RadioButton">
          <!-- rest of the template -->
      </ControlTemplate>
  </RadioButton.Template>
</RadioButton>
```

Using Expression Blend to Design a Template

Expression Blend offers excellent support for designing Silverlight user interfaces, including designing custom templates for controls. For a general introduction to Expression Blend usage and to UI design, refer to Chapters 1 and 3, respectively. This recipe discusses Expression Blend 3 features that apply to control template design.

Once you have the control added to your scene in the Expression Blend designer window, you can right-click the control to bring up its context menu, as shown in Figure 5-2.

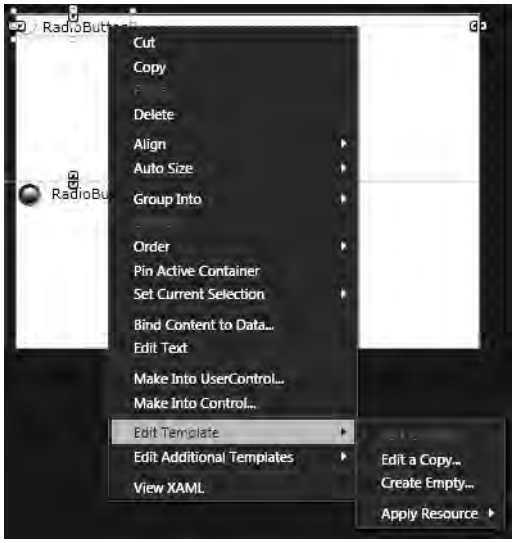


Figure 5-2. *Control context menu in Expression Blend*

You have the option of either creating an empty control template or having Expression Blend generate a copy of the default template. If the modifications you want to make are minor, it is often helpful to start with a copy. A copy also gives you a good look into the intentions of the original designers of the control. Note that when you choose to edit a copy, Expression Blend actually creates a style with the control template defined within that style using a setter for the Template property.

Once you specify a key for the new control template for the `RadioButton` as shown in Figure 5-3 (or the encapsulating style, in the event you decide to edit a copy), Expression Blend switches the designer over to the control template for the `RadioButton`. If you chose to create an empty template, Expression Blend creates a mostly empty visual tree for the control contained in a `Grid` for layout. If you chose to edit a copy, Expression Blend creates a style that contains a copy of the entire visual tree as supplied by the default template, which you can then modify. Figure 5-4 shows the differences.

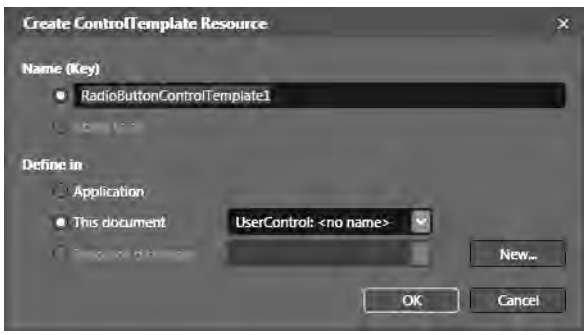


Figure 5-3. *Naming a template*

Figure 5-4. *Empty control template versus editing a copy*

From here on, designing the template is similar to designing any other XAML-based UI in Expression Blend. Some additional features are discussed next.

Template Bindings

When you are designing a control template, you have the option of setting values for the properties of the various elements that make up that template. In many cases, it may make sense to derive those values from the corresponding property settings on the control at the point of its use in an application. For example, you may want the `Background` property of an element inside the control template of a control to assume whatever value is set on the `Background` property on the control itself when it is being used. However, when you are designing the control template, you have no way of knowing what those values might be. Therefore, you need a mechanism to indicate that a certain property value on an element in the template will be bound to a matching property value of the control at the point of use. The `TemplateBinding` construct allows you to do just that:

```
<ControlTemplate x:Key="ctGelRadioButton" TargetType="RadioButton">
  <Grid MaxHeight="{TemplateBinding MaxHeight}"
        MaxWidth="{TemplateBinding MaxWidth}"
        Background="{TemplateBinding Background}">
      <Ellipse Margin="0,0,0,0" x:Name="OuterRing"
      Stroke="{TemplateBinding Foreground}" StrokeThickness="2">
      </Ellipse>
  </Grid>
</ControlTemplate>
```

For the `RadioButton` control template shown here, you have the `MaxHeight`, `MaxWidth`, and `Background` properties of the top-level `Grid` and the `Foreground` property of the `Ellipse` template bound. These template bindings will cause whatever values are supplied to these properties in a `RadioButton` declaration to be applied to these elements in the template. Template bindings are useful when you need the control consumer to be able to affect properties of the parts of the control template without

having direct access to the parts themselves. However, it is not mandatory that template bindings be used in every control template definition.

If you are designing the template in Expression Blend 3, the context menu for each property (accessible by clicking the little rectangle on the right of the property editor) offers the choices of parent properties that you can bind to (see Figure 5-5).

Figure 5-5. *Binding a property within a template using Expression Blend 3*

Content Model and Presenter Controls

Controls often present content to the user, as well as interactivity and event functionality. For example, in Figure 5-6, the Option 1 is the content being displayed by the radio button. The part of the control design that specifies how it displays content is called the content model of the control.

Figure 5-6. *Radio button with simple content*

To better understand this, let's consider the `System.Windows.Controls.ContentControl` type. The `ContentControl` has a dependency property called `Content` that can be set or bound to any content, which the `ContentControl` instance then displays. In case there is no built-in knowledge of how to display this content, you can also associate a data template through the `ContentTemplate` property to facilitate the display of the content. More than being useful in and of itself, the `ContentControl` serves as a base class for many other controls in Silverlight, such as `Label`, `Button`, or the `RadioButton` shown earlier.

The following code shows the XAML declaration for the `RadioButton` in Figure 5-6:

```
<RadioButton Content="Option 1" />
```

Figure 5-7 shows a radio button with slightly more complex content, including a text caption and an image displayed with the help of a data template.

Figure 5-7. *Radio button with complex content*

This XAML code shows the `RadioButton` declaration:

```
<RadioButton Content="{Binding}" x:Name="rbtn">
  <RadioButton.ContentTemplate>
      <DataTemplate>
          <Grid>
              <Grid.ColumnDefinitions>
                  <ColumnDefinition Width="Auto"/>
                  <ColumnDefinition Width="Auto"/>
              </Grid.ColumnDefinitions>
              <TextBlock Text="{Binding Caption}" Grid.Column="0"
TextAlignment="Center" HorizontalAlignment="Center" VerticalAlignment="Center"/>
              <Image Source="{Binding Icon}" Grid.Column="1" Stretch="Fill"
idth="24" Height="24" Margin="3,0,0,0"/>
          </Grid>
      </DataTemplate>
  </RadioButton.ContentTemplate>
</RadioButton>
```

The content for the `RadioButton` can be set by setting its `DataContext` property to some instance of a CLR type that exposes two properties: `Caption` and `Icon`.

When you modify the control template for a control, you should be aware of the intended content model for that control. To be fair to the control author's intentions, try to retain the same content model in your custom template. To facilitate this, the Silverlight control framework provides a specific category of controls called presenters. A presenter's purpose is to create a placeholder for content inside a control template. Through appropriate template bindings, content gets passed on to the presenter, which then displays the content in the rest of the visual tree of the template. You can also associate a data template (again, preferably through a template binding), which is then used by the presenter to display the content.

Several types of content models and corresponding presenters are supplied in the framework, and you will look at many of them in this chapter. For this sample, you need to understand the most fundamental of them all: the `ContentPresenter` control.

This XAML shows a `ContentPresenter` in action in a template for a `RadioButton`:

```
<ControlTemplate x:Key="ctCustomRadioButton"
                  TargetType="RadioButton">
  <Grid>
   <!-- rest of the template -->
    <ContentPresenter HorizontalAlignment="Center"
                      VerticalAlignment="Center"
                      Grid.Column="1" Margin="2,0,0,2"
          Content="{TemplateBinding Content}"
          ContentTemplate="{TemplateBinding ContentTemplate}"/>
  </Grid>
```

```
</ControlTemplate>
```

Notice the template bindings for the `Content` and the `ContentTemplate` properties of the `ContentPresenter`, which allow the values set for these properties on any instance of the `RadioButton` to be passed into the `ContentPresenter` for display. As you saw in Figures 5-6 and 5-7, the content (a string in the first case and some XAML with a specific data binding for the image in the second) is passed in using this mechanism. If those template bindings were absent or if you did not have a `ContentPresenter`, setting the `Content` or the `ContentTemplate` property on the `RadioButton` would have no effect, since there would be no placeholder inside the control's template to display that content.

Visual State Management

Controls often change their visual state as users interact with them. A check mark that appears in a `Checkbox` or a `Button` when it is clicked is an example of a visual state change. The Silverlight control framework includes a Visual State Manager (VSM) component that can be used to manage these state transitions.

The various possible visual states for a control are defined by the control author and further logically grouped into state groups. Each state managed by the VSM is implemented as a `StoryBoard` that can contain one or more animations that define the visual representation of moving from one state to another. When designing a control template using Expression Blend, you can see the various state groups and the specific states in the States editor, as shown in Figure 5-8.

Figure 5-8. *The control template's States editor in Expression Blend*

When you select a specific state, Expression Blend transitions into a storyboard recording mode for that state (see Figure 5-9).

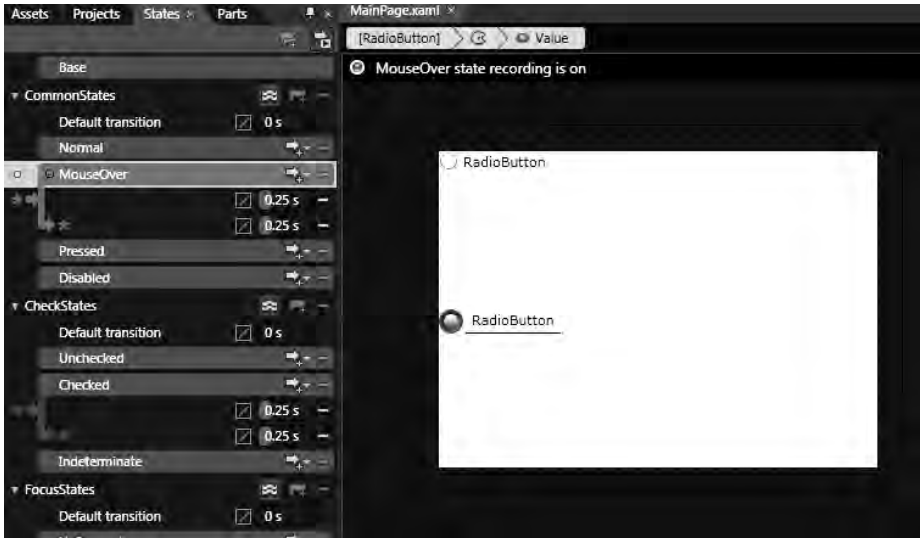


Figure 5-9. *Recording a state change*

Recording a state change works just like recording a regular storyboard in Expression Blend, including the use of the storyboard time line editor to define a timeline for a specific keyframe animation in the state storyboard. For more on animation and storyboards, refer to Chapter 3.

In addition to defining each individual state as a storyboard, you can also optionally define the time duration of the transition from one state to another. Clicking the state transition icon displays all the possible state transitions involving that state. Figure 5-10 shows the possible transitions to and from the `MouseOver` state for a control template, with * indicating any state.

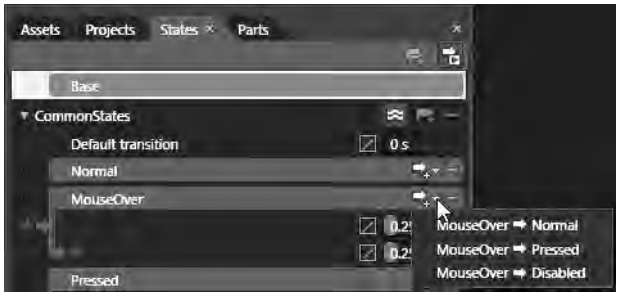


Figure 5-10. *State transitions for the MouseOver state*

In Figure 5-10, the transition duration from another state to the `MouseOver` state has been defined as a quarter of a second. The following XAML shows a sample set of states and some of the possible transitions defined:

```
<vsm:VisualStateManager.VisualStateGroups>
  <vsm:VisualStateGroup x:Name="CommonStates">
    <vsm:VisualStateGroup.Transitions>
      <vsm:VisualTransition  GeneratedDuration="00:00:00.2500000" To="MouseOver"/>
      <vsm:VisualTransition GeneratedDuration="00:00:00.2500000" From="MouseOver"/>
    </vsm:VisualStateGroup.Transitions>
    <vsm:VisualState x:Name="Disabled"/>
    <vsm:VisualState x:Name="Normal">
      <Storyboard/>
    </vsm:VisualState>
    <vsm:VisualState x:Name="MouseOver">
      <Storyboard>
        <ColorAnimationUsingKeyFrames BeginTime="00:00:00"
          Duration="00:00:00.0010000"
          Storyboard.TargetName="OuterRing"
          Storyboard.TargetProperty=
              "(Shape.Stroke).(SolidColorBrush.Color)">
          <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF144EEA"/>
        </ColorAnimationUsingKeyFrames>
        <ColorAnimationUsingKeyFrames BeginTime="00:00:00"
          Duration="00:00:00.0010000"
          Storyboard.TargetName="InnerCore"
          Storyboard.TargetProperty=
    "(Shape.Fill).(GradientBrush.GradientStops)[1].(GradientStop.Color)">
          <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF144EEA"/>
        </ColorAnimationUsingKeyFrames>
      </Storyboard>
    </vsm:VisualState>
    <vsm:VisualState x:Name="Pressed"/>
  </vsm:VisualStateGroup>
  <vsm:VisualStateGroup x:Name="FocusStates">
    <vsm:VisualState x:Name="Unfocused">
      <Storyboard>
        <ObjectAnimationUsingKeyFrames
          Storyboard.TargetName="FocusIndicator"
          Storyboard.TargetProperty="Visibility"
          Duration="0">
          <DiscreteObjectKeyFrame KeyTime="0">
            <DiscreteObjectKeyFrame.Value>
              <Visibility>Collapsed</Visibility>
            </DiscreteObjectKeyFrame.Value>
          </DiscreteObjectKeyFrame>
        </ObjectAnimationUsingKeyFrames>
      </Storyboard>
    </vsm:VisualState>
    <vsm:VisualState x:Name="Focused">
```

```
      <Storyboard>
        <ObjectAnimationUsingKeyFrames
          Storyboard.TargetName="FocusIndicator"
          Storyboard.TargetProperty="Visibility"
          Duration="0">
          <DiscreteObjectKeyFrame KeyTime="0">
            <DiscreteObjectKeyFrame.Value>
              <Visibility>Visible</Visibility>
            </DiscreteObjectKeyFrame.Value>
          </DiscreteObjectKeyFrame>
        </ObjectAnimationUsingKeyFrames>
      </Storyboard>
    </vsm:VisualState>
    <vsm:VisualState x:Name="ContentFocused">
      <Storyboard>
        <ObjectAnimationUsingKeyFrames
          Storyboard.TargetName="FocusIndicator"
          Storyboard.TargetProperty="Visibility"
          Duration="0">
          <DiscreteObjectKeyFrame KeyTime="0">
            <DiscreteObjectKeyFrame.Value>
              <Visibility>Visible</Visibility>
            </DiscreteObjectKeyFrame.Value>
          </DiscreteObjectKeyFrame>
        </ObjectAnimationUsingKeyFrames>
      </Storyboard>
    </vsm:VisualState>
  </vsm:VisualStateGroup>
  <vsm:VisualStateGroup x:Name="CheckStates">
    <vsm:VisualStateGroup.Transitions>
      <vsm:VisualTransition GeneratedDuration="00:00:00.2500000" To="Checked"/>
      <vsm:VisualTransition GeneratedDuration="00:00:00.2500000" From="Checked"/>
    </vsm:VisualStateGroup.Transitions>
    <vsm:VisualState x:Name="Unchecked">
      <Storyboard/>
    </vsm:VisualState>
    <vsm:VisualState x:Name="Checked">
      <Storyboard>
        <ColorAnimationUsingKeyFrames
          BeginTime="00:00:00"
          Duration="00:00:00.0010000"
          Storyboard.TargetName="InnerCore"
          Storyboard.TargetProperty=
    "(Shape.Fill).(GradientBrush.GradientStops)[0].(GradientStop.Color)">
          <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF144EEA"/>
```

```
        </ColorAnimationUsingKeyFrames>
      </Storyboard>
    </vsm:VisualState>
    <vsm:VisualState x:Name="Indeterminate"/>
  </vsm:VisualStateGroup>
</vsm:VisualStateManager.VisualStateGroups>
```

Each visual state for the control is declared as a `<vsm:VisualState>` element, and each state has an associated storyboard, which can include one or more animations that all get executed by the runtime when that visual state is reached. These animations typically animate various properties of different parts of the control template to give the necessary visual cue indicating the state change. As an example, in the `MouseOver` state storyboard, you have two animations defined within the storyboard. The first one animates the `Stroke` property on an element named `OuterRing` to a different solid color. The second one animates the `Fill` property of another element named `InnerCore` to a different gradient. You can also have an empty storyboard if you do not want to define any particular visual change for the control upon reaching that state. The control's code determines when a specific visual state is reached. You will see exactly how that is done in Recipe 5-11 which discusses a custom control implementing custom visual states.

You should also note the `<vsm:VisualStateGroup>` declarations that group visual states together. The `VisualStateManager` mandates that each state be contained in a group (even if that is the only state in it) and that each state be defined in exactly one group. You can also see `<vsm:VisualTransition>` elements declared inside a state group. Each defined visual transition is a way to specify a time duration over which a transition from one state to another in a group should happen. In the previous example, transition from any state to the `MouseOver` state or the reverse is specified to happen over a quarter of a second, as it is for the Checked state.

Note that you are not required to define an explicit storyboard for each state. For example, it is common to not define anything explicit for the `Normal` state, since the default visual representation of the control template can be considered its normal state. However, that does not mean that you can leave out the state definition completely. In the case of the `Normal` state, for example, the empty storyboard causes the `RadioButton` to revert to its default look when none of the other defined visual states are applicable; thus, the `Normal` state is reached. If you left out that state definition, the control would never revert to the default look once it transitions out of another state. Recipe 5-11 provides another look at visual states from a control author's perspective.

The Code

The code sample in this recipe replaces the default control template of a `RadioButton` with a custom template. Listing 5-2 shows the full XAML for the page.

Listing 5-2. *Defining and applying a custom RadioButton control template*

```
<UserControl x:Class="Recipe5_2.MainPage"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    Width="400" Height="300"
    xmlns:vsm="clr-namespace:System.Windows;assembly=System.Windows">
  <UserControl.Resources>
    <!-- The Custom Control Template targeting a RadioButton -->
    <ControlTemplate x:Key="ctCustomRadioButton"
                     TargetType="RadioButton">
```

```
    <Grid Background="{TemplateBinding Background}"
                MinHeight="{TemplateBinding MinHeight}"
                MinWidth="{TemplateBinding MinWidth}"
                MaxWidth="{TemplateBinding MaxWidth}"
                MaxHeight="{TemplateBinding MaxHeight}">
      <vsm:VisualStateManager.VisualStateGroups>
        <vsm:VisualStateGroup x:Name="CommonStates">
          <vsm:VisualStateGroup.Transitions>
            <vsm:VisualTransition  GeneratedDuration="00:00:00.2500000"
To="MouseOver"/>
            <vsm:VisualTransition GeneratedDuration="00:00:00.2500000"
From="MouseOver"/>
          </vsm:VisualStateGroup.Transitions>
          <vsm:VisualState x:Name="Disabled"/>
          <vsm:VisualState x:Name="Normal">
            <Storyboard/>
          </vsm:VisualState>
          <vsm:VisualState x:Name="MouseOver">
            <Storyboard>
              <ColorAnimationUsingKeyFrames BeginTime="00:00:00"
                Duration="00:00:00.0010000"
                Storyboard.TargetName="OuterRing"
                Storyboard.TargetProperty=
                    "(Shape.Stroke).(SolidColorBrush.Color)">
                <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF144EEA"/>
              </ColorAnimationUsingKeyFrames>
              <ColorAnimationUsingKeyFrames BeginTime="00:00:00"
                Duration="00:00:00.0010000"
                Storyboard.TargetName="InnerCore"
                Storyboard.TargetProperty=
          "(Shape.Fill).(GradientBrush.GradientStops)[1].(GradientStop.Color)">
                <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF144EEA"/>
              </ColorAnimationUsingKeyFrames>
            </Storyboard>
          </vsm:VisualState>
          <vsm:VisualState x:Name="Pressed"/>
        </vsm:VisualStateGroup>
        <vsm:VisualStateGroup x:Name="FocusStates">
          <vsm:VisualState x:Name="Unfocused">
            <Storyboard>
              <ObjectAnimationUsingKeyFrames
                Storyboard.TargetName="FocusIndicator"
                Storyboard.TargetProperty="Visibility"
                Duration="0">
                <DiscreteObjectKeyFrame KeyTime="0">
```

```
                <DiscreteObjectKeyFrame.Value>
                  <Visibility>Collapsed</Visibility>
                </DiscreteObjectKeyFrame.Value>
              </DiscreteObjectKeyFrame>
            </ObjectAnimationUsingKeyFrames>
          </Storyboard>
        </vsm:VisualState>
        <vsm:VisualState x:Name="Focused">
          <Storyboard>
            <ObjectAnimationUsingKeyFrames
              Storyboard.TargetName="FocusIndicator"
              Storyboard.TargetProperty="Visibility"
              Duration="0">
              <DiscreteObjectKeyFrame KeyTime="0">
                <DiscreteObjectKeyFrame.Value>
                  <Visibility>Visible</Visibility>
                </DiscreteObjectKeyFrame.Value>
              </DiscreteObjectKeyFrame>
            </ObjectAnimationUsingKeyFrames>
          </Storyboard>
        </vsm:VisualState>
        <vsm:VisualState x:Name="ContentFocused">
          <Storyboard>
            <ObjectAnimationUsingKeyFrames
              Storyboard.TargetName="FocusIndicator"
              Storyboard.TargetProperty="Visibility"
              Duration="0">
              <DiscreteObjectKeyFrame KeyTime="0">
                <DiscreteObjectKeyFrame.Value>
                  <Visibility>Visible</Visibility>
                </DiscreteObjectKeyFrame.Value>
              </DiscreteObjectKeyFrame>
            </ObjectAnimationUsingKeyFrames>
          </Storyboard>
        </vsm:VisualState>
      </vsm:VisualStateGroup>
      <vsm:VisualStateGroup x:Name="CheckStates">
        <vsm:VisualStateGroup.Transitions>
          <vsm:VisualTransition GeneratedDuration="00:00:00.2500000"
To="Checked"/>
          <vsm:VisualTransition GeneratedDuration="00:00:00.2500000"
From="Checked"/>
        </vsm:VisualStateGroup.Transitions>
        <vsm:VisualState x:Name="Unchecked">
          <Storyboard/>
```

```
    </vsm:VisualState>
    <vsm:VisualState x:Name="Checked">
      <Storyboard>
        <ColorAnimationUsingKeyFrames
          BeginTime="00:00:00"
          Duration="00:00:00.0010000"
          Storyboard.TargetName="InnerCore"
          Storyboard.TargetProperty=
    "(Shape.Fill).(GradientBrush.GradientStops)[0].(GradientStop.Color)">
          <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF144EEA"/>
        </ColorAnimationUsingKeyFrames>
      </Storyboard>
    </vsm:VisualState>
    <vsm:VisualState x:Name="Indeterminate"/>
  </vsm:VisualStateGroup>
</vsm:VisualStateManager.VisualStateGroups>
<Grid.ColumnDefinitions>
  <ColumnDefinition Width="0.20*"/>
  <ColumnDefinition Width="0.80*"/>
</Grid.ColumnDefinitions>
<Ellipse Margin="0,0,0,0" x:Name="OuterRing"
         Stroke="#00000000" StrokeThickness="2">
  <Ellipse.Fill>
    <LinearGradientBrush
      EndPoint="1.13300001621246,1.13999998569489"
      StartPoint="-0.06400000030398369,-0.0560000017285347">
      <GradientStop Color="#FF000000"/>
      <GradientStop Color="#FFADADAD" Offset="1"/>
    </LinearGradientBrush>
  </Ellipse.Fill>
</Ellipse>
<Grid Margin="0,0,0,0">
  <Grid.ColumnDefinitions>
    <ColumnDefinition Width="0.2*"/>
    <ColumnDefinition Width="0.6*"/>
    <ColumnDefinition Width="0.2*"/>
  </Grid.ColumnDefinitions>
  <Grid.RowDefinitions>
    <RowDefinition Height="0.2*"/>
    <RowDefinition Height="0.6*"/>
    <RowDefinition Height="0.2*"/>
  </Grid.RowDefinitions>
  <Ellipse x:Name="InnerRing"
           Fill="#FF000000"
           Grid.Column="1" Grid.Row="1"/>
```

```
        <Ellipse Grid.Row="1" Grid.Column="1"
                 x:Name="InnerCore" Margin="0,0,0,0">
          <Ellipse.Fill>
            <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
              <GradientStop Color="#FFFFFFFF"/>
              <GradientStop Color="#FF000000" Offset="1"/>
            </LinearGradientBrush>
          </Ellipse.Fill>
        </Ellipse>
      </Grid>
      <ContentPresenter HorizontalAlignment="Center"
                        VerticalAlignment="Center"
                        Grid.Column="1" Margin="2,0,0,2"
         Content="{TemplateBinding Content}"
         ContentTemplate="{TemplateBinding ContentTemplate}"/>
      <Rectangle Stroke="Black" x:Name="FocusIndicator" Grid.Column="1"
                 StrokeThickness="0.5" Height="1"
                 HorizontalAlignment="Stretch" VerticalAlignment="Bottom"
                 Margin="2,0,0,0" />
    </Grid>
  </ControlTemplate>

  <!-- A style targeting the RadioButton referencing the control template -->
  <Style TargetType="RadioButton" x:Name="styleGelRadioButton">
    <Setter Property="Template" Value="{StaticResource ctCustomRadioButton}"/>
    <Setter Property="Height" Value="20" />
    <Setter Property="Width" Value="100" />
    <Setter Property="Background" Value="Transparent" />
  </Style>
</UserControl.Resources>

<Grid x:Name="LayoutRoot" Background="White" Margin="20,20,20,20">
  <Grid.RowDefinitions>
    <RowDefinition Height="0.5*"/>
    <RowDefinition Height="0.5*"/>
  </Grid.RowDefinitions>
  <!-- A RadioButton with default look & feel -->
  <RadioButton  HorizontalAlignment="Left" VerticalAlignment="Top"
                Content="RadioButton" GroupName="Test" Grid.Row="0"/>
  <!-- A RadioButton with the style (and hence the custom template) applied -->
  <RadioButton  HorizontalAlignment="Left" VerticalAlignment="Top"
                Content="RadioButton"
                Style="{StaticResource styleGelRadioButton}"
                GroupName="Test" Grid.Row="1"/>
```

```
  </Grid>
</UserControl>
```

In Listing 5.2, the `RadioButton` control template, named `ctCustomRadioButton`, is primarily made up of three `Ellipses` (two `Ellipses` named `InnerRing` and `InnerCore`, situated in a `Grid` within the outer `Ellipse` named `OuterRing`). There is also a `ContentPresenter` to display any bound content, as well as a `Rectangle` (with `Height` set to 1 so that it appears as an underscore below the content) serving as a focus indicator, which has its `Visibility` initially set to `Collapsed`.

Figure 5-11 shows the `Normal` state comparisons between the custom template `RadioButton` and the default template.

Figure 5-11. *RadioButton Normal state with (left) and without (right) the custom template*

The `MouseOver` state is defined using a storyboard that changes the `Stroke` color of `OuterRing` and the `Fill` color of `InnerRing`. The result in comparison to the default `RadioButton` template is shown in Figure 5-12.

Figure 5-12. *RadioButton MouseOver state with (left) and without (right) the custom template*

The `Focused` and `ContentFocused` state storyboards make the `FocusIndicator` rectangle visible, while the `Unfocused` state storyboard hides it. The `Checked` state storyboard modifies the `Fill` color of the ellipse `InnerCore`. Figure 5-13 shows the `Checked` state of the `RadioButton` with focus on it.

Figure 5-13. *RadioButton Checked and Focused states with (left) and without (right) the custom template*

You also declare a style named `styleGelRadioButton`. You reference `ctCustomRadioButton` using a setter for the `Template` property and set a few other defaults for some of the other properties in the control template. And last, for the page's UI, you declare two `RadioButtons`—one using just the default look and feel defined by the framework and the other with the style `styleGelRadioButton` applied to it so that the custom template gets applied to it as well—to help you compare them visually.

Another important thing to note is the presence of specific elements in the control template definition with predetermined names. This is covered more in Recipe 5-10 when you learn how to write custom controls, but it is worth mentioning here in context of template customization. When the original control author designs the control, there may be dependencies in the control's code or in the definition of the default state change storyboards that require specific names for different parts of the control template. If you decide to leave those elements out of your new control template or name them differently, certain parts of the control's feature set or its visual representation may be rendered unavailable.

An example in Listing 5-2 is the `Rectangle` named `FocusIndicator`. The `RadioButton`'s default implementation includes state definitions for the `Focused`, `Unfocused`, and `ContentFocused` states that toggles the visibility of this `Rectangle` based on whether focus is on the control. If you leave

out or rename this `Rectangle` in your new template, you need to reauthor the state storyboards appropriately for the focus visual cue to function.

Control authors are advised to write controls defensively so that a name dependency does not crash an application; instead, the control just silently shuts down the dependent feature. However, depending on the importance of the named element in the control's overall functionality, leaving or renaming certain elements may render the control useless. We suggest that you look at the definition of the default control template in the documentation on the MSDN website. This knowledge can help you make an informed decision about any modifications.

However, if the dependency is in XAML through some state storyboard reference, you have the ability to modify the storyboard if you modify the element.

5-3. Customizing the Default ListBoxItem UI

Problem

You want to customize the default look and feel of an item inside a data-bound `ListBox` beyond what can be done using data templates.

Solution

Define and apply a custom control template to the `ListBoxItem` using the `ItemContainerStyle` on the `ListBox`.

How It Works

In data-bound `ListBox` scenarios, you typically do not explicitly add each individual item that the `ListBox` displays. When you bind the `ItemsSource` property on the `ListBox` to a collection (or set it in code), an entry is added to the `ListBox` automatically for each data item in the collection, optionally formatted based on a data template bound to the `ItemTemplate` property.

■ **Note** For more on data binding and data templates, refer to Chapter 4.

Perhaps you want to change the look and feel of the items beyond what the data template feature affords you. Say you want to change the selection behavior from the default display of a light blue selection bar to some other mode of selection display. Or you may notice that no matter what your data template specifies, each item is displayed within a rectangular boundary, and you don't like that look.

Each such generated item is of type `ListBoxItem`, in turn derived from `ContentControl`. The default template applied to this `ListBoxItem` specifies some of the UI behavior of these items, including the ones just mentioned as examples.

To customize that behavior, you need to design a custom template for the `ListBoxItem` control and apply it to each `ListBoxItem` in the `ListBox`. The `ListBox` control exposes a property named `ItemContainerStyle`, which can be bound to a style that gets applied to each `ListBoxItem` as it is generated. You can use this style to associate your custom template to the `ListBoxItems` in the `ListBox`.

The Code

This code sample demonstrates a custom template for a `ListBoxItem`. For the data source in this sample, use the `AdventureWorks` WCF service discussed in the introduction to this chapter. Listing 5-3 shows the XAML for the page with the control template defined in the resources section.

Listing 5-3. *XAML for the MainPage showing ListBoxItem control template*

```
<UserControl x:Class="Recipe5_3.MainPage"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    Width="700" Height="800"
    xmlns:vsm="clr-namespace:System.Windows;assembly=System.Windows">
  <UserControl.Resources>
    <DataTemplate x:Key="dtProductInfo">
      <Grid>
        <Grid.RowDefinitions>
          <RowDefinition Height="Auto" />
          <RowDefinition Height="Auto" />
          <RowDefinition Height="Auto" />
        </Grid.RowDefinitions>
        <TextBlock Grid.Row="0" VerticalAlignment="Center"
                   HorizontalAlignment="Left" Text="{Binding Name}"
                   Margin="3,3,3,3"/>
        <StackPanel HorizontalAlignment="Left" Grid.Row="1"
                    Orientation="Horizontal" Margin="3,3,3,3">
          <TextBlock Text="$" Margin="0,0,2,0" />
          <TextBlock Grid.Row="1" Text="{Binding ListPrice}"/>
        </StackPanel>

        <StackPanel HorizontalAlignment="Left" Grid.Row="2"
                    Orientation="Horizontal" Margin="3,3,3,3">
          <Ellipse Height="15" Width="15"
                   Fill="{Binding InventoryLevelBrush}" Margin="0,0,2,0" />
          <TextBlock Text="{Binding InventoryLevelMessage}"  />
        </StackPanel>
      </Grid>
    </DataTemplate>

    <!-- custom ListBoxItem control template -->
    <ControlTemplate x:Key="ctCustomListBoxItem" TargetType="ListBoxItem">
      <Grid Background="{TemplateBinding Background}"
            Margin="{TemplateBinding Margin}">
        <Grid.RowDefinitions>
          <RowDefinition Height="0.225*" MinHeight="20"/>
          <RowDefinition Height="0.775*"/>
        </Grid.RowDefinitions>
```

```
<vsm:VisualStateManager.VisualStateGroups>
  <vsm:VisualStateGroup x:Name="CommonStates">
    <vsm:VisualStateGroup.Transitions>
      <vsm:VisualTransition
        GeneratedDuration="00:00:00.0500000" To="MouseOver"/>
      <vsm:VisualTransition
        GeneratedDuration="00:00:00.0500000" From="MouseOver"/>
    </vsm:VisualStateGroup.Transitions>
    <vsm:VisualState x:Name="Normal">
      <Storyboard/>
    </vsm:VisualState>
    <vsm:VisualState x:Name="MouseOver">
      <Storyboard>
        <ColorAnimationUsingKeyFrames
          BeginTime="00:00:00"
          Duration="00:00:00.0010000"
          Storyboard.TargetName="BottomBorder"
          Storyboard.TargetProperty=
          "(Border.Background).(SolidColorBrush.Color)">
          <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF68A3DE"/>
        </ColorAnimationUsingKeyFrames>
      </Storyboard>
    </vsm:VisualState>
  </vsm:VisualStateGroup>
  <vsm:VisualStateGroup x:Name="SelectionStates">
    <vsm:VisualState x:Name="Unselected">
      <Storyboard/>
    </vsm:VisualState>
    <vsm:VisualState x:Name="Selected">
      <Storyboard>
        <ColorAnimationUsingKeyFrames
        BeginTime="00:00:00"
        Duration="00:00:00.0010000"
        Storyboard.TargetName="TopBorder"
        Storyboard.TargetProperty=
          "(Border.Background).(SolidColorBrush.Color)">
          <SplineColorKeyFrame KeyTime="00:00:00" Value="#FFFF2D00"/>
        </ColorAnimationUsingKeyFrames>
        <ObjectAnimationUsingKeyFrames
        BeginTime="00:00:00"
        Duration="00:00:00.0010000"
        Storyboard.TargetName="SelectionIndicator"
        Storyboard.TargetProperty="(UIElement.Visibility)">
          <DiscreteObjectKeyFrame KeyTime="00:00:00">
            <DiscreteObjectKeyFrame.Value>
              <vsm:Visibility>Visible</vsm:Visibility>
```

```
            </DiscreteObjectKeyFrame.Value>
          </DiscreteObjectKeyFrame>
        </ObjectAnimationUsingKeyFrames>
      </Storyboard>
    </vsm:VisualState>
    <vsm:VisualState x:Name="SelectedUnfocused">
      <Storyboard>
        <ColorAnimationUsingKeyFrames
        BeginTime="00:00:00"
        Duration="00:00:00.0010000"
        Storyboard.TargetName="TopBorder"
        Storyboard.TargetProperty=
          "(Border.Background).(SolidColorBrush.Color)">
          <SplineColorKeyFrame KeyTime="00:00:00" Value="#FFFF2D00"/>
        </ColorAnimationUsingKeyFrames>
        <ObjectAnimationUsingKeyFrames
        BeginTime="00:00:00"
        Duration="00:00:00.0010000"
        Storyboard.TargetName="SelectionIndicator"
        Storyboard.TargetProperty="(UIElement.Visibility)">
          <DiscreteObjectKeyFrame KeyTime="00:00:00">
            <DiscreteObjectKeyFrame.Value>
              <vsm:Visibility>Visible</vsm:Visibility>
            </DiscreteObjectKeyFrame.Value>
          </DiscreteObjectKeyFrame>
        </ObjectAnimationUsingKeyFrames>
      </Storyboard>
    </vsm:VisualState>
  </vsm:VisualStateGroup>
  <vsm:VisualStateGroup x:Name="FocusStates">
    <vsm:VisualState x:Name="Unfocused">
      <Storyboard/>
    </vsm:VisualState>
    <vsm:VisualState x:Name="Focused">
      <Storyboard>
        <ObjectAnimationUsingKeyFrames
        BeginTime="00:00:00"
        Duration="00:00:00.0010000"
        Storyboard.TargetName="FocusRect"
        Storyboard.TargetProperty="(UIElement.Visibility)">
          <DiscreteObjectKeyFrame KeyTime="00:00:00">
            <DiscreteObjectKeyFrame.Value>
              <vsm:Visibility>Visible</vsm:Visibility>
            </DiscreteObjectKeyFrame.Value>
          </DiscreteObjectKeyFrame>
```

```
            </ObjectAnimationUsingKeyFrames>
          </Storyboard>
        </vsm:VisualState>
      </vsm:VisualStateGroup>
    </vsm:VisualStateManager.VisualStateGroups>
    <Border HorizontalAlignment="Stretch"
            Margin="0,0,0,0"
            VerticalAlignment="Stretch"
            CornerRadius="5,5,0,0"
            BorderBrush="#FF000000"
            BorderThickness="2,2,2,0"
            Background="#00000000"
            x:Name="TopBorder">
      <Grid x:Name="SelectionIndicator" Visibility="Collapsed"
            Width="18" Height="18"
            HorizontalAlignment="Left"
            VerticalAlignment="Center" Margin="2,2,2,2">
        <Path x:Name="Path" Stretch="Fill"
              StrokeThickness="1.99975" StrokeLineJoin="Round"
              Stroke="#FF000000" Fill="#FF27BC0F"
              Data="F1 M 0.999876,18.0503C 2.60366,
              16.4731 4.23013,14.9006 5.86216,13.3491L 12.6694,
              18.7519C 14.239,10.2011 20.9487,3.27808 29.8744,
              0.999878L 31.4453,2.68387C 23.1443,
              9.95105 17.8681,19.7496 16.5592,
              30.3293L 16.5592,30.2592L 0.999876,18.0503 Z "/>
      </Grid>
    </Border>
    <Border Margin="0,0,0,0" CornerRadius="0,0,5,5"
            BorderBrush="#FF000000" BorderThickness="2,2,2,2"
            Grid.Row="1" Padding="3,3,3,3" x:Name="BottomBorder"
            Background="#00000000">
      <Grid>
        <ContentPresenter  HorizontalAlignment="Left"
          Margin="3,3,3,3"
          Content="{TemplateBinding Content}"
          ContentTemplate="{TemplateBinding ContentTemplate}"/>
        <Rectangle HorizontalAlignment="Stretch" Margin="0,0,0,0" Width="Auto"
                   Stroke="#FF000000"
                   StrokeDashArray="0.75 0.15 0.25 0.5 0.25"
                   x:Name="FocusRect" Visibility="Collapsed"/>
      </Grid>
    </Border>
  </Grid>
</ControlTemplate>
```

```
    <!-- style using the custom ListBoxItem control template -->
    <Style x:Key="styleCustomListBoxItem" TargetType="ListBoxItem">
      <Setter Property="Template"
            Value="{StaticResource ctCustomListBoxItem}"/>
      <Setter Property="Margin" Value="3,5,3,5" />
    </Style>
  </UserControl.Resources>
  <Grid x:Name="LayoutRoot" Background="White" Height="Auto" Margin="20,20">
    <StackPanel Orientation="Horizontal" VerticalAlignment="Stretch"
                HorizontalAlignment="Stretch">
      <ListBox x:Name="lbxStandard" HorizontalAlignment="Stretch"
               VerticalAlignment="Stretch" Margin="0,0,25,0"
               ItemTemplate="{StaticResource dtProductInfo}" />

      <!-- applying a custom ListBoxItemTemplate using the ItemContainerStyle -->
      <ListBox x:Name="lbxCustom"
               HorizontalAlignment="Stretch"
               VerticalAlignment="Stretch"
               ItemTemplate="{StaticResource dtProductInfo}"
               ItemContainerStyle="{StaticResource styleCustomListBoxItem}"/>
    </StackPanel>

  </Grid>
</UserControl>
```

Your control template named `ctCustomListBoxItem` is defined as two `Border` elements placed in two `Rows` of a top-level `Grid`. The `Border` element named `TopBorder` contains a `Grid SelectionIndicator`, encapsulating a `Path` that represents a check mark. The `BottomBorder` element contains a `ContentPresenter` with appropriate `TemplateBindings` defined for several properties, including the `Content` and the `ContentTemplate` properties so that, once data bound, the data for each `ListBoxItem` gets displayed through this `ContentPresenter` inside `BottomBorder`. You also include a `Rectangle` named `FocusRect` with a dotted border; this `Rectangle` is overlaid on the `ContentPresenter` but is initially kept hidden because you set the `Visibility` property to `Visibility.Collapsed`.

Figure 5-14 compares the `Normal` state of a `ListBoxItem` using this template to that of the default look and feel (with both `ListBoxes` bound to the same data source and using the same data template, defined as `dtProductInfo` in Listing 5-3). For more on data templates, refer to Chapter 4.

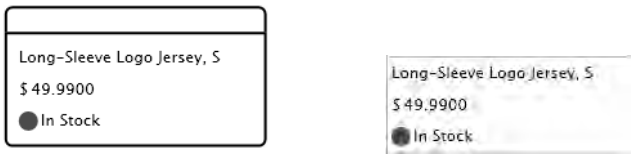


Figure 5-14. *Normal ListBoxItem state with (left) and without (right) the custom template*

If you refer to the storyboard for the MouseOver visual state in Listing 5-3, you will see that the background color of BottomBorder changes to indicate the state change. Figure 5-15 shows the result.

Figure 5-15. *MouseOver state with (left) and without (right) the custom template*

On a transition to the Selected state, you change the background color of TopBorder and make visible the SelectionIndicator Grid that contains the check mark. This gives the selected item a colored top bar with a check mark in it. For the Focused state, you make visible the focus indicator Rectangle FocusRect. Note that you also define a storyboard for the SelectedUnfocused state when an item is selected but the current focus is elsewhere; in that case, the colored top border and check mark are visible but the focus rectangle is hidden. Figure 5-16 shows the results in comparison.

Figure 5-16. *Selected state with focus with (left) and without (right) the custom template*

You also define a style resource, styleCustomListBoxItem, in Listing 5-3 that associates the control template to a ListBoxItem. To show the control template in action, you have added two ListBoxes, named lbxStandard and lbxCustom, to your page, each using the same data template (dtProductInfo) as the ItemTemplate. However, lbxCustom has its style set to styleCustomListBoxItem.

Listing 5-4 shows the codebehind for the page.

Listing 5-4. *Codebehind for the MainPage containing the ListBox*

```
using System;
using System.Windows.Controls;
using System.Windows.Media;
using Recipe5_3.AdvWorks;

namespace Recipe5_3
{
  public partial class MainPage : UserControl
  {
    //WCF service client
    AdvWorksDataServiceClient client =
      new AdvWorksDataServiceClient();
    public MainPage()
    {
```

```
      InitializeComponent();
      GetData();
    }

    private void GetData()
    {
      client.GetInventoryCompleted +=
        new EventHandler<GetInventoryCompletedEventArgs>(
          delegate(object sender, GetInventoryCompletedEventArgs e)
          {
            Product product = e.UserState as Product;
            product.ProductInventories = e.Result;
            product.InventoryLevelBrush = null;
            product.InventoryLevelMessage = null;

          });
      client.GetProductsCompleted +=
        new EventHandler<GetProductsCompletedEventArgs>(
          delegate(object sender, GetProductsCompletedEventArgs e)
          {

            lbxStandard.ItemsSource = e.Result;
            lbxCustom.ItemsSource = e.Result;

            foreach (Product p in e.Result)
            {
              client.GetInventoryAsync(p, p);
            }
          });

      client.GetProductsAsync();
    }
  }
}

namespace Recipe5_3.AdvWorks
{

  public partial class Product
  {
    private SolidColorBrush _InventoryLevelBrush;

    public SolidColorBrush InventoryLevelBrush
    {
      get
```

```
      {
        return (this.ProductInventories == null
          || this.ProductInventories.Count == 0) ?
          new SolidColorBrush(Colors.Gray) :
          (this.ProductInventories[0].Quantity > this.SafetyStockLevel ?
          new SolidColorBrush(Colors.Green) :
          (this.ProductInventories[0].Quantity > this.ReorderPoint ?
          new SolidColorBrush(Colors.Yellow) : new SolidColorBrush(Colors.Red)));
      }
      set
      {
        //no actual value set here - just property change raised
        //can be set to null in code to cause rebinding, when
        //ProductInventories changes
        RaisePropertyChanged("InventoryLevelBrush");
      }

    }
    private string _InventoryLevelMessage;

    public string InventoryLevelMessage
    {
      get
      {
        return (this.ProductInventories == null
          || this.ProductInventories.Count == 0) ? "Stock Level Unknown"
          : (this.ProductInventories[0].Quantity > this.SafetyStockLevel
          ? "In Stock" :
          (this.ProductInventories[0].Quantity > this.ReorderPoint ?
          "Low Stock" : "Reorder Now"));
      }
      set
      {
        //no actual value set here - just property change raised
        //can be set to null in code to cause rebinding,
        //when ProductInventories changes
        RaisePropertyChanged("InventoryLevelMessage");
      }
    }
  }
}
```

You set the `ItemsSource` properties for both `lbxStandard` and `lbxCustom` to a list of `Product` data items obtained from the `AdventureWorks` WCF service, as shown in the `GetData()` method in Listing 5-4. You also populate inventory information for each `Product` instance from the same service as a collection of `ProductInventory` instances.

In the declaration of dtProductInfo in Listing 5-3, note the Ellipse with its Fill property bound to InventoryLevelBrush and the TextBlock with its Text property bound to InventoryLevelMessage. These are both calculated values, exposed as properties on the Product class extended using the partial class facility, as shown in Listing 5-4. The InventoryLevelBrush property returns a SolidColorBrush of different colors based on whether the total inventory is above or below certain levels, indicated by the SafetyStockLevel and ReorderPoint properties of the Product data class. The InventoryLevelMessage property applies the same logic to return differently formatted text messages instead.

5-4. Displaying Information in a Pop-up

Problem

You want to display a portion of the UI in a pop-up in response to an input event such as a mouse click.

Solution

Use the Popup element to contain and display the necessary UI.

How It Works

Pop-ups are frequently used in UI design to display on-the-fly information in response to input events. Typical examples include cascading menus, context menus, the drop-down portion of a combo box, and tooltips. Silverlight includes a type named Popup in the System.Windows.Controls.Primitives namespace. The Popup type is used by several other controls in the framework, such as the DatePicker, the ToolTip, and the DataGrid. You can use it in your own code as well.

Creating and Initializing the Pop-up

The Popup type is not a control—it derives directly from the FrameworkElement type. It is meant to be a container for a tree of elements and, therefore, has no visual representation of its own. While you can include a Popup in XAML, because of positioning requirements, it is much more common to create an instance of the Popup in code and set its Child property to the root of the element tree representing the content you want to display inside the Popup. This code shows setting a ListBox as the Popup.Child:

```
Popup popupProducts = new Popup();
ListBox popupContent = new ListBox();
popupProducts.Child = popupContent;
```

Once you have prepared the Popup, you can toggle the Popup.IsOpen property to show or hide it.

Positioning the Pop-up

In most cases, you want to display the Popup at a dynamically determined position on the page, relative to coordinates of an input event, such as a mouse click, or to that of some other element on the form. This explains why a Popup is typically not included by a designer in the XAML for the page but rather created in code—it does not make sense to subject it to the constraints of the layout system and determine its position up front unless you are using absolute positioning and a container like the Canvas.

To assist in the process of determining its position, the Popup type exposes two properties of type double: VerticalOffset and HorizontalOffset. These properties define offsets from the top and left corners, respectively, of the root element of the Page and are both set to zero by default, causing the Popup to display at the top-left corner of the Page root. To determine the appropriate page-based offsets for a Popup relative to some other element on the page, you need to perform some coordinate transforms. To understand this problem a little better, take a look at Figure 5-17.

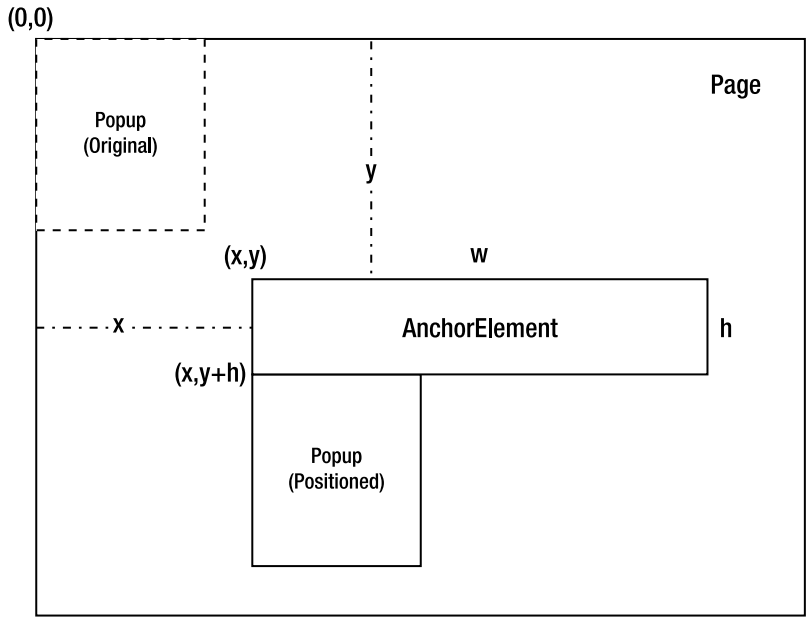


Figure 5-17. *Coordinate transformation for a Popup instance*

When you initially create a Popup instance, it is located at the top-left corner of the Page at coordinates (0,0) which is shown by the dotted outline of the Popup in Figure 5-17.

Let's assume you need to align the Popup to the bottom-left corner of an element in the Page named AnchorElement, which has Width set to *w* and Height set to *h*; its top-left coordinates are (x,y) relative to the Page, as shown in Figure 5-17. If you defined the Popup's desired coordinates with respect to the AnchorElement's coordinate space alone, they would be (0,h).

However, since you are going to position the Popup within the Page, you need to translate (0,h) in AnchorElement's coordinate space (the source coordinate space) to a suitable set of coordinates in the Page's coordinate space (the target coordinate space). Those would be (x,y + h) for it to be positioned at the desired spot, which means that the Popup needs to be offset by x horizontally and by $y + h$ vertically from its original position of (0,0) within the Page to reach its new position.

The following code shows how to achieve this:

```
GeneralTransform coordTnsfrm = this.TransformToVisual(AnchorElement);
Point pt = coordTnsfrm.Transform(new Point(0.0, AnchorElement.ActualHeight));
popupProducts.HorizontalOffset = pt.X;
popupProducts.VerticalOffset = pt.Y;
```

Here you invoke `TransformToVisual()` on an `UIElement` that owns the target coordinate space and pass in another `UIElement` whose coordinate space acts as the source. The `GeneralTransform` that is returned from the call to `TransformToVisual()` can then be used to transform a `Point` defined in the source space to one in the target space.

You also transform a `Point` in `AnchorElement`'s coordinate space with `X` set to 0 and `Y` set to the height of `AnchorElement` (i.e., the bottom-left corner of `AnchorElement`) to the appropriate equivalent in the `Page`'s coordinate space. You then use the `X,Y` values of the resulting `Point` to set the `HorizontalOffset` and the `VerticalOffset` values on the `Popup` to position it as you intended on the page.

Creating Pop-up Content

In initializing a `Popup` in code with content—that is, setting its `Child` property—you should avoid creating and initializing the entire content in code, especially if the content represents a fairly complex UI. You almost always want to take advantage of tools like Expression Blend to do that.

In the following code sample, you simply need a single `ListBox` to be the only child of the `Popup`. Therefore, you are not burdened with creating an overly complex UI in code. However, if you are ever faced with this challenge elsewhere and want to avoid the need to code an UI tree, you can use the `ContentControl` and data templates shown here:

```
Popup popupProducts = new Popup();
ContentControl popupContent = new ContentControl();
popupContent.ContentTemplate = this.Resources["dtPopupData"] as DataTemplate;
popupProducts.Child = popupContent;
popupContent.DataContext = ProdList;
```

Set the `ContentTemplate` of the `ContentControl` to a data template resource, initialize `Popup.Child` with the `ContentControl`, and then bind the `ContentControl` to appropriate data. This gives you the opportunity to host a fairly complex UI in a `Popup` but design it as a data template using a tool like Expression Blend, thus expressing it as XAML and keeping your code free of significant element creation and initialization logic.

The Code

The code sample for this recipe uses the `Popup` type to build a cascading menu that looks similar to the ones in Visual Studio.

Figure 5-18 shows the resulting menu's look and feel. Keep in mind that this sample does not aim to illustrate a full-scale menu framework but rather just a usage pattern for the `Popup` type. However, if you ever do build a menu system using Silverlight, you will probably use the `Popup` type, and the code in this sample will come in handy.

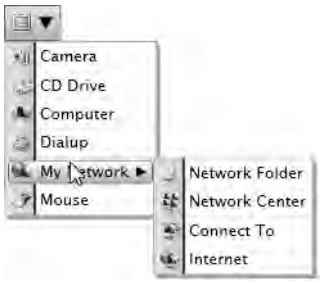


Figure 5-18. *A cascading menu built using the Popup type*

Listing 5-5 shows the `MenuItemData` class used to hold the data for a single menu item.

Listing 5-5. *Data type for a single menu item*

```
using System.Collections.Generic;
using System.Windows;
using System.Windows.Media.Imaging;

namespace Recipe5_4
{
  //data for a single menu item
  public class MenuItemData
  {
    //image URI string used to load the image
    internal string ImageUri
    {
      set
      {
        MenuItemImage = new BitmapImage();
        MenuItemImage.SetSource(this.GetType().Assembly.
          GetManifestResourceStream(this.GetType().Namespace + "." + value));
      }
    }
    //menu item image
    public BitmapImage MenuItemImage { get; set; }
    //menu item caption
    public string MenuItemCaption { get; set; }
    //children items for submenus
    public List<MenuItemData> Children { get; set; }
    //parent menu item
    public MenuItemData Parent { get; set; }
    //toggle submenu arrow visibility based on presence of children items
    public Visibility SubMenuArrow
    {
```

```
      get
      {
        return (Children == null
          || Children.Count == 0 ?
          Visibility.Collapsed : Visibility.Visible);
      }
    }
  }
}
```

The `ImageUri` property setter is used to load an image bitmap that can be accessed through the `MenuItemImage` property. See Chapter 2 for more about loading assembly-embedded resources using `GetManifestResourceStream()`. A submenu is defined by having entries in the `Children` collection. For an item in a submenu, the parent `MenuItemData` instance is contained in the `Parent` property. The `SubMenuArrow` property will be bound appropriately in XAML to control the visibility of the right arrow mark that indicates the presence of a submenu.

Listing 5-6 shows the codebehind for the page.

Listing 5-6. *Codebehind for the MainPage used to display the pop-up menu*

```
using System.Collections.Generic;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Controls.Primitives;
using System.Windows.Input;
using System.Windows.Media;

namespace Recipe5_4
{
  public partial class MainPage : UserControl
  {
    //data for the top level menu
    internal List<MenuItemData> TopMenuData = null;
    //popups for the topmenu and the submenu
    Popup TopMenu, SubMenu;
    //Listboxes for the menu content
    ListBox lbxTopMenu, lbxSubMenu;

    public MainPage()
    {
      InitializeComponent();
      //initialize the menu data
      TopMenuData = new List<MenuItemData>
      {
        new MenuItemData{MenuItemCaption="Camera", ImageUri="Camera.png"},
        new MenuItemData{MenuItemCaption="CD Drive",ImageUri="CD_Drive.png"},
```

```
      new MenuItemData{MenuItemCaption="Computer",ImageUri="Computer.png"},
      new MenuItemData{MenuItemCaption="Dialup",ImageUri="Dialup.png"},
      new MenuItemData{MenuItemCaption="My Network",ImageUri="mynet.png"},
      new MenuItemData{MenuItemCaption="Mouse",ImageUri="Mouse.png"}
    };

    TopMenuData[4].Children = new List<MenuItemData>
      {
          new MenuItemData{MenuItemCaption="Network Folder",
            ImageUri="Network_Folder.png",Parent = TopMenuData[4]},
          new MenuItemData{MenuItemCaption="Network Center",
            ImageUri="Network_Center.png",Parent = TopMenuData[4]},
          new MenuItemData{MenuItemCaption="Connect To",
            ImageUri="Network_ConnectTo.png",Parent = TopMenuData[4]},
          new MenuItemData{MenuItemCaption="Internet",
            ImageUri="Network_Internet.png",Parent = TopMenuData[4]}
          };

    //create and initialize the top menu popup
    TopMenu = new Popup();
    lbxTopMenu = new ListBox();
    //set the listbox style to apply the menu look templating
    lbxTopMenu.Style = this.Resources["styleMenu"] as Style;
    //bind the topmenu data
    lbxTopMenu.ItemsSource = TopMenuData;
    TopMenu.Child = lbxTopMenu;

    //create and initialize the submenu
    SubMenu = new Popup();
    lbxSubMenu = new ListBox();
    lbxSubMenu.MouseLeave += new MouseEventHandler(lbxSubMenu_MouseLeave);
    lbxSubMenu.Style = this.Resources["styleMenu"] as Style;
    SubMenu.Child = lbxSubMenu;
  }

  //set the top menu position
  private void SetTopMenuPosition(Popup Target,
    FrameworkElement CoordSpaceSource)
  {
    //get the transform to use
    GeneralTransform transform = this.TransformToVisual(CoordSpaceSource);
    //transform the left-bottom corner
    Point pt = transform.Transform(new Point(0.0,
      CoordSpaceSource.ActualHeight));
    //set offsets accordingly
```

```
  Target.HorizontalOffset = pt.X;
  Target.VerticalOffset = pt.Y;
}
//set the submenu position
private void SetSubMenuPosition(Popup Target,
  FrameworkElement CoordSpaceSource, int ItemIndex,
  FrameworkElement ParentMenuItem)
{

  //get the transform to use
  GeneralTransform transform = this.TransformToVisual(CoordSpaceSource);
  //transform the right-top corner
  Point pt = transform.Transform(
    new Point(ParentMenuItem.ActualWidth,
      CoordSpaceSource.ActualHeight +
      (ParentMenuItem.ActualHeight * ItemIndex)));
  //set offsets accordingly
  Target.HorizontalOffset = pt.X;
  Target.VerticalOffset = pt.Y;
}

private void btnDropDown_Click(object sender, RoutedEventArgs e)
{
  //position the top menu
  SetTopMenuPosition(TopMenu, LayoutRoot);
  //show or hide
  TopMenu.IsOpen = !TopMenu.IsOpen;
}

private void LbxItemRoot_MouseEnter(object sender, MouseEventArgs e)
{
  //get the listboxitem for the selected top menu item
  ListBoxItem lbxItem = (sender as Grid).Parent as ListBoxItem;
  //get the bound MenuItemData
  MenuItemData midTop = (sender as Grid).DataContext as MenuItemData;
  //do we have children and are we on the top menu?
  if (midTop.Parent == null &&
    (midTop.Children == null || midTop.Children.Count == 0))
  {
    //do not show the submenu
    SubMenu.IsOpen = false;
  }
  else if (midTop.Children != null && midTop.Children.Count > 0)
  {
    //yes - position sub menu
    SetSubMenuPosition(SubMenu, LayoutRoot, TopMenuData.IndexOf(midTop),
```

```
          (sender as Grid));
        //bind to children MenuItemData collection
        lbxSubMenu.ItemsSource = midTop.Children;
        //show  submenu
        SubMenu.IsOpen = true;
      }

    }
    //leaving submenu - close it
    void lbxSubMenu_MouseLeave(object sender, MouseEventArgs e)
    {
      SubMenu.IsOpen = false;
    }
  }
}
```

In the constructor, you populate the data structures needed to create and initialize two `Popups`: `TopMenu` for the top-level menu, and `SubMenu` for a cascading submenu. `ListBoxes` `lbxTopMenu` and `lbxSubMenu` are used to provide the content inside the `Popups`, with a style named `styleMenu` customizing them to look like a menu. The data for the menus is stored as `MenuItemData` instances in the `TopMenuData` collection, with the `Children` property of the `MenuItemData` captioned My Network filled with items for a submenu.

The top menu is displayed in the click handler `btnDropDown_Click()` of the menu drop-down button. You first call `SetTopMenuPosition()` to position the `Popup`, and then toggle its `IsOpen` property so that the menu either displays or is removed if it is already on display. The cascading submenu is displayed in the `MouseEnter` handler `LbxItemRoot_MouseEnter()` of an item in the top-level menu. You check to see if the top-level menu item has children, and if it does, you invoke `SetSubMenuPosition()` to position the submenu, set its data source `Children` collection, and toggle its display. In the `MouseLeave` event handler of the `ListBox` `lbxSubMenu` representing the submenu, you turn off the submenu.

Let's look at the `SetTopMenuPosition()` and `SetSubMenuPosition()` methods used to position the `Popups`. In both methods, the second parameter named `CoordSpaceSource` represents the source element whose coordinate space you need to transform from. In Listing 5-6, in the case of `SetTopMenuPosition()`, this parameter is `LayoutRoot`, which is the `Grid` containing the menu drop-down button. The top menu `Popup` is then positioned along the `Grid`'s bottom-left corner. In `SetSubMenuPosition()`, you again use `LayoutRoot`. But `SetSubMenuPosition()` accepts two additional parameters. The third parameter, named `ItemIndex`, represents the index of the selected item in `lbxTopMenu`, and the fourth parameter, named `ParentMenuItem`, is the containing `Grid` for the `ListBoxItem` on the top menu that has been just selected. To align the submenu pop-up with the top-right corner of the `ListBoxItem`, you acquire the coordinate space transform as before. But then you transform the point using `ParentMenuItem.ActualWidth` as the `x` parameter to the `Point` instance, and the total height of all menu items up to but not including the one identified by `ItemIndex` as the `y` parameter. This causes the submenu to be positioned along the right edge of the top menu, with its top edge horizontally aligned with the parent menu item currently selected in the top menu.

Listing 5-7 shows the XAML for the page.

Listing 5-7. *XAML for the page hosting the pop-up menu*

```
<UserControl x:Class="Recipe5_4.MainPage"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
```

```
  Width="400" Height="300"
  xmlns:vsm="clr-namespace:System.Windows;assembly=System.Windows">
<UserControl.Resources>

  <ControlTemplate x:Key="ctMenuItem" TargetType="ListBoxItem">
    <Grid x:Name="LbxItemRoot" Height="20"
          MouseEnter="LbxItemRoot_MouseEnter"
      DataContext="{TemplateBinding Content}" >
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="24.0" MaxWidth="24.0"/>
        <ColumnDefinition Width="*"/>
      </Grid.ColumnDefinitions>
      <vsm:VisualStateManager.VisualStateGroups>
        <vsm:VisualStateGroup x:Name="CommonStates">
          <vsm:VisualState x:Name="Normal">
            <Storyboard/>
          </vsm:VisualState>
          <vsm:VisualState x:Name="MouseOver">
            <Storyboard>
              <ObjectAnimationUsingKeyFrames
                 BeginTime="00:00:00"
                 Duration="00:00:00.0010000"
                 Storyboard.TargetName="SelectionIndicator"
                 Storyboard.TargetProperty="(UIElement.Visibility)">
                <DiscreteObjectKeyFrame KeyTime="00:00:00">
                  <DiscreteObjectKeyFrame.Value>
                    <vsm:Visibility>Visible</vsm:Visibility>
                  </DiscreteObjectKeyFrame.Value>
                </DiscreteObjectKeyFrame>
              </ObjectAnimationUsingKeyFrames>
            </Storyboard>
          </vsm:VisualState>
        </vsm:VisualStateGroup>
        <vsm:VisualStateGroup x:Name="SelectionStates">
          <vsm:VisualState x:Name="Unselected"/>
          <vsm:VisualState x:Name="Selected"/>
          <vsm:VisualState x:Name="SelectedUnfocused"/>
        </vsm:VisualStateGroup>
        <vsm:VisualStateGroup x:Name="FocusStates">
          <vsm:VisualState x:Name="Unfocused"/>
          <vsm:VisualState x:Name="Focused"/>
        </vsm:VisualStateGroup>
      </vsm:VisualStateManager.VisualStateGroups>
      <Border Margin="0,0,0,0" Grid.Column="0" BorderThickness="0,0,2,0">
        <Border.Background>
```

```
    <LinearGradientBrush
      EndPoint="0.912000000476837,0.509999990463257"
      StartPoint="0,0.514999985694885">
      <GradientStop Color="#FFDDE9F4"/>
      <GradientStop Color="#FFADD5F5" Offset="1"/>
    </LinearGradientBrush>
  </Border.Background>
  <Border.BorderBrush>
    <LinearGradientBrush
      EndPoint="1.37399995326996,0.485000014305115"
      StartPoint="0.275000005960464,0.485000014305115">
      <GradientStop Color="#FF000000" Offset="0.5"/>
      <GradientStop Color="#FFFFFFFF" Offset="1"/>
    </LinearGradientBrush>
  </Border.BorderBrush>
</Border>
<Border Grid.Column="1" Background="White" />
<Border HorizontalAlignment="Stretch"
        Margin="2,2,2,2" Width="Auto"
        Grid.Column="0" Grid.ColumnSpan="2"
        CornerRadius="3,3,3,3"
        BorderBrush="#FF1E7CDA"
        BorderThickness="1,1,1,1" x:Name="SelectionIndicator"
        Visibility="Collapsed">
  <Border.Background>
    <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
      <GradientStop Color="#FFFFFFFF" Offset="0.009"/>
      <GradientStop Color="#FF7AC5F0" Offset="1"/>
    </LinearGradientBrush>
  </Border.Background>
</Border>
<Grid Margin="2,2,2,2" Grid.ColumnSpan="2" HorizontalAlignment="Stretch"
      VerticalAlignment="Stretch" Background="Transparent">
  <Grid.ColumnDefinitions>
    <ColumnDefinition Width="22px"/>
    <ColumnDefinition Width="auto"/>
    <ColumnDefinition Width="auto"/>
  </Grid.ColumnDefinitions>
  <Image
        Source="{Binding MenuItemImage}"
        Width="16" Height="16" Stretch="Fill"
        Margin="3,0,3,0" Grid.Column="0"/>
  <TextBlock
            Text="{Binding MenuItemCaption}" Margin="3,0,3,0"
            Grid.Column="1"/>
```

```
        <Path x:Name="SubMenuArrow" Width="8" Height="8" Stretch="Fill"
              Fill="#FF000000"
              Data="F1 M 8.25,4.76315L 0,0L 0,9.52628L 8.25,4.76315 Z "
              Grid.Column="2" Visibility="{Binding SubMenuArrowVisibility}"
              Margin="3,0,5,0"/>
      </Grid>
    </Grid>
  </ControlTemplate>

  <Style TargetType="ListBoxItem" x:Key="styleMenuItem">
    <Setter Property="Template" Value="{StaticResource ctMenuItem}" />
  </Style>

  <ControlTemplate x:Key="ctMenuList" TargetType="ListBox">
    <Grid>
      <Border HorizontalAlignment="Stretch" VerticalAlignment="Stretch"
              Background="Black"  Margin="2.5,2.5,-2.5,-2.5" Opacity="0.35"/>
      <Border BorderBrush="#FFA7A7A7" BorderThickness="1"
              HorizontalAlignment="Left" VerticalAlignment="Top" >
        <ItemsPresenter/>
      </Border>
    </Grid>
  </ControlTemplate>

  <Style x:Key="styleMenu" TargetType="ListBox">
    <Setter Property="Template" Value="{StaticResource ctMenuList}" />
    <Setter Property="ItemContainerStyle"
            Value="{StaticResource styleMenuItem}" />
  </Style>

  <ControlTemplate TargetType="Button" x:Key="ctButton">
    <ContentPresenter HorizontalAlignment="Center" VerticalAlignment="Center"
      Content="{TemplateBinding Content}"
      ContentTemplate="{TemplateBinding ContentTemplate}"
      />
  </ControlTemplate>

</UserControl.Resources>
<Grid x:Name="LayoutRoot" HorizontalAlignment="Left" VerticalAlignment="Top">
  <StackPanel Orientation="Horizontal">
    <Border  BorderThickness="1,1,0,1" BorderBrush="#FF4169B1"
             HorizontalAlignment="Left" x:Name="border">
      <Border.Background>
        <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
          <GradientStop Color="#FFD9E9FB"/>
```

```
            <GradientStop Color="#FF88BCF9" Offset="1"/>
          </LinearGradientBrush>
        </Border.Background>
        <Image Width="16" Height="16" Source="Menu.png" Margin="5,5,5,5"/>
      </Border>
      <Border BorderThickness="0,1,1,1" BorderBrush="#FF4169B1"
              HorizontalAlignment="Left" x:Name="border1">
        <Border.Background>
          <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
            <GradientStop Color="#FFD9E9FB"/>
            <GradientStop Color="#FF88BCF9" Offset="1"/>
          </LinearGradientBrush>
        </Border.Background>
        <Button Height="16" Template="{StaticResource ctButton}"
                x:Name="btnDropDown" Margin="0,5,5,5" HorizontalAlignment="Stretch"
                VerticalAlignment="Stretch" Click="btnDropDown_Click"
Padding="5,5,5,5">
          <Button.Content>
            <Path x:Name="Path" Width="11.2578" Height="9.80142"  Stretch="Fill"
              Fill="#FF000000"
              Data="F1 M 12.3926,10.3748L 18.1113,0.677055L 6.85348,
                  0.573364L 12.3926,10.3748 Z "/>
          </Button.Content>
        </Button>
      </Border>
    </StackPanel>
  </Grid>
</UserControl>
```

The UI contains only the representation of the initial menu drop-down button. This consists of everything that is inside the `Grid` named `LayoutRoot`, primarily a `Button` with its content set to a `Path` that displays the down arrow and an `Image` that is bound to a resource in the assembly named `Menu.png`, both contained inside some `Borders`.

The control template `ctMenuItem` is what gives each item the look and feel when it is applied to a `ListBoxItem`. Each `ListBoxItem` is bound to an instance of `MenuItemData` and is implemented using an `Image` bound to `MenuItemImage`, a `TextBlock` bound to `MenuItemCaption`, and a `Path` displaying a right arrow with its `Visibility` property bound to `SubMenuArrow`. The selection indicator is implemented as a `Border` with initial `Visibility` set to `Collapsed`. The visual state for `MouseOver` is used to make the selection indicator visible as the user moves her mouse among items in the menu. You also customize the `ListBox` that represents an entire drop-down by applying another control template named `ctMenuList` to it. This puts an `ItemsPresenter` control inside a couple of `Borders` and gets rid of the usual scroll bars and other elements that are a part of a `ListBox` default template.

You apply the control templates to the `Popups` when you create the code, via the `Style` named `styleMenu`, as you have already seen in Listing 5-6.

5-5. Displaying Row Details in a DataGrid

Problem

You need to display additional detail information about a bound row in a `DataGrid` on demand so that the details portion is displayed in place within the `DataGrid`.

Solution

Use the `RowDetailsTemplate` property of the `DataGrid` to associate a data template that can be used to display additional data on demand.

How It Works

The `DataGrid.RowDetailsTemplate` property accepts a data template (covered in Chapter 4) that can be used to display additional data in place, associated with a bound row. This feature comes handy in many scenarios—to provide master-detail data where multiple detail records need to be displayed for a top-level row or where additional information, not otherwise bound to top-level columns, needs to be displayed adjacent to a row.

The `DataGrid.RowDetailsVisibilityMode` property controls the visibility of the row details information at `DataGrid` scope. That is, setting it to `Visible` keeps it always visible for every bound row, whereas setting it to `VisibleWhenSelected` makes the details portion of a row visible when the row is selected and collapsed back when selection moves off to another row. To control row details' visibility in code, set this property to `Collapsed`, which hides row details for every row, and instead use the `DataGridRow.DetailsVisibility` property on the individual row.

The `DataGrid` also exposes two useful events: `LoadingRowDetails` and `UnloadingRowDetails`. `LoadingRowDetails` is raised when the `DataGrid` initially applies the `RowDetailsTemplate` to the row. This is especially useful if you want to load the data for the row details in a delayed fashion—placing the code to load the data in the handler for `LoadingRowDetails` ensures that the data is only loaded when the user first expands the row details and is never executed again, unless the row details are explicitly unloaded. `UnloadingRowDetails` is raised when the rows are unloaded, such as when a method like `DataGrid.ClearRows()` is invoked.

The `DataGrid` also raises another event called `RowDetailsVisibilityChanged` every time a row detail is either made visible or is collapsed.

■ **Note** The `DataGrid` control is found in the `System.Windows.Controls.Data` assembly in the `System.Windows.Controls` namespace.

The Code

For this code sample, you bind a `DataGrid` to product data sourced from the `AdventureWorks` WCF service. Each row, in addition to the bound columns, also displays some row details data, including an image of the product, inventory information, a product description, and another `DataGrid` displaying the cost history records of the product demonstrating a master-detail arrangement. Figure 5-19 shows the `DataGrid` with the row details of a row expanded.

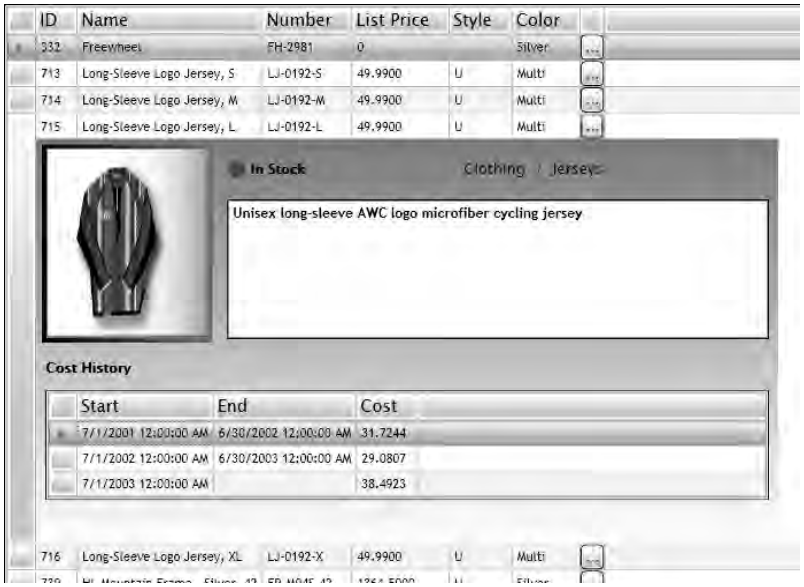


Figure 5-19. *Bound DataGrid using a RowDetailstemplate*

Listing 5-8 shows the XAML for the page.

Listing 5-8. *XAML for the page hosting the DataGrid with row details*

```
<UserControl x:Class="Recipe5_5.MainPage"
  xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
  xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
  xmlns:data=
  "clr-namespace:System.Windows.Controls;assembly=System.Windows.Controls.Data"
  Width="900" Height="600" >
  <UserControl.Resources>
    <DataTemplate x:Key="dtProductRowDetails">
      <Grid Height="350" Width="646">
        <Grid.RowDefinitions>
          <RowDefinition Height="0.127*"/>
          <RowDefinition Height="0.391*"/>
          <RowDefinition Height="0.482*"/>
        </Grid.RowDefinitions>
        <Grid.Background>
          <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
            <GradientStop Color="#FF7D7A7A"/>
            <GradientStop Color="#FFFFFFFF" Offset="1"/>
          </LinearGradientBrush>
        </Grid.Background>
        <Grid.ColumnDefinitions>
```

```
  <ColumnDefinition Width="0.245*"/>
  <ColumnDefinition Width="0.755*"/>
</Grid.ColumnDefinitions>
<Border HorizontalAlignment="Stretch" Margin="5,5,5,5"
      VerticalAlignment="Stretch" Grid.RowSpan="2"
      BorderThickness="4,4,4,4">
  <Border.BorderBrush>
    <LinearGradientBrush
    EndPoint="1.02499997615814,0.448000013828278"
    StartPoint="-0.0130000002682209,0.448000013828278">
      <GradientStop Color="#FF000000"/>
      <GradientStop Color="#FF6C6C6C" Offset="1"/>
    </LinearGradientBrush>
  </Border.BorderBrush>
  <Image  MinHeight="50" MinWidth="50"
        Source="{Binding ProductPhoto.LargePhotoPNG}"
        Stretch="Fill"
        VerticalAlignment="Stretch"
        HorizontalAlignment="Stretch"/>
</Border>
<Grid HorizontalAlignment="Stretch" Margin="8,8,8,0"
    VerticalAlignment="Stretch"
    Grid.Column="1" Grid.RowSpan="1">
  <Grid.ColumnDefinitions>
    <ColumnDefinition Width="0.25*"/>
    <ColumnDefinition Width="0.3*"/>
    <ColumnDefinition Width="0.05*"/>
    <ColumnDefinition Width="0.4*"/>
  </Grid.ColumnDefinitions>
  <StackPanel HorizontalAlignment="Stretch" Grid.Column="0"
              Orientation="Horizontal" Margin="1,0,1,0">
    <Ellipse Height="15" Width="15"
             Fill="{Binding InventoryLevelBrush}" Margin="0,0,2,0" />
    <TextBlock Text="{Binding InventoryLevelMessage}" FontSize="12"
            FontWeight="Bold"
            VerticalAlignment="Center" Margin="2,0,0,0"/>
  </StackPanel>
  <TextBlock HorizontalAlignment="Stretch"
           VerticalAlignment="Center"
           Grid.ColumnSpan="1"
           Text="{Binding ProductCategory.Name}"
           TextAlignment="Right" TextWrapping="Wrap"
           Grid.Column="1" FontSize="13"/>
  <TextBlock HorizontalAlignment="Stretch"
           VerticalAlignment="Center"
           Grid.Column="2" Text="/"
```

```
            TextWrapping="Wrap" TextAlignment="Center"
            FontSize="13" />
  <TextBlock HorizontalAlignment="Stretch"
            VerticalAlignment="Center"
            Grid.Column="3" Grid.ColumnSpan="1"
            Text="{Binding ProductSubCategory.Name}"
            TextWrapping="Wrap" TextAlignment="Left"
            FontSize="13"/>
</Grid>
<StackPanel Orientation="Vertical"
          HorizontalAlignment="Stretch"
          VerticalAlignment="Stretch"
          Margin="8,8,8,8"
          Grid.ColumnSpan="2"
          Grid.Row="2" Grid.RowSpan="1" >
  <TextBlock Height="Auto" Width="Auto"
            FontSize="12" FontWeight="Bold"
            Text="Cost History" Margin="0,0,0,10"/>
  <data:DataGrid AutoGenerateColumns="False"
              ItemsSource="{Binding ProductCostHistories}">
    <data:DataGrid.Columns>
      <data:DataGridTextColumn Binding="{Binding StartDate}"
                            Header="Start"/>
      <data:DataGridTextColumn Binding="{Binding EndDate}"
                            Header="End"/>
      <data:DataGridTextColumn
        Binding="{Binding StandardCost}"
        Header="Cost"/>
    </data:DataGrid.Columns>
  </data:DataGrid>
</StackPanel>
<Border HorizontalAlignment="Stretch"
      Margin="8,8,8,8"
      VerticalAlignment="Stretch"
      Grid.Column="1"
      Grid.Row="1"
      Grid.RowSpan="1"
      BorderBrush="#FF000000"
      BorderThickness="1,1,1,1">
  <TextBox Height="Auto" Width="Auto"
         FontSize="12"
         FontWeight="Bold"
         Text="{Binding ProductDescription.Description,Mode=TwoWay}"
         TextWrapping="Wrap"/>
</Border>
```

```
      </Grid>
    </DataTemplate>
  </UserControl.Resources>

  <Grid x:Name="LayoutRoot" Background="White">
    <data:DataGrid x:Name="dgProducts" AutoGenerateColumns="False"
             RowDetailsTemplate="{StaticResource dtProductRowDetails}"
             RowDetailsVisibilityMode="Collapsed">
      <data:DataGrid.Columns>
        <data:DataGridTextColumn
          Binding="{Binding ProductID}" Header="ID" />
        <data:DataGridTextColumn
          Binding="{Binding Name}" Header="Name" />
        <data:DataGridTextColumn
          Binding="{Binding ProductNumber}" Header="Number"/>
        <data:DataGridTextColumn
          Binding="{Binding ListPrice}" Header="List Price"/>
        <data:DataGridTextColumn
          Binding="{Binding Style}" Header="Style"/>
        <data:DataGridTextColumn
          Binding="{Binding Color}" Header="Color"/>
        <data:DataGridTemplateColumn>
          <data:DataGridTemplateColumn.CellTemplate>
            <DataTemplate x:Key="dtShowDetailTemplate">
              <Button Content="..." x:Name="ShowDetails"
                      Click="ShowDetails_Click" />
            </DataTemplate>
          </data:DataGridTemplateColumn.CellTemplate>
        </data:DataGridTemplateColumn>
      </data:DataGrid.Columns>
    </data:DataGrid>
  </Grid>
</UserControl>
```

The data template used for the `RowDetailsTemplate` is named `dtProductRowDetails` and contains fields bound to several properties in the `Product` data class plus some nested classes. It displays an image of the product along with category and inventory information.

To use the data template in the `DataGrid` named `dgProducts`, set the `DataGrid.RowDetailsVisibilityMode` to `Collapsed` so that all rows have their detail information hidden to start with. To allow users to display row details on demand, an extra column of type `DataGridTemplateColumn` is added to the `DataGrid` with a specific `CellTemplate` containing a `Button`. (You will learn more about column templates in the next recipe.) The `CellTemplate` causes a `Button` to be displayed in the last column of each bound row, and you use the `Button`'s click handler `ShowDetails_Click()` to allow the user to toggle the `Visibility` of the row detail information, as shown the codebehind for the page in Listing 5-9.

Listing 5-9. *Codebehind for the MainPage hosting the DataGrid*

```
using System;
using System.IO;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Media;
using System.Windows.Media.Imaging;
using Recipe5_5.AdvWorks;

namespace Recipe5_5
{
  public partial class MainPage : UserControl
  {
    AdvWorksDataServiceClient client =
      new AdvWorksDataServiceClient();


    public MainPage()
    {
      InitializeComponent();
      //async completion callbacks for the web service calls to get data
      client.GetPhotosCompleted +=
        new EventHandler<GetPhotosCompletedEventArgs>(
          delegate(object s1, GetPhotosCompletedEventArgs e1)
          {
            (e1.UserState as Product).ProductPhoto = e1.Result;
          });
      client.GetInventoryCompleted +=
        new EventHandler<GetInventoryCompletedEventArgs>(
          delegate(object s2, GetInventoryCompletedEventArgs e2)
          {
            (e2.UserState as Product).ProductInventories = e2.Result;
            (e2.UserState as Product).InventoryLevelBrush = null;
            (e2.UserState as Product).InventoryLevelMessage = null;
          });
      client.GetCategoryCompleted +=
        new EventHandler<GetCategoryCompletedEventArgs>(
         delegate(object s3, GetCategoryCompletedEventArgs e3)
         {
           (e3.UserState as Product).ProductCategory = e3.Result;
         });
      client.GetSubcategoryCompleted +=
        new EventHandler<GetSubcategoryCompletedEventArgs>(
          delegate(object s4, GetSubcategoryCompletedEventArgs e4)
```

```
      {
        (e4.UserState as Product).ProductSubCategory = e4.Result;
      });
  client.GetDescriptionCompleted +=
    new EventHandler<GetDescriptionCompletedEventArgs>(
      delegate(object s5, GetDescriptionCompletedEventArgs e5)
      {
        (e5.UserState as Product).ProductDescription = e5.Result;
      });
  client.GetProductCostHistoryCompleted +=
    new EventHandler<GetProductCostHistoryCompletedEventArgs>(
      delegate(object s6, GetProductCostHistoryCompletedEventArgs e6)
      {
        (e6.UserState as Product).ProductCostHistories = e6.Result;
      });

  //LoadingRowDetails handler - here we make the calls to load
  //row details data on demand
  dgProducts.LoadingRowDetails +=
    new EventHandler<DataGridRowDetailsEventArgs>(
      delegate(object sender, DataGridRowDetailsEventArgs e)
      {
        Product prod = e.Row.DataContext as Product;
        if (prod.ProductInventories == null)
          client.GetInventoryAsync(prod, prod);
        if (prod.ProductCategory == null && prod.ProductSubcategoryID != null)
          client.GetCategoryAsync(prod, prod);
        if (prod.ProductSubCategory == null &&
          prod.ProductSubcategoryID != null)
          client.GetSubcategoryAsync(prod, prod);
        if (prod.ProductDescription == null)
          client.GetDescriptionAsync(prod, prod);
        if (prod.ProductPhoto == null)
          client.GetPhotosAsync(prod, prod);
        if (prod.ProductCostHistories == null)
          client.GetProductCostHistoryAsync(prod, prod);
      });
  GetData();
}

private void GetData()
{
  //get the top level product data
  client.GetProductsCompleted +=
    new EventHandler<GetProductsCompletedEventArgs>(
```

```
          delegate(object sender, GetProductsCompletedEventArgs e)
          {
            dgProducts.ItemsSource = e.Result;
          });
      client.GetProductsAsync();
    }


    private void ShowDetails_Click(object sender, RoutedEventArgs e)
    {
      DataGridRow row = DataGridRow.GetRowContainingElement(sender as Button);
      row.DetailsVisibility =
        (row.DetailsVisibility == Visibility.Collapsed ?
        Visibility.Visible : Visibility.Collapsed);
    }
  }
}

namespace Recipe5_5.AdvWorks
{
  public partial class ProductPhoto
  {
    private BitmapImage _LargePhotoPNG;

    public BitmapImage LargePhotoPNG
    {
      get
      {
        BitmapImage bim = new BitmapImage();
        MemoryStream ms = new MemoryStream(this.LargePhoto.Bytes);
        bim.SetSource(ms);
        ms.Close();
        return bim;
      }
      set
      {
        RaisePropertyChanged("LargePhotoPNG");
      }
    }
  }


public partial class Product
  {
    private SolidColorBrush _InventoryLevelBrush;
```

```
public SolidColorBrush InventoryLevelBrush
{
  get
  {
    return (this.ProductInventories == null
      || this.ProductInventories.Count == 0) ?
      new SolidColorBrush(Colors.Gray) :
        (this.ProductInventories[0].Quantity > this.SafetyStockLevel ?
          new SolidColorBrush(Colors.Green) :
            (this.ProductInventories[0].Quantity > this.ReorderPoint ?
               new SolidColorBrush(Colors.Yellow) :
                new SolidColorBrush(Colors.Red)));
  }
  set
  {
    //no actual value set here - just property change raised
    RaisePropertyChanged("InventoryLevelBrush");
  }

}
private string _InventoryLevelMessage;
public string InventoryLevelMessage
{
  get
  {
    return (this.ProductInventories == null
      || this.ProductInventories.Count == 0) ?
      "Stock Level Unknown" :
        (this.ProductInventories[0].Quantity > this.SafetyStockLevel ?
        "In Stock" :
          (this.ProductInventories[0].Quantity > this.ReorderPoint ?
            "Low Stock" : "Reorder Now"));
  }
  set
  {
    //no actual value set here - just property change raised
    RaisePropertyChanged("InventoryLevelMessage");
  }
}
private ProductSubcategory _productSubCategory;
public ProductSubcategory ProductSubCategory
{
  get { return _productSubCategory; }
  set
  {
```

```
        _productSubCategory = value;
        RaisePropertyChanged("ProductSubCategory");
      }
    }
    private ProductCategory _productCategory;
    public ProductCategory ProductCategory
    {
      get { return _productCategory; }
      set { _productCategory = value; RaisePropertyChanged("ProductCategory"); }
    }
    private ProductDescription _productDescription;
    public ProductDescription ProductDescription
    {
      get { return _productDescription; }
      set
      {
        _productDescription = value;
        RaisePropertyChanged("ProductDescription");
      }
    }
    private ProductReview _productReview;
    public ProductReview ProductReview
    {
      get { return _productReview; }
      set { _productReview = value; RaisePropertyChanged("ProductReview"); }
    }
    private ProductPhoto _productPhoto;
    public ProductPhoto ProductPhoto
    {
      get { return _productPhoto; }
      set { _productPhoto = value; RaisePropertyChanged("ProductPhoto"); }
    }
  }
}
```

Once again, the data is acquired by calling the `AdventureWorks` WCF service. The `GetData()` method loads the initial product data into the rows to which the `DataGrid` is bound. You set the `DataGrid`'s `ItemsSource` in the completion handler for the `GetProductsAsync()` web service call. When the user toggles the visibility of a row's details for the first time, the `LoadingRowDetails` event is raised, and the row detail data is fetched from the web service in that handler, defined using an anonymous delegate.

The row detail data, once fetched, is bound to various parts of the UI by setting appropriate properties in the already bound `Product` instance, which, in turn, uses property change notification to update the UI. Just as in the previous recipes, you extend the `Product` partial class, as generated by the WCF service proxy, to include the additional property definitions.

5-6. Applying Custom Templates to a DataGrid Cell

Problem

You need a customized way of viewing and editing data that is not supported out of the box by any of the typed DataGridColumns like DataGridTextColumn or DataGridCheckBoxColumn. For example, say you want to view a color value rendered as a color stripe instead of the color name string literal.

Solution

Use the CellTemplate and the CellEditingTemplate properties of the DataGridTemplateColumn to apply custom viewing and editing templates.

How It Works

The various DataGridColumn types like DataGridTextColumn and DataGridCheckBoxColumn are designed to support binding to specific CLR data types, such as String and Boolean, or to types that can be automatically converted to these types. The way that the data is viewed and edited in cells of these specific column types is predetermined by the framework. However, the need for custom UIs for viewing and editing data was well anticipated; the DataGridTemplateColumn is supplied for exactly that purpose.

The DataGridTemplateColumn exposes two properties, CellTemplate and CellEditingTemplate, both of which accept data templates. Data templates are covered in greater detail in Chapter 4. When the column is data bound, the DataGrid binds the cell data item to the data template specified in CellTemplate to display the data in view mode. When the cell enters edit mode, the DataGrid switches to the CellEditingTemplate.

The Code

In this sample, you use a DataGrid bound to product data fetched from the AdventureWorks WCF service. The Product class exposes a Color property, which is defined as a String on the class. You bind the Color property to one of the DataGrid columns and thereby create a more intuitive interface where the user can actually view the color itself for both viewing and editing the Color value, as compared to the default string editing experience exposed by the DataGridTextColumn. Listing 5-10 shows the XAML.

Listing 5-10. *XAML for the MainPage Used to Demonstrate Custom DataGrid Column Templates*

```
<UserControl x:Class="Recipe5_6.MainPage"
  xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
  xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
  xmlns:data=
  "clr-namespace:System.Windows.Controls;assembly=System.Windows.Controls.Data"
  xmlns:local="clr-namespace:Recipe5_6"
  Width="800" Height="400"

>
```

```
<UserControl.Resources>
  <local:ColorNameToBrushConverter x:Key="REF_ColorNameToBrushConverter"/>
  <DataTemplate x:Key="dtColorViewTemplate">
    <Border CornerRadius="5,5,5,5" BorderBrush="Black"
            BorderThickness="1,1,1,1" VerticalAlignment="Stretch"
            HorizontalAlignment="Stretch" Margin="1,1,1,1"
            Background="{Binding Color,
              Converter={StaticResource REF_ColorNameToBrushConverter}}"/>
  </DataTemplate>
  <DataTemplate x:Key="dtColorEditingTemplate">
    <Grid>
      <Grid.RowDefinitions>
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
      </Grid.RowDefinitions>
      <ListBox Grid.Row="0" VerticalAlignment="Stretch"
               HorizontalAlignment="Stretch"
               ItemsSource="{Binding ColorList}"
               SelectedItem="{Binding Color, Mode=TwoWay}"
               Height="200">
        <ListBox.ItemTemplate>
          <DataTemplate>
            <Border CornerRadius="5,5,5,5" BorderBrush="Black"
                    BorderThickness="1,1,1,1" Height="25" Width="70"
                    Margin="2,5,2,5"
                    Background=
                    "{Binding Converter=
                        {StaticResource REF_ColorNameToBrushConverter}}"/>
          </DataTemplate>
        </ListBox.ItemTemplate>
      </ListBox>
    </Grid>
  </DataTemplate>
</UserControl.Resources>
<Grid x:Name="LayoutRoot" Background="White">
  <data:DataGrid x:Name="dgProducts" AutoGenerateColumns="False">
    <data:DataGrid.Columns>
      <data:DataGridTextColumn Binding="{Binding ProductID}"
                               Header="ID" />
      <data:DataGridTextColumn Binding="{Binding Name}"
                               Header="Name" />
      <data:DataGridTemplateColumn
        CellTemplate="{StaticResource dtColorViewTemplate}"
        CellEditingTemplate="{StaticResource dtColorEditingTemplate}"
        Header="Color" Width="100"/>
```

```
      </data:DataGrid.Columns>
    </data:DataGrid>
  </Grid>
</UserControl>
```

In the DataGrid declaration named dgProducts, you use a DataGridTemplateColumn to bind to Product.Color. To get the custom UI for viewing and editing the Color property, you define two data templates, dtColorTemplate and dtColorEditingTemplate, and use them to set the CellTemplate and the CellEditingTemplate properties.

In view mode, where the bound DataGridTemplateColumn uses the CellTemplate to bind the data, you bind the Color value to the Background property of a Border, as shown in the dtColorViewTemplate template. In edit mode, where CellEditingTemplate is used, dtColorEditingTemplate uses a ListBox to display the list of available colors. The ListBox.SelectedItem is bound to Product.Color to represent the currently selected color. The binding mode is set to TwoWay so that any changes made by the user updates the Product instance and is reflected in the DataGrid when the cell moves out of edit mode.

Listing 5-11 shows the codebehind for the page.

Listing 5-11. *Codebehind for the MainPage Demonstrating Custom DataGrid Column Templates*

```
using System;
using System.Collections.Generic;
using System.Collections.ObjectModel;
using System.Linq;
using System.Reflection;
using System.Windows.Controls;
using System.Windows.Data;
using System.Windows.Media;
using Recipe5_6.AdvWorks;

namespace Recipe5_6
{
  public partial class MainPage : UserControl
  {
    AdvWorksDataServiceClient client =
      new AdvWorksDataServiceClient();
    bool EditingColor = false;
    public MainPage()
    {
      InitializeComponent();
      GetData();
    }

    private void GetData()
    {
      client.GetProductsCompleted +=
        new EventHandler<GetProductsCompletedEventArgs>(
          delegate(object sender, GetProductsCompletedEventArgs e)
```

```
        {
          dgProducts.ItemsSource = e.Result;
        });

    client.GetProductsAsync();
  }
}


public class ColorNameToBrushConverter : IValueConverter
{
  //convert from a string Color name to a SolidColorBrush
  public object Convert(object value, Type targetType,
    object parameter, System.Globalization.CultureInfo culture)
  {
    //substitute a null with Transparent
    if (value == null)
      value = "Transparent";
    //make sure the right types are being converted
    if (targetType != typeof(Brush) || value.GetType() != typeof(string))
      throw new NotSupportedException(
        string.Format("{0} to {1} is not supported by {2}",
        value.GetType().Name,
        targetType.Name,
        this.GetType().Name));

    SolidColorBrush scb = null;
    try
    {
      //get all the static Color properties defined in
      //System.Windows.Media.Colors
      List<PropertyInfo> ColorProps = typeof(Colors).
        GetProperties(BindingFlags.Public | BindingFlags.Static).ToList();
      //use LINQ to find the property whose name equates
      //to the string literal we are trying to convert
      List<PropertyInfo> piTarget = (from pi in ColorProps
                                     where pi.Name == (string)value
                                     select pi).ToList();
      //create a SolidColorBrush using the found Color property.
      //If none was found i.e. the string literal being converted
      //did not match any of the defined Color properties in Colors
      //use Transparent
      scb = new SolidColorBrush(piTarget.Count == 0 ?
        Colors.Transparent : (Color)(piTarget[0].GetValue(null, null)));
    }
    catch
```

```
      {
        //on exception, use Transparent
        scb = new SolidColorBrush(Colors.Transparent);
      }
      return scb;


    }
    //convert from a SolidColorBrush to a string Color name
    public object ConvertBack(object value, Type targetType,
      object parameter, System.Globalization.CultureInfo culture)
    {
      //make sure the right types are being converted
      if (targetType != typeof(string) || value.GetType() != typeof(Brush))
        throw new NotSupportedException(
          string.Format("{0} to {1} is not supported by {2}",
          value.GetType().Name,
          targetType.Name,
          this.GetType().Name));

      string ColorName = null;
      try
      {
        //get all the static Color properties defined
        //in System.Windows.Media.Colors
        List<PropertyInfo> ColorProps = typeof(Colors).
          GetProperties(BindingFlags.Public | BindingFlags.Static).ToList();
        //use LINQ to find the property whose value equates to the
        //Color on the Brush we are trying to convert
        List<PropertyInfo> piTarget = (from pi in ColorProps
                                       where (Color)pi.GetValue(null, null)
                                       == ((SolidColorBrush)value).Color
                                       select pi).ToList();
        //If a match is found get the Property name, if not use "Transparent"
        ColorName = (piTarget.Count == 0 ? "Transparent" : piTarget[0].Name);
      }
      catch
      {
        //on exception use Transparent
        ColorName = "Transparent";
      }
      return ColorName;
    }
  }
}
```

```
namespace Recipe5_6.AdvWorks
{
  public partial class Product
  {
    private ObservableCollection<string> _ColorList;
    //color literals defined in System.Windows.Media.Colors
    public ObservableCollection<string> ColorList
    {
      get
      {
        return new ObservableCollection<string> {
        "Black",
        "Blue",
        "Brown",
        "Cyan",
        "DarkGray",
        "Gray",
        "Green",
        "LightGray",
        "Magenta",
        "Orange",
        "Purple",
        "Red",
        "Transparent",
        "White",
        "Yellow" };
      }
    }
  }
}
```

The `ListBox.ItemsSource` is bound to the `Product.ColorList` property, defined in a partial extension of the `Product` proxy data type, which returns a collection of string literals representing names of the `Color` properties, as defined in the `System.Windows.Media.Colors` type. To display each item, an `ItemTemplate` similar to that in the view mode is used, where a `Border` is used to display the color choice by binding the `Color` value to `Border.Background`.

Figure 5-20 compares the `DataGrid` `Color` column in view mode and edit mode.

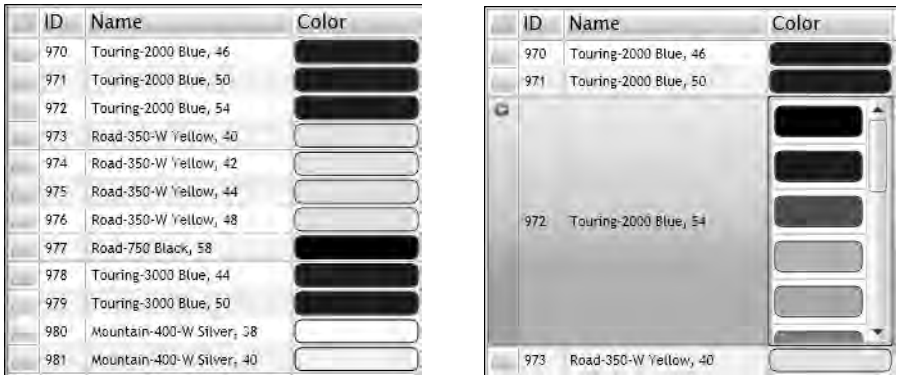


Figure 5-20. *The Color column in view mode (left) and edit mode (right)*

Also note in Listing 5-10 the use of a value converter of type `ColorNameToBrushConverter`. Since the `Border.Background` property is of type `SolidColorBrush` and `Product.Color` is a string literal, you need to facilitate an appropriate value conversion. Listing 5-11 shows the value converter code as well in the `ColorNameToBrushConverter` class. See Chapter 4 for more details on a value converter.

In both the conversion functions in the value converter implementation, you use reflection to enumerate the list of static properties of type `Color` defined on the type `System.Windows.Media.Colors`, each of which are named for the `Color` they represent. In `Convert()`, while trying to convert a `Color` name string to a `SolidColorBrush`, you find the matching `Color` property in the enumerated list of properties and use that to create and return the brush. In `ConvertBack()`, while trying to convert a `SolidColorBrush` to a color name string, you find the property with a `Color` value matching the `SolidColorBrush.Color` and use the property name as the color name string. If no matches are found or if exceptions occur, it falls back to `Colors.Transparent` as the default value.

5-7. Creating Custom Column Types for a DataGrid

Problem

You want to create a custom column type for a `DataGrid` to enable specific functionality to handle a particular data type or data item.

Solution

Extend the `DataGridBoundColumn` class, and add functionality to handle the view and edit modes for the intended data type or data item.

How It Works

The framework ships with a few prebuilt `DataGrid` column types for handling some of the standard data types. `DataGridTextColumn` is one of the most useful ones and can be used to view and edit any data that can be converted to a meaningful text representation. `DataGridCheckBoxColumn` is another one that can

be used to view and edit a Boolean value as a CheckBox and with the current value mapped to its checked state.

In some situations, you want to implement custom logic to handle a specific data type or a program data item bound to a DataGrid column. One way to achieve that is through the use of the DataGridTemplateColumn column type and the use of CellTemplate and CellEditingTemplate, as shown in Recipe 5-6. Yet another way is to create a new column type that encapsulates the custom logic, much like the ones that the framework ships with. The logic encapsulation in creating this custom column offers you the advantage of not having to rely on the consumers (UI layer developers) of your data to supply appropriate data templates, as well as the ability to standardize and lock down how a specific data type or item gets treated inside a DataGrid.

In this second approach, you start by creating a new class extending the System.Windows.Controls.DataGridBoundColumn class in the System.Windows.Controls.Data assembly, which is also the base class for the framework-provided column types mentioned earlier. The DataGridBoundColumn exposes an API of abstract methods that allows you to easily control the UI and data-binding logic of cells in the custom column as they are switched between view and edit modes. The methods in this API that you will override most often are GenerateElement(), GenerateEditingElement(), PrepareCellForEdit(), and CancelCellEdit(). All of these methods, except CancelCellEdit(), are abstract methods; therefore it is mandatory that you provide an appropriate implementation in your custom column code.

The GenerateElement() Method

This method is expected to create the UI that would be used by the DataGrid to display the bound value in every cell of that column. The created UI is returned in the form of a FrameworkElement from GenerateElement(). By overriding this method and supplying your custom logic, you can change the UI a bound cell uses to display its content. You are also expected to create and set appropriate data bindings for your newly created UI in this method so that data items are appropriately displayed in every cell. To do that, you can obtain the data binding set by the user in the XAML for the column through the DataGridBoundColumn.Binding property. You can then use the SetBinding() method to apply that binding to the appropriate parts of the UI you create before returning the UI as a FrameworkElement.

Also note that this method accepts two parameters passed in by the containing DataGrid: a cell of type DataGridCell and a data item of type object. The first parameter contains a reference to the instance of the DataGridCell that is currently being generated, and the second parameter refers to the data item bound to the current row. You don't have to use these parameters to successfully implement this method. One interesting use of these parameters is in a computed column scenario. Since the dataItem parameter contains the entire item bound to that row, you can easily compute a value based on parts of the data item and use that as the cell value bound to the UI you return from this method. We leave it to you to experiment further with these parameters.

The GenerateEditingElement() Method

This method is somewhat similar to GenerateElement() in purpose but is used for edit mode rather than view mode. When the user switches a cell to edit mode—for example, by clicking it—the DataGrid calls this method on the column type to generate the UI for the editing experience. The generated UI is again returned as a FrameworkElement. You can override this method in your custom column type to create a custom edit UI for your data type or item. The same requirements for applying the appropriate data bindings before you return the generated UI, as discussed for GenerateElement() earlier, apply here. Also note that this method accepts the same parameter set as GenerateElement().

The PrepareCellForEdit() Method

This method is called by the `DataGrid` to obtain the unedited value from the bound cell before entering edit mode. The unedited value is retained by the `DataGrid` and made available to you in `CancelCellEdit()` so that edits made to the cell can be undone should a user choose to cancel an edit operation. The `FrameworkElement` type you created for the edit mode UI in `GenerateEditingElement()` is made available to you as the `editingElement` parameter. You can use that to obtain the current unedited value for the cell. The second parameter to this method, `editingEventArgs`, is of type `RoutedEventArgs`. It contains information about the user gesture that caused the cell to move to edit mode. For keyboard-based input, it can be cast to `KeyEventArgs`; for mouse input gestures, it can be cast to `MouseButtonEventArgs`. You should check the result of your cast to verify that it is non-null before using the parameter. This parameter can be used to implement additional logic, such as different editing behaviors if a specific key is pressed.

The CancelCellEdit() Method

This method is called if a user cancels an edit operation. The unedited value bound to the cell, prior to any changes made by the user in edit mode, is made available to you via the `uneditedValue` parameter, as is the `FrameworkElement` representing the edit UI through the `editingElement` parameter. You can undo the changes made by resetting the `editingElement` using the `uneditedValue`. The `uneditedValue` parameter is of type `object`, and consequently you will need to cast it to the appropriate type based on the bound data before you use it to reset the edit changes.

The Code

The code sample in this recipe creates a custom column type named `DataGridDateColumn` for editing `DateTime` types using the `DatePicker` control. Listing 5-12 shows the code for `DataGridDateColumn`.

Listing 5-12. *DataGridDateColumn Class*

```
using System;
using System.ComponentModel;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Data;
using System.Windows.Media;

namespace Recipe5_7
{
  public class DataGridDateColumn : DataGridBoundColumn
  {
    [TypeConverter(typeof(DataGridDateTimeConverter))]
    public DateTime DisplayDateStart { get; set; }

    public Binding DisplayDateEndBinding { get; set; }

    protected override void CancelCellEdit(FrameworkElement editingElement,
      object uneditedValue)
```

```
    {
      //get the DatePicker
      DatePicker datepicker = (editingElement as Border).Child as DatePicker;
      if (datepicker != null)
      {
        //rest the relevant properties on the DatePicker to the original value
        //to reflect cancellation and undo changes made
        datepicker.SelectedDate = (DateTime)uneditedValue;
        datepicker.DisplayDate = (DateTime)uneditedValue;
      }
    }

    //edit mode
    protected override FrameworkElement GenerateEditingElement(
DataGridCell cell, object dataItem)
    {
      //create an outside Border
      Border border = new Border();
      border.BorderBrush = new SolidColorBrush(Colors.Blue);
      border.BorderThickness = new Thickness(1);
      border.HorizontalAlignment = HorizontalAlignment.Stretch;
      border.VerticalAlignment = VerticalAlignment.Stretch;
      //create the new DatePicker
      DatePicker datepicker = new DatePicker();
      //bind the DisplayDate to the bound data item
      datepicker.SetBinding(DatePicker.DisplayDateProperty,
        base.Binding);
      //bind the SelectedDate to the same
      datepicker.SetBinding(DatePicker.SelectedDateProperty,
        base.Binding);
      //bind the DisplayDate range
      //start value is provided directly through a property
      datepicker.DisplayDateStart = this.DisplayDateStart;
      //end value is another binding allowing developer to bind
      datepicker.SetBinding(DatePicker.DisplayDateEndProperty,
        this.DisplayDateEndBinding);
      border.Child = datepicker;
      //return the new control
      return border;
    }

    //view mode
    protected override FrameworkElement GenerateElement(DataGridCell cell,
object dataItem)
    {
```

```
      //create a TextBlock
      TextBlock block = new TextBlock();
      //bind the displayed text to the bound data item
      block.SetBinding(TextBlock.TextProperty, base.Binding);
      //return the new control
      return block;
    }

    protected override object PrepareCellForEdit(FrameworkElement editingElement,
      RoutedEventArgs editingEventArgs)
    {
      //get the datepicker
      DatePicker datepicker = (editingElement as Border).Child as DatePicker;
      //return the initially displayed date, which is the
      //same as the unchanged data item value
      return datepicker.DisplayDate;
    }
  }
}
```

In `GenerateElement()`, you create a `TextBlock` as your control of choice to display the bound data. You then set the binding on the `TextBlock.Text` property to the `Binding` property on the column so that the date is displayed inside the `TextBlock`. In `GenerateEditingElement()`, you instead create a `Border` and nest a `DatePicker` control in it for date editing. Once the `DatePicker` control is created, you set both the `DisplayDate` (the date displayed in the editable text portion of the `DatePicker`) and the `SelectedDate` (the date value selected in the drop-down portion of the `DatePicker`) initially to the `Binding` property on the column. You also set a couple of other bindings that will be explained later in the recipe before you return the `Border`. In `PrepareCellForEdit()`, you return the currently displayed date to the `DataGrid` for retention in case of a cancellation, and in `CancelCellEdit()`, you reset the appropriate values on the `DatePicker` instance to the unedited value saved earlier through `PrepareCellForEdit()`.

Listing 5-13 shows the XAML declaration of a `DataGrid` using the `DataGridDateColumn` type. Again, you use the `AdventureWorks` WCF service as a data source.

Listing 5-13. *XAML for the MainPage Demonstrating Custom DataGrid Column*

```
<UserControl x:Class="Recipe5_7.MainPage"
  xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
  xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
  xmlns:data=
  "clr-namespace:System.Windows.Controls;assembly=System.Windows.Controls.Data"
  xmlns:local="clr-namespace:Recipe5_7"
  Width="800" Height="400"
  xmlns:d="http://schemas.microsoft.com/expression/blend/2008"
  xmlns:mc="http://schemas.openxmlformats.org/markup-compatibility/2006"
  mc:Ignorable="d">
  <UserControl.Resources>
```

```
  </UserControl.Resources>
  <Grid x:Name="LayoutRoot" Background="White">
  <data:DataGrid x:Name="dgProducts" AutoGenerateColumns="False">
    <data:DataGrid.Columns>
      <data:DataGridTextColumn
        Binding="{Binding ProductID}" Header="ID" />
      <data:DataGridTextColumn
        Binding="{Binding Name}" Header="Name" />
      <local:DataGridDateColumn
        Binding="{Binding SellStartDate}"
        DisplayDateStart="01/01/2000"
        DisplayDateEndBinding="{Binding DisplayDateEnd}"
        Header="Available From" />
    </data:DataGrid.Columns>
  </data:DataGrid>
  </Grid>
</UserControl>
```

One of the challenges of this approach is that the developer using the `DataGridDateColumn` may want to control some behavior of the internal `DatePicker` instance. For example, the `DatePicker` control exposes `DisplayDateStart` and `DisplayDateEnd` properties that determine the date range that the `DatePicker` drop-down is limited to; however, the developer may want to specify this range when using the `DataGridDateColumn`. Unfortunately, since the `DatePicker` control instance is not visible outside the `DataGridDateColumn` code, there is no direct way for the developer to do so.

One way to allow developers to control these properties is to create corresponding properties on `DataGridDateColumn` so that they can be set in XAML, and those values can be used in the code to set the `DatePicker` properties. Referring to the `DataGridDateColumn` class in Listing 5-12, you can see the `DisplayDateStart` property of type `DateTime`; note that it is being set to a date string in the XAML in Listing 5-13. The value of this property is then used inside `GenerateEditingElement()` to set the similarly named property on the `DatePicker` instance.

Since the date string set in XAML needs to be converted to a `DateTime` type for the code to work correctly, you need a type conversion mechanism. The framework contains the `TypeConverter` class, which you can extend to create a type converter of your own. Listing 5-14 shows a type converter that converts from `String` to `DateTime`.

Listing 5-14. *DataGridDateTimeConverter Class*

```
using System;
using System.ComponentModel;
using System.Globalization;

namespace Recipe5_7
{
  public class DataGridDateTimeConverter : TypeConverter
  {
    public override bool CanConvertFrom(ITypeDescriptorContext context,
      Type sourceType)
    {
```

```
      return (typeof(string) == sourceType);
    }
    public override bool CanConvertTo(ITypeDescriptorContext context,
      Type destinationType)
    {
      return (typeof(DateTime) == destinationType);
    }
    public override object ConvertFrom(ITypeDescriptorContext context,
      CultureInfo culture, object value)
    {
      DateTime target;
      target = DateTime.ParseExact(value as string, "d",
        CultureInfo.CurrentUICulture);
      return target;
    }
  }
}
```

The `TypeConverterAttribute` can be used to attach this type converter to your `DataGridDateColumn.DisplayDateStart` property, as shown in Listing 5-12. Note that in overriding the `ConvertFrom()` method in the `TypeConverter` implementation, the system passes in a `CultureInfo` instance as the second parameter. The `CultureInfo` parameter allows you to inspect the current culture. If you need to implement any additional conversion logic based on the locale, you can check this parameter and take the needed action in your code. In your case, you do not use the value, but just pass in `CultureInfo.CurrentUICulture` in your call to `Datetime.ParseExact()` to allow the `DateTime` value type to handle the rest of the conversion logic.

You might want to have such a property set as a binding instead of a direct value setting, much like the `Binding` property on any `DataGrid` column. This allows the developer to associate a data binding with the property and lets its value be derived at runtime from the source it is bound to, as opposed to being hard-coded.

As an example, say you want to expose a property named `DisplayDateEndBinding` on the `DataGridDateColumn` and use that to drive the value of the `DisplayDateEnd` property of the `DatePicker` instance. You can see the declaration of this property in Listing 5-12, and it is bound to a property named `DisplayDateEnd` on the data source in the XAML in Listing 5-13. It can then be used to attach the same binding to the `DatePicker.DisplayDateEnd` property, as shown in the `GenerateEditingElement()` method in Listing 5-12. There is not much code to discuss, beyond a call to the `AdventureWorks` WCF service; we encourage the user to refer to the sample code for the book.

Figure 5-21 shows the `DataGridDateColumn` in action.

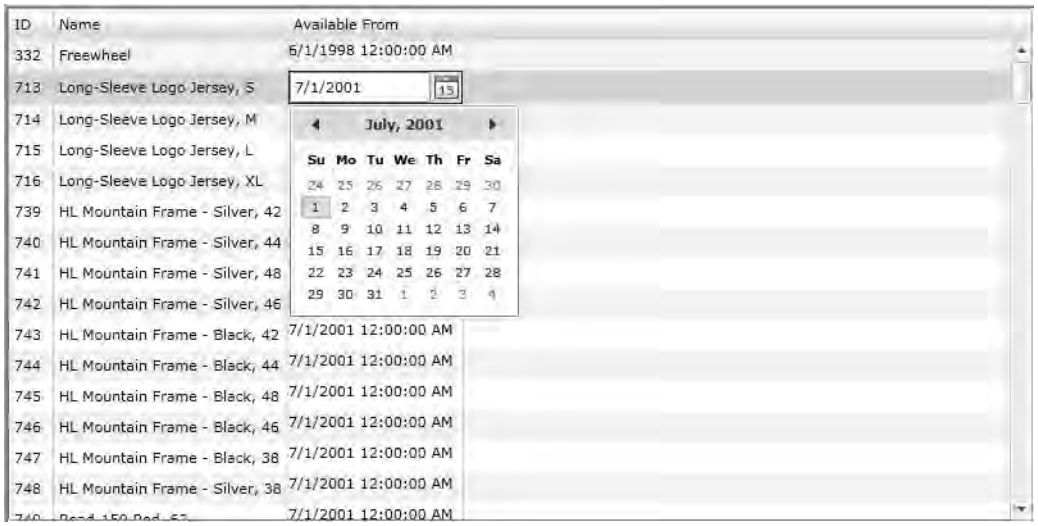


Figure 5-21. *DataGridDateColumn in edit mode*

5-8. Creating a Composite User Control

Problem

You need to compose a UI using existing controls and package it in a reusable format.

Solution

Use the Visual Studio 2010 Silverlight user control template to create a new class deriving from `UserControl`, and then add controls to `UserControl` to compose an UI.

How It Works

Silverlight offers two kinds of controls: user controls and custom controls. User controls are an effective way to package UI and related client-side processing logic tied to a specific business or application domain into a reusable unit that can then be consumed as a tag in XAML, similar to any other built-in primitive shape like `Ellipse` or `Rectangle`. There is excellent tool support for designing and implementing user controls both in Visual Studio and Expression Blend, making it the default choice for creating reusable user interface components with reasonable ease.

User controls allow you to create composite UIs by combining other custom or user controls. This ability makes them especially suitable for writing composite controls—in fact, most user controls that you end up writing will be composite controls.

Custom controls, on the other hand, are the more powerful controls in Silverlight. All the controls in the `System.Windows.Controls` namespace that come with the framework are built as custom controls; using them is typically the preferred way of implementing more general-purpose UI components that are not limited to one particular application or business domain. Custom controls also enable

powerful features, such as control templates that allow radical customization of the control user interface. The recipes later in this chapter cover custom control development in greater detail.

The following sections review a few concepts critical to understanding how a control works. This information will increase your understanding of a user control and it will be good background for later recipes that discuss custom controls.

User Control Structure

Creating a user control is fairly easy if you are using Visual Studio 2010. With the Silverlight tools installed, Visual Studio offers you a template to add a new user control to a Silverlight project, through the Add New Item dialog box (see Figure 5-22).

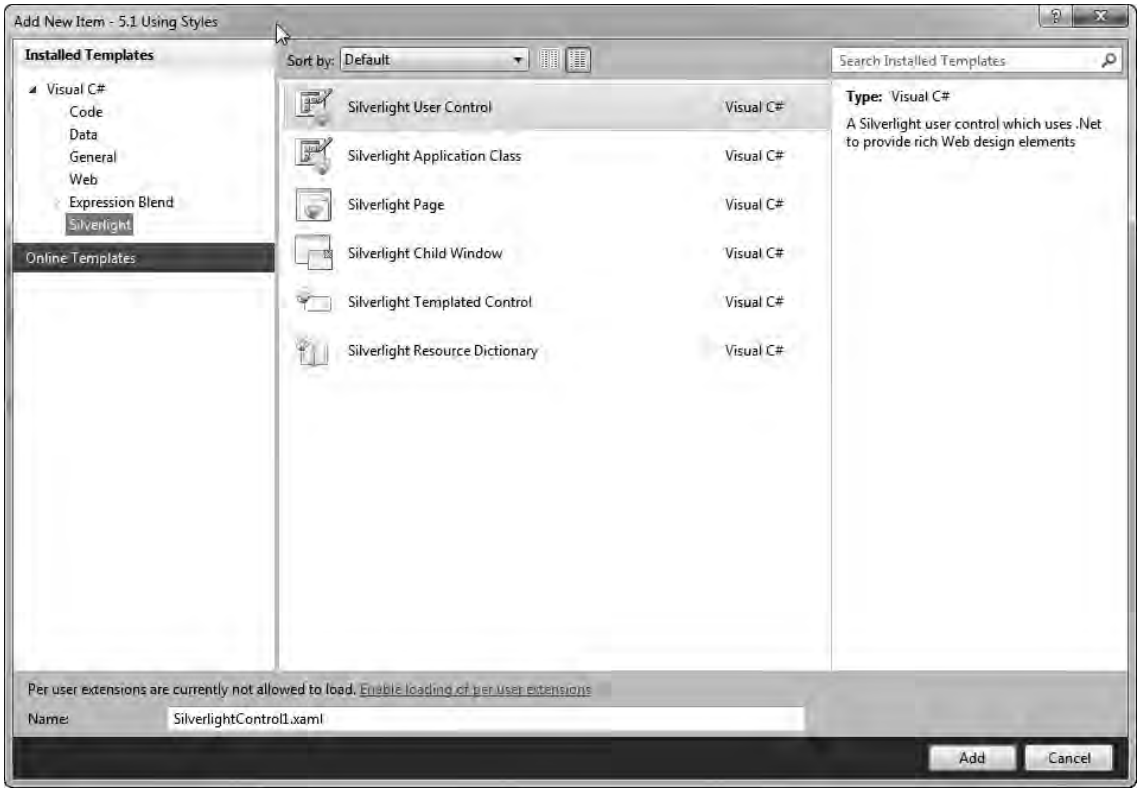


Figure 5-22. *Adding a new Silverlight user control to your project*

Once you add a user control, you should see a XAML document coupled with a codebehind file defining the user control. User controls are defined as partial classes deriving from the `UserControl` type in the `System.Windows.Controls` namespace. Visual Studio generates one such class when you add a new user control. The following is such a class for a user control named `PagedProductsGrid`:

```
namespace CompositeControlLib
{
  public partial class PagedProductsGrid : UserControl
  {

    public PagedProductsGrid()
    {
      InitializeComponent();
    }

  }
}
```

In the generated XAML document for the user control, you should see some skeletal XAML initially generated by Visual Studio, as shown here:

```
<UserControl
        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"
        mc:Ignorable="d"
        x:Class="CompositeControlLib .PagedProductsGrid"
        d:DesignWidth="640" d:DesignHeight="480">
        <Grid x:Name="LayoutRoot"/>
    </UserControl>
```

You will notice that the Visual Studio template adds a top-level `Grid` (conventionally named `LayoutRoot`) in the XAML. You can define the rest of the UI for the user control inside this `Grid`. Should you choose to, you can rename the `Grid` or even replace the `Grid` with some other container.

Note the `x:Class` attribute in the `UserControl` declaration in XAML. The value set here needs to be the namespace-qualified name of the partial class defined in the codebehind file. This mechanism allows the XAML declaration of the user control to be associated with the user control class at compile time.

XAML Loading

So how does the XAML for the user control get loaded at runtime? When you compile the user control project, a XAML parser generates some additional code to extend the user control partial class. This code is usually found in a file named `<controlname>.g.i.cs` inside the `\obj\debug` folder below your project's root folder. This generated code adds some startup functionality, which is encapsulated in a method named `InitializeComponent()`. You will find that the Visual Studio template already adds a call to `InitializeComponent()` to the constructor of your user control class. Listing 5-15 shows the generated code for a user control.

Listing 5-15. *Visual Studio–generated startup code for a UserControl*

```
namespace CompositeControlLib
{
  public partial class PagedProductsGrid : System.Windows.Controls.UserControl
  {
    internal System.Windows.Controls.Grid LayoutRoot;
    internal System.Windows.Controls.DataGrid dgProductPage;
    internal System.Windows.Controls.ListBox lbxPageNum;
    private bool _contentLoaded;

    /// <summary>
    /// InitializeComponent
    /// </summary>
    [System.Diagnostics.DebuggerNonUserCodeAttribute()]
    public void InitializeComponent()
    {
      if (_contentLoaded)
      {
        return;
      }
      _contentLoaded = true;
      System.Windows.Application.LoadComponent(
        this,
        new System.Uri("/CompositeControlLib;component/PagedProductsGrid.xaml",
          System.UriKind.Relative));
      this.LayoutRoot =
        ((System.Windows.Controls.Grid)(this.FindName("LayoutRoot")));
      this.dgProductPage =
        ((System.Windows.Controls.DataGrid)(this.FindName("dgProductPage")));
      this.lbxPageNum =
        ((System.Windows.Controls.ListBox)(this.FindName("lbxPageNum")));
    }
  }
}
```

At the crux of this code is the `LoadComponent()` method, used at runtime to load the XAML included as a resource in the compiled assembly. Once the element tree defined in the XAML is formed, the `FrameworkElement.FindName()` is used to locate and store the instances for every named control in your XAML definition so that you can refer to them in your code. To learn more about resources and resource loading, refer to the recipes in Chapter 2 of this book.

Dependency Properties

Control types expose properties as a means to allow the control consumer (a developer or a designer) to get or set various attributes of a control instance. Since controls in Silverlight are also .NET classes, properties can be implemented using the standard CLR property syntax.

Silverlight provides an extension to the standard CLR property system by introducing a new concept called a dependency property. A dependency property provides additional functionality that cannot be implemented using standard CLR properties. Among other features, the extended functionality includes the following:

- *Data binding*: Dependency properties can be data bound using either the XAML {`Binding. .`} markup extension or the `Binding` class in code, thus allowing evaluation of its value at runtime. For more on data binding, see Chapter 4.
- *Styles*: Dependency properties can be set using setters in a style. For more on using styles, see recipe 5-1. Note that only dependency properties can be set using styles.
- *Resource referencing*: A dependency property can be set to refer to a predefined resource defined in a resource dictionary using the {`StaticResource. . .`} markup extension in XAML. For more on resources, refer to Chapter 2.
- *Animations*: For a property to be animated, it needs to be a dependency property. For more on animations, see Chapter 3.

A dependency property is implemented in code as a public static member of type `DependencyProperty`, where the implementing type needs to derive from `DependencyObject`. Listing 5-16 shows a sample declaration of a dependency property named `MaximumProperty`, representing a double valued maximum for some range.

Listing 5-16. *Sample DependencyProperty declaration*

```
public static DependencyProperty MaximumProperty =
  DependencyProperty.Register("Maximum",
  typeof(double?),
  typeof(NumericUpdown),
  new PropertyMetadata(100,new PropertyChangedCallback(MaximumChangedCallback)));

public double? Maximum
{
  get
  {
    return (double?)GetValue(MaximumProperty);
  }
  set
  {
    SetValue(MaximumProperty, value);
  }
}

internal static void MaximumChangedCallback(DependencyObject Target,
DependencyPropertyChangedEventArgs e)
```

```
{
  NumericUpdown target = Target as NumericUpdown;
  //other code to respond to the property change
}
```

The static method `DependencyProperty.Register()` is used to register the property with the Silverlight property system. The parameters to the method are a name for the property, the property data type, the containing type, and a `PropertyMetadata` instance. In the code above, note the string `"Maximum"` as the property name, `double?` as the data type for the property, and the property owner as a type named `NumericUpdown`. The `PropertyMetadata` parameter is constructed by passing in a default value for the property and a delegate to a static callback method that is invoked when the property value changes. Notice that the `defaultValue` parameter is of type `object`. Also note that the callback method is only required if you intend to take some action when the value of the dependency property changes. If the value change has no impact on your control's logic, `PropertyMetadata` has another constructor that only accepts the `defaultValue` parameter.

A conventional way of naming the dependency property is by concatenating the string `"Property"` to the property name. You are free to change that convention; however, it is to your benefit to stick with it. The framework and the Silverlight SDK follow the same convention, and developers around the world will soon get used to this convention to determine whether or not a property is a dependency property.

Although the dependency property is declared static, the Silverlight property system maintains and provides access to values of the property on a per-instance basis. The `DependencyObject.GetValue()` method accepts a dependency property and returns the value of the property for the instance of the declaring type within which `GetValue()` is invoked. The returned value is typed as Object, and you will need to cast it to the appropriate type before using it. `SetValue()` accepts a dependency property and a value and sets that value for the instance within which `SetValue()` is invoked. A CLR property wrapper of the same name, minus the `"Property"` extension (as shown in Listing 5-16) is typically provided as shorthand to using the `GetValue()/SetValue()` pair for manipulating the property in code.

The instance on which the property change happened is passed in as the first parameter to the static property change callback handler. This allows you to cast it appropriately, as shown in `MaximumChangedCallback()` in Listing 5-16, and then take action on that instance in response to the property value change. The second parameter of type `DependencyPropertyChangedEventArgs` exposes two useful properties: the `OldValue` property exposes the value of the property before the change, and the `NewValue` property exposes the changed value.

The Code

The code sample for this recipe builds a user control named `PagedProductsGrid` that displays `Product` data in a grid form, coupled with paging logic, where the consumer of the control gets to specify how many records to display per page and the control automatically adds a pager at the bottom that allows the user to navigate through pages.

Figure 5-23 shows the control in action. Also shown is the pager at the bottom, with the selected page in a solid blue rectangle.

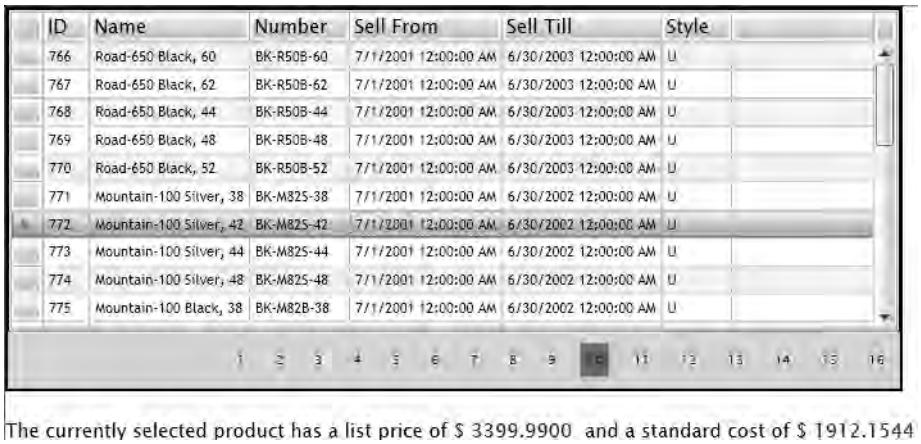


Figure 5-23. *Paged product data composite control*

Listing 5-17 shows the XAML for the `PagedProductsGrid` user control.

Listing 5-17. *XAML for PagedProductsGrid user control*

```
<UserControl
  x:Class="Recipe5_8.PagedProductsGrid"
  xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
  xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
  xmlns:vsm="clr-namespace:System.Windows;assembly=System.Windows"
  xmlns:data=
  "clr-namespace:System.Windows.Controls;assembly=System.Windows.Controls.Data"
  Width="700" Height="300">
  <UserControl.Resources>
    <!-- control template for Pager ListBoxItem -->
    <ControlTemplate TargetType="ListBoxItem" x:Key="ctLbxItemPageNum">
      <Grid>
        <vsm:VisualStateManager.VisualStateGroups>
          <vsm:VisualStateGroup x:Name="CommonStates">
            <vsm:VisualState x:Name="Normal">
              <Storyboard/>
            </vsm:VisualState>
            <vsm:VisualState x:Name="MouseOver">
              <Storyboard>
                <ColorAnimationUsingKeyFrames
                  BeginTime="00:00:00"
                  Duration="00:00:00.0010000"
                  Storyboard.TargetName="ContentBorder"
                  Storyboard.TargetProperty=
                  "(Border.BorderBrush).(SolidColorBrush.Color)">
```

```
            <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF091F88"/>
          </ColorAnimationUsingKeyFrames>
        </Storyboard>
      </vsm:VisualState>
    </vsm:VisualStateGroup>
    <vsm:VisualStateGroup x:Name="SelectionStates">
      <vsm:VisualState x:Name="Unselected">
        <Storyboard/>
      </vsm:VisualState>
      <vsm:VisualState x:Name="Selected">
        <Storyboard>
          <ColorAnimationUsingKeyFrames
            BeginTime="00:00:00"
            Duration="00:00:00.0010000"
            Storyboard.TargetName="ContentBorder"
            Storyboard.TargetProperty=
            "(Border.Background).(SolidColorBrush.Color)">
            <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF1279F5"/>
          </ColorAnimationUsingKeyFrames>
        </Storyboard>
      </vsm:VisualState>
      <vsm:VisualState x:Name="SelectedUnfocused">
        <Storyboard>
          <ColorAnimationUsingKeyFrames
            BeginTime="00:00:00"
            Duration="00:00:00.0010000"
            Storyboard.TargetName="ContentBorder"
            Storyboard.TargetProperty=
            "(Border.Background).(SolidColorBrush.Color)">
            <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF1279F5"/>
          </ColorAnimationUsingKeyFrames>
        </Storyboard>
      </vsm:VisualState>
    </vsm:VisualStateGroup>
    <vsm:VisualStateGroup x:Name="FocusStates">
      <vsm:VisualState x:Name="Unfocused">
        <Storyboard/>
      </vsm:VisualState>
      <vsm:VisualState x:Name="Focused">
        <Storyboard/>
      </vsm:VisualState>
    </vsm:VisualStateGroup>
  </vsm:VisualStateManager.VisualStateGroups>

  <Border HorizontalAlignment="Left"
```

```
                VerticalAlignment="Top"
                Margin="5,5,5,5"
                Padding="5,5,5,5"
                BorderBrush="#00091F88"
                BorderThickness="2,2,2,2"
                Background="#001279F5"
                x:Name="ContentBorder">
          <ContentPresenter
            Content="{TemplateBinding Content}"
            ContentTemplate="{TemplateBinding ContentTemplate}"/>
        </Border>
      </Grid>
    </ControlTemplate>
    <!-- style applying the Pager ListBoxItem control template -->
    <Style x:Key="stylePageNum" TargetType="ListBoxItem">
      <Setter Property="Template" Value="{StaticResource ctLbxItemPageNum}" />
    </Style>
    <!-- Horizontal panel for the Pager ListBox -->
    <ItemsPanelTemplate x:Key="iptHorizontalPanel">
      <StackPanel Orientation="Horizontal"/>
    </ItemsPanelTemplate>

    <!--Control template for Pager ListBox-->
    <ControlTemplate x:Key="ctlbxPager" TargetType="ListBox">
      <Grid>
        <ItemsPresenter HorizontalAlignment="Left" VerticalAlignment="Top" />
      </Grid>
    </ControlTemplate>
  </UserControl.Resources>

  <Border Background="LightGray" BorderBrush="Black" BorderThickness="2,2,2,2">
    <Grid x:Name="LayoutRoot">
      <Grid.RowDefinitions>
        <RowDefinition Height="85*" />
        <RowDefinition Height="15*" />
      </Grid.RowDefinitions>
      <!-- data grid to display Products data -->
      <data:DataGrid x:Name="dgProductPage" AutoGenerateColumns="False"
                     Grid.Row="0"
                     SelectionChanged="dgProductPage_SelectionChanged">
        <data:DataGrid.Columns>
          <data:DataGridTextColumn Binding="{Binding ProductID}"
                                   Header="ID" />
          <data:DataGridTextColumn Binding="{Binding Name}"
                                   Header="Name"/>
```

```
          <data:DataGridTextColumn Binding="{Binding ProductNumber}"
                                   Header="Number"/>
          <data:DataGridTextColumn Binding="{Binding SellStartDate}"
                                   Header="Sell From"/>
          <data:DataGridTextColumn Binding="{Binding SellEndDate}"
                                   Header="Sell Till"/>
          <data:DataGridTextColumn Binding="{Binding Style}"
                                   Header="Style"/>
        </data:DataGrid.Columns>
      </data:DataGrid>
      <!-- Pager Listbox-->
      <ListBox x:Name="lbxPager" Grid.Row="1"
               HorizontalAlignment="Right" VerticalAlignment="Center"
               SelectionChanged="lbxPager_SelectionChanged"
               ItemsPanel="{StaticResource iptHorizontalPanel}"
               ItemContainerStyle="{StaticResource stylePageNum}"
               Template="{StaticResource ctlbxPager}">
      </ListBox>
    </Grid>
  </Border>
</UserControl>
```

The user control has two primary parts: a `DataGrid` named `dgProductPage` with columns bound to the `Product` data type, and a `ListBox` named `lbxPager` acting as a pager.

The first thing to note about the pager `ListBox` is that you replace its default `ItemsPanel` with a horizontal `StackPanel` so that the page numbers appear horizontally moving from left to right. This is done by defining a custom `ItemsPanelTemplate`, named `iptHorizontalPanel`, and associating that with the `ItemsPanel` property on the `ListBox`. Panel customization is discussed in greater detail in later recipes.

You apply a custom control template, named `ctlbxPager`, to the `ListBox`. It simplifies the `ListBox` significantly, just leaving an `ItemsPresenter` for displaying the items inside a `Grid`.

You also customize each `ListBoxItem` by applying a custom control template, named `ctLbxItemPageNum`, to the `ListBoxItem`. The template defines the `ListBoxItem` as a `ContentPresenter` within a `Border` and adds storyboards for the `MouseOver`, `Selected`, and `SelectedUnfocused` visual states (a solid blue rectangle around the page number to indicate the selected page and a blue border to indicate the one on which the mouse is hovering). A style named `StylePageNum` is used to associate this with the `ListBox` through its `ItemContainerStyle` property.

Again, the `AdventureWorks` WCF service delivers the data to the control. The following code shows the implementation of the `AdventureWorks` WCF service operation `GetProductPage()`, which returns a page of product data:

```
public List<Product> GetProductPage(int SkipCount, int TakeCount)
{
  ProductsDataContext dc = new ProductsDataContext();

  return (from Prod in dc.Products select Prod).Skip(SkipCount).
Take(TakeCount).ToList();
}
```

The SkipCount parameter to GetProductPage() indicates the number of rows to skip, and the TakeCount parameter indicates the number of rows to return after the skipping is done. LINQ exposes two handy operators, Skip and Take, that allow you to do just that on a collection of items.

Listing 5-18 shows the control codebehind.

Listing 5-18. *Codebehind for the PagedProductsGrid Control*

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Windows;
using System.Windows.Controls;
using Recipe5_8.AdvWorks;

namespace Recipe5_8
{
  public partial class PagedProductsGrid : UserControl
  {
    //WCF service proxy
    AdvWorksDataServiceClient client = new AdvWorksDataServiceClient();
    //raise an event when current record selection changes
    public event EventHandler<DataItemSelectionChangedEventArgs>
      DataItemSelectionChanged;
    //RecordsPerPage DP
    DependencyProperty RecordsPerPageProperty =
      DependencyProperty.Register("RecordsPerPage",
      typeof(int),
      typeof(PagedProductsGrid),
      new PropertyMetadata(20,
        new PropertyChangedCallback(
          PagedProductsGrid.RecordsPerPageChangedHandler)
        ));
    //CLR DP Wrapper
    public int RecordsPerPage
    {
      get
      {
        return (int)GetValue(RecordsPerPageProperty);
      }

    set
      {
        SetValue(RecordsPerPageProperty, value);
      }
    }
    //RecordPerPage DP value changed
```

```
internal static void RecordsPerPageChangedHandler(DependencyObject sender,
  DependencyPropertyChangedEventArgs e)
{
  PagedProductsGrid dg = sender as PagedProductsGrid;
  //call init data
  dg.InitData();
}

public PagedProductsGrid()
{
  InitializeComponent();
}

internal void InitData()
{
  //got data
  client.GetProductPageCompleted +=
    new EventHandler<GetProductPageCompletedEventArgs>(
      delegate(object Sender, GetProductPageCompletedEventArgs e)
      {
        //bind grid
        dgProductPage.ItemsSource = e.Result;
      });

  //got the count
  client.GetProductsCountCompleted +=
    new EventHandler<GetProductsCountCompletedEventArgs>(
      delegate(object Sender, GetProductsCountCompletedEventArgs e)
      {
        //set the pager control
        lbxPager.ItemsSource = new List<int>(Enumerable.Range(1,
          (int)Math.Ceiling(e.Result / RecordsPerPage)));
        //get the first page of data
        client.GetProductPageAsync(0, RecordsPerPage);
      });
  //get the product count
  client.GetProductsCountAsync();
}
//page selection changed
private void lbxPager_SelectionChanged(object sender,
  SelectionChangedEventArgs e)
{
  //get page number
  int PageNum = (int)(lbxPager.SelectedItem);
  //fetch that page - handler defined in InitData()
```

```
      client.GetProductPageAsync(RecordsPerPage * (PageNum - 1), RecordsPerPage);

    }
    //record selection changed
    private void dgProductPage_SelectionChanged(object sender, EventArgs e)
    {
      if (this.DataItemSelectionChanged != null)
      {
        //raise DataItemSelectionChanged
        this.DataItemSelectionChanged(this,
          new DataItemSelectionChangedEventArgs {
            CurrentItem = dgProductPage.SelectedItem as Product
          });
      }
    }
  }

  public class DataItemSelectionChangedEventArgs : EventArgs
  {
    public Product CurrentItem { get; internal set; }
  }
}
```

The `InitData()` function is used to load the data into the `DataGrid`. To facilitate paging, you first record the total number of `Products` available by calling the `GetProductsCountAsync()` service operation. In the callback handler for `GetProductsCountAsync()`, you set the `lbxPager ListBox` data to be a range of numbers, starting with 1 and ending at the maximum number of pages expected based on the record count retrieved earlier. You set the value of the `RecordsPerPage` property that the developer has set.

You then call the service operation `GetProductPageAsync()` with `SkipCount` set to 0 and `TakeCount` set to the value of `RecordsPerPage`. The retrieved `Product` data gets bound to the `DataGrid dgProductPage` as the first page of data.

If the value of `RecordsPerPage` changes at runtime, you reinitialize the grid by calling `InitData()` again in `RecordsPerPageChangedHandler()`. You also handle the navigation to a different page by handling the `SelectionChanged` event in `lbxPager`, where you retrieve the page requested and call `GetProductsDataAsync()` again, with `SkipCount` set to the product of `RecordsPerPage` times the number of pages before the current one selected and `TakeCount` again set to `RecordsPerPage`.

To demonstrate events from a user control, you also define and raise an event named `DataItemSelectionChanged` whenever the current row selection in a `DataGrid` changes. You handle a change in row selection in the internal `DataGrid dgProductPage`, and in that handler, you raise the event.

A custom event argument type of `DataItemSelectionChangedEventArgs`, also shown in Listing 5-18, is used to pass the actual `Product` instance bound to the current row to the event consumer.

To consume the user control in a page, you add a reference to the assembly containing the user control to your project. You then add a custom namespace declaration to dereference the types within the assembly in the page's XAML. Finally, you declare an instance of the control prefixed with the custom namespace in the XAML. Listing 5-19 shows the XAML for your consuming page.

■ Note There is no strict requirement to implement your user control in a separate assembly from the application consuming it. We simply find it to be a best practice to follow, one that makes the control a lot more distributable and reusable.

Listing 5-19. *XAML for the Test Page Hosting the User Control*

```
<UserControl x:Class="Recipe5_8.MainPage"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    xmlns:composite=
"clr-namespace:Recipe5_8;assembly=Recipe5_8.ControlLib"
    >
  <Grid x:Name="LayoutRoot">
    <Grid.RowDefinitions>
      <RowDefinition Height="Auto"/>
      <RowDefinition Height="Auto" />
    </Grid.RowDefinitions>
    <!-- user control declaration -->
    <composite:PagedProductsGrid x:Name="PagedGrid"
           RecordsPerPage="30"
           DataItemSelectionChanged="PagedGrid_DataItemSelectionChanged"
           Grid.Row="0"  HorizontalAlignment="Left"/>
    <!-- content control with a data template that gets bound to
    selected data passed through user control raised event -->
    <ContentControl x:Name="ProductCostInfo" Grid.Row="1" Margin="0,20,0,0">
      <ContentControl.ContentTemplate>
        <DataTemplate>
          <StackPanel Orientation="Horizontal">
            <TextBlock
              Text="The currently selected product has a list price of $ "/>
            <TextBlock Text="{Binding ListPrice}"
                       Margin="0,0,10,0"
                       Foreground="Blue"/>
            <TextBlock Text="and a standard cost of $ "/>
            <TextBlock Text="{Binding StandardCost}"
                       Foreground="Blue"/>
          </StackPanel>
        </DataTemplate>
      </ContentControl.ContentTemplate>
    </ContentControl>
  </Grid>
</UserControl>
```

The custom namespace composite brings in the actual .NET namespace and the assembly reference into the XAML so that control can be referenced. You can then declare the control by prefixing its opening and closing tags with the namespace prefix. In Listing 5-19, you set the RecordsPerPage property to a value of 30 so that the control displays 30 records per page. If you refer to Listing 5-18, you will note a default value of 20 to RecordsPerPage in the PropertyMetadata constructor while registering the DependencyProperty. In the event you do not bind the RecordsPerPage property to some value in XAML, 20 will be the value applied as a default. To illustrate consuming the DataItemChanged event that you equipped the user control to raise, you also add a ContentControl named ProductCostInfo in your page with a data template that binds a couple of TextBlocks to the ListPrice and the StandardCost properties of a Product instance. You handle the DataItemChanged event, and in the handler, you bind the Product received through the event arguments to the ContentControl, as shown in the codebehind for the page in Listing 5-20.

Listing 5-20. *Codebehind for the test page hosting the UserControl*

```
using System.Windows.Controls;

namespace Recipe5_8
{
  public partial class MainPage : UserControl
  {
    public MainPage()
    {
      InitializeComponent();

    }

    private void PagedGrid_DataItemSelectionChanged(object sender,
      DataItemSelectionChangedEventArgs e)
    {
      if (e.CurrentItem != null)
        ProductCostInfo.Content = e.CurrentItem;
    }
  }
}
```

If you refer to Figure 5-23, you will see the resulting text on the page, right below the user control, showing the ListPrice and the StandardCost of the currently selected Product.

5-9. Creating a Custom Layout Container

Problem

You need to implement custom layout logic for child controls inside a parent container.

Solution

Implement a custom `Panel` to encapsulate the custom layout logic.

How It Works

Laying out your controls and other visual elements is an important part of crafting a compelling user interface. However, it always helps if the framework you are using provides some assistance in achieving that layout. There are some common layout scenarios, such as arranging your elements in a stack either vertically or horizontally, or specifying their position in terms of rows and columns in a table-like arrangement. There is also absolute positioning, where you provide the exact X and Y coordinates for your element.

The Silverlight libraries include several layout containers that help the process. Layout containers are elements that can contain other elements such as children and implement a specific layout logic that arranges the children accordingly. `Canvas`, `StackPanel`, and `Grid` found in `System.Windows.Controls` are a few of these layout containers, with their layout logic consisting of absolute positioning, ordered stacking, and table style positioning, respectively. For more on layout containers and design-time support, refer to Chapter 3.

Motivation and Mechanics

The challenge for framework designers is that it is hard to foresee all possible layout scenarios and implement a container for each in the framework. Consequently, there needs to be a way in which you can easily implement your own layout logic and plug it in so that it functions seamlessly with the rest of the framework types, just the way the built-in containers do.

The `System.Windows.Controls.Panel` abstract class was designed for exactly this purpose. The set of standard built-in layout containers like `Grid` and `StackPanel` extend the `Panel` class to implement their layout logic, and so can you.

To create your custom layout logic, you need to provide implementations of two virtual methods: `MeasureOverride()` and `ArrangeOverride()`. At runtime, these two methods are called on any custom panel implementation you build to give you an opportunity to appropriately lay out any contained children. Note that these two methods are defined in the `FrameworkElement` type, from which `Panel` itself derives. However, `FrameworkElement` has no built-in notion of child items, whereas the `Panel` class does by exposing a `Children` collection. Therefore, you will use the `Panel` class as the root for all custom layout containers.

Now, let's look at the `MeasureOverride()` and `ArrangeOverride()` methods.

The MeasureOverride() Method

Layout essentially happens in two passes. In the first pass, the runtime provides an opportunity for the container to evaluate the size requirements of all its children and return the total size requirement based on its layout logic.

This first pass is implemented in `MeasureOverride()`. The parameter passed in to `MeasureOverride()` by the runtime is the total `availableSize` for all children of that container to be laid out. The goal of the `MeasureOverride()` method is to look at each child individually, calculate the size requirements of each, and compute a total size requirement, which is then returned from `MeasureOverride()` to the runtime. It is in computing this calculated total that you apply your layout logic. However, there is a standard way for measuring the desired size of each child that goes into that calculation. You need to call the `Measure()` method on each child, passing in the `availableSize` parameter, and the child returns its desired size. `Measure()` is a method implemented in `UIElement`, and

it is a requirement to call Measure() on each child to guarantee accurate size measurement and placement in your layout.

This computed total may be greater than the availableSize parameter passed in, to indicate that more room is required for ideal layout of all the children for this container. However, what is finally granted is up to the runtime, based on the overall UI and the room available within the plug-in to display all content inside and outside this container.

The ArrangeOverride() Method

In the second pass of the layout process, the layout system calculates the most space it can allocate to a container based on the rest of the UI, and then calls ArrangeOverride(), passing that value in as the finalSize parameter. Keep in mind that the finalSize value may be less than the desired size that your MeasureOverride() implementation had calculated.

It is now up to your implementation of ArrangeOverride() to figure out a strategy of laying out the child elements within the finalSize determined by the layout system. The actual process of laying each individual child is done by calling the Arrange() method on the child itself. The Arrange() method accepts a Rectangle that determines the final area within which the child should be positioned. The return value from ArrangeOverride() is the finalSize required by the container, and unless your implementation can lay everything out within a space smaller than the finalSize value passed in, this in most cases is the unchanged value contained in the finalSize parameter.

Note that it is mandatory to call the Measure() and Arrange() methods on all children elements to have them laid out and rendered by the layout system. And since that is what you do inside MeasureOverride() and ArrangeOverride(), implementing overrides for both of these methods is also a requirement when implementing a layout container like a custom panel.

The Code

In this code sample, you will build a layout container extending the Panel type that can arrange its children in either a horizontal orientation (in rows) or a vertical one (in columns). It also automatically wraps all its children into successive rows or columns based on available space. The implementing type is named WrapPanel, and Listing 5-21 shows the code.

Listing 5-21. *WrapPanel implementation*

```
using System;
using System.Windows;
using System.Windows.Controls;

namespace Recipe5_9
{
  public class WrapPanel : Panel
  {
    //Orientation dependency property
    DependencyProperty OrientationProperty =
      DependencyProperty.Register("Orientation", typeof(Orientation),
      typeof(WrapPanel),
      new PropertyMetadata(
        new PropertyChangedCallback(OrientationPropertyChangedCallback)));
```

```
public Orientation Orientation
{
  get
  {
    return (Orientation)GetValue(OrientationProperty);
  }
  set
  {
    SetValue(OrientationProperty, value);
  }
}
private static void OrientationPropertyChangedCallback(
  DependencyObject target, DependencyPropertyChangedEventArgs e)
{
  //cause the layout to be redone on change of Orientation
  if (e.OldValue != e.NewValue)
    (target as WrapPanel).InvalidateMeasure();
}

public WrapPanel()
{
  //initialize the orientation
  Orientation = Orientation.Horizontal;
}
protected override Size MeasureOverride(Size availableSize)
{
  double DesiredWidth = 0;
  double DesiredHeight = 0;
  double RowHeight = 0;
  double RowWidth = 0;
  double ColHeight = 0;
  double ColWidth = 0;

  //call Measure() on each child - this is mandatory.
  //get the true measure of things by passing in infinite sizing
  foreach (UIElement uie in this.Children)
    uie.Measure(availableSize);
  //for horizontal orientation - children laid out in rows
  if (Orientation == Orientation.Horizontal)
  {
    //iterate over children
    for (int idx = 0; idx < this.Children.Count; idx++)
    {

      //if we are at a point where adding the next child would
```

```
        //put us at greater than the available width
        if (RowWidth + Children[idx].DesiredSize.Width
          >= availableSize.Width)
        {
          //set the desired width to the max of row width so far
          DesiredWidth = Math.Max(RowWidth, DesiredWidth);
          //accumulate the row height in preparation to move on to the next row
          DesiredHeight += RowHeight;
          //initialize the row height and row width for the next row iteration
          RowWidth = 0;
          RowHeight = 0;
        }
        //if on the other hand we are within width bounds
        if (RowWidth + Children[idx].DesiredSize.Width
          < availableSize.Width)
        {
          //increment the width of the current row by the child's width
          RowWidth += Children[idx].DesiredSize.Width;
          //set the row height if this child is taller
          //than the others in the row so far
          RowHeight = Math.Max(RowHeight,
            Children[idx].DesiredSize.Height);

        }
        //this means we ran out of children in the middle or exactly at the end
        //of a row
        if (RowWidth != 0 && RowHeight != 0)
        {
          //account for the last row
          DesiredWidth = Math.Max(RowWidth, DesiredWidth);
          DesiredHeight += RowHeight;
        }

      }
    }
    else //vertical orientation - children laid out in columns
    {
      //iterate over children
      for (int idx = 0; idx < this.Children.Count; idx++)
      {
        //if we are at a point where adding the next child would
        //put us at greater than the available height
        if (ColHeight + Children[idx].DesiredSize.Height
          >= availableSize.Height)
        {
```

```
        //set the desired height to max of column height so far
        DesiredHeight = Math.Max(ColHeight, DesiredHeight);
        //accumulate the column width in preparation to
        //move on to the next column
        DesiredWidth += ColWidth;
        //initialize the column height and column width for the
        //next column iteration
        ColHeight = 0;
        ColWidth = 0;
      }
      //if on the other hand we are within height bounds
      if (ColHeight + Children[idx].DesiredSize.Height
        < availableSize.Height)
      {
        //increment the height of the current column by the child's height
        ColHeight += Children[idx].DesiredSize.Height;
        //set the column width if this child is wider
        //than the others in the column so far
        ColWidth = Math.Max(ColWidth,
          Children[idx].DesiredSize.Width);
      }
    }
    //this means we ran out of children in the middle or exactly at the end
    //of a column
    if (RowWidth != 0 && RowHeight != 0)
    {
      //account for the last row
      DesiredHeight = Math.Max(ColHeight, DesiredHeight);
      DesiredWidth += ColWidth;
    }
  }
  //return the desired size
  return new Size(DesiredWidth, DesiredHeight);
}

protected override Size ArrangeOverride(Size finalSize)
{
  double ChildX = 0;
  double ChildY = 0;
  double FinalHeight = 0;
  double FinalWidth = 0;
  //horizontal orientation - children in rows
  if (Orientation == Orientation.Horizontal)
  {
    double RowHeight = 0;
```

```
    //iterate over children
    for (int idx = 0; idx < this.Children.Count; idx++)
    {
      //if we are about to go beyond width bounds with the next child
      if (ChildX + Children[idx].DesiredSize.Width
        >= finalSize.Width)
      {
        //move to next row
        ChildY += RowHeight;
        FinalHeight += RowHeight;
        FinalWidth = Math.Max(FinalWidth, ChildX);
        //shift to the left edge to start next row
        ChildX = 0;
      }
      //if we are within width bounds
      if (ChildX + Children[idx].DesiredSize.Width
        < finalSize.Width)
      {
        //lay out child at the current X,Y coords with
        //the desired width and height
        Children[idx].Arrange(new Rect(ChildX, ChildY,
          Children[idx].DesiredSize.Width,
          Children[idx].DesiredSize.Height));
        //increment X value to position next child horizontally right after the
        //currently laid out child
        ChildX += Children[idx].DesiredSize.Width;
        //set the row height if this child is taller
        //than the others in the row so far
        RowHeight = Math.Max(RowHeight,
          Children[idx].DesiredSize.Height);
      }
    }
  }
  else //vertical orientation - children in columns
  {
    double ColWidth = 0;
    //iterate over children
    for (int idx = 0; idx < this.Children.Count; idx++)
    {
      //if we are about to go beyond height bounds with the next child
      if (ChildY + Children[idx].DesiredSize.Height
        >= finalSize.Height)
      {
        //move to next column
        ChildX += ColWidth;
```

```
            FinalWidth += ColWidth;
            FinalHeight = Math.Max(FinalHeight, ChildY);
            //shift to the top edge to start next column
            ChildY = 0;
          }
          //if we are within height bounds
          if (ChildY + Children[idx].DesiredSize.Height
            < finalSize.Height)
          {
            //lay out child at the current X,Y coords with
            //the desired width and height
            Children[idx].Arrange(new Rect(ChildX, ChildY,
              Children[idx].DesiredSize.Width,
              Children[idx].DesiredSize.Height));
            //increment Y value to position next child vertically right below the
            //currently laid out child
            ChildY += Children[idx].DesiredSize.Height;
            //set the column width if this child is wider
            //than the others in the column so far
            ColWidth = Math.Max(ColWidth,
              Children[idx].DesiredSize.Width);
          }
        }
      }
      //return the original final size
      return finalSize;
    }
  }
}
```

Let's first look at the measure pass. As noted previously, in `MeasureOverride()`, you are given the available size to work with, and you return the total desired size of the container in question with all its children. You can see in Listing 5-21 that you start off by calling `Measure()` on every child in the `Children` collection.

It is worth noting here that the measuring and arranging tasks are both recursive in nature. When you call `Measure()` on every child, the runtime ultimately calls `MeasureOverride()` on that child, which in turn calls `Measure()` on any children that child might have, and so on until `MeasureOverride()` gets called on every leaf element (i.e., an element without any more children). The desired size returned by `MeasureOverride()` at every level of recursion travels back to its parent and is available through the `DesiredSize` property on the child.

Once you call `Measure()` on each of the children in your code, and consequently populate the `DesiredSize` property on each of them, you then need to calculate the desired size of the entire `WrapPanel` based on the individual desired sizes of each child. To do that, you iterate over the `Children` collection and try to arrange them along rows or columns, based on the `Orientation` value of `Horizontal` or `Vertical`, respectively. Note that you do not actually create any rows or columns; rather, you simply try to calculate the size of such rows or columns.

So for example, in a `Horizontal` orientation, as you iterate over each child you add its width to a counter named `RowWidth`, indicating the current row's width. You also keep a track of the row's height

by constantly evaluating the maximum height among the children added to that row up to that point. Once you reach a point where the addition of the next child would cause the row to go beyond the `Width` component of the `DesiredSize` parameter, you consider the row complete.

At this point, you track the maximum width of any such row calculated so far in a counter named `DesiredWidth`. The assumption is that the children could all have different sizes. In case they are all similarly sized, all those rows would be equal width as well, since the rows would break off at the exact same point every time. You also keep a measure of how much you are consuming on the Y axis with each row, using a counter named `DesiredHeight`, by adding up each row's height.

If the orientation was vertical, a similar logic is followed, with height and width interchanged. Once you have iterated over each child, you have your desired size in the combination of the `DesiredWidth` and `DesiredHeight` counters, and you pass that out of `MeasureOverride()`.

The arrange pass is similar in logic. You get the `finalSize` as the parameter to `ArrangeOverride()`. You break up your logic based on the `Orientation` setting as before. But this time, you actually lay each child out by calling the `Arrange()` method on the child. The `UIElement.Arrange()` method accepts a `Rectangle` and lays the element inside that `Rectangle`. As you iterate through each element, you increment placement coordinates (either the *x* value or the *y* value based on whether you are laying out in rows or columns) to position child elements one after the other, and when you reach bounds where you have to break into the next row or column, you move by either the row height or the column width calculated in a similar fashion, as you did in the `MeasureOverride()` implementation.

The `Orientation` property is implemented as a dependency property of type `System.Windows.Controls.Orientation` that can be used to specify a horizontal or vertical layout. In `OrientationPropertyChangedCallback()`, you call `InvalidateMeasure()` on the `WrapPanel` instance, if the property value is being changed. `InvalidateMeasure()` causes the layout system to redo the layout, starting again with the measure pass.

Using the WrapPanel

Let's consider using the `WrapPanel` in a user interface. One straightforward option is to use it in similar fashion to a `StackPanel`:

```
<wrappanellib:WrapPanel Orientation="Horizontal">
  <TextBlock Text="Child 1"/>
  <TextBlock Text="Child 2"/>
  <TextBlock Text="Child 3"/>
  <TextBlock Text="Child 4"/>
  <TextBlock Text="Child 5"/>
  <TextBlock Text="Child 6"/>
  <TextBlock Text="Child 7"/>
  <TextBlock Text="Child 8"/>
  <Button Content="Child 9" Width="60" Height="30"/>
  <Button Content="Child 10" Width="70" Height="30"/>
  <Button Content="Child 11" Width="60" Height="30"/>
  <RadioButton Content="Child 12" Width="90" Height="30"/>
  <RadioButton Content="Child 13" Width="60" Height="30"/>
  <Button Content="Child 14" Width="80" Height="30"/>
  <Button Content="Child 15" Width="60" Height="30"/>
</wrappanellib:WrapPanel>
```

This code shows the standard XAML usage pattern where all children, a mixed bag of controls in this case, are listed within the `WrapPanel` declaration, much in the fashion of any other layout container. You should be able to cut and paste this code in your own sample application and use it as is. Just remember to reference the assembly from the sample code, and create a namespace mapping (you have mapped the `wrappanellib` namespace here).

One of the interesting usages of a panel is to assist in the layout process of an `ItemsControl`, which is the primary base control for visually representing a collection of many items. `ItemsControl` exposes a property named `ItemsPanel` of type `ItemsPanelTemplate` that can be defined in terms of any type that extends `Panel`. A better control is the `ListBox`, which extends the `ItemsControl` and, by virtue of that, uses a panel internally for layout. Let's see how to replace the layout panel for a `ListBox` and control some of the panel's properties as well.

Listing 5-22 shows the XAML for a page with a `ListBox` in it, with its default panel replaced with your own `WrapPanel` from this recipe.

Listing 5-22. *XAML for a ListBox using the WrapPanel for layout*

```
<UserControl x:Class="Recipe5_9.MainPage"
  xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
  xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
  xmlns:local="clr-namespace:Recipe5_9"
  xmlns:wrappanellib=
"clr-namespace:Recipe5_9;assembly=Recipe5_9.WrapPanel"
  Width="585" Height="440">
  <UserControl.Resources>

    <local:ImagesCollection x:Key="dsImages" />

    <DataTemplate x:Key="dtImageItem">
      <Grid Background="#007A7575" Margin="10,10,10,10" >

        <Rectangle  Fill="#FF7A7575" Stroke="#FF000000"
                    RadiusX="5" RadiusY="5"/>
        <Image Margin="10,10,10,10" Width="50" Height="50"
               VerticalAlignment="Center"
               HorizontalAlignment="Center"
               Source="{Binding ImageFromResource}"/>

      </Grid>
    </DataTemplate>

<Style TargetType="ListBox" x:Key="STYLE_WrapPanelListBox">
      <Setter Property="ItemsPanel">
        <Setter.Value>
          <ItemsPanelTemplate>
            <wrappanellib:WrapPanel Orientation="{Binding CurrentOrientation}"
                                    Width="600" Height="600"/>
          </ItemsPanelTemplate>
        </Setter.Value>
```

```
      </Setter>
    </Style>

  </UserControl.Resources>

  <Grid x:Name="LayoutRoot" Background="White">
    <Grid.RowDefinitions>
      <RowDefinition Height="*" />
      <RowDefinition Height="Auto" />
    </Grid.RowDefinitions>
    <ListBox x:Name="lbxWrapPanelTest"  Grid.Row="0"
             ItemTemplate="{StaticResource dtImageItem}"
             ItemsSource="{StaticResource dsImages}"
             Style="{StaticResource STYLE_WrapPanelListBox}">
    </ListBox>
    <StackPanel Orientation="Horizontal" Grid.Row="1">
      <RadioButton Content="Horizontal Arrangement" Margin="0,0,20,0"
                   GroupName="OrientationChoice" x:Name="rbtnHorizontal"
                   Checked="rbtnHorizontal_Checked" IsChecked="True"/>
      <RadioButton Content="Vertical Arrangement" Margin="0,0,0,0"
                   GroupName="OrientationChoice" x:Name="rbtnVertical"
                   Checked="rbtnVertical_Checked"/>
    </StackPanel>
  </Grid>

</UserControl>
```

The first thing to note is the `ItemsPanelTemplate` definition for the `ListBox`. The internal implementation of the `ListBox` in the framework uses a `StackPanel` as the panel, but you redefine it to use your own `WrapPanel` and set it as the value of the `ItemsPanel` property in a style targeting a `ListBox`. You then apply the style to the `ListBox` `lbxWrapPanelTest`. We will come back to this definition in a moment.

Also notice that `lbxWrapPanelTest` gets its data from a data source named `dsImages` pointing to a collection named `ImagesCollection`. The `ItemTemplate` is set to a data template `dtImageItem` that displays some images contained in `dsImages`; each image is encapsulated in a type named `CustomImageSource`.

Listing 5-23 shows the code for `CustomImageSource` and `ImagesCollection`.

Listing 5-23. *Code for CustomImageSource and ImagesCollection types*

```
using System.Windows.Media.Imaging;
using System.Reflection;
using System.Collections.Generic;

namespace Recipe5_9
{
  public class CustomImageSource
```

```
  {
    public string ImageName { get; set; }
    private BitmapImage _bitmapImage;
    public BitmapImage ImageFromResource
    {
      get
      {
        if (_bitmapImage == null)
        {
          _bitmapImage = new BitmapImage();
          _bitmapImage.SetSource(
            this.GetType().Assembly.GetManifestResourceStream(ImageName));
        }

        return _bitmapImage;
      }
    }
  }
  public class ImagesCollection : List<CustomImageSource>
  {
    public ImagesCollection()
    {
      Assembly thisAssembly = this.GetType().Assembly;
      List<string> ImageNames =
        new List<string>(thisAssembly.GetManifestResourceNames());

      foreach (string Name in ImageNames)
      {
        if (Name.Contains(".png"))
          this.Add(new CustomImageSource { ImageName = Name });
      }
    }
  }
}
```

The images used in this sample are embedded as resources in the project assembly. `ImagesCollection` uses `GetManifestResourceNames()` to get a collection of the string names of all the embedded resources. It then iterates over the collection of resource names and uses `GetManifestResourceStream()` to acquire each resource as a stream. It creates a new `CustomImageSource` for each one ending with the `.png` extension indicating an image resource, and the `CustomImageSource` type constructor loads the image.

Let's take another look at that `ItemsPanelTemplate` definition. Once the `ItemsPanel` property is set on the `ListBoxItem`, the panel instance that is created internally by the `ListBox` is not made available to your application code in any way. However, there may be a need to access properties on the underlying panel from application code. An example could be the need to change your `WrapPanel`'s

Orientation property to influence the ListBox's layout. However, since the panel is not directly exposed, you need to take a slightly indirect approach to this.

Inside the ItemsPanelTemplate declaration, the WrapPanel has full access to the DataContext of its parent ListBox lbxWrapPanelTest. This gives you a way to bind a property exposed by the panel to application data, as long as that data is made available through the ListBox's DataContext. As shown in Listing 5-21, you bind the WrapPanel.Orientation property to the CurrentOrientation property of some data item. Further, you have two RadioButtons on the page with Checked event handlers defined in the codebehind. Listing 5-24 shows the codebehind for the page.

Listing 5-24. *Codebehind for the MainPage hosting the ListBox*

```
using System.Windows.Controls;
using System.ComponentModel;

namespace Recipe5_9
{
  public partial class MainPage : UserControl
  {
    ListBoxPanelOrientation CurrentLbxOrientation =
      new ListBoxPanelOrientation { CurrentOrientation = Orientation.Horizontal };
    public MainPage()
    {
      InitializeComponent();
      lbxWrapPanelTest.DataContext = CurrentLbxOrientation;
    }

    private void rbtnHorizontal_Checked(object sender,
      System.Windows.RoutedEventArgs e)
    {
      CurrentLbxOrientation.CurrentOrientation = Orientation.Horizontal;
    }

    private void rbtnVertical_Checked(object sender,
      System.Windows.RoutedEventArgs e)
    {
      CurrentLbxOrientation.CurrentOrientation = Orientation.Vertical;
    }
  }
  public class ListBoxPanelOrientation : INotifyPropertyChanged
  {
    public event PropertyChangedEventHandler PropertyChanged;

    private Orientation _Current;
    public Orientation CurrentOrientation
    {
      get { return _Current; }
```

```
      set
      {
        _Current = value;
        if (PropertyChanged != null)
          PropertyChanged(this,
            new PropertyChangedEventArgs("CurrentOrientation"));
      }
    }
  }
}
```

The `ListBoxPanelOrientation` type exposes the `CurrentOrientation` property enabled with property change notification. You construct and initialize an instance of `ListBoxPanelOrientation`, and set it to the `ListBox`'s `DataContext`. This causes the internal `WrapPanel` instance to adopt this orientation through the binding discussed earlier. In the `Checked` event handlers of the `RadioButtons`, you change the `CurrentOrientation` value, which causes the `ListBox` to change its orientation dynamically, again because of the property change notification flowing back to the `WrapPanel` through the binding.

Figure 5-24 shows the `ListBox` and the contained `WrapPanel` in action.

Figure 5-24. *A ListBox using the WrapPanel with different orientations*

5-10. Creating a Custom Control

Problem

You need to create a control structured in the same way as the controls in the framework, offering some of the same facilities like control templating.

Solution

Create a class that derives from either control or another type control derived type, provide a default control template in XAML, and implement control behavior by adding code to the derived class.

How It Works

For a general introduction to controls, dependency properties, and events, check out Recipe 5-8. You can also look at Recipe 5-1 for background information on styles and Recipe 5-2 for information on control templates. In this recipe, we assume that you understand these topics.

Custom Control Structure

Custom controls are types that extend the `Control`, `ContentControl`, or `ItemsControl` class. The first thing to note is how a custom control defines its user interface.

Every assembly containing a custom control needs to contain a XAML file named `generic.xaml` as an assembly resource embedded in a folder named `Themes`. This naming standard is mandatory because this resource is where the runtime looks for the default control UI. However, Visual Studio 2010 does not automatically generate a `generic.xaml` for you; you have to explicitly create and add the file to your project. To do this, first add a blank project folder named `Themes` to your control project. Then, add a blank text file named `generic.xaml` to the `Themes` folder.

The `generic.xaml` file has to contain a `ResourceDictionary`, which in turn contains styles that define the default UI for each custom control contained in that assembly. This code shows a sample:

```
<ResourceDictionary
xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
xmlns:local="clr-namespace:Recipe5_10">
  <!-- BEGIN: Progress Bar -->
  <ControlTemplate TargetType="local:ProgressBar" x:Key="ctProgressBar">
    <Grid>
      <!-- template definition -->
  </ControlTemplate>
  <Style TargetType="local:ProgressBar">
    <Setter Property="Template" Value="{StaticResource ctProgressBar}"/>
    <!-- other setters -->
  </Style>
  <!-- END: Progress Bar -->
</ResourceDictionary>
```

■ **Note** The code below contains a `ProgressBar` control sample. This does not reflect the template for the `ProgressBar` control that is shipped with the Silverlight libraries. It is purely an example that we chose to illustrate the concept here.

If you copy the `ResourceDictionary` snippet without the content in between to your `generic.xaml`, you have the basic structure ready to start adding templates to it.

As you can see, the UI of the control is defined as a control template, and then a style targeted toward the control's type associates the control template with the `Template` property. In the constructor of the custom control, you need to instruct the runtime to apply this style to your custom control by setting the `DefaultStyleKey` property defined on the `Control` base class to the type of the control itself. As you may have noted in the earlier code snippet, the style in this case does not need an `x:Key` attribute. This association is mandatory as well, since without it, your custom control will not have a default UI.

The following code shows an example:

```
public ProgressBar()
{
  base.DefaultStyleKey = typeof(ProgressBar);
}
```

With the `DefaultStyleKey` properly set, the runtime calls the `OnApplyTemplate()` virtual method on the control class. `OnApplyTemplate()` is an interception of the template-loading process, where your control code is given an opportunity to access the constituent parts of the template, store them for future references in your control code elsewhere, and initialize any of these parts as needed. To take advantage of this, you provide an override of `OnApplyTemplate()`. To acquire references to any of the parts of the template, you can use the `GetTemplateChild()` method in that override. The following code snippet shows how to acquire an element named `elemPBar` in an `OnApplyTemplate()` override, store it in a local variable, and initialize its `Width` to 10:

```
internal FrameworkElement elemPBar { get; set; }

public override void OnApplyTemplate()
{
  base.OnApplyTemplate();
  elemPBar = this.GetTemplateChild("elemPBar") as FrameworkElement;
  if(elemPBar != null)
    elemPBar.Width = 10;
}
```

Note that providing an override to `OnApplyTemplate()` is not mandatory. However, in real situations, very rarely will you author a control that does not need to manipulate some part of its UI, and `OnApplyTemplate()` is the only place where you can get access to those elements.

You may also have observed that a hard dependency is created on the expected template structure in this process, because `GetTemplateChild()` looks for a part by its name (provided through the `x:Name` attribute in the template definition). Keep the following in mind:

- In your implementation of `OnApplyTemplate()`, always remember to call `OnApplyTemplate()` on the base class. This is especially important since you might be extending another custom control (and not `Control` or `ContentControl` directly). Calling `OnApplyTemplate()` on the base type gives it the opportunity to do its own initialization properly.
- Code defensively by being prepared to encounter situations where a certain named template part you are looking for using `GetTemplateChild()` may not exist. This could happen if a developer was applying his or her own custom control template to your control and that template was designed without this named part in it. Checking for a `null` value before referencing the part anywhere else in your code is a good practice, since `GetTemplateChild()` would return `null` if the part was not found.

- Try to use a highest base class approach in assuming the part's CLR type in your code. For example, in the previous code where you demonstrated `OnApplyTemplate()`, you were casting the part to a `FrameworkElement` and then accessing its `Width` property. If the properties and methods exposed by a `FrameworkElement` provided enough functionality to manipulate the part to the desired level everywhere in your code, using it as a `FrameworkElement` is sufficient for your needs. This allows a developer applying a custom template to your code to specify a different type for the same named part, as long as both the original and the replacement both inherit from the same base class (in your case `FrameworkElement`). For instance, the default template may have a part as a `Rectangle`. Since you only use its `Width` and `Height` properties in your control code, a developer can easily substitute that with a `Border` with the same name in his or her custom template.

Even with all of these safeguards, it never hurts to let other developers know your original intent for the template, what type it is, and which parts of the template are named. To assist in this, the framework defines an attribute named `TemplatePartAttribute` in `System.Windows` with two properties: `Name`, which contains the string name of a part, and `Type`, which contains the CLR type of the part element. Applying this attribute to your control class allows other code and design tools to use reflection on your control type and discover your template part name and type requirements. You can apply it multiple times, once for each named part required. This code shows an application:

```
[TemplatePart(Name="elemPBar",Type=typeof(FrameworkElement))]
public class ProgressBar : ContentControl
{
}
```

One other thing to consider while implementing a custom control from scratch (that is, if you are not extending an existing control) is the choice of using the `Control`, `ContentControl`, or `ItemsControl` type as the base class. The general guideline is that if your control needs to display additional content beyond what is specified in the control's template, and if you need to allow developers to specify where that content comes from and how it is displayed, you should extend `ContentControl`. The `Content` property defined on `ContentControl` allows your control to take advantage of data binding for the content, and the `ContentTemplate` property lets you use a data template to display the content. If your control is expected to display a collection of data items with the ability to bind to a source for those items plus specify a data template for displaying each item, you should extend `ItemsControl`; the `ItemsSource` and `ItemTemplate` properties on the `ItemsControl` facilitate those features. If none of the above is a requirement, you are free to directly extend the `Control` class.

TemplateBinding vs. RelativeSource Binding to TemplatedParent

In Recipe 5-2, while discussing control templating, we pointed out the `TemplateBinding` declaration that allows you to bind the value of an element's property to another property on the template parent (i.e., an instance of the control whose control template the element is situated in). However, there is an alternative to the `TemplateBinding` syntax.

Recipe 4-5 in Chapter 4 discussed the `RelativeSource` property on the `Binding` type, but only the effect of setting `RelativeSource` to `RelativeSource.Self`. Setting the property of an element within a control template to use a binding with `RelativeSource` set to `RelativeSource.TemplatedParent` has the same effect as using a `TemplateBinding`. So, in effect, the two syntaxes in the following code achieve similar results:

```
PropertyFoo="{TemplateBinding SomeParentProperty}"

PropertyFoo=
    "{Binding SomeParentProperty, RelativeSource={RelativeSource TemplatedParent}}"
```

There are some significant advantages in using the latter syntax based on a regular `Binding`: you can take advantage of all the usual `Binding` niceties, like value conversion if the values of the source and the destination are incompatible and binding direction settings to control the flow of data between the two.

You may be wondering which syntax to use in control templating scenarios and when. Our general guidance is to use the regular `Binding` syntax with `RelativeSource` set to `TemplatedParent` whenever possible, as this gives you a much richer programming model and better control on the binding for reasons mentioned above. There is a supposed minimal performance gain in using `TemplateBinding` over a regular `Binding`, but we have not seen any noticeable difference in a decent-sized control template (one with 10 to 30 template bindings) versus a similar number of regular bindings with `RelativeSource.TemplatedParent`.

The rest of the functionality of the custom control can be implemented using familiar concepts such as dependency properties, events, methods, and control template design. The only other concept of paramount importance in custom control authoring is that of visual states. For more on visual states from a control consumer's perspective, refer to Recipe 5-2. We will discuss visual state management from a control author's perspective in more detail in the next recipe. In the code sample for this recipe, we deliberately do not deal with visual states in an effort to simplify the example.

The Code

The code sample for this recipe illustrates the basic custom control concepts by implementing a `ProgressBar` control.

■ **Note** The Silverlight control framework includes a `ProgressBar` control, and we in no way claim that you should use this implementation over the framework-supplied one. We chose this purely as a way to show you how to write a custom control, and we hope that purpose will be served here.

Listing 5-25 shows the `generic.xaml` for the `ProgressBar` control default UI.

Listing 5-25. *The generic.xaml for ProgressBar*

```
<ResourceDictionary
xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
xmlns:local="clr-namespace:Recipe5_10">

  <local:OrientationToTransformConverter
    x:Key="REF_OrientationToTransformConverter" />
```

```
  <ControlTemplate TargetType="local:ProgressBar" x:Key="ctProgressBar">
    <Grid RenderTransformOrigin="0.5,0.5"
          x:Name="LayoutRoot"
          RenderTransform="{Binding Orientation,
            RelativeSource={RelativeSource TemplatedParent},
            Converter={StaticResource REF_OrientationToTransformConverter}}">
      <Rectangle Fill="{TemplateBinding Background}"
                 Stroke="Transparent" HorizontalAlignment="Stretch"
                 VerticalAlignment="Stretch" x:Name="rectBackground"/>
      <Rectangle x:Name="elemPBar"
                 Fill="{TemplateBinding Foreground}"
                 Stroke="Transparent"
                 VerticalAlignment="Stretch"
                 Width="0" HorizontalAlignment="Left"/>
      <ContentPresenter
        ContentTemplate="{TemplateBinding ContentTemplate}"
        Content="{TemplateBinding Content}"
        HorizontalAlignment="{TemplateBinding HorizontalContentAlignment}"
        VerticalAlignment="{TemplateBinding VerticalContentAlignment}"/>
    </Grid>
  </ControlTemplate>

  <Style TargetType="local:ProgressBar">
    <Setter Property="Template" Value="{StaticResource ctProgressBar}"/>
    <Setter Property="Height" Value="30" />
    <Setter Property="Width" Value="200" />
    <Setter Property="MaximumValue" Value="100" />
    <Setter Property="MinimumValue" Value="0" />
    <Setter Property="Orientation"
            Value="Horizontal" />
    <Setter Property="Foreground" >
      <Setter.Value>
        <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
          <GradientStop Color="#FF004OFF"/>
          <GradientStop Color="#FF8FA8F5" Offset="1"/>
        </LinearGradientBrush>
      </Setter.Value>
    </Setter>
    <Setter Property="Background" Value="White" />
  </Style>

</ResourceDictionary>
```

The control template `ctProgressBar` is made up of two `Rectangles`, one acting as a background for the control, and the other (named `elemPBar`) acting as the progress meter with its initial `Width` set to 0.

This is the named template part that you acquire in your code later, and you'll change the `Width` based on `CurrentValue`.

You would like the user to have the ability to place content such as the current progress amount inside the control. You would also like users to be able to associate a data template with the control, and thus define how any content should be formatted. As you will see when we discuss the control code, your control class will extend `ContentControl`, and you include a `ContentPresenter` with the appropriate `TemplateBindings` in place. For some background on the control content model and `TemplateBinding`, refer to Recipe 5-2.

Also note the resource declaration of a type named `OrientationToTransformConverter` and a binding setting on the `RenderTransform` property of the Grid `LayoutRoot`.

The style targeted to the `ProgressBar` control is what allows you to associate this template with the `DefaultStyleKey` property in code.

Listing 5-26 shows the control code.

Listing 5-26. *ProgressBar control code*

```
using System.Windows;
using System.Windows.Controls;
using System.Windows.Shapes;
using System.ComponentModel;

namespace Recipe5_10
{
  [TemplatePart(Name="elemPBar",Type=typeof(FrameworkElement))]
  public class ProgressBar : ContentControl
  {
    public static DependencyProperty CurrentValueProperty =
      DependencyProperty.Register("CurrentValue",
      typeof(double), typeof(ProgressBar),
      new PropertyMetadata(0.0,
        new PropertyChangedCallback(ProgressBar.OnCurrentValueChanged)));
    public double CurrentValue
    {
      get { return (double)GetValue(CurrentValueProperty); }
      set { SetValue(CurrentValueProperty, value); }
    }

    public static DependencyProperty MaximumValueProperty =
      DependencyProperty.Register("MaximumValue",
      typeof(double), typeof(ProgressBar), new PropertyMetadata(100.0));
    public double MaximumValue
    {
      get { return (double)GetValue(MaximumValueProperty); }
      set { SetValue(MaximumValueProperty, value); }
    }
    public static DependencyProperty MinimumValueProperty =
      DependencyProperty.Register("MinimumValue",
```

```
    typeof(double), typeof(ProgressBar), new PropertyMetadata(0.0));
  public double MinimumValue
  {
    get { return (double)GetValue(MinimumValueProperty); }
    set { SetValue(MinimumValueProperty, value); }    }


  public Orientation Orientation
  {
    get { return (Orientation)GetValue(OrientationProperty); }
    set { SetValue(OrientationProperty, value); }
  }

  public static readonly DependencyProperty OrientationProperty =
      DependencyProperty.Register("Orientation",
      typeof(Orientation), typeof(ProgressBar),
      new PropertyMetadata(Orientation.Horizontal));



  internal FrameworkElement elemPBar { get; set; }

  public ProgressBar()
  {
    base.DefaultStyleKey = typeof(ProgressBar);
  }

  public override void OnApplyTemplate()
  {
    base.OnApplyTemplate();
    elemPBar = this.GetTemplateChild("elemPBar") as FrameworkElement;
  }
  internal static void OnCurrentValueChanged(DependencyObject Target,
    DependencyPropertyChangedEventArgs e)
  {
    ProgressBar pBar = Target as ProgressBar;
    if (pBar.elemPBar != null)
    {
      pBar.elemPBar.Width = (pBar.ActualWidth * (double)e.NewValue)
        / (pBar.MaximumValue - pBar.MinimumValue);
    }

  }


}
```

```
}
```

Your ProgressBar control exposes three dependency properties all of type double: MaximumValue and MinimumValue, which indicate the range of progress, and CurrentValue, which indicates the current progress at any instant. As you see in the constructor, you load the default UI by setting the DefaultStyleKey property to the type of the ProgressBar control itself, which will load the style targeted to this control type from generic.xaml defined in Listing 5-25. In OnApplyTemplate(), you try to acquire a reference to a template part named elemPBar as a FrameworkElement and store it. Note that in the template in Listing 5-25, the template part is defined as a Rectangle, but you expect it to be any derivative of FrameworkElement in your code, since all you need is the Width property.

Accordingly, you also decorate the ProgressBar class with a TemplatePartAttribute appropriately initialized.

In the property change callback for the CurrentValue dependency property, you check to see if you indeed have access to a template named elemPBar. If you do, you set the Width property of that FrameworkElement to a ratio of the CurrentValue, available through the NewValue property of the DependencyPropertyChangedEventArgs parameter, to the range of the ProgressBar instance.

Also note the Orientation DependencyProperty defined on the control. You want the ProgressBar to be displayed either horizontally or vertically depending on the Orientation setting. An easy way of doing this would be to apply a RotateTransform of –90 degrees to the entire ProgressBar whenever the Orientation changes to Vertical. To facilitate that, you first define a value converter that accepts an Orientation and returns a Transform. Listing 5-27 shows the code for this value converter.

Listing 5-27. *Value converter to convert orientation to a RotateTransform*

```
using System;
using System.Windows.Controls;
using System.Windows.Data;
using System.Windows.Media;
namespace Recipe5_10
{
  public class OrientationToTransformConverter : IValueConverter
  {
    public object Convert(object value, Type targetType,
      object parameter, System.Globalization.CultureInfo culture)
    {
      //check to see that the parameter types are conformant
      if (value == null || !(value is Orientation) ||
        targetType != typeof(Transform))
        return null;
      if ((Orientation)value == Orientation.Horizontal)
      {
        return new RotateTransform() { Angle = 0 };
      }
      else
      {
        return new RotateTransform() { Angle = -90 };
      }

    }
```

```
    public object ConvertBack(object value, Type targetType,
      object parameter, System.Globalization.CultureInfo culture)
    {
      throw new NotImplementedException();
    }
  }
}
```

If you refer to the control template XAML in Listing 5-25, you will see that the `RenderTransform` property on the outermost `Grid` named `LayoutRoot` is now bound to the `Orientation` property on the control using a regular binding with `RelativeSource` set to `TemplatedParent` and using the `OrientationToTransformConveter` from Listing 5-27. Had you used a `TemplateBinding` instead, you would not have the ability to use the value converter the way you did here.

Using the Control

To use your code, you build a small application that downloads all the photos in the `ProductPhotos` table through the `AdventureWorks` WCF service. Use the `WebClient` type to download the photos (for more on the `WebClient`, see recipe 7-4).

You display the photos in a `ListBox` and use the `WrapPanel` you created in Recipe 5-10 to lay out the photos. You use `ProgressBar` controls to display the individual download progress of each photo and another one for overall progress.

Listing 5-28 shows the XAML for your test page.

Listing 5-28. *XAML for the MainPage hosting the photo ListBox*

```
<UserControl x:Class="Recipe5_10.MainPage"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    xmlns:custom=
"clr-namespace:Recipe5_10;assembly=Recipe5_10.PBarLib"
    xmlns:wrap=
"clr-namespace:Recipe5_9;assembly=Recipe5_9.WrapPanel"
    Width="700" Height="500">
  <UserControl.Resources>
    <DataTemplate x:Key="dtImageDisplay">
      <Border BorderBrush="Black" Padding="3,3,3,3"
              BorderThickness="2,2,2,2" CornerRadius="2,2,2,2">
        <Grid>
          <Image Source="{Binding PngImage}" Height="75"
                 Width="75" Stretch="Uniform"
                 Visibility="{Binding ImageVisible}"/>
          <custom:ProgressBar Height="25" Width="70" Margin="2,0,2,0"
                              CurrentValue="{Binding DownloadProgress}"
                              Content="{Binding DownloadProgress}"
```

```
                        Visibility="{Binding ProgBarVisible}"
                        MaximumValue="100" MinimumValue="0"
                        HorizontalAlignment="Center"
                        VerticalAlignment="Center"
                        HorizontalContentAlignment="Left"
                        VerticalContentAlignment="Center">
        <custom:ProgressBar.ContentTemplate>
          <DataTemplate>
            <StackPanel Orientation="Horizontal">
              <TextBlock FontSize="10" Text="Downloaded" Margin="0,0,2,0"/>
              <TextBlock FontSize="10" Text="{Binding}" Margin="0,0,2,0"/>
              <TextBlock FontSize="10" Text="%" />
            </StackPanel>
          </DataTemplate>
        </custom:ProgressBar.ContentTemplate>
      </custom:ProgressBar>
    </Grid>
  </Border>
</DataTemplate>
<ControlTemplate TargetType="custom:ProgressBar" x:Key="ctCustomProgressBar">
  <Grid>
    <Border Background="{TemplateBinding Background}"
            BorderBrush="Black"
            HorizontalAlignment="Stretch" CornerRadius="5,5,5,5"
            VerticalAlignment="Stretch"/>
    <Border x:Name="elemPBar"
             Background="{TemplateBinding Foreground}"
             BorderBrush="Transparent"
             VerticalAlignment="Stretch" CornerRadius="5,5,5,5"
             Width="0" HorizontalAlignment="Left"/>
    <ContentPresenter
    ContentTemplate="{TemplateBinding ContentTemplate}"
    Content="{TemplateBinding Content}"
    HorizontalAlignment="{TemplateBinding HorizontalContentAlignment}"
    VerticalAlignment="{TemplateBinding VerticalContentAlignment}"
    HorizontalContentAlignment="{TemplateBinding HorizontalContentAlignment}"
    VerticalContentAlignment="{TemplateBinding VerticalContentAlignment}"
    Foreground="Black"/>
  </Grid>
</ControlTemplate>

<Style TargetType="custom:ProgressBar" x:Key="STYLE_CustomProgressBar" >
  <Setter Property="Template" Value="{StaticResource ctCustomProgressBar}"/>
  <Setter Property="Foreground" >
    <Setter.Value>
```

```
        <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
          <GradientStop Color="#FF004OFF"/>
          <GradientStop Color="#FF8FA8F5" Offset="1"/>
        </LinearGradientBrush>
      </Setter.Value>
    </Setter>
    <Setter Property="Background" Value="White" />
  </Style>

</UserControl.Resources>
<Grid x:Name="LayoutRoot" Background="White">
  <Grid.RowDefinitions>
    <RowDefinition Height="*"/>
    <RowDefinition Height="Auto"/>

  </Grid.RowDefinitions>
  <ListBox ItemTemplate="{StaticResource dtImageDisplay}" x:Name="lbxImages" >
    <ListBox.ItemsPanel>
      <ItemsPanelTemplate>
        <wrap:WrapPanel Orientation="Horizontal" Height="1300" Width="700"/>
      </ItemsPanelTemplate>
    </ListBox.ItemsPanel>
  </ListBox>
  <custom:ProgressBar x:Name="pbarOverallProgress " Height="40" Width="600"
                      CurrentValue="{Binding ImageCount}"
                      Grid.Row="1" Margin="0,10,0,0"
                      MaximumValue="{Binding TotalImages}"
                      MinimumValue="0"
                      Content="{Binding}"
                      Style="{StaticResource STYLE_CustomProgressBar}"
                      HorizontalAlignment="Center" VerticalAlignment="Center"
                      HorizontalContentAlignment="Center"
                      VerticalContentAlignment="Center">
    <custom:ProgressBar.ContentTemplate>
      <DataTemplate>
        <StackPanel Orientation="Horizontal">
          <TextBlock FontSize="13" Text="Downloaded" Margin="0,0,2,0"/>
          <TextBlock FontSize="13" Text="{Binding ImageCount}"
                     Margin="0,0,2,0"/>
          <TextBlock FontSize="13" Text="of" Margin="0,0,2,0"/>
          <TextBlock FontSize="13" Text="{Binding TotalImages}"
                     Margin="0,0,2,0"/>
          <TextBlock FontSize="13" Text="images" />
        </StackPanel>
      </DataTemplate>
```

```
      </custom:ProgressBar.ContentTemplate>
    </custom:ProgressBar>

  </Grid>
</UserControl>
```

You use a data template named `dtImageDisplay` to display the images as items in your `ListBox` `lbxImages`. Note that `dtImageDisplay` includes an `Image` control and a `ProgressBar` control. `Image.Source` is bound to the `PngImage` property of the current data item. The `MinimumValue` and `MaximumValue` properties on `ProgressBar` are set to a range of 0 to 100 to indicate a percentage value of progress, and the `CurrentValue` is bound to the `DownloadProgress` property of the current data item. The `Content` property on the `ProgressBar` is also bound to the `DownloadProgress` value, and a `ContentTemplate` is defined for the `ProgressBar` so that the `DownloadProgress` is displayed in a `TextBlock` within the `ContentTemplate`. The `Visibility` properties of both the `Image` and the `ProgressBar` controls are bound to two properties on the current data item as well.

The `pbarOverallProgress` `Progressbar` is set with its `CurrentValue` bound to the `ImageCount` property and its `MaximumValue` bound to the `TotalImages` property of the `DataContext` of the `LayoutRoot` `Grid`. You again define an appropriate `ContentTemplate` to display the overall progress of your download in terms of the number of images downloaded.

Also note that you define a custom control template for the `ProgressBar` control and associate it with `pbarOverallProgress` through a style. In this template, you use `Borders` with rounded corners to replace the `Rectangles` used in the default template. Since you satisfy the named template part requirement, and both `Border` and `Rectangle` extend `FrameworkElement` (which is what you expect in your control code), your control continues to work fine with this new control template.

Listing 5-29 shows the codebehind for the page.

Listing 5-29. *Codebehind for the page populating the photo ListBox*

```
using System;
using System.Collections.ObjectModel;
using System.ComponentModel;
using System.IO;
using System.Net;
using System.Threading;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Media.Imaging;
using System.Xml.Linq;
using Recipe5_10.AdvWorks;

namespace Recipe5_10
{
  public partial class MainPage : UserControl
  {
    AdvWorksDataServiceClient client =
      new AdvWorksDataServiceClient();

    private const string DownloadSvcUri =
      "http://localhost:9191/AdvWorksPhotoService.svc/Photos?Id={0}";
```

```
internal TotalDownloadCounter TotalDownloadData = null;

internal ObservableCollection<ImageData> listImages =
  new ObservableCollection<ImageData>();

public MainPage()
{
  InitializeComponent();
  GetPhotos();
}

private void GetPhotos()
{
  listImages.Clear();
  lbxImages.ItemsSource = listImages;

  client.GetPhotoIdsCompleted +=
    new EventHandler<GetPhotoIdsCompletedEventArgs>(
      delegate(object sender, GetPhotoIdsCompletedEventArgs e)
      {
        TotalDownloadData =
          new TotalDownloadCounter
          {
            ImageCount = 0,
            TotalImages = e.Result.Count
          };
        LayoutRoot.DataContext = TotalDownloadData;
        foreach (int PhotoId in e.Result)
        {
          ImageData TempImageData =
            new ImageData
            {
              DownloadProgress = 0,
              ImageVisible = Visibility.Collapsed,
              ProgBarVisible = Visibility.Visible,
              PngImage = new BitmapImage()
            };

          listImages.Add(TempImageData);
          DownloadPhoto(PhotoId, TempImageData);
        }
      });
  client.GetPhotoIdsAsync();
}
```

```
  private void DownloadPhoto(int PhotoId, ImageData TempImageData)
  {
    WebClient wc = new WebClient();
    wc.DownloadProgressChanged +=
      new DownloadProgressChangedEventHandler(
        delegate(object sender, DownloadProgressChangedEventArgs e)
        {
          (e.UserState as ImageData).DownloadProgress = e.ProgressPercentage;
          Thread.Sleep(5);
        });
    wc.DownloadStringCompleted +=
      new DownloadStringCompletedEventHandler(
        delegate(object sender, DownloadStringCompletedEventArgs e)
        {
          ImageData ImgSource = e.UserState as ImageData;
          //parse XML formatted response string into an XDocument
          XDocument xDoc = XDocument.Parse(e.Result);
          //grab the root, and decode the default base64
          //representation into the image bytes
          byte[] Buff = Convert.FromBase64String((string)xDoc.Root);
          //wrap in a memory stream, and
          MemoryStream ms = new MemoryStream(Buff);
          ImgSource.PngImage.SetSource(ms);
          ms.Close();
          (e.UserState as ImageData).ProgBarVisible = Visibility.Collapsed;
          (e.UserState as ImageData).ImageVisible = Visibility.Visible;
          ++TotalDownloadData.ImageCount;
        });

    wc.DownloadStringAsync(new Uri(
      string.Format(DownloadSvcUri, PhotoId)), TempImageData);
  }
}

public class TotalDownloadCounter : INotifyPropertyChanged
{
  public event PropertyChangedEventHandler PropertyChanged;
  private double _TotalImages;
  public double TotalImages
  {
    get { return _TotalImages; }
    set
    {
      _TotalImages = value;
      if (PropertyChanged != null)
```

```
            PropertyChanged(this, new PropertyChangedEventArgs("TotalImages"));
        }
      }
private double _ImageCount;
      public double ImageCount
      {
        get { return _ImageCount; }
        set
        {
          _ImageCount = value;
          if (PropertyChanged != null)
            PropertyChanged(this, new PropertyChangedEventArgs("ImageCount"));
        }
      }
    }

    public class ImageData : INotifyPropertyChanged
    {
      public event PropertyChangedEventHandler PropertyChanged;
      private double _DownloadProgress;
      public double DownloadProgress
      {
        get { return _DownloadProgress; }
        set
        {
          _DownloadProgress = value;
          if (PropertyChanged != null)
            PropertyChanged(this, new PropertyChangedEventArgs("DownloadProgress"));
        }
      }
      private Visibility _ImageVisible;
      public Visibility ImageVisible
      {
        get { return _ImageVisible; }
        set
        {
          _ImageVisible = value;
          if (PropertyChanged != null)
            PropertyChanged(this, new PropertyChangedEventArgs("ImageVisible"));
        }
      }
private Visibility _ProgBarVisible;
      public Visibility ProgBarVisible
      {
        get { return _ProgBarVisible; }
```

```
      set
      {
        _ProgBarVisible = value;
        if (PropertyChanged != null)
          PropertyChanged(this, new PropertyChangedEventArgs("ProgBarVisible"));
      }
    }
    private BitmapImage _PngImage;
    public BitmapImage PngImage
    {
      get { return _PngImage; }
      set
      {
        _PngImage = value;
        if (PropertyChanged != null)
          PropertyChanged(this, new PropertyChangedEventArgs("PngImage"));
      }
    }
  }
}
```

Instances of the `TotalDownloadCounter` and the `ImageData` types serve as the data sources for various bindings in your XAML in Listing 5-28.

In the `GetPhotos()` method, you first get all the photo IDs through the `GetPhotoIds()` service operation. On completion, you initialize a new instance of `TotalDownloadCounter` and set the `DataContext` on `LayoutRoot`. You then iterate over the photo IDs and use the `DownloadPhoto()` method to download the photo. You create and initialize an `ImageData` instance so that the individual `ProgressBar` in the photo data template is visible, add it to the collection data source bound to the `ListBox`, and pass it to `DownloadPhoto()`.

In `DownloadPhoto()`, you handle the `DownloadProgressChanged` event on the `WebClient` and update the `DownloadProgress` property of the `ImageData` instance, which causes each individual `ProgressBar` to report the download progress of that photo. Once the download is completed, you handle `DownloadStringCompleted`, where you convert the downloaded Base64 encoded string into an image and set the `PngImage` property to display the image. You also hide the individual `ProgressBar` and display the `Image` by setting the appropriately bound `Visibility` properties. Finally, you increment the `TotalDownloadData.ImageCount` so the `pbarOverallProgress` reports the number of full images downloaded so far.

To test the `Orientation` property of the `ProgressBar` control discussed earlier, set the `Orientation` property on the individual `ProgressBar` controls in the `dtImageDisplay` data template shown in Listing 5-28 to `Vertical`.

Figure 5-25 shows the user interface for the sample.

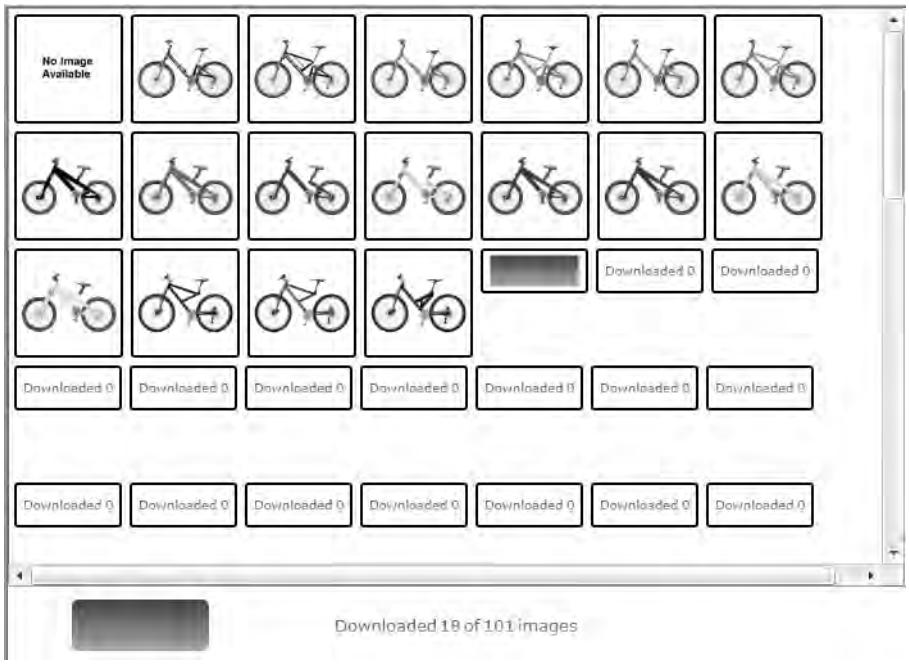


Figure 5-25. *Displaying a progress bar when downloading photos*

5-11. Defining a Custom Visual State

Problem

You want to define a custom visual state in a custom control that you are creating.

Solution

Use the `TemplateVisualStateAttribute` to declare the custom visual state on the control, define storyboards for the states in the control template, and then use `VisualStateManager.GoToState()` to navigate to the state when appropriate.

How It Works

As mentioned in Recipe 5-2, a visual state is identified by its `x:Name` attribute value and its membership is specified in a named group of states. And you also saw that a visual state is implemented in terms of a storyboard inside the control template for the control. Consult Recipe 5-2 for detailed background information on how you might be able to use them while consuming a control. This recipe covers how to add your own visual state definition to a custom control.

The TemplateVisualStateAttribute type is the mechanism you use to add a visual state to your custom control implementation, where you specify the name and group membership of the state. This code shows an example of adding two visual states to a custom control type named Expander:

```
[TemplateVisualState(Name = "Expanded", GroupName = "ExpanderStates")]
[TemplateVisualState(Name = "Normal", GroupName = "CommonStates")]
public class Expander : ContentControl
{

}
```

Note that the TemplateVisualState attribute declarations are purely suggestive in nature and are not required in order for visual states to work correctly. They help in providing information to the developer and to tools like Expression Blend (through .NET reflection) as to what visual states and state groups are expected by the control in its control template.

The System.Windows.VisualStateManager type is central to how visual states work. You use the VisualStateManager.GoToState() static method in appropriate places in your code where you might want to navigate the control to that state. The following code shows an example where you are navigating to the Expanded state on a specific event handler inside a control's implementation:

```
void btnToggler_Checked(object sender, RoutedEventArgs e)
{
  VisualStateManager.GoToState(this, "Expanded", true);
}
```

The first parameter to GoToState() is the control instance itself, and the last parameter, if set to true, instructs the VisualStateManager to use any transitions defined in the control template; if it's set to false, transitions are ignored.

The Code

The code sample implements an Expander custom control with a header and body area, each with their own content and content template options. The default template also defines a Systems.Windows.Controls.Primitives.ToggleButton used to expand and contract the body of the Expander. The ToggleButton type is the base class for multistate buttons like CheckBox and RadioButton and exposes Checked and Unchecked states.

Listing 5-30 shows the control implementation for Expander.

Listing 5-30. *Expander control code*

```
using System.Windows;
using System.Windows.Controls;
using System.Windows.Controls.Primitives;

namespace Recipe5_11
{
  [TemplateVisualState(Name = "Expanded", GroupName = "ExpanderStates")]
  [TemplateVisualState(Name = "Normal", GroupName = "CommonStates")]
  public class Expander : ContentControl
```

```
{

  public static DependencyProperty HeaderContentProperty =
    DependencyProperty.Register("HeaderContent", typeof(object),
    typeof(Expander),
    new PropertyMetadata(null));
  public object HeaderContent
  {
    get
    {
      return GetValue(HeaderContentProperty);
    }
    set
    {
      SetValue(HeaderContentProperty, value);
    }
  }

  public static DependencyProperty HeaderContentTemplateProperty =
    DependencyProperty.Register("HeaderContentTemplate", typeof(DataTemplate),
    typeof(Expander),
    new PropertyMetadata(null));
  public object HeaderContentTemplate
  {
    get
    {
      return (DataTemplate)GetValue(HeaderContentTemplateProperty);
    }
    set
    {
      SetValue(HeaderContentTemplateProperty, value);
    }
  }

  private ToggleButton btnToggler;

  public Expander()
  {
    base.DefaultStyleKey = typeof(Expander);
  }
  public override void OnApplyTemplate()
  {
    base.OnApplyTemplate();
    btnToggler = GetTemplateChild("toggler") as ToggleButton;
    if (btnToggler != null)
```

```
      {
        btnToggler.Checked += new RoutedEventHandler(btnToggler_Checked);
        btnToggler.Unchecked += new RoutedEventHandler(btnToggler_Unchecked);
      }
    }

    void btnToggler_Unchecked(object sender, RoutedEventArgs e)
    {
      VisualStateManager.GoToState(this, "Normal", true);
    }

    void btnToggler_Checked(object sender, RoutedEventArgs e)
    {
      VisualStateManager.GoToState(this, "Expanded", true);
    }

  }
}
```

You can see the definitions for the two visual states `Expanded` and `Normal` in Listing 5-30. In `OnApplyTemplate()`, you try to acquire the `ToggleButton` that you expect to be in the template. If you do, you attach handlers to the `Checked` and `Unchecked` events. In the `btnToggler_Checked()` handler, you navigate to the `Expanded` visual state, and in the `btnToggler_Unchecked()` handler, you navigate back to the `Normal` visual state.

As far as the control implementation goes, this is all you need to do to enable the visual states. The rest of the control's code is to support the `Expander` functionality. The two dependency properties, `HeaderContent` and `HeaderContentTemplate`, are defined to give the user an opportunity to provide content and define a data template for the Header part of the control. The `Content` and the `ContentTemplate` properties that the control inherits from `ContentControl` serve the same purpose for `Expander` body.

Listing 5-31 shows `generic.xaml` for the `Expander`.

Listing 5-31. *The generic.xaml for the Expander control*

```
<ResourceDictionary
  xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
  xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
  xmlns:local="clr-namespace:Recipe5_11"
 xmlns:vsm="clr-namespace:System.Windows;assembly=System.Windows"
   >
  <ControlTemplate TargetType="ToggleButton" x:Key="ctExpanderToggle">
    <Grid>
      <Grid.RowDefinitions>
        <RowDefinition Height="0.3*" />
        <RowDefinition Height="0.4*" />
        <RowDefinition Height="0.3*" />
      </Grid.RowDefinitions>
```

```
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.3*" />
      <ColumnDefinition Width="0.4*" />
      <ColumnDefinition Width="0.3*" />
    </Grid.ColumnDefinitions>
    <vsm:VisualStateManager.VisualStateGroups>
      <vsm:VisualStateGroup x:Name="CommonStates">
        <vsm:VisualStateGroup.Transitions>
          <vsm:VisualTransition GeneratedDuration="00:00:00.2000000"
                                To="MouseOver"/>
          <vsm:VisualTransition GeneratedDuration="00:00:00" From="MouseOver"/>
        </vsm:VisualStateGroup.Transitions>
        <vsm:VisualState x:Name="Normal">
          <Storyboard/>
        </vsm:VisualState>
        <vsm:VisualState x:Name="MouseOver">
          <Storyboard>
            <ColorAnimationUsingKeyFrames BeginTime="00:00:00"
            Duration="00:00:00.0010000"
            Storyboard.TargetName="Path"
            Storyboard.TargetProperty="(Shape.Fill).(SolidColorBrush.Color)">
              <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF000000"/>
            </ColorAnimationUsingKeyFrames>
          </Storyboard>
        </vsm:VisualState>

      </vsm:VisualStateGroup>

    </vsm:VisualStateManager.VisualStateGroups>
    <Path x:Name="Path" Stretch="Fill" Fill="#FF054B4A"
      Data="F1 M 15.1257,30.0726L 30.1081,0L 0,0.0718536L 15.1257,30.0726 Z "
      RenderTransformOrigin="0.5,0.5" Grid.Row="1" Grid.Column="1"/>
  </Grid>
</ControlTemplate>

<Style x:Key="styleExpanderToggle" TargetType="ToggleButton">
  <Setter Property="Template" Value="{StaticResource ctExpanderToggle}"/>
</Style>

<ControlTemplate x:Key="ctExpander" TargetType="local:Expander">
  <Grid HorizontalAlignment="{TemplateBinding HorizontalAlignment}"
        VerticalAlignment="{TemplateBinding VerticalAlignment}">
    <vsm:VisualStateManager.VisualStateGroups>
      <vsm:VisualStateGroup x:Name="ExpanderStates">
        <vsm:VisualStateGroup.Transitions>
```

```
      <vsm:VisualTransition GeneratedDuration="00:00:00.2000000"
                            To="Expanded"/>
      <vsm:VisualTransition GeneratedDuration="00:00:00.2000000"
                            From="Expanded"/>
    </vsm:VisualStateGroup.Transitions>
    <vsm:VisualState x:Name="Normal">
      <Storyboard/>
    </vsm:VisualState>
    <vsm:VisualState x:Name="Expanded">
      <Storyboard>
        <ObjectAnimationUsingKeyFrames BeginTime="00:00:00"
                           Duration="00:00:00.0010000"
                           Storyboard.TargetName="Body"
                           Storyboard.TargetProperty="Visibility">
          <DiscreteObjectKeyFrame KeyTime="0">
            <DiscreteObjectKeyFrame.Value>
              <Visibility>Visible</Visibility>
            </DiscreteObjectKeyFrame.Value>
          </DiscreteObjectKeyFrame>
        </ObjectAnimationUsingKeyFrames>
      </Storyboard>
    </vsm:VisualState>
  </vsm:VisualStateGroup>
</vsm:VisualStateManager.VisualStateGroups>
<Grid.RowDefinitions>
  <RowDefinition Height="0.2*"/>
  <RowDefinition Height="0.8*"/>
</Grid.RowDefinitions>
<Border Height="Auto" Margin="0,0,0,0" VerticalAlignment="Stretch"
        Grid.Row="0" BorderThickness="2,2,2,2" BorderBrush="#FF000000"
        x:Name="Header">
  <Border.Background>
    <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
      <GradientStop Color="#FF0BC4C3"/>
      <GradientStop Color="#FF055352" Offset="1"/>
    </LinearGradientBrush>
  </Border.Background>
  <Grid>
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.80*"/>
      <ColumnDefinition Width="0.20*"/>
    </Grid.ColumnDefinitions>
    <ToggleButton HorizontalAlignment="Center" VerticalAlignment="Center"
                  Content="ToggleButton" Margin="2,2,2,2" Grid.Column="1"
                  Style="{StaticResource styleExpanderToggle}"
```

```
                        x:Name="toggler" >
          </ToggleButton>
          <ContentPresenter HorizontalAlignment="Center"
                            VerticalAlignment="Center"
          Content="{TemplateBinding HeaderContent}"
          ContentTemplate="{TemplateBinding HeaderContentTemplate}"
          x:Name="cpHdr"/>
        </Grid>
      </Border>
      <Border Height="Auto" Margin="0,0,0,0" VerticalAlignment="Stretch"
              Grid.Row="1" Background="#FFFFFFFF"
              BorderThickness="2,0,2,2" BorderBrush="#FF000000"
              x:Name="Body"
              Visibility="Collapsed">
        <ContentPresenter HorizontalAlignment="Stretch"
                          VerticalAlignment="Stretch"
                          Content="{TemplateBinding Content}"
                          ContentTemplate="{TemplateBinding ContentTemplate}"
                          x:Name="cpBody"/>
      </Border>
    </Grid>

  </ControlTemplate>
  <Style TargetType="local:Expander">
    <Setter Property="HeaderContent" Value="Header here" />
    <Setter Property="HeaderContentTemplate">
      <Setter.Value>
        <DataTemplate>
          <TextBlock Text="{Binding}" />
        </DataTemplate>
      </Setter.Value>
    </Setter>
    <Setter Property="Content" Value="Body here" />
    <Setter Property="ContentTemplate">
      <Setter.Value>
        <DataTemplate>
          <TextBlock Text="{Binding}" />
        </DataTemplate>
      </Setter.Value>
    </Setter>
    <Setter Property="Template" Value="{StaticResource ctExpander}" />
  </Style>
</ResourceDictionary>
```

The ctExpander control template is made up of two primary parts: the header and the body. The header portion is a Border named Header, a ContentPresenter named cpHdr, and a ToggleButton named toggler. cpHdr has its Content and ContentTemplate properties bound to the HeaderContent and the HeaderContentTemplate dependency properties, respectively, on the control. The body is a Border named Body, within which is another ContentPresenter cpBody with its Content and ContentTemplate properties bound to the identical properties on the Expander control itself. The Border named Body has its initial visibility set to Collapsed. You also apply a custom template to the ToggleButton to fix its content to a Path representing a directional arrow pointing downward and include a specific MouseOver state to vary the color.

In ctExpander, you can also see the Expanded visual state defined as a storyboard, in which you use an ObjectAnimation to transition Body to a Visible state. Note that this is the default implementation of the state storyboard as defined by the original control author in the default template.

If you were to use the Expander control as defined here on a page, you would see the output as shown in Figure 5-26, which shows the Expander both in its Normal and Expanded states.

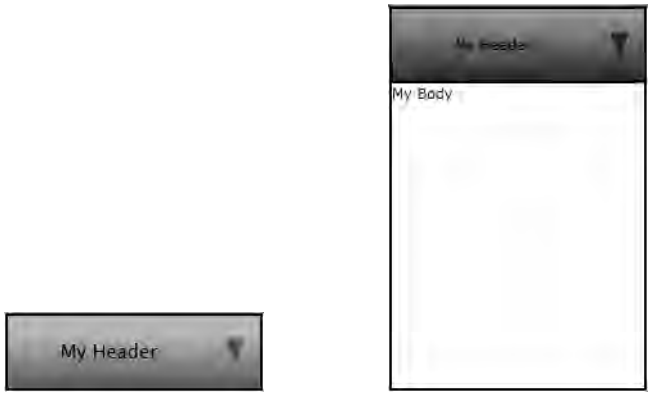


Figure 5-26. *Expander control using default UI in Normal and Expanded states*

Now, let's say you want to rotate the ToggleButton directional arrow to point upward when the body is expanded to provide a visual cue to the user that the body will be Collapsed again on the next click of the ToggleButton. You want to do this without changing the control, but by providing a custom template when you use the control. Listing 5-32 shows an XAML page where you create a copy of the Expander control template and add an additional animation to the Expanded visual state to achieve this.

Listing 5-32. *Addition to the Expanded visual state through a custom yemplate*

```
<UserControl x:Class="Recipe5_11.MainPage"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    xmlns:exp=
"clr-namespace:Recipe5_11;assembly=Recipe5_11.ExpLib"
    xmlns:vsm="clr-namespace:System.Windows;assembly=System.Windows"
    Width="400" Height="300">
  <UserControl.Resources>
    <ControlTemplate TargetType="ToggleButton" x:Key="ctExpanderToggle">
      <Grid>
```

```
      <Grid.RowDefinitions>
        <RowDefinition Height="0.3*" />
        <RowDefinition Height="0.4*" />
        <RowDefinition Height="0.3*" />
      </Grid.RowDefinitions>
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="0.3*" />
        <ColumnDefinition Width="0.4*" />
        <ColumnDefinition Width="0.3*" />
      </Grid.ColumnDefinitions>
      <vsm:VisualStateManager.VisualStateGroups>
        <vsm:VisualStateGroup x:Name="CommonStates">
          <vsm:VisualStateGroup.Transitions>
            <vsm:VisualTransition GeneratedDuration="00:00:00.2000000"
                                  To="MouseOver"/>
            <vsm:VisualTransition GeneratedDuration="00:00:00" From="MouseOver"/>
          </vsm:VisualStateGroup.Transitions>
          <vsm:VisualState x:Name="Normal">
            <Storyboard/>
          </vsm:VisualState>
          <vsm:VisualState x:Name="MouseOver">
            <Storyboard>
              <ColorAnimationUsingKeyFrames BeginTime="00:00:00"
            Duration="00:00:00.0010000"
            Storyboard.TargetName="Path"
            Storyboard.TargetProperty="(Shape.Fill).(SolidColorBrush.Color)">
                <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF000000"/>
              </ColorAnimationUsingKeyFrames>
            </Storyboard>
          </vsm:VisualState>
        </vsm:VisualStateGroup>
      </vsm:VisualStateManager.VisualStateGroups>
      <Path x:Name="Path" Stretch="Fill" Fill="#FF054B4A"
      Data="F1 M 15.1257,30.0726L 30.1081,0L 0,0.0718536L 15.1257,30.0726 Z "
      RenderTransformOrigin="0.5,0.5" Grid.Row="1" Grid.Column="1"/>
    </Grid>
  </ControlTemplate>
  <Style x:Key="styleExpanderToggle" TargetType="ToggleButton">
    <Setter Property="Template" Value="{StaticResource ctExpanderToggle}"/>
  </Style>
  <ControlTemplate x:Key="ctCustomExpander" TargetType="exp:Expander">
    <Grid HorizontalAlignment="{TemplateBinding HorizontalAlignment}"
        VerticalAlignment="{TemplateBinding VerticalAlignment}">
      <vsm:VisualStateManager.VisualStateGroups>
        <vsm:VisualStateGroup x:Name="ExpanderStates">
```

```
            <vsm:VisualStateGroup.Transitions>
              <vsm:VisualTransition GeneratedDuration="00:00:00.2000000"
                                    To="Expanded"/>
              <vsm:VisualTransition GeneratedDuration="00:00:00.2000000"
                                    From="Expanded"/>
            </vsm:VisualStateGroup.Transitions>
            <vsm:VisualState x:Name="Normal">
              <Storyboard/>
            </vsm:VisualState>
            <vsm:VisualState x:Name="Expanded">
              <Storyboard>
                 <DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
                 Duration="00:00:00.0010000"
                 Storyboard.TargetName="toggler"
                 Storyboard.TargetProperty=
"(UIElement.RenderTransform).(TransformGroup.Children)[2].(RotateTransform.Angle)">
                <SplineDoubleKeyFrame KeyTime="00:00:00" Value="-180"/>
              </DoubleAnimationUsingKeyFrames>
                <ObjectAnimationUsingKeyFrames BeginTime="00:00:00"
                                Duration="00:00:00.0010000"
                                Storyboard.TargetName="Body"
                                Storyboard.TargetProperty="Visibility">
                  <DiscreteObjectKeyFrame KeyTime="0">
                    <DiscreteObjectKeyFrame.Value>
                      <Visibility>Visible</Visibility>
                    </DiscreteObjectKeyFrame.Value>
                  </DiscreteObjectKeyFrame>
                </ObjectAnimationUsingKeyFrames>
              </Storyboard>
            </vsm:VisualState>
          </vsm:VisualStateGroup>
        </vsm:VisualStateManager.VisualStateGroups>
        <Grid.RowDefinitions>
          <RowDefinition Height="0.2*"/>
          <RowDefinition Height="0.8*"/>
        </Grid.RowDefinitions>
        <Border Height="Auto" Margin="0,0,0,0" VerticalAlignment="Stretch"
              Grid.Row="0" BorderThickness="2,2,2,2" BorderBrush="#FF000000"
              x:Name="Header">
          <Border.Background>
            <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
              <GradientStop Color="#FF0BC4C3"/>
              <GradientStop Color="#FF055352" Offset="1"/>
            </LinearGradientBrush>
          </Border.Background>
```

```
        <Grid>
          <Grid.ColumnDefinitions>
            <ColumnDefinition Width="0.80*"/>
            <ColumnDefinition Width="0.20*"/>
          </Grid.ColumnDefinitions>
          <ToggleButton HorizontalAlignment="Center" VerticalAlignment="Center"
                      Content="ToggleButton" Margin="2,2,2,2" Grid.Column="1"
                      Style="{StaticResource styleExpanderToggle}"
                      x:Name="toggler" RenderTransformOrigin="0.5,0.5">
            <ToggleButton.RenderTransform>
              <TransformGroup>
                <ScaleTransform/>
                <SkewTransform/>
                <RotateTransform/>
                <TranslateTransform/>
              </TransformGroup>
            </ToggleButton.RenderTransform>
          </ToggleButton>
          <ContentPresenter HorizontalAlignment="Center"
                            VerticalAlignment="Center"
          Content="{TemplateBinding HeaderContent}"
          ContentTemplate="{TemplateBinding HeaderContentTemplate}"
          x:Name="cpHdr"/>
          </Grid>
        </Border>
        <Border Height="Auto" Margin="0,0,0,0" VerticalAlignment="Stretch"
              Grid.Row="1" Background="#FFFFFFFF"
              BorderThickness="2,0,2,2" BorderBrush="#FF000000"
              x:Name="Body"
              Visibility="Collapsed">
          <ContentPresenter HorizontalAlignment="Stretch"
                            VerticalAlignment="Stretch"
                            Content="{TemplateBinding Content}"
                            ContentTemplate="{TemplateBinding ContentTemplate}"
                            x:Name="cpBody"/>
        </Border>
      </Grid>
    </ControlTemplate>
    <Style TargetType="exp:Expander" x:Key="STYLE_Expander">
      <Setter Property="Template" Value="{StaticResource ctCustomExpander}" />
    </Style>

  </UserControl.Resources>
    <Grid x:Name="LayoutRoot" Background="White">
    <exp:Expander Height="300" Width="200" Content="My Body"
```

```
                HeaderContent="My Header"
                Style="{StaticResource STYLE_Expander}" />
  </Grid>
</UserControl>
```

As mentioned before, `ctCustomExpander` is a copy of the default control template for the `Expander` control. You can use Expression Blend to create a copy of a control template for a control. Recipe 5-2 covers provides more information on using Expression Blend for control templates. The addition to note here is the definition of the `Expanded` visual state in the `ctCustomExpander` control template, as well as in the `ToggleButton` named `toggler`. You add a `TransformGroup` to `toggler` and set its `RenderTransformOrigin` to (0.5,0.5). You then add an animation targeting `toggler` to the `Expanded` state storyboard to animate the angle of a `RotateTransform` on `toggler` to –180 degrees. This has the desired effect. Since the normal state defines no modifications to the template parts, the `ToggleButton` returns to its original downward-pointing state, once you move off of the `Expanded` state, by clicking it again to collapse the body. You can find more on animations in Chapter 3.

Also note that in both the default control template definition for the `Expander` in Listing 5-31 and in the custom control template definition for the same in Listing 5-32, you have left out several of the common state storyboard definitions for the `ToggleButton`, such as those for the `Checked` and `Unchecked` visual states. This is because, in your example, you do not need to provide the user with any specific visual cues when these states occur. However, that does not mean that these states are not occurring at all. The `ToggleButton` control's code implementation does navigate to these states, but because of the lack of a storyboard definition in the templates, no corresponding visual state change occurs. Also note that you have defined the `Normal` visual state for the `ToggleButton` in both cases as an empty storyboard. You need this definition to allow visual state navigation to the initial normal visual state of the `ToggleButton` from any of our other visual states, like `Expanded`. Without this definition, once a visual state change took place, the `ToggleButton` control would never be able to return to its normal visual state.

Figure 5-27 shows the `Expander` control with the additions made to the `Expanded` visual state.

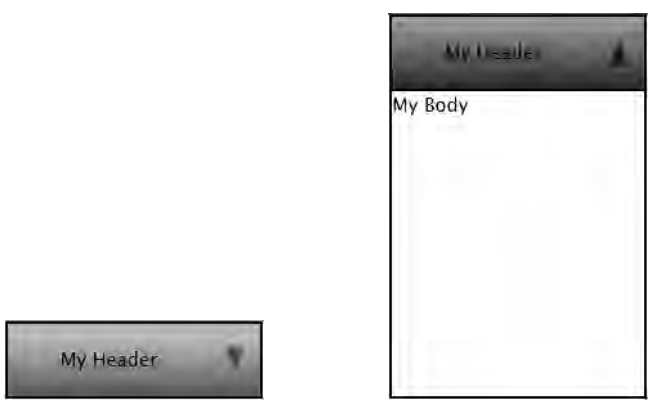


Figure 5-27. *Expander control with Expanded visual state additions through a custom template*

5-12. Controlling ScrollViewer Scroll Behavior

Problem

You want to programmatically control the scroll behavior of elements placed within a `ScrollViewer` control.

Solution

Traverse the visual tree to access the `ScrollBars` in the `ScrollViewer`, and handle `ScrollBar.ValueChanged` events to determine element positioning within the `ScrollViewer`.

How It Works

The `System.Windows.Controls.ScrollViewer` is a container control that can host content whose dimensions are much larger than the dimensions of the `ScrollViewer` itself. When the hosted content dimensions become larger in either `Width` or `Height` or both than the containing `ScrollViewer`, horizontal and vertical `Scrollbars` can be automatically displayed by the `ScrollViewer` to allow the user to view the content by scrolling within the `ScrollViewer`. In fact, many of the built-in controls like `ListBox` and `DataGrid` utilize a `ScrollViewer` internally to host content that has dimensions much greater than the container itself.

In scenarios where a `ScrollViewer` is used, you may also encounter the need to have some of the elements in the contained content follow a different scroll behavior than the default behavior imposed by the containing `ScrollViewer`. For instance, you may want a portion of the content to be constantly visible no matter in which direction and by how much the `ScrollViewer` is scrolled.

An appropriate attempt would be to figure out the amount of scroll and then apply an appropriate margin to the element that you want to keep visible (i.e., move the element in the direction of the scroll to keep it from disappearing beyond the visible bounds of the `ScrollViewer`).

The challenge with this is that the `ScrollViewer` does not raise any events as users scroll through the content. If you could access the `ScrollBar` controls contained in the `ScrollViewer`, you could attach handlers to the `ValueChanged` events of the `ScrollBar` and implement the necessary logic. Given that the `ScrollViewer` does not provide direct access to the internal `ScrollBar` control instances, how do you go about doing that?

The VisualTreeHelper class

The `System.Windows.Media.VisualTreeHelper` class can help in traversing a visual tree and accessing elements in the tree that you do not have access to. The `VisualTreeHelper` class has several static utility methods that can be used to access the visual tree in several ways. The `FindElementsInHostCoordinates()` method has two overloads that accept a `Rect` or a `Point` defined in host coordinates (that is the coordinate system of the application's root visual) and find all the elements in the visual tree that intersect with that `Point` or fall within that `Rect`. Each overload also accepts a `UIElement` as a second parameter to denote the root of the search in the visual tree. If this parameter is set to `null`, the search covers the entire tree starting from the root. The `VisualTreeHelper` has other interesting methods like `GetParent()` to get the visual parent of an element or `GetChild()` to retrieve a child of an element at a specific index, and we encourage the reader to look up `VisualTreeHelper` documentation in MSDN at `msdn.microsoft.com/en-us/library/system.windows.media.visualtreehelper(VS.95).aspx`. This class can come in handy very often.

For this recipe, you can use `FindElementsInHostCoordinates()` to locate the `ScrollBars` internal to the `ScrollViewer`'s template definition and then respond to their events to control the scrolling behavior.

Let's now look at the code sample to see exactly how all of this ties together.

The Code

The code sample for this recipe hosts a `ListBox` within a `ScrollViewer`. The `ListBox` uses the `WrapPanel` developed and used in Recipe 5-9 as its `ItemsPanel`. Within the `ScrollViewer` is also a separate menu area that contains a `ComboBox` populated by product category data retrieved from the `AdventureWorks` WCF service discussed at the beginning of this chapter. Also, a `Button` in the menu area fetches all the products for that product category and populates the `ListBox`. Once the `ListBox` is populated, you will notice that scrolling the `ScrollViewer` scrolls the `ListBox`, but the menu area remains constantly in its position no matter the amount or the direction of the scroll.

Figure 5-28 shows the user interface of the application with the `ScrollViewer` scrolled partially both downward and to the right.

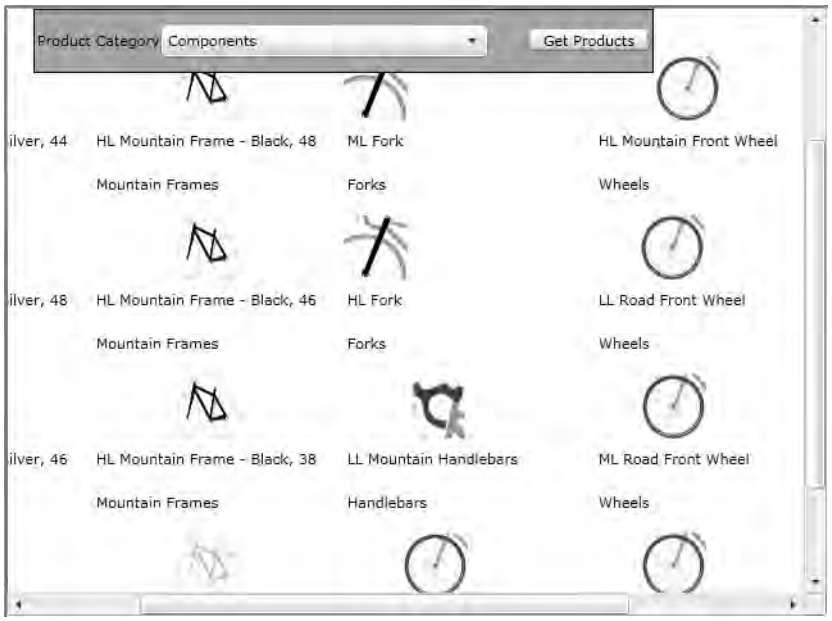


Figure 5-28. *ScrollViewer in a partially scrolled state with scroll invariant content*

Listing 5-33 shows the XAML for the page.

Listing 5-33. *XAML for MainPage*

```
<UserControl x:Class="Recipe5_12.MainPage"
             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:Panel=
"clr-namespace:Recipe5_9;assembly=Recipe5_9.WrapPanel"
            Width="640"
            Height="474">
  <UserControl.Resources>

    <DataTemplate x:Key="dtProductItem">
      <Grid>
        <Grid.RowDefinitions>
          <RowDefinition Height="0.694*" />
          <RowDefinition Height="0.153*" />
          <RowDefinition Height="0.153*" />
        </Grid.RowDefinitions>
        <Image  MaxHeight="50"
                MaxWidth="50"
                Source="{Binding ProductPhoto.LargePhotoPNG}"
                Stretch="Fill"
                VerticalAlignment="Stretch"
                HorizontalAlignment="Stretch" />
        <TextBlock Text="{Binding Name}"
                   TextWrapping="Wrap"
                   Margin="8,8,8,10"
                   Grid.Row="1" />
        <TextBlock Text="{Binding ProductSubCategory.Name}"
                   TextWrapping="Wrap"
                   Margin="8,8,8,10"
                   Grid.Row="2" />
      </Grid>
    </DataTemplate>
      <DataTemplate x:Key="dtCategory">
      <TextBlock Text="{Binding Name}" />
    </DataTemplate>
  </UserControl.Resources>

  <ScrollViewer VerticalScrollBarVisibility="Auto"
                x:Name="scrollViewer"
                Padding="0"
                HorizontalScrollBarVisibility="Auto">
    <Grid x:Name="LayoutRoot">

      <Grid x:Name="ProductsData"
            Margin="0,50,0,0">
        <ListBox x:Name="lbxProducts"
```

```
            ItemTemplate="{StaticResource dtProductItem}"
            SelectionMode="Single">
      <ListBox.ItemsPanel>
        <ItemsPanelTemplate>
          <Panel:WrapPanel Orientation="Vertical"
                           Width="950"
                           Height="650" />
        </ItemsPanelTemplate>
      </ListBox.ItemsPanel>
    </ListBox>
  </Grid>

  <Border x:Name="brdrTopMenu"
          Height="50"
          VerticalAlignment="Top"
          HorizontalAlignment="Left"
          Margin="20,0,0,0"
          BorderBrush="Black"
          BorderThickness="1"
          Background="#FFA8A3A3"
          Padding="2,2,2,2">
    <Grid>
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="0.194*" />
        <ColumnDefinition Width="0.414*" />
        <ColumnDefinition Width="0.392*" />
      </Grid.ColumnDefinitions>
      <ComboBox x:Name="cbxCategories"
                ItemTemplate="{StaticResource dtCategory}"
                HorizontalAlignment="Right"
                VerticalAlignment="Center"
                Width="256"
                Height="26"
                Grid.Column="1" />
      <TextBlock HorizontalAlignment="Center"
                 VerticalAlignment="Center"
                 Text="Product Category"
                 TextWrapping="Wrap" />
      <Button x:Name="btnGetProducts"
              Margin="31,11,0,14"
              Content="Get Products"
              HorizontalAlignment="Left"
              Width="95"
              Grid.Column="2"
              VerticalAlignment="Center"
```

```
                Click="btnGetProducts_Click" />
        </Grid>
      </Border>

    </Grid>
  </ScrollViewer>

</UserControl>
```

The Grid named ProductsData contains the ListBox that displays the product items. The Border named brdrTopMenu contains the ComboBox displaying the product category information and the Button that causes the product items for that category to be fetched and displayed. Both productsData and brdrTopMenu are further contained within a Grid named LayoutRoot, which in turn sits within a ScrollViewer named scrollViewer. The goal is to have scrollViewer be scrolled in any direction and have productsData (and hence the contained ListBox) be scrolled accordingly, but brdrTopMenu (and everything within) be always visible at the same position.

Listing 5-34 shows the codebehind implementing the necessary logic.

Listing 5-34. *Codebehind for MainPage*

```
using System;
using System.Collections.Generic;
using System.IO;
using System.Linq;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Controls.Primitives;
using System.Windows.Media;
using System.Windows.Media.Imaging;
using Recipe5_12.AdvWorks;

namespace Recipe5_12
{
  public partial class MainPage : UserControl
  {
    internal ScrollBar HScollBar = null;
    internal ScrollBar VScollBar = null;

    public MainPage()
    {
      InitializeComponent();

      AdvWorksDataServiceClient client = new AdvWorksDataServiceClient();
      client.GetAllCategoriesCompleted +=
        new EventHandler<GetAllCategoriesCompletedEventArgs>((s, e) =>
        {
```

```
      cbxCategories.ItemsSource = e.Result;
    });
  client.GetAllCategoriesAsync();

  scrollViewer.LayoutUpdated += new EventHandler((s, e) =>
  {
    if (HScollBar == null || VScollBar == null)
    {
      List<ScrollBar> scbars =
        VisualTreeHelper.FindElementsInHostCoordinates(
      scrollViewer.TransformToVisual(
        Application.Current.RootVisual).TransformBounds(
        new Rect(0, 0, scrollViewer.ActualWidth, scrollViewer.ActualHeight)),
            scrollViewer).
              Where((uie) => uie is ScrollBar).Cast<ScrollBar>().ToList();

      foreach (ScrollBar sc in scbars)
      {
        if (sc.Orientation == Orientation.Horizontal && HScollBar == null)
        {
          HScollBar = sc;
          sc.ValueChanged +=
        new RoutedPropertyChangedEventHandler<double>(OnHScrollValueChanged);
        }
        else if (sc.Orientation == Orientation.Vertical && VScollBar == null)
        {
          VScollBar = sc;
          sc.ValueChanged +=
        new RoutedPropertyChangedEventHandler<double>(OnVScrollValueChanged);
        }
      }
    }
  });
}

void OnHScrollValueChanged(object sender,
  RoutedPropertyChangedEventArgs<double> e)
{

  brdrTopMenu.Margin = new Thickness
  {
    Left = brdrTopMenu.Margin.Left + (e.NewValue - e.OldValue),
    Top = brdrTopMenu.Margin.Top,
    Right = brdrTopMenu.Margin.Right,
    Bottom = brdrTopMenu.Margin.Bottom
```

```
    };

  }

  void OnVScrollValueChanged(object sender,
    RoutedPropertyChangedEventArgs<double> e)
  {
    brdrTopMenu.Margin = new Thickness
    {
      Left = brdrTopMenu.Margin.Left,
      Top = brdrTopMenu.Margin.Top + (e.NewValue - e.OldValue),
      Right = brdrTopMenu.Margin.Right,
      Bottom = brdrTopMenu.Margin.Bottom
    };
  }

  private void btnGetProducts_Click(object sender, RoutedEventArgs e)
  {
    AdvWorksDataServiceClient client = new AdvWorksDataServiceClient();
    client.GetProductsForCategoryCompleted +=
      new EventHandler<GetProductsForCategoryCompletedEventArgs>((s, args) =>
      {
        lbxProducts.ItemsSource = args.Result;
        client.GetSubcategoryCompleted +=
          new EventHandler<GetSubcategoryCompletedEventArgs>((s1, e1) =>
        {
          (e1.UserState as Product).ProductSubCategory = e1.Result;
        });
        client.GetPhotosCompleted +=
          new EventHandler<GetPhotosCompletedEventArgs>((s2, e2) =>
        {
          (e2.UserState as Product).ProductPhoto = e2.Result;
        });
        client.GetInventoryCompleted +=
          new EventHandler<GetInventoryCompletedEventArgs>((s3, e3) =>
          {
            Product p = (e3.UserState as Product);
            p.ProductInventories = e3.Result;
            p.InventoryLevelBrush = null;
            p.InventoryLevelMessage = null;
          });
        foreach (Product prod in args.Result)
        {
          client.GetPhotosAsync(prod, prod);
          client.GetSubcategoryAsync(prod, prod);
          client.GetInventoryAsync(prod, prod);
```

```
          }

        });
      if (cbxCategories.SelectedItem != null)
        client.
          GetProductsForCategoryAsync(
          cbxCategories.SelectedItem as ProductCategory);
    }

  }
}
namespace Recipe5_12.AdvWorks
{
  public partial class ProductPhoto
  {
    private BitmapImage _LargePhotoPNG;

    public BitmapImage LargePhotoPNG
    {
      get
      {
        BitmapImage bim = new BitmapImage();
        MemoryStream ms = new MemoryStream(this.LargePhoto.Bytes);
        bim.SetSource(ms);
        ms.Close();
        return bim;
      }
      set
      {
        RaisePropertyChanged("LargePhotoPNG");
      }
    }
  }

  public partial class Product
  {
    private SolidColorBrush _InventoryLevelBrush;
    public SolidColorBrush InventoryLevelBrush
    {
      get
      {
        return (this.ProductInventories == null
          || this.ProductInventories.Count == 0) ?
          new SolidColorBrush(Colors.Gray) :
            (this.ProductInventories[0].Quantity > this.SafetyStockLevel ?
```

```
            new SolidColorBrush(Colors.Green) :
              (this.ProductInventories[0].Quantity > this.ReorderPoint ?
                 new SolidColorBrush(Colors.Yellow) :
                  new SolidColorBrush(Colors.Red)));
    }
    set
    {
      //no actual value set here - just property change raised
      RaisePropertyChanged("InventoryLevelBrush");
    }
  }
  private string _InventoryLevelMessage;
  public string InventoryLevelMessage
  {
    get
    {
      return (this.ProductInventories == null
        || this.ProductInventories.Count == 0) ?
        "Stock Level Unknown" :
          (this.ProductInventories[0].Quantity > this.SafetyStockLevel ?
          "In Stock" :
            (this.ProductInventories[0].Quantity > this.ReorderPoint ?
              "Low Stock" : "Reorder Now"));
    }
    set
    {
      //no actual value set here - just property change raised
      RaisePropertyChanged("InventoryLevelMessage");
    }
  }
  private ProductSubcategory _productSubCategory;
  public ProductSubcategory ProductSubCategory
  {
    get { return _productSubCategory; }
    set
    {
      _productSubCategory = value;
      RaisePropertyChanged("ProductSubCategory");
    }
  }
  private ProductCategory _productCategory;
  public ProductCategory ProductCategory
  {
    get { return _productCategory; }
    set { _productCategory = value; RaisePropertyChanged("ProductCategory"); }
```

```
    }

    private ProductPhoto _productPhoto;
    public ProductPhoto ProductPhoto
    {
      get { return _productPhoto; }
      set { _productPhoto = value; RaisePropertyChanged("ProductPhoto"); }
    }
  }
}
```

We are going to discuss only the portions of the code that pertain to the immediate problem here. For an explanation of the rest of the code, most of which deals with WCF service calls to the `AdventureWorks` service to fetch data, refer to Recipe 5-3.

In Listing 5-34, note the handler for the `LayoutUpdated` event for the `ScrollViewer`. You use the `VisualTreeHelper.FindElementsInHostCoordinates()` method to try to locate the two `ScrollBars` in the `ScrollViewer`. You pass in a `Rect` instance that contains a rectangle defining the bounds of the `ScrollViewer` transformed to host coordinates. For an explanation of coordinate system transformation using the `TransformToVisual()` method, refer to Recipe 5-4. You also pass in the `ScrollViewer` as the second parameter to start the search of the visual tree at the `ScrollViewer` moving down. Finally, you filter the resulting collection using LINQ to extract just the `ScrollBar` typed instances.

Once that is done, wire up the handler to the `ValueChanged` events of each `ScrollBar`, and store them in two member variables named `HScrollBar` and `VScrollBar`, respectively. This needs a little bit more explanation. The `ScrollViewer` can be configured to display its `ScrollBars` automatically as needed (i.e., when the content dimensions grow beyond the visible bounds). Thus, depending on the current dimensions of the content and the `ScrollViewer` settings, either or neither `ScrollBar` may show up initially. Since the `LayoutUpdated` event gets raised by the `ScrollViewer` each time such a layout change occurs, you are guaranteed to eventually locate both `ScrollBars`, even if they are not available on the first occurrence of that event. To avoid attaching event handlers multiple times to the `ValueChanged` events, you store them in local variables and check for `null` to ensure this is the first time you are locating them.

If you look at the handlers for the `ValueChanged` events, named `OnHScrollValueChanged` and `OnVScrollValueChanged`, you simply set the appropriate `Margin` dimension on the `brdrTopMenu` element to the amount covered in the last scroll event. The `Margin` dimension is either `Margin.Left` or `Margin.Top` depending on whether the scroll is a horizontal or a vertical one. This shift of `Margin` works both ways—depending on the direction of the scroll, the difference of `e.NewValue` and `e.OldValue` may be a positive or a negative value, thus moving the `brdrTopMenu` further away from or closer to the edge in question. This causes the `brdrTopMenu` to always seem to stay visible at the same position with respect to the visible portion of the content within the `ScrollViewer`.

5-13. Customizing the Binding Validation User Interface

Problem

You want to customize the default user interface built into Silverlight for displaying binding validation errors and validation summary.

Solution

To modify the validation error displayed at the control that is in error, customize the control template and change the `ValidationTooltipTemplate`. To customize the `ValidationSummary` user interface, modify the `ValidationSummary` control template, which is a new addition in Silverlight 3.

How It Works

This recipe discusses the mechanisms to modify that default user interface. For more details on how the default user interface for displaying binding validation errors are utilized, refer to Recipe 4-6.

Validation Error Tooltip

The default user interface of a validation error involves a red border and a corner glyph on the control concerned and a `ToolTip` containing the error message that appears alongside the control when the user hovers on the glyph. Figure 5-29a shows this user interface.

Figure 5-29a. *Default user interface for validation error message*

This user interface is built into the template of the control with which the error display is associated. Unfortunately, there is no straightforward way to replace this user interface other than modifying the control template of the control in question. Let's use a `TextBox` control as an example, with its default control template shown in Listing 5-35. For the sake of brevity, we have listed only the portions pertinent to validation error display.

Listing 5-35. *Partial control template of a TextBox control*

```
<Style x:Key="styleTextBoxDefault" TargetType="TextBox">
  <Setter Property="BorderThickness" Value="1"/>
  <Setter Property="Background" Value="#FFFFFFFF"/>
  <Setter Property="Foreground" Value="#FF000000"/>
  <Setter Property="Padding" Value="2"/>
  <Setter Property="BorderBrush">
    <Setter.Value>
      <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
        <GradientStop Color="#FFA3AEB9" Offset="0"/>
        <GradientStop Color="#FF8399A9" Offset="0.375"/>
        <GradientStop Color="#FF718597" Offset="0.375"/>
        <GradientStop Color="#FF617584" Offset="1"/>
      </LinearGradientBrush>
    </Setter.Value>
  </Setter>
  <Setter Property="Template">
```

```
<Setter.Value>
  <ControlTemplate TargetType="TextBox">
    <Grid x:Name="RootElement">
      <VisualStateManager.VisualStateGroups>
        ...
        <VisualStateGroup x:Name="ValidationStates">
          <VisualState x:Name="Valid"/>
          <VisualState x:Name="InvalidUnfocused">
            <Storyboard>
              <ObjectAnimationUsingKeyFrames
                Storyboard.TargetName="ValidationErrorElement"
                Storyboard.TargetProperty="Visibility">
                <DiscreteObjectKeyFrame KeyTime="0">
                  <DiscreteObjectKeyFrame.Value>
                    <Visibility>Visible</Visibility>
                  </DiscreteObjectKeyFrame.Value>
                </DiscreteObjectKeyFrame>
              </ObjectAnimationUsingKeyFrames>
            </Storyboard>
          </VisualState>
          <VisualState x:Name="InvalidFocused">
            <Storyboard>
              <ObjectAnimationUsingKeyFrames
                Storyboard.TargetName="ValidationErrorElement"
                Storyboard.TargetProperty="Visibility">
                <DiscreteObjectKeyFrame KeyTime="0">
                  <DiscreteObjectKeyFrame.Value>
                    <Visibility>Visible</Visibility>
                  </DiscreteObjectKeyFrame.Value>
                </DiscreteObjectKeyFrame>
              </ObjectAnimationUsingKeyFrames>
              <ObjectAnimationUsingKeyFrames
                Storyboard.TargetName="validationTooltip"
                Storyboard.TargetProperty="IsOpen">
                <DiscreteObjectKeyFrame KeyTime="0">
                  <DiscreteObjectKeyFrame.Value>
                    <System:Boolean>True</System:Boolean>
                  </DiscreteObjectKeyFrame.Value>
                </DiscreteObjectKeyFrame>
              </ObjectAnimationUsingKeyFrames>
            </Storyboard>
          </VisualState>
        </VisualStateGroup>
      </VisualStateManager.VisualStateGroups>
      ...
```

```
        <Border x:Name="ValidationErrorElement" Visibility="Collapsed"
                BorderBrush="#FFDB000C" BorderThickness="1" CornerRadius="1">
          <ToolTipService.ToolTip>
            <ToolTip x:Name="validationTooltip"
      DataContext="{Binding RelativeSource={RelativeSource TemplatedParent}}"
                     Template="{StaticResource ValidationToolTipTemplate}"
                     Placement="Right"
                     PlacementTarget=
                "{Binding RelativeSource={RelativeSource TemplatedParent}}">
              <ToolTip.Triggers>
                <EventTrigger RoutedEvent="Canvas.Loaded">
                  <BeginStoryboard>
                    <Storyboard>
                      <ObjectAnimationUsingKeyFrames
                        Storyboard.TargetName="validationTooltip"
                        Storyboard.TargetProperty="IsHitTestVisible">
                        <DiscreteObjectKeyFrame KeyTime="0">
                          <DiscreteObjectKeyFrame.Value>
                            <System:Boolean>true</System:Boolean>
                          </DiscreteObjectKeyFrame.Value>
                        </DiscreteObjectKeyFrame>
                      </ObjectAnimationUsingKeyFrames>
                    </Storyboard>
                  </BeginStoryboard>
                </EventTrigger>
              </ToolTip.Triggers>
            </ToolTip>
          </ToolTipService.ToolTip>
          <Grid Height="12" HorizontalAlignment="Right" Margin="1,-4,-4,0"
                VerticalAlignment="Top" Width="12" Background="Transparent">
            <Path Fill="#FFDC000C" Margin="1,3,0,0"
                  Data="M 1,0 L6,0 A 2,2 90 0 1 8,2 L8,7 z"/>
            <Path Fill="#ffffff" Margin="1,3,0,0"
                  Data="M 0,0 L2,0 L 8,6 L8,8"/>
          </Grid>
        </Border>
      </Grid>
    </ControlTemplate>
  </Setter.Value>
</Setter>
</Style>
```

The first thing to notice is the `Border` element named `ValidationErrorElement`, which has additional elements in it that constitute the red border and glyph displayed on a validation error. If you look at the visual states defined on the `TextBox` control, you will see that the `InvalidFocused` and

InvalidUnfocused states actually make the validationErrorElement visible and those states are navigated to from within the TextBox code when a validation error happens.

You should also note the ToolTip named validationToolTip associated with validationErrorElement. This is what causes the ToolTip error to display when the user hovers on the glyph. tooltipErrorDisplay has its control template bound to a control template name ValidationToolTipTemplate. This control template is also automatically created whenever you create a custom template for the TextBox (or any other control that supports validation) in Expression Blend 3; the default version is listed in Listing 5-36.

Listing 5-36. *Default ValidationTooltipTemplate definition*

```
<ControlTemplate x:Key="ValidationToolTipTemplate">
  <Grid x:Name="Root" Margin="5,0" Opacity="0" RenderTransformOrigin="0,0">
    <VisualStateManager.VisualStateGroups>
      <VisualStateGroup x:Name="OpenStates">
        <VisualStateGroup.Transitions>
          <VisualTransition GeneratedDuration="0"/>
          <VisualTransition GeneratedDuration="0:0:0.2" To="Open">
            <Storyboard>
              <DoubleAnimationUsingKeyFrames Storyboard.TargetName="xform"
                                             Storyboard.TargetProperty="X">
                <SplineDoubleKeyFrame KeyTime="0:0:0.2" Value="0"/>
              </DoubleAnimationUsingKeyFrames>
              <DoubleAnimationUsingKeyFrames Storyboard.TargetName="Root"
                                           Storyboard.TargetProperty="Opacity">
                <SplineDoubleKeyFrame KeyTime="0:0:0.2" Value="1"/>
              </DoubleAnimationUsingKeyFrames>
            </Storyboard>
          </VisualTransition>
        </VisualStateGroup.Transitions>
        <VisualState x:Name="Closed">
          <Storyboard>
            <DoubleAnimationUsingKeyFrames Storyboard.TargetName="Root"
                                           Storyboard.TargetProperty="Opacity">
              <SplineDoubleKeyFrame KeyTime="0" Value="0"/>
            </DoubleAnimationUsingKeyFrames>
          </Storyboard>
        </VisualState>
        <VisualState x:Name="Open">
          <Storyboard>
            <DoubleAnimationUsingKeyFrames Storyboard.TargetName="xform"
                                           Storyboard.TargetProperty="X">
              <SplineDoubleKeyFrame KeyTime="0" Value="0"/>
            </DoubleAnimationUsingKeyFrames>
            <DoubleAnimationUsingKeyFrames Storyboard.TargetName="Root"
                                           Storyboard.TargetProperty="Opacity">
```

```
            <SplineDoubleKeyFrame KeyTime="0" Value="1"/>
          </DoubleAnimationUsingKeyFrames>
        </Storyboard>
      </VisualState>
    </VisualStateGroup>
  </VisualStateManager.VisualStateGroups>
  <Grid.RenderTransform>
    <TranslateTransform x:Name="xform" X="-25"/>
  </Grid.RenderTransform>
  <Border Margin="4,4,-4,-4" Background="#052A2E31" CornerRadius="5"/>
  <Border Margin="3,3,-3,-3" Background="#152A2E31" CornerRadius="4"/>
  <Border Margin="2,2,-2,-2" Background="#252A2E31" CornerRadius="3"/>
  <Border Margin="1,1,-1,-1" Background="#352A2E31" CornerRadius="2"/>
  <Border Background="#FFDC000C" CornerRadius="2"/>
  <Border CornerRadius="2">
    <TextBlock Margin="8,4,8,4" MaxWidth="250" UseLayoutRounding="false"
               Foreground="White"
               Text="{Binding (Validation.Errors)[0].ErrorContent}"
               TextWrapping="Wrap"/>
  </Border>
 </Grid>
</ControlTemplate>
```

The easiest place to start modifying the default appearance of the validation error display is by modifying the `ValidationTooltipTemplate`. There is a small example of this in the code sample to follow.

Also note the binding declaration for the `Text` property of the `TextBlock` displaying the error message. The `System.Windows.Controls.Validation` class is static and exposes a dependency property named `Errors`, defined as a collection of `ValidationError` types. The `ValidationError` type, in turn, exposes an `ErrorContent` property of type `Object` and an `Exception` property of type `Exception` to define the actual error that it represents. Binding the `Text` property to the `ErrorContent` property of the `ValidationError` type causes the error to be displayed within the `ToolTip`.

The ValidationSummary Control

The `ValidationSummary` control is used to display a collection of all validation errors on a form at any time during the edit process, and its default use is described in Recipe 4-6, whereas Figure 5-29b shows an example of the default user interface.

Figure 5-29b *Default User Interface for Validation Summary*

To enable customizing the header area of the `ValidationSummary` control, a `HeaderTemplate` property of type `DataTemplate` is available on the `ValidationSummary` control, which, in turn, uses the value set in the `ValidationSummary.Header` property as its data source. There is an example of this later on in the code sample.

The `ValidationSummary` control internally uses a `ListBox` to display the list of errors. Each item in the `ListBox` gets bound to an instance of a `System.Windows.Controls.ValidationSummaryItem` type. The `ValidationSummaryItem` instance is created automatically by the runtime for each validation error and exposes a `MessageHeader` and `Message` property that gets bound to each item in the `ListBox` using the `ItemTemplate` property setting on the internal `ListBox`.

The data template used for the `ListBox.ItemTemplate` inside the `ValidationSummary` is unfortunately defined within the default control template and not exposed externally through the `ValidationSummary` control. So, to replace that data template and change how the `ValidationSummaryItem` properties get bound and displayed, you need to provide a custom template for the entire `ValidationSummary` control.

If, however, you want to change the UI for each `ListBoxItem` that represents an error item, you can set `ValidationSummary.ErrorStyle` to a custom style containing your custom control template for a `ListBoxItem` without having to modify the entire `ValidationSummary` control template. The style applied here gets bound to the `ItemContainerStyle` property of the `ListBox` that `ValidationSummary` uses internally, and hence impacts the look and feel of the `ListBoxItem` for each individual error item. We will look at an example of this as well.

The Code

To illustrate these ideas, we extend the code sample from Recipe 4-7. Since there are no changes to the codebehind for this, we only focus on the XAML, listing only the pertinent parts. We encourage you to go to the download files available for this book for the complete code listings. Let's start with a customization to the `ValidationToolTipTemplate` control template, as shown in Listing 5-37.

Listing 5-37. *Customized ValidationToolTipTemplate*

```
<ControlTemplate x:Key="CustomValidationToolTipTemplate">
  <Grid x:Name="Root"
        Margin="5,0"
        Opacity="0"
        RenderTransformOrigin="0,0">
    <VisualStateManager.VisualStateGroups>
      <VisualStateGroup x:Name="OpenStates">
        <VisualStateGroup.Transitions>
          <VisualTransition GeneratedDuration="0" />
          <VisualTransition GeneratedDuration="0:0:0.2"
                            To="Open">
            <Storyboard>
              <DoubleAnimationUsingKeyFrames Storyboard.TargetName="xform"
                                             Storyboard.TargetProperty="X">
                <SplineDoubleKeyFrame KeyTime="0:0:0.2"
                                      Value="0" />
              </DoubleAnimationUsingKeyFrames>
              <DoubleAnimationUsingKeyFrames Storyboard.TargetName="Root"
                                        Storyboard.TargetProperty="Opacity">
                <SplineDoubleKeyFrame KeyTime="0:0:0.2"
                                      Value="1" />
              </DoubleAnimationUsingKeyFrames>
            </Storyboard>
          </VisualTransition>
        </VisualStateGroup.Transitions>
        <VisualState x:Name="Closed">
          <Storyboard>
            <DoubleAnimationUsingKeyFrames Storyboard.TargetName="Root"
                                           Storyboard.TargetProperty="Opacity">
              <SplineDoubleKeyFrame KeyTime="0"
                                    Value="0" />
            </DoubleAnimationUsingKeyFrames>
          </Storyboard>
        </VisualState>
        <VisualState x:Name="Open">
          <Storyboard>
            <DoubleAnimationUsingKeyFrames Storyboard.TargetName="xform"
                                           Storyboard.TargetProperty="X">
              <SplineDoubleKeyFrame KeyTime="0"
                                    Value="0" />
            </DoubleAnimationUsingKeyFrames>
            <DoubleAnimationUsingKeyFrames Storyboard.TargetName="Root"
                                           Storyboard.TargetProperty="Opacity">
```

```
          <SplineDoubleKeyFrame KeyTime="0"
                                Value="1" />
        </DoubleAnimationUsingKeyFrames>
      </Storyboard>
    </VisualState>
  </VisualStateGroup>
</VisualStateManager.VisualStateGroups>
<Grid.RenderTransform>
  <TranslateTransform x:Name="xform"
                      X="-25" />
</Grid.RenderTransform>
<Border Margin="4,4,-4,-4"
        Background="#052A2E31"
        CornerRadius="5" />
<Border Margin="3,3,-3,-3"
        Background="#152A2E31"
        CornerRadius="4" />
<Border Margin="2,2,-2,-2"
        Background="#252A2E31"
        CornerRadius="3" />
<Border Margin="1,1,-1,-1"
        Background="#352A2E31"
        CornerRadius="2" />
<Border Background="#FFDC000C"
        CornerRadius="2" />
<Border CornerRadius="2">
  <Grid>
    <Grid.RowDefinitions>
      <RowDefinition Height="Auto" />
      <RowDefinition Height="Auto" />
    </Grid.RowDefinitions>
    <TextBlock Margin="8,4,8,4"
               MaxWidth="250"
               UseLayoutRounding="false"
               Foreground="White"
               Text="{Binding (Validation.Errors)[0].ErrorContent}"
               TextWrapping="Wrap" />
    <Border Background="White"
            Margin="6,2,6,2"
            BorderThickness="1"
            BorderBrush="Black"
            Grid.Row="1">
      <TextBlock UseLayoutRounding="false"
                 MaxWidth="250"
                 Margin="2"
```

```
                    Foreground="Black"
                   Text="{Binding (Validation.Errors)[0].Exception.StackTrace}"
                    TextWrapping="Wrap" />
        </Border>
      </Grid>
    </Border>
  </Grid>
</ControlTemplate>
```

If you compare this with the default implementation in Listing 5-34, you will note the addition of an extra `TextBlock` contained with a `Border` to the template with the `TextBlock.Text` property bound to the `ValidationError.Exception.StackTrace` property for the error being displayed.

Listing 5-38 shows the binding of the `CustomValidationTooltipTemplate` control template to the `ToolTip.Template` property for the `validationToolTip` within the `TextBox` control template and the containing `TextBox` style being applied to a `TextBox`.

Listing 5-38. *Applying CustomValidationToolTipTemplate to a TextBox*

```
<Style x:Key="styleTextBox"
       TargetType="TextBox">
  ...
  <Setter Property="Template">
    <Setter.Value>
      <ControlTemplate TargetType="TextBox">
        <Grid x:Name="RootElement">
          ...
          <Border x:Name="ValidationErrorElement"
                  Visibility="Collapsed"
                  BorderBrush="#FFDB000C"
                  BorderThickness="1"
                  CornerRadius="1">
            <ToolTipService.ToolTip>
              <ToolTip x:Name="validationTooltip"
                       DataContext=
                       "{Binding RelativeSource={RelativeSource TemplatedParent}}"
                       Template="{StaticResource CustomValidationToolTipTemplate}"
                       Placement="Right"
                       PlacementTarget="
                       {Binding RelativeSource={RelativeSource TemplatedParent}}">
                ...
              </ToolTip>
            </ToolTipService.ToolTip>
            ...
        </Grid>
      </ControlTemplate>
    </Setter.Value>
```

```
  </Setter>
</Style>

…
…

<TextBox Background="Transparent"
         Grid.Column="3"
         Margin="1,1,1,1"
         Grid.Row="3"
         Text="{Binding Address.State, Mode=TwoWay,
  NotifyOnValidationError=True, UpdateSourceTrigger=Explicit,
  ValidatesOnExceptions=True}"
         x:Name="tbxState"
         Style="{StaticResource styleTextBox}" />
```

This causes the stack trace to be displayed right below the error message, as shown in Figure 5-30a.

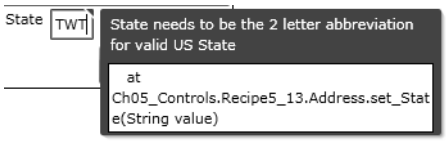


Figure 5-30a. *Customized ValidationToolTipTemplate with a stack trace display*

Let's look at the `ValidationSummary` control customization now. Start by creating a custom control template for each individual `ListBoxItem` within the `ValidationSummaryItem`, as shown in Listing 5-39. Recall that this template can be applied through the `ValidationSummary.ErrorStyle` property to change the look and feel of each individual error item.

Listing 5-39. *Control Template for the ListBoxItem used to display individual error items in a Validation Summary*

```
<Style x:Key="styleValidationSummaryErrorItem" TargetType="ListBoxItem">
  <Setter Property="Padding" Value="3"/>
  <Setter Property="HorizontalContentAlignment" Value="Left"/>
  <Setter Property="VerticalContentAlignment" Value="Top"/>
  <Setter Property="Background" Value="Transparent"/>
  <Setter Property="BorderThickness" Value="1"/>
  <Setter Property="TabNavigation" Value="Local"/>
  <Setter Property="Template">
    <Setter.Value>
      <ControlTemplate TargetType="ListBoxItem">
        <Grid x:Name="grid" Background="{TemplateBinding Background}">
          <VisualStateManager.VisualStateGroups>
            <VisualStateGroup x:Name="CommonStates">
```

```
            <VisualState x:Name="Normal"/>
            <VisualState x:Name="MouseOver">
              <Storyboard>
                <DoubleAnimationUsingKeyFrames
      Storyboard.TargetName="fillColor" Storyboard.TargetProperty="Opacity">
                  <SplineDoubleKeyFrame KeyTime="0" Value=".35"/>
                </DoubleAnimationUsingKeyFrames>
              </Storyboard>
            </VisualState>
            <VisualState x:Name="Disabled">
              <Storyboard>
                <DoubleAnimationUsingKeyFrames
  Storyboard.TargetName="contentPresenter" Storyboard.TargetProperty="Opacity">
                  <SplineDoubleKeyFrame KeyTime="0" Value=".55"/>
                </DoubleAnimationUsingKeyFrames>
              </Storyboard>
            </VisualState>
          </VisualStateGroup>
          <VisualStateGroup x:Name="SelectionStates">
            <VisualState x:Name="Unselected"/>
            <VisualState x:Name="Selected">
              <Storyboard>
                <DoubleAnimationUsingKeyFrames

      Storyboard.TargetName="fillColor2"
                  Storyboard.TargetProperty="Opacity">
                  <SplineDoubleKeyFrame KeyTime="0" Value=".75"/>
                </DoubleAnimationUsingKeyFrames>
                <DoubleAnimationUsingKeyFrames
                  BeginTime="00:00:00"
                  Duration="00:00:00.0010000"
                  Storyboard.TargetName="contentPresenter"
Storyboard.TargetProperty="(UIElement.Effect).(DropShadowEffect.ShadowDepth)">
                  <EasingDoubleKeyFrame KeyTime="00:00:00" Value="8"/>
                </DoubleAnimationUsingKeyFrames>
                <DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
                                               Duration="00:00:00.0010000"
    Storyboard.TargetName="contentPresenter"
    Storyboard.TargetProperty="(UIElement.Effect).(DropShadowEffect.Opacity)">
                  <EasingDoubleKeyFrame KeyTime="00:00:00" Value="1"/>
                </DoubleAnimationUsingKeyFrames>
              </Storyboard>
            </VisualState>
            <VisualState x:Name="SelectedUnfocused">
              <Storyboard>
```

```
                <DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
                                               Duration="00:00:00.0010000"
 Storyboard.TargetName="contentPresenter"
 Storyboard.TargetProperty="(UIElement.Effect).(DropShadowEffect.ShadowDepth)">
                  <EasingDoubleKeyFrame KeyTime="00:00:00" Value="5"/>
                </DoubleAnimationUsingKeyFrames>
                <DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
                                               Duration="00:00:00.0010000"
    Storyboard.TargetName="contentPresenter"
    Storyboard.TargetProperty="(UIElement.Effect).(DropShadowEffect.Opacity)">
                  <EasingDoubleKeyFrame KeyTime="00:00:00" Value="0.6"/>
                </DoubleAnimationUsingKeyFrames>
              </Storyboard>
            </VisualState>
          </VisualStateGroup>
          <VisualStateGroup x:Name="FocusStates">
            <VisualState x:Name="Focused">
              <Storyboard>
                <ObjectAnimationUsingKeyFrames Duration="0"
Storyboard.TargetName="FocusVisualElement" Storyboard.TargetProperty="Visibility">
                  <DiscreteObjectKeyFrame KeyTime="0">
                    <DiscreteObjectKeyFrame.Value>
                      <Visibility>Visible</Visibility>
                    </DiscreteObjectKeyFrame.Value>
                  </DiscreteObjectKeyFrame>
                </ObjectAnimationUsingKeyFrames>
              </Storyboard>
            </VisualState>
            <VisualState x:Name="Unfocused"/>
          </VisualStateGroup>
        </VisualStateManager.VisualStateGroups>
        <Rectangle x:Name="fillColor" Fill="#FFBADDE9" RadiusX="1" RadiusY="1"
                   IsHitTestVisible="False" Opacity="0"/>
        <Rectangle x:Name="fillColor2" Fill="#FFBADDE9" RadiusX="1"
                   RadiusY="1" IsHitTestVisible="False" Opacity="0"/>
        <ContentPresenter x:Name="contentPresenter"
                          HorizontalAlignment=
                          "{TemplateBinding HorizontalContentAlignment}"
                          Margin="{TemplateBinding Padding}"
                          Content="{TemplateBinding Content}"
                          ContentTemplate=
                          "{TemplateBinding ContentTemplate}">
          <ContentPresenter.Effect>
            <DropShadowEffect Opacity="0"/>
          </ContentPresenter.Effect>
```

```
          </ContentPresenter>
          <Rectangle x:Name="FocusVisualElement" Stroke="#FF6DBDD1"
                     StrokeThickness="1" RadiusX="1" RadiusY="1"
                     Visibility="Collapsed"/>
        </Grid>
      </ControlTemplate>
    </Setter.Value>
  </Setter>
</Style>
```

This control template is pretty much identical to the original as generated through Expression Blend. The only changes are the addition of a `DropShadowEffect` to the `ContentPresenter` in the template and some animated changes to some `DropShadowEffect` properties as the various selection state changes happen on the `ListBoxItem`. You can, however, change this template as much as you want to as long as it targets a `ListBoxItem`.

Listing 5-40 also shows a custom template for the entire `ValidationSummary` control that changes the `ItemTemplate` data template for the internal `ListBox`. In the interest of brevity, only the pertinent portions are shown.

Listing 5-40. *Partial implementation of a ValidationSummary control template*

```
<Style x:Key="styleValidationSummary"
       TargetType="input:ValidationSummary">
   ...
  <Setter Property="Template">
    <Setter.Value>
      <ControlTemplate TargetType="input:ValidationSummary">
        <Grid x:Name="ValidationSummary">

         ...
              <ListBox x:Name="SummaryListBox"
                       Height="Auto"
                       Style="{TemplateBinding SummaryListBoxStyle}"
                       Background="{x:Null}"
                       BorderThickness="0"
                       Foreground="{TemplateBinding Foreground}"
                       Padding="{TemplateBinding Padding}"
                       Grid.Row="1"
                       ItemContainerStyle="{TemplateBinding ErrorStyle}">
                <ListBox.ItemTemplate>
                  <DataTemplate>
                    <StackPanel Orientation="Horizontal">
                      <TextBlock Margin="4,0,0,0"
                                 FontWeight="Bold"
                                 Foreground="Red"
                                 Text="{Binding MessageHeader}" />
                      <TextBlock Margin="4,0,0,0"
```

```
                                Text="{Binding Message}" />
                    </StackPanel>
                  </DataTemplate>
                </ListBox.ItemTemplate>
              </ListBox>
             ...

            </Grid>
          </Border>
        </Grid>
      </ControlTemplate>
    </Setter.Value>
  </Setter>
</Style>
```

The only change here is in the `DataTemplate` definition; you turn the `ForeGround` color of the message header `TextBlock` to red. Listing 5-41 shows how all of this can be applied to a `ValidationSummary` control.

Listing 5-41. *ValidationSummary control with a custom template and custom header and item styles*

```
<input:ValidationSummary Grid.Row="2"
            Header="{Binding ElementName=lbx_Employees, Path=SelectedItem}"
                        Margin="0,10,0,5"
                        ErrorStyle=
                        "{StaticResource styleValidationSummaryErrorItem}"
                        Style="{StaticResource styleValidationSummary}" >
  <input:ValidationSummary.HeaderTemplate>
    <DataTemplate>
      <Grid Background="Blue">
        <Grid.ColumnDefinitions>
          <ColumnDefinition Width="Auto" />
          <ColumnDefinition Width="Auto" />
        </Grid.ColumnDefinitions>
        <TextBlock UseLayoutRounding="False"
                   Foreground="White"
                   Text="Editing Errors:" />
        <TextBlock UseLayoutRounding="False"
                   Foreground="White"
                   FontWeight="Bold"
                   Text="{Binding FullName}"
                   Grid.Column="1" />
      </Grid>
    </DataTemplate>
  </input:ValidationSummary.HeaderTemplate>
</input:ValidationSummary>
```

Note in Listing 5-40 that you apply the `ListBoxItem` template by applying the containing style to the `ValidationSummary.ErrorStyle` property and apply the custom `ValidationSummary` template by applying the containing style to the `ValidationSummary` control itself. Note also that you define a new `HeaderTemplate` data template. You display the full name of the employee whose information has suffered the edit errors by binding a `TextBlock` in the `HeaderTemplate` to the `FullName` property of the currently selected `Employee`. And the current employee selection is passed in by binding the `ValidationSummary.Header` property to the `SelectedItem` property of `lbx_Employees ListBox` using the `ElementName` attribute on the binding.

Figure 5-30b shows the `ValidationSummary` customizations applied.

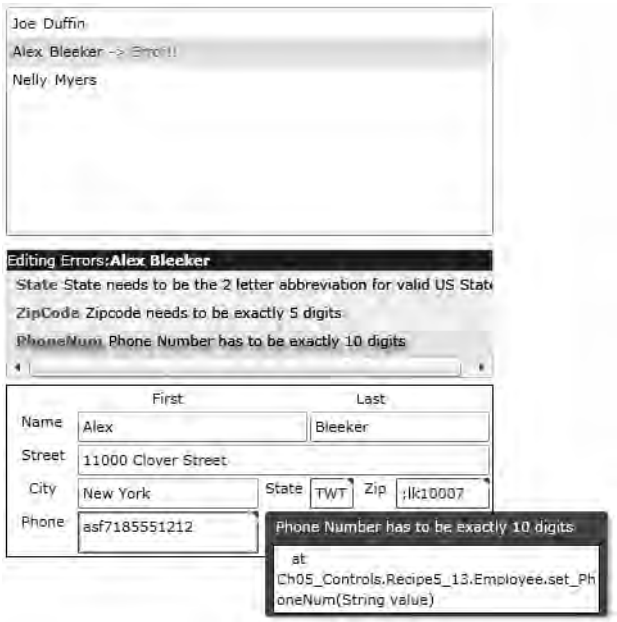


Figure 5-30b. *ValidationSummary Control customizations*

■ **Note** As a final note, we have deliberately kept the amount of modifications made to the validation UI templates here to a minimum. Our intention with this recipe was to show you the "where" and "how" of the validation UI customization mechanism. Once you know the right hooks, your creativity is the only limiting factor to how much customization you can make.

5-14. Control Behavior in Expression Blend

Problem

You want to author custom controls that integrate well with the Expression Blend 3 design environment.

Solution

Use the various designer-targeted attributes to decorate your control properties and take appropriate care to not execute control code in design mode that can cause problems within a designer environment.

How It Works

If you intend to develop custom Silverlight controls, there is always a chance that your controls will be used by designers from within Expression Blend to design application user interfaces. There are steps you can take as a control author to ensure that your controls are well behaved when used with the Expression Blend environment.

Property Attributes

There are several attributes in the `System.ComponentModel` namespace in the `System` assembly that you can use to make sure that the control properties are well integrated with the Expression Blend property editor.

CategoryAttribute

As you may have noticed, control properties are grouped into categories within the Expression Blend property editor. Some of the common property categories within Expression Blend are `Layout` and `Appearance`. To make sure your control property is displayed in the appropriate category, you can decorate your property declaration with the `CategoryAttribute`, passing in a category name string. The following code shows a sample attribution for a dependency property named `CurrentValue` to a category named `ProgressBar Values`:

```
[Category("ProgressBar Values")]
    public double CurrentValue
    {
      get { return (double)GetValue(CurrentValueProperty); }
      set { SetValue(CurrentValueProperty, value); }
}
```

This will cause a new category pane with the title ProgressBar Values to be introduced in the Blend property editor, and this property will show up in that category pane, as shown in Figure 5-31.

Figure 5-31. *A custom property category in Expression Blend*

Note that you can also add a custom control property to a pre-existing category using the same attribute—just use the pre-existing category name as the parameter when you apply the `CategoryAttribute`. Figure 5-32 shows a custom property named `Orientation` showing up in the Layout category in Blend, along with several other properties that the control inherited.

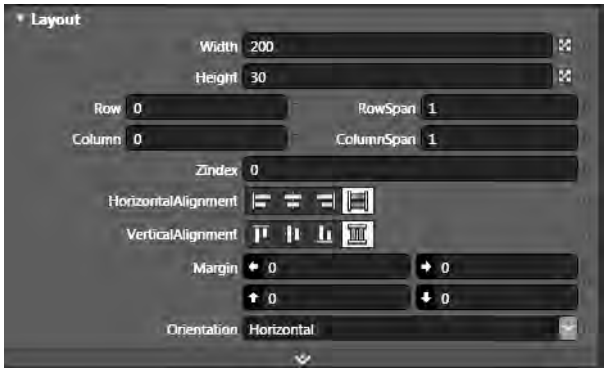


Figure 5-32. *A property added to an existing category in Expression Blend*

Also note that if you do not supply a `CategoryAttribute` to a custom property, it is displayed in the Miscellaneous category within Blend. It is always a good idea to supply a `CategoryAttribute` to help the designer intuitively find the property in an aptly named category.

DescriptionAttribute

The `DescriptionAttribute` allows you to add a short description to your property. When the designer hovers over the property label in the Expression Blend property editor, Blend displays this description in a tooltip. If applied well, these descriptions can be immensely helpful to the designer in deciphering the purpose of the property. The following code shows the `Description` attribute applied to a custom property:

```
[Description("The current value as indicated by the Progress Bar.")]
    public double CurrentValue
    {
      get { return (double)GetValue(CurrentValueProperty); }
      set { SetValue(CurrentValueProperty, value); }
}
```

Figure 5-33 shows this description being displayed within the Expression Blend property tooltip.

Figure 5-33. *DescriptionAttribute applied to a property*

EditorBrowsableAttribute

The `EditorBrowsableAttribute` controls whether a property can be made visible in the property editor in Expression Blend, and if so, in what capacity. You can pass in one of three possible enumerated values in constructing the attribute instance. `EditorBrowsableState.Always` causes the property to be displayed in the default manner, whereas `EditorBrowsableState.Never` hides the property from being visible in the property editor. If you have a property that you intend to set only programmatically and not by a designer, this option might be a good one to use. And last, `EditorBrowsableState.Advanced` shows the property in the advanced section of the property pane for that category. The advanced section is collapsed by default and can be expanded by clicking the small arrow icon at the bottom-center of the property pane. This expanded section allows you to potentially mark certain properties for only advanced use. The following code applies the `EditorBrowsableAttribute` to a property, using the `EditorBrowsableState.Advanced` enumerated value. Also note that more than one of these attributes can be applied to a property as needed:

```
[Category("ProgressBar Values")]
    [Description("The maximum value that can be measured by the Progress Bar")]
    [EditorBrowsable(EditorBrowsableState.Advanced)]
    public double MaximumValue
    {
      get { return (double)GetValue(MaximumValueProperty); }
      set { SetValue(MaximumValueProperty, value); }
}
```

Figure 5-34 shows this property in the advanced portion of the property pane.

Figure 5-34. *EditorBrowsableAttribute setting on a property*

Designer-Unsafe Code

Although a custom control should be as general purpose as possible, there are custom controls in which control logic involves execution of code that relies on other aspects of the consuming application. An example of this could be parts of the control code calling out to a web service or being reliant on the presence of another application object in memory.

Keep in mind that when your control is loaded by Expression Blend, it is not running within the context of an application. In fact, application-dependent logic may actually cause exceptions that will result in Expression Blend failing to loading your control at design time. If you cannot avoid having that kind of logic in your control, you need to guard it so that it does not execute when the control is loaded in a designer.

The best way to protect your application-dependent logic is to use the `System.ComponentModel.DesignerProperties` static class. The `DesignerProperties.IsInDesignTool` property returns `true` when the control is in design mode, and `false` otherwise. So when you want to execute control logic only if the control is being used outside the designer environment, you can conditionally execute that code only when `DesignerProperties.IsInDesignTool` is `false`.

When Expression Blend loads your custom control to the design surface, it will execute the control constructor and your override for the `OnApplyTemplate()` method, if you have one. It will also execute any `DependencyProperty` change handlers that you may have associated with your `DependencyProperty` definitions when these properties are set for the first time (the default settings applied through the `PropertyMetadata`) or as they are set at design time through the property editor. These areas in your control code are where you should be especially careful to guard any code that might not execute successfully outside the context of an application.

Including Sample Data

Controls often get the data they display from runtime data bindings. `ContentControl` and `ItemsControl` types (and their derivatives) are great examples of this. However, at design time, for a user to visualize the changes that some of their property settings might make on the control's look and feel, it is beneficial to have the control show some sample data within the designer. You can easily supply this data in your code, but you need to make sure that this code executes only when the control is being used within a designer—in effect, exactly the opposite behavior from that discussed in the previous section. The `DesignerProperties.IsInDesignTool` property can help here as well. With it, you can execute the code that adds sample data to your control at design time, only when the `IsInDesignTool` property is set to `True`. The following code shows the `Content` property of a custom `ProgressBar` control being set to some mock content at design time—in both the `OnApplyTemplate()` override as the initial value and the `DependencyProperty` change handler for the `CurrentValue` property. In both cases, you guard the code to ensure that this code only executes within the designer like so:

```
public override void OnApplyTemplate()
{
  base.OnApplyTemplate();
  //other code
  if (DesignerProperties.IsInDesignTool)
  {
    this.Content = string.Format("Progress {0}%", this.CurrentValue);
  }

}
internal static void OnCurrentValueChanged(DependencyObject Target,
  DependencyPropertyChangedEventArgs e)
{
  ProgressBar pBar = Target as ProgressBar;
  //other code
  if (DesignerProperties.IsInDesignTool)
  {
    pBar.Content = string.Format("Progress {0}%", (double)e.NewValue);
  }

}
```

Figure 5-35 shows the state of the `ProgressBar` control with the sample data in the designer when the `CurrentValue` property is changed to 30.

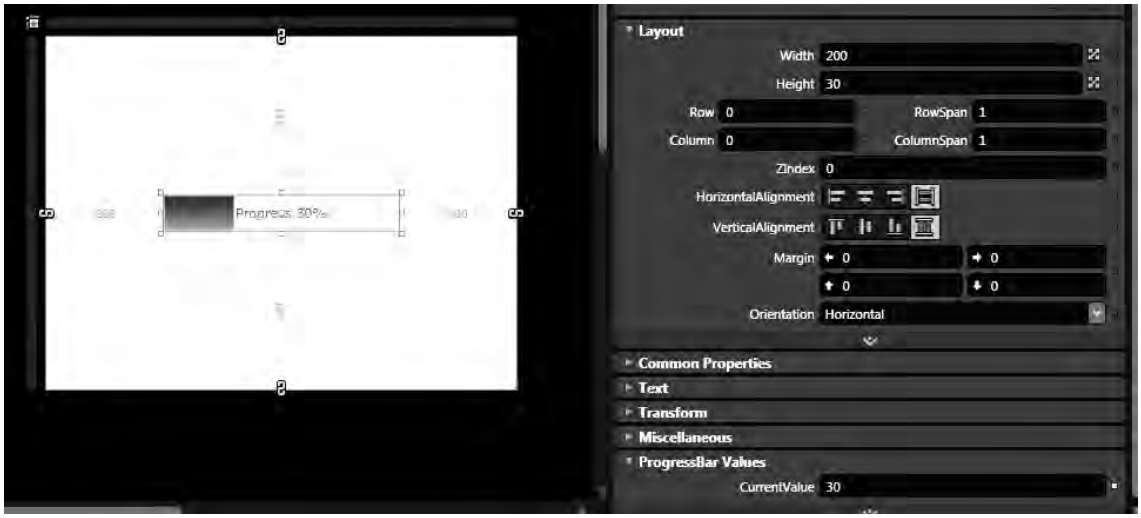


Figure 5-35. *Custom Control with sample content*

The Code

To illustrate these ideas, we show the application of the attributes and practices discussed on the sample ProgressBar control built in Recipe 5-10. Listing 5-42 shows the code for the control. Since there are no changes to the control template, the XAML is not listed here. To see the effects of this code, place this control on a XAML page within Expression Blend and play with the various custom properties in the property editor.

Listing 5-42. *ProgressBar control sample with designer-related attribution and practices*

```
using System.Windows;
using System.Windows.Controls;
using System.Windows.Shapes;
using System.ComponentModel;

namespace Recipe5_14
{
  [TemplatePart(Name="elemPBar",Type=typeof(FrameworkElement))]
  public class ProgressBar : ContentControl
  {

    public static DependencyProperty CurrentValueProperty =
      DependencyProperty.Register("CurrentValue",
      typeof(double), typeof(ProgressBar),
      new PropertyMetadata(0.0,
        new PropertyChangedCallback(ProgressBar.OnCurrentValueChanged)));
    [Category("ProgressBar Values")]
```

```
[Description("The current value indicated by the Progress Bar")]
public double CurrentValue
{
  get { return (double)GetValue(CurrentValueProperty); }
  set { SetValue(CurrentValueProperty, value); }
}

public static DependencyProperty MaximumValueProperty =
  DependencyProperty.Register("MaximumValue",
  typeof(double), typeof(ProgressBar), new PropertyMetadata(100.0));

[Category("ProgressBar Values")]
[Description("The maximum value that can be measured by the Progress Bar")]
[EditorBrowsable(EditorBrowsableState.Advanced)]
public double MaximumValue
{
  get { return (double)GetValue(MaximumValueProperty); }
  set { SetValue(MaximumValueProperty, value); }
}

public static DependencyProperty MinimumValueProperty =
  DependencyProperty.Register("MinimumValue",
  typeof(double), typeof(ProgressBar), new PropertyMetadata(0.0));

[Category("ProgressBar Values")]
[EditorBrowsable(EditorBrowsableState.Advanced)]
[Description("The minimum value that can be measured by the Progress Bar")]
public double MinimumValue
{
  get { return (double)GetValue(MinimumValueProperty); }
  set { SetValue(MinimumValueProperty, value); }    }

[Category("Layout")]
public Orientation Orientation
{
  get { return (Orientation)GetValue(OrientationProperty); }
  set { SetValue(OrientationProperty, value); }
}

public static readonly DependencyProperty OrientationProperty =
    DependencyProperty.Register("Orientation",
    typeof(Orientation), typeof(ProgressBar),
    new PropertyMetadata(Orientation.Horizontal));
internal FrameworkElement elemPBar { get; set; }
```

```
    public ProgressBar()
    {
      base.DefaultStyleKey = typeof(ProgressBar);
    }

    public override void OnApplyTemplate()
    {
      base.OnApplyTemplate();
      elemPBar = this.GetTemplateChild("elemPBar") as FrameworkElement;

      if (DesignerProperties.IsInDesignTool)
      {
        this.Content = string.Format("Progress {0}%",this.CurrentValue);
      }

    }


    internal static void OnCurrentValueChanged(DependencyObject Target,
      DependencyPropertyChangedEventArgs e)
    {
      ProgressBar pBar = Target as ProgressBar;
      if (pBar.elemPBar != null)
      {
        pBar.elemPBar.Width = (pBar.ActualWidth * (double)e.NewValue)
          / (pBar.MaximumValue - pBar.MinimumValue);
      }
      if (DesignerProperties.IsInDesignTool)
      {
        pBar.Content = string.Format("Progress {0}%", (double)e.NewValue);
      }

    }

  }
}
```

5.15 Enhancing the Design Experience with Behaviors and Triggers

Problem

You want to package reusable application behaviors in code for easy consumption by designers using Expression Blend.

Solution

Use the behavior, trigger, and action concepts from the Expression Blend SDK to package and expose your reusable behaviors.

How It Works

It is not uncommon for developers to have to add repetitive code to expose certain behaviors in their applications. Take, for example, a video player that has a `MediaElement` and a `Slider` control representing the video timeline. It is common practice to add a timer to your code and move the slider thumb automatically as the timer ticks, in response to the playing video's progression through its duration. What is the best way to package such code so that designers (who typically work within Expression Blend and not directly with code) can easily use a visual paradigm, such as drag and drop, to add these types of behaviors to the application at design time?

The Expression Blend SDK exposes the concepts of behaviors, triggers, and actions that allow a developer to encapsulate code and expose them to designers through Blend so that they can be applied to all applications at design time.

The sample here uses Expression Blend and the associated SDK. You will find all the necessary classes in a namespace named `System.Windows.Interactivity` in an identically named assembly available as a part of the Expression Blend SDK.

Behavior

A Blend behavior is represented by the `Behavior<T>` type where T is the type of object that the behavior can be associated with at design time. The `Behavior<T>` type extends the `Behavior` type which defines the `Behavior.AssociatedObject` property and two virtual methods, `OnAttached()` and `OnDetaching()`. To implement your custom behavior, you will need to derive from `Behavior<T>` and associate the behavior with the target object in XAML. Once the behavior is added to your project, Blend displays the behavior in the Assets tab. Then, you attach the behavior to the target object by dragging and dropping the behavior on the object in Blend. Figure 5-36 shows the Assets tab with the Behaviors listed and the object tree with the `Behavior` applied to a `MediaElement`.

Figure 5-36. *Assets tab with behaviors*

A `Behavior` instance does not need any external stimulus to act; it simply executes a set of methods during the lifecycle of the object it is associated with. The `OnAttached()` method is executed when the behavior attaches itself to the target object, and the `OnDetaching()` method executes when the behavior detaches itself from the target object (typically when the target object goes out of scope). To implement your own custom behavior, you will need to provide concrete implementations of `OnAttached()` and `OnDetaching()` in your `Behavior<t>` derived class. The `Behavior.AssociatedObject` property represents the actual object instance at the runtime that the behavior is attached to. Most custom behaviors typically associate event handlers to events on the `AssociatedObject` in the `OnAttached()` implementation and take specific actions when those events occur to express the desired behavior. You will see a behavior implementation in the code sample later.

Triggers and Actions

While behaviors do not accept a specific stimulus to get executed, that scenario is enabled using a trigger/action pair. A trigger represents a specific stimulus and causes one or more actions to execute.

A trigger is represented through the `TriggerBase` class, with a `TriggerBase<T>` class derived from `TriggerBase` that allows you to specify the type to which the trigger applies. `TriggerBase` also defines the `OnAttached()` and `OnDetaching()` methods and the `AssociatedObject` property similar to a `Behavior` with the same intended usage. To implement your concrete trigger, you will typically derive from `TriggerBase<T>.`

`TriggerBase` also defines an `Invoke()` method which you can call from your trigger implementation to actually cause the trigger to fire all associated actions. The associated actions are contained in the `Actions` property of type `TriggerActionCollection` on the `TriggerBase` class. The `Invoke()` method accepts a parameter of type `Object` that gets passed in to the action. This allows you to pass in any state information from the trigger to the action.

To implement an action, you can derive from either `TriggerAction<T>` or `TargetedTriggerAction<T>`, where T is the type of the object the action acts upon. Both types define the standard `OnAttached( )` and `OnDetaching()` lifecycle methods, as well as the `AssociatedObject` property with identical semantics as described before. They also provide a virtual method named `Invoke()` which you override in your derived action implementation to implement the actual action logic. The state passed in through the `Trigger.Invoke()` method is made available to your implementation of the action through the only parameter to the `Invoke()` method on the action.

The `TargetedTriggerAction<T>` type is special in that it allows you to have the action be executed on a target object that is different from the object on which the trigger was fired. The `Target` property on the `TargetedTriggerAction` specifies the target to which the action is applied, which is different from the `AssociatedObject` property.

TargetedTriggerAction also exposes a TargetChanged() method that is executed whenever the target of the action is first set and later changed, and the oldTarget and newTarget parameters provide you the old and new target objects. Associating a TriggerAction with an object in Blend is very similar to associating a behavior.

The Code

The code sample illustrates a Behavior and a TriggerBase/TargetedTriggerAction pair. Both are implemented in the 5.15 TriggerLib project in the sample code for this recipe.

The behavior targets the MediaElement type and allows the user to click on the any MediaElement to which the behavior is attached to start playing if it is paused or pause if it is playing. Listing 5-43 shows the behavior code.

Listing 5-43. *Code for MediaElementStartPauseBehavior*

```
public class MediaElementStartPauseBehavior : Behavior<MediaElement>
{
  bool MouseDown = false;
  protected override void OnAttached()
  {
    base.OnAttached();
    //handle the appropriate mouse events on the MediaElement
    this.AssociatedObject.MouseLeftButtonDown +=
      new MouseButtonEventHandler(AssociatedObject_MouseLeftButtonDown);
    this.AssociatedObject.MouseLeftButtonUp +=
      new MouseButtonEventHandler(AssociatedObject_MouseLeftButtonUp);
    this.AssociatedObject.MouseLeave +=
      new MouseEventHandler(AssociatedObject_MouseLeave);
  }

  void AssociatedObject_MouseLeave(object sender, MouseEventArgs e)
  {
    //leaving the MediaElement - release capture is captured
    if (MouseDown)
    {
      MouseDown = false;
      this.AssociatedObject.ReleaseMouseCapture();
    }
  }

  void AssociatedObject_MouseLeftButtonUp(object sender,
    MouseButtonEventArgs e)
  {
    //click completed
    if (MouseDown)
    {
```

```
      //if playing
      if (this.AssociatedObject.CurrentState == MediaElementState.Playing)
      {
        //pause
        this.AssociatedObject.Pause();
      }
      else
      {
        //play
        this.AssociatedObject.Play();
      }
      //release capture
      this.AssociatedObject.ReleaseMouseCapture();
      MouseDown = false;
    }
  }

  void AssociatedObject_MouseLeftButtonDown(object sender,
    MouseButtonEventArgs e)
  {
    //capture mouse
    if (MouseDown == false)
    {
      MouseDown = true;
      this.AssociatedObject.CaptureMouse();
    }
  }

  protected override void OnDetaching()
  {
    base.OnDetaching();
    //unhook handlers
    this.AssociatedObject.MouseLeftButtonDown -=
      AssociatedObject_MouseLeftButtonDown;
    this.AssociatedObject.MouseLeftButtonUp -=
      AssociatedObject_MouseLeftButtonUp;
    this.AssociatedObject.MouseLeave -=
      AssociatedObject_MouseLeave;
  }
}
```

As you can see, you attach handlers to the appropriate mouse events on the `MediaElement` (made available through the `AssociatedObject` property) in the `OnAttached()` override and detach the handlers in the `OnDetaching()` implementation. In your `MouseLeftButtonUp` event handler, you simply check the `MediaElement.CurrentState` property and accordingly either start playing or pause the media. The rest

of the mouse event handlers implement some housekeeping code around mouse event handling. Listing 5-44 shows the XAML for the behavior attached to a `MediaElement`, where `i` is the XML namespace declaration for the assembly containing the behavior.

Listing 5-44. *XAML for the behavior applied to a MediaElement*

```
<MediaElement x:Name="mediaElement" AutoPlay="True" Height="270"
            Margin="15,15,8,15"
            Source="http://localhost/media/AdrenalineRush.wmv"
            Stretch="Fill">
  <i:Interaction.Behaviors>
    <Triggers:MediaElementStartPauseBehavior/>
  </i:Interaction.Behaviors>
</MediaElement>
```

For your trigger/action sample, you implement a trigger that applies to a `MediaElement` that starts a timer and executes at a specific interval while the media plays. Listing 5-45 shows the code for the trigger.

Listing 5-45. *Code for MediaElementPlaybackTrigger*

```
public class MediaElementPlaybackTrigger : TriggerBase<MediaElement>
{
  DispatcherTimer playbacktimer = new DispatcherTimer();
  public double Interval
  {
    get { return (double)GetValue(IntervalProperty); }
    set { SetValue(IntervalProperty, value); }
  }

  // Using a DependencyProperty as the backing store for Interval.  This enables animation,
styling, binding, etc...
  public static readonly DependencyProperty IntervalProperty =
      DependencyProperty.Register("Interval", typeof(double),
      typeof(MediaElementPlaybackTrigger), new PropertyMetadata(200));

  protected override void OnAttached()
  {
    base.OnAttached();
    this.AssociatedObject.CurrentStateChanged +=
      new RoutedEventHandler(AssociatedObject_CurrentStateChanged);
    playbacktimer.Interval = TimeSpan.FromMilliseconds(Interval);
    playbacktimer.Tick += new EventHandler(playbacktimer_Tick);
  }

  void playbacktimer_Tick(object sender, EventArgs e)
  {
```

```
    this.InvokeActions(this.AssociatedObject.Position.TotalMilliseconds /
      this.AssociatedObject.NaturalDuration.TimeSpan.TotalMilliseconds);
  }

  void AssociatedObject_CurrentStateChanged(object sender, RoutedEventArgs e)
  {
    if (this.AssociatedObject.CurrentState == MediaElementState.Playing)
    {
      playbacktimer.Start();
    }
    else
    {
      playbacktimer.Stop();
    }
  }
  protected override void OnDetaching()
  {
    base.OnDetaching();
    this.AssociatedObject.CurrentStateChanged -=
      AssociatedObject_CurrentStateChanged;
    playbacktimer.Tick -= playbacktimer_Tick;
  }
}
```

You declare a property named `Interval` that allows the designer to specify in milliseconds how frequently the timer needs to fire. In the `OnAttached()` implementation, you initialize the timer and set its interval as set in the `Interval` property. You also attach a handler to the `Tick` event of the timer, as well as the `CurrentStateChanged` event of the `MediaElement` (available through the `AssociatedObject` property). In the handler for the `MediaElement.CurrentStateChanged`, you either start or stop the timer depending on whether the media is playing or not. In the `Tick` event handler of the timer, you invoke any associated actions passing in the current state of play as a ratio of the current position to the total duration in milliseconds. Listing 5-46 shows the related `TargetedTriggerAction`.

Listing 5-46. *Code for the SliderPlaybackProgressAction*

```
public class SliderPlaybackProgressAction : TargetedTriggerAction<Slider>
{
  protected override void OnAttached()
  {
    base.OnAttached();
  }
  protected override void OnDetaching()
  {
    base.OnDetaching();
  }
  protected override void OnTargetChanged(Slider oldTarget, Slider newTarget)
```

```
  {
    base.OnTargetChanged(oldTarget, newTarget);
  }
  protected override void Invoke(object parameter)
  {
    (this.Target as Slider).Value = 100 * (double)parameter;
  }
}
```

In the `Invoke()` override in the action, you simply set the `Slider.Value` to a percentage value as obtained through the passed in state. In your implementation, the `Slider.MaxValue` is set to 100 and the `Slider.MinValue` is set to 1, but if you define a different range, you will need to change this logic appropriately. Listing 5-47 shows the XAML of the trigger and the action applied to the `MediaElement`.

Listing 5-47 *XAML for the trigger and the action*

```
<MediaElement x:Name="mediaElement" AutoPlay="True" Height="270"
              Margin="15,15,8,15" Source="http://localhost/media/AdrenalineRush.wmv"
              Stretch="Fill">
        <i:Interaction.Triggers>
                <Triggers:MediaElementPlaybackTrigger>
                        <Triggers:SliderPlaybackProgressAction TargetName="slider"
 />
                </Triggers:MediaElementPlaybackTrigger>
        </i:Interaction.Triggers>
        <i:Interaction.Behaviors>
                <Triggers:MediaElementStartPauseBehavior/>
        </i:Interaction.Behaviors>
</MediaElement>
<Slider x:Name="slider" Minimum="0" Maximum="100" Value="0" Margin="0"/>
```

Note that the action actually refers to the `Slider` control through its `TargetName` property. This is possible because you use the `TargetedTriggerAction` type as the base class, which allows you to target the action to a different element on the page other than the `MediaElement`.

To associate the trigger and the action, you drag and drop the action on the `MediaElement` in Blend as you would do for the behavior. Once you have associated the action, you can go to the property page of the associated action and select a trigger for the action. Figure 5-37 shows the action property page.

Figure 5-37. *Property page for SliderPlaybackProgressAction.*

You can click the New button for the TriggerType field, which brings up a selection dialog shown in Figure 5-38 to allow you to select the appropriate trigger for the action.

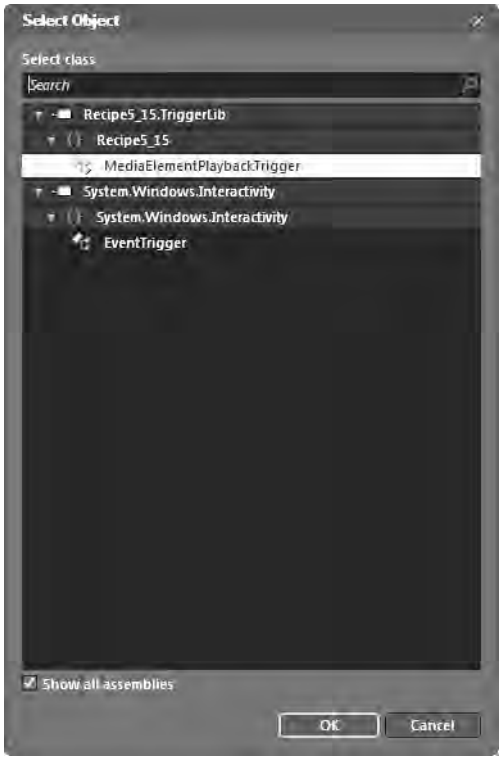


Figure 5-38. *Trigger selection dialog.*

Once you select the `MediaElementPlaybackTrigger`, you are returned to the property page for the action, where you can now set the Interval property on the trigger as well, as shown in Figure 5-39.

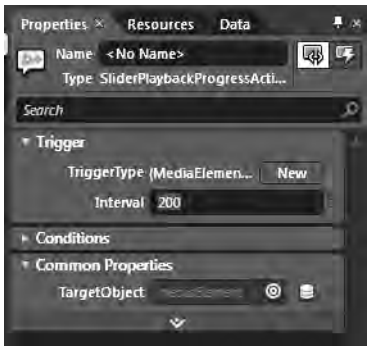


Figure 5-39. *Trigger property setting*

Note that the XAML for the trigger, action, and behavior shown earlier is automatically generated as you use Blend to apply these constructs to your code.

CHAPTER 6

Browser Integration

Silverlight 4 is a web browser–hosted control that runs in Internet Explorer, Firefox, and Chrome on the PC and Macintosh computers. As such, there will be scenarios where developers need to customize how the control is configured. There will also be cases where developers need to modify the web browser Document Object Model (DOM) from Silverlight as well as situations where developers need to modify the Silverlight application from the DOM.

Note Any performance or functionality differences that appear among Firefox, Safari, and Internet Explorer are considered bugs by Microsoft.

In Chapter 2, which focuses on the basics of the Silverlight programming model, we included recipes related to interacting with the browser:

- **Recipe 2-1. Leverage and Locate Custom Controls** demonstrates how to use `FindName` from JavaScript to locate and manipulate XAML elements from JavaScript.
- **Recipe 2-2. Dynamically Loading XAML** implements JavaScript that creates a piece of XAML and attaches it to the Silverlight control Visual Tree.

In this chapter, we cover how to customize the Silverlight 4 plug-in control within the browser. We also explain how to interact with the web browser DOM to provide a fully integrated web browsing experience.

6-1. Host Silverlight on Any Technology

Problem

You need to host the Silverlight 4 content in any technology that renders HTML.

Solution

Configure the Silverlight 4 browser control directly in HTML using the `<object>` tag. Modify or create JavaScript functions for error handling, loading, resizing, and so forth.

How It Works

The Silverlight 4 browser control is configurable with any web server-side technology such as ASP.NET, ASP classic, Java Server Pages (JSP), Ruby, or PHP because it is configured using the standard HTML `<object>` tag.

When you create a new Silverlight application, you have the option of having the project wizard create two test pages for the new Silverlight application, an `.aspx` test page and an `.html` test page. These pages serve as a starting point for configuring the Silverlight control. Here is a sample `<object>` tag that can be placed into any HTML page rendering technology, whether ASP.NET, Java Server Pages, PHP, or plain old HTML:

```
<object data="data:application/x-silverlight-2,"
type="application/x-silverlight-2"
  width="100%" height="100%">
  <param name="source" value="ClientBin/Ch06_BrowserIntegration.Recipe6_1.xap" />
  <param name="onError" value="onSilverlightError" />
  <param name="background" value="white" />
  <param name="minRuntimeVersion" value="4.0.50401.0" />
  <param name="autoUpgrade" value="true" />
  <a href="http://go.microsoft.com/fwlink/?LinkID=
149156&v=4.0.50401.0" style="text-decoration: none">
    <img src="http://go.microsoft.com/fwlink/?
LinkId=161376" alt="Get Microsoft Silverlight"
      style="border-style: none" />
  </a>
</object>
```

The typical page includes a few CSS styles and a JavaScript function named `onSilverlightError` as well as a script include for `Silverlight.js`. The `onSilverlightError` function provides reporting for errors that are not handled within the Silverlight application. Some errors cannot be handled in the Silverlight application, such as problems downloading the application `.xap` file.

Unhandled errors in the Silverlight application will bubble up to the Silverlight browser control and be reported to the user via the `onSilverlightError` function or any custom JavaScript function you write. By default, the `onSilverlightError` function is wired to the Silverlight control in the following line of code:

```
<param name="onerror" value="onSilverlightError" />
```

You do not have to use the `onSilverlightError` function as is. You can customize it or tap into any existing JavaScript error-handling routines that are part of an existing application as long at the handler has the same message signature.

■ **Caution** Any errors bubbled up to the `onSilverlightError` function will cause the Silverlight application to stop working. Try to handle all errors within the Silverlight application. Only catastrophic errors should be allowed to bubble up.

Within the `<object>` tag are `<param>` tags that define parameters configured for the Silverlight browser plug-in. The one mandatory parameter is `source`, which defines the location of the application `.xap` file, or optionally, points to inline XAML if you're using the Silverlight unmanaged JavaScript programming model.

Recommended events are `onError` and `onResize`. As mentioned earlier, by default, the `onError` parameter is set to the `onSilverlightError` function to report unhandled exceptions as well as runtime errors that occur at the plug-in level in the HTML page. The `onResize` event is covered in Recipe 6-4. Table 6-1 lists other interesting parameters.

Table 6-1. *Additional Optional Parameters*

Parameter	Description
`autoUpgrade`	Allows the developer to control whether an end user's Silverlight plug-in should be upgraded. The end user can still opt out even if the option is set to `true`.
`background`	Sets the background color for the Silverlight 4 plug-in behind any Silverlight application content that renders to the content area but in front of HTML. This property defaults to `null`.
`enableFramerateCounter`	Displays the current frame rate in the browser's status bar in Internet Explorer on Windows. The default is `false`.
`enableHtmlAccess`	Enables or disables access to the web browser DOM. The default value is `false`. Set it to `true` if you want to access the web page from Silverlight. See Recipe 6-5 for more information.
`initParams`	Comma-delimited string of initialization information in the form of `key1=value1, key2=value2,` and so on that can be accessed within Silverlight using managed code. Recipes 6-7 and 6-8 show you how to process parameters.
`minRuntimeVersion`	Specifies the minimum Silverlight runtime version required by the Silverlight application.
`maxFrameRate`	Specifies the upper limit on the frame rate for rendering content, with a default value of 60 frames per second.
`onLoad`	Set to a JavaScript function that fires after the Silverlight plug-in is instantiated and the XAML Visual Tree is loaded. See Recipe 2-4 for an example that uses `onLoad`.

windowless	When the windowless param is set to true (not the default), the Silverlight plug-in does not have its own rendering window. Instead, the plug-in content is displayed directly by the browser window. This enables Silverlight content to visually overlap and blend with HTML content if the plug-in and its content both specify background transparency.
splashScreenSource	Set to the value of an .xaml file that is displayed as a splash screen while the application pointed to in the Source parameter is downloaded. See the MSDN documentation at msdn.microsoft.com/en-us/library/system.web.ui.silverlightcontrols.silverlight.splashscreensource(VS.95).aspx.

For more information on the other available parameters and instantiation objects, refer to the MSDN Silverlight documentation at msdn.microsoft.com/en-us/library/cc838259%28v=VS.95%29.aspx.

Within the <object> tag is an <a> HTML tag that displays the "Get Silverlight" image when the browser plug-in is not installed. Clicking the image will download the browser plug-in required by the Silverlight application. Since this recipe is about the HTML page, we don't do anything relevant within the Silverlight application itself.

The Code

We generally do not show the source code for the hosting HTML page or ASPX page in our recipes, because most of the work is done in the MainPage.xaml and MainPage.xaml.cs files that are in the Silverlight 4 application project. In this recipe, however, we will walk through the source for the HTML test page, which can be used with any web serving technology. Listing 6-1 serves as a starting point for hosting the Silverlight browser control generated by Visual Studio, but you can use it as a starting point for hosting Silverlight 4 in any web technology.

The HTML page in Listing 6-1 consists of a few CSS styles to lay out the page, an error handling JavaScript script, and the HTML to host the control. The script reports runtime errors or unhandled exceptions by passing the error message to the browser in this line of code:

```
throw new Error(errMsg);
```

You can modify the JavaScript event as needed. For example, at the end of the onSilverlightError function you could instead assign errMessage to a tag added to the page, and the message will be displayed in the tag to the user with a message to restart.

Listing 6-1. *Typical Recipe HTML Test Page File*

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
  "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head runat="server">
  <title>Test Page for Recipe 6.1</title>
  <style type="text/css">
    html, body
    {
      height: 100%;
```

```
    overflow: auto;
  }
  body
  {
    padding: 0;
    margin: 0;
  }
  #silverlightControlHost
  {
    height: 100%;
    text-align: center;
  }
</style>
<script type="text/javascript" src="Silverlight.js"></script>
<script type="text/javascript">
  function onSilverlightError(sender, args) {
    var appSource = "";
    if (sender != null && sender != 0) {
      appSource = sender.getHost().Source;
    }

    var errorType = args.ErrorType;
    var iErrorCode = args.ErrorCode;

    if (errorType == "ImageError" || errorType == "MediaError") {
      return;
    }

    var errMsg = "Unhandled Error in Silverlight Application "
     + appSource + "\n";

    errMsg += "Code: " + iErrorCode + "    \n";
    errMsg += "Category: " + errorType + "       \n";
    errMsg += "Message: " + args.ErrorMessage + "     \n";

    if (errorType == "ParserError") {
      errMsg += "File: " + args.xamlFile + "     \n";
      errMsg += "Line: " + args.lineNumber + "     \n";
      errMsg += "Position: " + args.charPosition + "     \n";
    }
    else if (errorType == "RuntimeError") {
      if (args.lineNumber != 0) {
        errMsg += "Line: " + args.lineNumber + "     \n";
        errMsg += "Position: " + args.charPosition + "     \n";
      }
```

```
        errMsg += "MethodName: " + args.methodName + "     \n";
      }

      throw new Error(errMsg);
    }
  </script>
</head>
<body>
  <form id="form1" runat="server" style="height: 100%">
  <div id="silverlightControlHost">
    <object data="data:application/x-silverlight-2,"
      type="application/x-silverlight-2"
      width="100%" height="100%">
      <param name="source" value="ClientBin/Ch06_BrowserIntegration.Recipe6_1.xap" />
      <param name="onError" value="onSilverlightError" />
      <param name="background" value="white" />
      <param name="minRuntimeVersion" value="4.0.50401.0" />
      <param name="autoUpgrade" value="true" />
      <a href="http://go.microsoft.com/fwlink/?
    LinkID=149156&v=4.0.50401.0" style="text-decoration: none">
        <img src="http://go.microsoft.com/fwlink/?
    LinkId=161376" alt="Get Microsoft Silverlight"
          style="border-style: none" />
      </a>
    </object>
    <iframe id="_sl_historyFrame"
     style="visibility:hidden;height:0px;width: 0px;
      border:0px"></iframe>
  </div>
  </form>
</body>
</html>
```

6-2. Setting Focus for Keyboard Input

Problem

You want to ensure that the Silverlight control in a web page has focus when the page initially loads.

Solution

Create a JavaScript event handler and assign it to the Silverlight browser control's `onLoad` event handler.

How It Works

There are two levels of focus within a Silverlight application: at the browser level and within the Silverlight control itself. The Silverlight control cannot receive keyboard input unless it has focus within the web browser.

One way to ensure that the Silverlight application is completely downloaded and fully loaded is to create an `onload` JavaScript event handler sets the focus to the Silverlight control. Attach the `onload` event handler to the Silverlight browser control, and then set the focus on the control.

The Code

First, create a simple Silverlight application that has a `TextBlock` with a title for the screen and three `TextBox` controls for first name, last name, and favorite color.

Besides the layout and gradient modifications, you also set `TabIndex` to 0 for the Enter First Name `TextBox`, set `TabIndex` to 1 for the Enter Last Name `TextBox`, and set `TabIndex` to 2 for the Enter Favorite Color `TextBox`. At this point, when you run the application, the cursor is not blinking in the `TextFirstName` `TextBox`, because the Silverlight application does not have focus on initial web page load. If you click anywhere on the Silverlight application, focus is sent to the `TextFirstName` `TextBox` because it has a tab index of 0.

The next bit of code for this recipe sets focus on the Silverlight browser control using JavaScript on the web page. You first modify the HTML page by assigning an ID of `Silverlight1` to the `<object>` element that defines the Silverlight browser control. After that, you add a simple JavaScript event handler to a `<script>` block that sets focus on the `<object>` element for the Silverlight browser control:

```
function onSilverlightLoad(sender, args)
{
  var ctrl = document.getElementById("Silverlight1");
  ctrl.focus();
}
```

The final step is to wire the `onSilverlightLoad` event handler into the Silverlight browser control's `onload` event with this line of code within the `<object>` tag:

```
<param name="onload" value="onSilverlightLoad" />
```

When you run the page, you can see that focus is set on the first `TextBox` on loading the web page. To verify the behavior, remove the `<param>` tag for setting `onload`, and run the page again to see that focus is not moved to the Silverlight control without the `onload` event handler. Figure 6-1 shows the page as initially loaded without clicking the web page or the Silverlight browser control. Listing 6-2 shows the source code for the Silverlight application, and Listing 6-3 contains the source code for the HTML file, which is the same for the .aspx file.

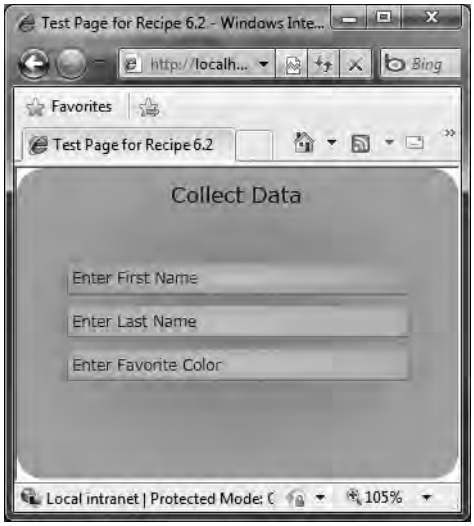


Figure 6-1. *Focus set on TextBox with TabIndex of 0*

Listing 6-2. *Recipe 6-2's MainPage.xaml File*

```
<UserControl x:Class="Ch06_BrowserIntegration.Recipe6_2.MainPage"
    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"
    mc:Ignorable="d"
    d:DesignHeight="204" d:DesignWidth="199">
  <Border CornerRadius="20,20,20,20">
    <Border.Background>
      <RadialGradientBrush>
        <GradientStop Color="#FFFA6607" Offset="0.0040000001899898052"/>
        <GradientStop Color="#FFD4A282" Offset="1"/>
      </RadialGradientBrush>
    </Border.Background>
    <Grid x:Name="LayoutRoot" Margin="4,4,4,4">
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="0.078*"/>
        <ColumnDefinition Width="0.844*"/>
        <ColumnDefinition Width="0.078*"/>
      </Grid.ColumnDefinitions>
      <Grid.RowDefinitions>
        <RowDefinition Height="0.26*"/>
        <RowDefinition Height="0.74*"/>
      </Grid.RowDefinitions>
```

```
      <TextBlock Margin="4,4,6,23" FontSize="16" TextAlignment="Center"
       TextWrapping="Wrap" Grid.Column="1" d:LayoutOverrides="Height">
       <Run Foreground="#FF000080" Text="Collect Data"/></TextBlock>
      <StackPanel Margin="4,4,4,4" Grid.Row="1" Grid.Column="1">
        <Border Height="Auto" Width="Auto" CornerRadius="10,10,10,10"
           Margin="4,4,4,4">
          <Border.Background>
            <RadialGradientBrush SpreadMethod="Pad">
              <GradientStop Color="#FFD0CDAF"/>
              <GradientStop Color="#FF69E247" Offset="1"/>
            </RadialGradientBrush>
          </Border.Background>
          <TextBox Background="{x:Null}" Height="Auto" x:Name="TextFirstName"
           Width="Auto" Foreground="#FF0000FF" Text="Enter First Name"
           TextWrapping="Wrap" TabIndex="0"/>
        </Border>
        <Border Height="Auto" CornerRadius="10,10,10,10" Width="Auto"
          Margin="4,4,4,4">
          <Border.Background>
            <RadialGradientBrush SpreadMethod="Pad">
              <GradientStop Color="#FFD0CDAF"/>
              <GradientStop Color="#FF94E247" Offset="1"/>
            </RadialGradientBrush>
          </Border.Background>
          <TextBox Background="{x:Null}" Height="Auto" x:Name="TextLastName"
           Width="Auto" Foreground="#FF0000FF" Text="Enter Last Name"
           TextWrapping="Wrap" TabIndex="1"/>
        </Border>
        <Border Height="Auto" CornerRadius="10,10,10,10" Width="Auto"
         Margin="4,4,4,4">
          <Border.Background>
            <RadialGradientBrush SpreadMethod="Pad">
              <GradientStop Color="#FFD0CDAF"/>
              <GradientStop Color="#FF94E247" Offset="1"/>
            </RadialGradientBrush>
          </Border.Background>
          <TextBox Background="{x:Null}" Height="Auto" x:Name="TextFavoriteColor"
           Width="Auto" Foreground="#FF0000FF" Text="Enter Favorite Color"
           TextWrapping="Wrap" TabIndex="2"/>
        </Border>
      </StackPanel>
    </Grid>
  </Border>
</UserControl>
```

Listing 6-3. *Recipe 6-2's TestPage.html File*

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
  <title>Test Page for Recipe 6.2</title>
  <style type="text/css">
    html, body
    {
      height: 100%;
      overflow: auto;
    }
    body
    {
      padding: 0;
      margin: 0;
    }
    #silverlightControlHost
    {
      height: 100%;
      text-align: center;
    }
  </style>
  <script type="text/javascript" src="Silverlight.js"></script>
  <script type="text/javascript">
    function onSilverlightLoad(sender, args) {
      var ctrl = document.getElementById("Silverlight1");
      ctrl.focus();
    }
  </script>
  <script type="text/javascript">
    function onSilverlightError(sender, args) {
      var appSource = "";
      if (sender != null && sender != 0) {
        appSource = sender.getHost().Source;
      }

      var errorType = args.ErrorType;
      var iErrorCode = args.ErrorCode;

      if (errorType == "ImageError" || errorType == "MediaError")
      {
        return;
      }
```

```
      var errMsg = "Unhandled Error in Silverlight Application " +
      appSource + "\n";

      errMsg += "Code: " + iErrorCode + "    \n";
      errMsg += "Category: " + errorType + "       \n";
      errMsg += "Message: " + args.ErrorMessage + "     \n";

      if (errorType == "ParserError") {
        errMsg += "File: " + args.xamlFile + "     \n";
        errMsg += "Line: " + args.lineNumber + "     \n";
        errMsg += "Position: " + args.charPosition + "     \n";
      }
      else if (errorType == "RuntimeError") {
        if (args.lineNumber != 0) {
          errMsg += "Line: " + args.lineNumber + "     \n";
          errMsg += "Position: " + args.charPosition + "     \n";
        }
        errMsg += "MethodName: " + args.methodName + "     \n";
      }

      throw new Error(errMsg);
    }
  </script>
</head>
<body>
  <form id="form1" runat="server" style="height: 100%">
  <div id="silverlightControlHost">
    <object id="Silverlight1" data="data:application/x-silverlight-2,"
     type="application/x-silverlight-2"
      width="100%" height="100%">
      <param name="source" value="ClientBin/Ch06_BrowserIntegration.Recipe6_2.xap" />
      <param name="onError" value="onSilverlightError" />
      <param name="onload" value="onSilverlightLoad" />
      <param name="background" value="white" />
      <param name="minRuntimeVersion" value="4.0.50401.0" />
      <param name="autoUpgrade" value="true" />
      <a href="http://go.microsoft.com/fwlink/?LinkID=149156&v=
       4.0.50401.0" style="text-decoration: none">
        <img src="http://go.microsoft.com/fwlink/?LinkId=161376"
        alt="Get Microsoft Silverlight"
          style="border-style: none" />
      </a>
    </object>
    <iframe id="_sl_historyFrame" style="visibility: hidden;
```

```
    height: 0px; width: 0px;border: 0px"></iframe>
  </div>
  </form>
</body>
</html>
```

6-3. Implementing a Full-Screen UI

Problem

You want your Silverlight application to run in full-screen mode as well as embedded mode.

Solution

To support full-screen mode, create an input mechanism such as a button or key combination to initiate full-screen mode. In the event handler for the button or key press, set `IsFullScreen` on the plug-in to `true`, and resize the UI elements to take up the entire screen.

How It Works

All of the examples in the previous chapters run Silverlight in embedded mode within the boundaries of the browser window. In full-screen mode, the Silverlight plug-in displays over the entire screen contents, rendering at the current resolution of the operating system. To toggle full-screen mode, call this line of code:

```
Application.Current.Host.Content.IsFullScreen =
  !Application.Current.Host.Content.IsFullScreen;
```

This line of code toggles full-screen mode, switching to full-screen mode if the plug-in is currently in embedded mode. This line of code will work only if it is in either a button or key press event handler. This is for security reasons— to ensure that user input has switched the plug-in to full-screen mode. In other words, the application user initiated the action and she knows that the plug-in is running in full-screen mode.

■ **Note** If you try to switch to full-screen mode in the `Load` event, it will be ignored for security reasons. Full-screen mode requires that the user initiate full screen via a button click or key press event handler.

Once in full-screen mode, the UI elements do not automatically resize. Figure 6-2 shows what a 216 x 334-pixel UI looks like when `IsFullScreen` is set to `true` on a monitor that is set to a 1680 x 1050-pixel screen resolution.

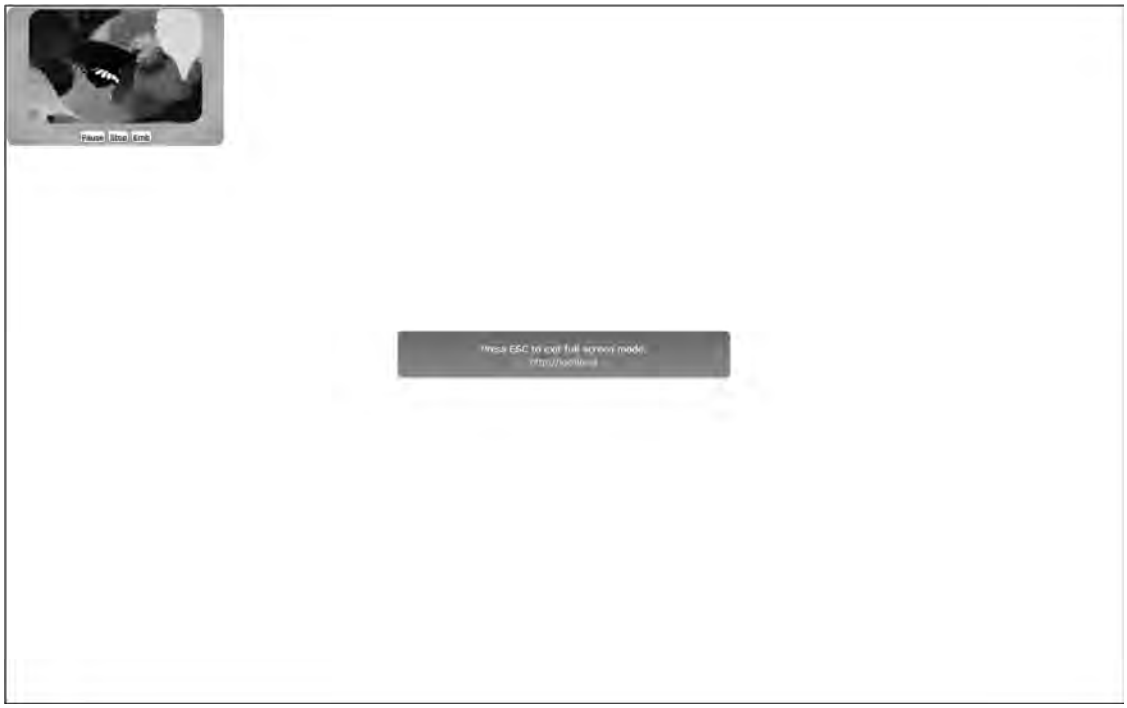


Figure 6-2. *Full-screen mode without resizing content*

The embedded UI renders in full screen at the same size as when in embedded mode unless the developer takes steps to resize the content in the `Application.Current.Host.Content.FullScreenChanged` event. There are generally three ways to handle resizing the UI:

- Automatically resize using a `ScaleTransform`.
- Manually resize by scaling pieces of the UI and repositioning elements as necessary to achieve the desired appearance.
- Leverage the VisualStateManager to define an embedded and full-screen state.

Using a `ScaleTransform` is the quickest way to implement full screen because it takes advantage of the scalable vector graphics to maintain a crisp appearance upon resize. The downside is that applying a `ScaleTransform` to the entire UI may scale up parts of the UI that shouldn't be scaled, such as text or buttons.

Manually resizing pieces of the UI and manually repositioning elements provides precise control but takes more work. The advantage is that you can achieve the exact desired appearance for the entire UI by only scaling and repositioning as needed when done manually.

We cover how to design a UI with the Visual State Manager in Chapter 5, which is the recommended way to proceed.

The Code

This recipe demonstrates using the `ScaleTransform`, but with a twist. You will employ an overall `ScaleTransform` to scale up the UI when in full-screen mode, but you will also apply another `ScaleTransform` to limit how large the buttons grow when in full-screen mode.

Figure 6-3 shows the UI for the application before implementing full-screen mode. The application includes a `Border`, a `MediaElement`, and a few `Button` controls to control the content playback. Set a `RectangleGeometry` on the `MediaElement.Clip` property to give it rounded corners.

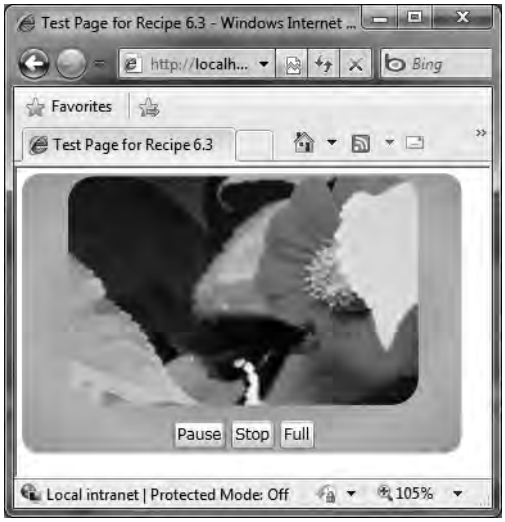


Figure 6-3*. Embedded view of the simple media player*

Copy a video from the sample videos included with Windows into the `ClientBin/Video` folder in the `TestWeb` web application project and rename the video to `video.wmv`.

■ **Note** Chapter 8 provides in-depth coverage on how to integrate rich media.

You configure `/Video/video.wmv` for the `MediaElement.Source` property so that video plays when the UI is run. You also implement the events for the Play/Pause `Button`, the Stop `Button`, and the `FullScreen Button` to create the UI in Figure 6-3; the latter's event handler is shown here:

```
private void FullScreenButton_Click(object sender, RoutedEventArgs e)
{
  Application.Current.Host.Content.IsFullScreen =
    !Application.Current.Host.Content.IsFullScreen;
  if (Application.Current.Host.Content.IsFullScreen)
```

```
  {
    FullScreenButton.Content = "Emb";
  }
  else
  {
    FullScreenButton.Content = "Full";
  }
}
```

Next, you implement resizing functionality when the browser plug-in switches between full-screen and embedded mode. First, create a `ScaleTransform` for the entire UI with this XAML:

```
<UserControl.RenderTransform>
  <ScaleTransform ScaleX="1" ScaleY="1" x:Name="ScaleToFullScreen" />
</UserControl.RenderTransform>
```

Then, implement the `FullScreenChanged` event on the browser plug-in by adding this code to the constructor for the `Page` class:

```
Application.Current.Host.Content.FullScreenChanged +=
  new EventHandler(Content_FullScreenChanged);
```

We initialize the `embeddedWidth` / `embeddedHeight` and `pluginWidth` / `pluginHeight` variables in the Loaded event for the page. Here is the `Content_FullScreenChanged` event handler where we use thse values to adjust when the application runs full screen or not:

```
void Content_FullScreenChanged(object sender, EventArgs e)
{
  if (!Application.Current.Host.Content.IsFullScreen)
  {
    ScaleToFullScreen.ScaleX = 1.0d;
    ScaleToFullScreen.ScaleY = 1.0d;
  }
  else
  {
    double pluginWidth = Application.Current.Host.Content.ActualWidth;
    double pluginHeight = Application.Current.Host.Content.ActualHeight;
    double scaleX = pluginWidth / _embeddedWidth;
    double scaleY = pluginHeight / _embeddedHeight;

    ScaleToFullScreen.ScaleX = scaleX;
    ScaleToFullScreen.ScaleY = scaleY;
  }
}
```

The code first checks to see if the browser plug-in is not in full-screen mode and sets the `ScaleToFullScreen ScaleTransform`'s `ScaleX` and `ScaleY` attributes to 1 or embedded mode. To calculate

the scaling factors, you use the ActualWidth and ActualHeight values to determine the scaling factor. ActualWidth and ActualHeight reflect the actual rendering size of the Silverlight plug-in. When the ActualWidth or ActualHeight changes, it causes the onResize event configured in the HTML as a JavaScript function that fires when the plug-in is in embedded mode. If the browser plug-in is in full-screen mode, the onResize event fires. It first obtains the screen width and height from the ActualWidth and ActualHeight properties. Next, it calculates a scale factor to apply to the ScaleToFullScreen transform for the entire content, immediately resulting in scaling the UI to full the screen. Figure 6-4 shows the results.

Figure 6-4. *Full-screen mode with uniform scale applied*

There may be scenarios where you don't want all of the content to be scaled uniformly. In this example, when viewed on a monitor in full-screen mode with the uniform scale applied, the Button elements appear a bit large even though they were evenly scaled.

In this case, you can apply a different scale to the Button elements so that they are scaled up to a lesser degree in full-screen mode. You can also reposition the buttons to the lower-right corner when in full-screen mode. You first create a ScaleTransform resource on the UserControl element so that you can apply it to multiple parts of the UI if desired:

```
<UserControl.Resources>
  <ScaleTransform ScaleX="1" ScaleY="1" x:Key="ReduceScaleTransform" />
</UserControl.Resources>
```

You apply the ReduceScaleTransform to the StackPanel element containing the Buttons by setting the RenderTransform attribute on the StackPanel like this:

```
RenderTransform="{StaticResource ReduceScaleTransform}"
```

You alter the `FullScreenChanged` event so that it applies a reduced scale for this transform by adding this code when in full-screen mode:

```
((ScaleTransform)this.Resources["ReduceScaleTransform"]).ScaleX = scaleX * .10d;
((ScaleTransform)this.Resources["ReduceScaleTransform"]).ScaleY = scaleY * .10d;
ButtonPanel.HorizontalAlignment = HorizontalAlignment.Right;
```

You reduce the scale by taking the calculated uniform scale in the local variable `scaleX` and multiplying it by 0.1, which was determined by trial and error to look good on the screen. You also align the `StackPanel` to the right in full-screen mode and return to the center when in embedded mode. Figure 6-5 has the final UI in full screen mode.

Figure 6-5. *Recipe 6-3's final full screen UI*

In Figure 6-5, the buttons are a little smaller and don't have giant text, which would detract from the video. As you can see, it is possible to use multiple `ScaleTransform` objects to achieve a reasonable user interface. Listings 6-4 and 6-5 contain the XAML and code for this recipe.

Listing 6-4. *Recipe 6-3's MainPage.xaml File*

```
<UserControl x:Class="Ch06_BrowserIntegration.Recipe6_3.MainPage"
    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"
    mc:Ignorable="d" Height="216" Width="334">
```

```
  <UserControl.Resources>
    <ScaleTransform ScaleX="1" ScaleY="1" x:Key="ReduceScaleTransform" />
  </UserControl.Resources>
  <UserControl.RenderTransform>
    <ScaleTransform ScaleX="1" ScaleY="1" x:Name="ScaleToFullScreen" />
  </UserControl.RenderTransform>
  <Border CornerRadius="13,13,13,13" Margin="4"
          x:Name="MediaPlayerFrame">
    <Border.Background>
      <RadialGradientBrush SpreadMethod="Reflect">
        <GradientStop Color="#FF28D7A4" Offset="0.5"/>
        <GradientStop Color="#FF70E1BF" Offset="1"/>
        <GradientStop Color="#FF70E1BF" Offset="0.0040000001899898052"/>
      </RadialGradientBrush>
    </Border.Background>
    <Grid x:Name="MediaPlayerPanel" Height="210" Width="328">
      <Grid.RowDefinitions>
        <RowDefinition Height="0.848*"/>
        <RowDefinition Height="0.152*"/>
      </Grid.RowDefinitions>
      <MediaElement x:Name="mediaElement" Source="/Video/Video.wmv"
          Margin="4,2,4,2" MediaEnded="mediaElement_MediaEnded">
        <MediaElement.Clip>
          <RectangleGeometry  Rect="0,0,260,170" RadiusX="20"  RadiusY="20"/>
        </MediaElement.Clip>
      </MediaElement>
      <StackPanel x:Name="ButtonPanel" Grid.Column="0" Grid.Row="1"
       Orientation="Horizontal"  Margin="2" HorizontalAlignment="Center"
       RenderTransform="{StaticResource ReduceScaleTransform}" Height="26">
        <Button x:Name="PlayPauseButton" Content="Pause" Margin="2"
                Click="PlayPauseButton_Click" MaxWidth="57" MaxHeight="34.5"/>
        <Button Content="Stop" x:Name="StopButton" Margin="2"
                Click="StopButton_Click" MaxWidth="47" MaxHeight="35" />
        <Button Content="Full" x:Name="FullScreenButton" Margin="2"
                Click="FullScreenButton_Click" MaxWidth="47" MaxHeight="38"/>
      </StackPanel>
    </Grid>
  </Border>
</UserControl>
```

Listing 6-5. *Recipe 6-4's MainPage.xaml.cs File*

```
using System;
using System.Windows;
using System.Windows.Controls;
```

```
using System.Windows.Media;

namespace Ch06_BrowserIntegration.Recipe6_3
{
  public partial class MainPage : UserControl
  {
    private double _embeddedWidth;
    private double _embeddedHeight;

    public MainPage()
    {
      InitializeComponent();
      Application.Current.Host.Content.FullScreenChanged += new
    EventHandler(Content_FullScreenChanged);
      this.Loaded += new RoutedEventHandler(Page_Loaded);
    }

    void Page_Loaded(object sender, RoutedEventArgs e)
    {
      //Store the embedded with and height so that we can
      //calculate the proper scale factor
      _embeddedWidth = this.Width;
      _embeddedHeight = this.Height;
    }

    void Content_FullScreenChanged(object sender, EventArgs e)
    {
      if (!Application.Current.Host.Content.IsFullScreen)
      {
        ScaleToFullScreen.ScaleX = 1.0d;
        ScaleToFullScreen.ScaleY = 1.0d;
        ((ScaleTransform)this.Resources["ReduceScaleTransform"]).ScaleX = 1.0d;
        ((ScaleTransform)this.Resources["ReduceScaleTransform"]).ScaleY = 1.0d;
        ButtonPanel.HorizontalAlignment = HorizontalAlignment.Center;
      }
      else
      {
        double pluginWidth = Application.Current.Host.Content.ActualWidth;
        double pluginHeight = Application.Current.Host.Content.ActualHeight;
        double scaleX = pluginWidth / _embeddedWidth;
        double scaleY = pluginHeight / _embeddedHeight;

        ScaleToFullScreen.ScaleX = scaleX;
        ScaleToFullScreen.ScaleY = scaleY;
        ((ScaleTransform)this.Resources["ReduceScaleTransform"]).ScaleX =
```

```
        scaleX * .10d;
        ((ScaleTransform)this.Resources["ReduceScaleTransform"]).ScaleY =
        scaleY * .10d;
        ButtonPanel.HorizontalAlignment = HorizontalAlignment.Right;
      }
    }

    private void FullScreenButton_Click(object sender, RoutedEventArgs e)
    {
      Application.Current.Host.Content.IsFullScreen =
        !Application.Current.Host.Content.IsFullScreen;
      if (Application.Current.Host.Content.IsFullScreen)
      {
        FullScreenButton.Content = "Emb";
      }
      else
      {
        FullScreenButton.Content = "Full";
      }
    }

    private void PlayPauseButton_Click(object sender, RoutedEventArgs e)
    {
      if ((mediaElement.CurrentState == MediaElementState.Stopped) ||
         (mediaElement.CurrentState == MediaElementState.Paused))
      {
        mediaElement.Play();
        PlayPauseButton.Content = "Pause";
      }
      else if (mediaElement.CurrentState == MediaElementState.Playing)
      {
        mediaElement.Pause();
        PlayPauseButton.Content = "Play";
      }
    }

    private void StopButton_Click(object sender, RoutedEventArgs e)
    {
      mediaElement.Stop();
      PlayPauseButton.Content = "Play";
    }

    private void mediaElement_MediaEnded(object sender, RoutedEventArgs e)
    {
      mediaElement.Position = new TimeSpan(0);
```

```
      PlayPauseButton.Content = "Play";
    }
  }
}
```

6-4. Calling a JavaScript Method from Managed Code

Problem

You have existing JavaScript code in a web application that you want to integrate into your Silverlight application without converting it to managed code.

Solution

Take advantage of the HTML Bridge to access JavaScript elements via the `System.Windows.Browser` namespace. Use the `HtmlDocument` object to obtain a reference to the HTML page's DOM. Use the `HtmlPage` object to invoke JavaScript methods.

How It Works

Silverlight 4 has technology for interacting between the Silverlight 4 managed code and the hosting browser's HTML DOM called the HTML Bridge. The HTML Bridge enables developers to call JavaScript from Silverlight managed code and expose entire managed code types to JavaScript. We'll cover the latter in Recipe 6-5.

Developers can enable or disable HTML Bridge functionality by setting the `enableHtmlAccess` parameter on the Silverlight browser plug-in to `true`; the default is `false`, to disable the HTML Bridge as a security best practice.

For the default test page, add the following `<param>` to the `<object>` tag that instantiates the Silverlight plug-in:

```
<param name="enableHtmlAccess" value="true" />
```

Once this step is complete, it is possible to interact between managed code and the HTML DOM. For more information on the HTML Bridge security settings, go to `msdn.microsoft.com/en-us/library/cc645023(VS.96).aspx`.

Managed types can be passed as parameters to JavaScript functions and objects, and managed types can be returned from JavaScript functions. You can also assign managed types as event handlers for JavaScript as well as call JavaScript event handlers from managed types. Visit this site for more information on how to map types between the technologies: `msdn.microsoft.com/en-us/library/cc645079(VS.96).aspx`

When writing JavaScript, you access HTML DOM objects using the `document.getElementById` method to obtain a reference to a named object within the HTML web page. Silverlight has similar functionality using this code:

```
HtmlDocument doc = HtmlPage.Document;
HtmlElement element = doc.GetElementById("Button1");
```

This code obtains a reference to Button1 on the HTML page as an HtmlElement object in managed code. With the HtmlElement reference, developers can manipulate properties, attach events, and invoke methods, among other abilities listed in the MSDN Silverlight documentation at: `msdn.microsoft.com/en-us/library/system.windows.browser.htmlelement(VS.96).aspx`

The `System.Windows.Browser` namespace has other useful classes when interacting with JavaScript and the browser; these are listed in Table 6-2.

Table 6-2. *Key Classes in System.Windows.Browser Namespace*

Class	Description
`BrowserInformation`	Obtains the name, version, and operating system of the web browser hosting Silverlight.
`HtmlDocument`	Used to access the HTML DOM from managed code.
`HtmlElement`	Represents an HTML element in the DOM.
`HtmlPage`	Grants access to the browser's DOM via the `Document` property, which can be assigned to and accessed via an instance of `HtmlDocument`.
`HtmlWindow`	Represents a JavaScript window object in managed code.
`HtmlUtility`	Provides useful methods to encode and decode HTML and URL strings.

Additional classes related to making managed code are available in JavaScript (see Recipe 6-6).

Here, you focus on accessing JavaScript elements and methods from managed code. To call JavaScript from managed code, you have to first enable browser interaction as described earlier by setting `enableHtmlAccess` to true. Next, you can invoke the JavaScript method from Silverlight by using the following line of code:

```
HtmlPage.Window.Invoke("fooGetData", args);
```

This line of code calls a JavaScript method named fooGetData, passing in arguments in an object array named args. The Invoke() method returns an object so if the JavaScript function fooGetData returns data, it can be received directly in Silverlight per the rules on mapping data types between Silverlight and JavaScript. See this site for details: `msdn.microsoft.com/en-us/library/cc645079(VS.96).aspx`

The code for this recipe takes advantage of the HTML Bridge functionality to manipulate elements in the browser DOM as well as to invoke a JavaScript AJAX call from managed code and then have the JavaScript AJAX method call back into the Silverlight application with the returned data.

■ **Note** In Recipe 6-5, you will learn how to call managed code from JavaScript.

The Code

You first create a simple user interface based on Recipe 2-5, where you pull in XML data embedded into the .xap file. In this recipe, you call a JavaScript method that uses the Microsoft AJAX Library to make a web request to retrieve the XML data from the server. However, before you find out how to retrieve the XML data via JavaScript, let's look at some additional points on the Silverlight and web page user interface.

In the Silverlight application UI for this recipe, you add a button called Update Data that, when clicked, makes the JavaScript call to retrieve the data. You also apply a little bit of styling by wrapping the `Grid` named `LayoutRoot` within a `Border` control named `LayoutRootBorder`. Then, on the outside, you apply another `Grid` with a `Background` `SolidColorBrush` that matches the second gradient stop on the `GradientBrush` applied to the `LayoutRootBorder` object.

You use the same brush for the outer `Grid` so that it blends with the background color set on the hosting web page. In `Page_Loaded` for the Silverlight application, you apply a bit of styling to the web page:

```
doc = HtmlPage.Document;
doc.SetProperty("bgColor", GetColor());
doc.GetElementById("silverlightControlHost").
            SetStyleAttribute("width",this.Width.ToString());
doc.GetElementById("silverlightControlHost").
            SetStyleAttribute("height", this.Height.ToString());
```

You obtain a reference to the DOM and set the background color (`bgColor`) of the web page to match the second gradient stop `SolidColorBrush` value on the `Border` control, which you obtain in the `GetColor()` method shown here:

```
private string GetColor()
{
  GradientBrush gb = LayoutRootBorder.Background as GradientBrush;
  //Set background color to second gradient stop
  GradientStop gs = gb.GradientStops[1];
  return gs.Color.R.ToString("X2") + gs.Color.G.ToString("X2") +
                                     gs.Color.B.ToString("X2");
}
```

In the `default` test pages, you modify the default styling for the div tag hosting the Silverlight control to this:

```
#silverlightControlHost
{
  top: 100px;
  left: 100px;
  float: right;
}
```

The style is applied to the `<div>` tag containing the Silverlight plug-in control by name because the name of the div tag is `silvelightcontrolhost`.

This style repositions the Silverlight plug-in along the right side of the browser window with some space from the right edge. There is some random chapter text at the top of the page just to fill in the page a bit (see Figure 6-6). Listing 6-6 has the XAML and Listing 6-7 has the codebehind for this recipe.

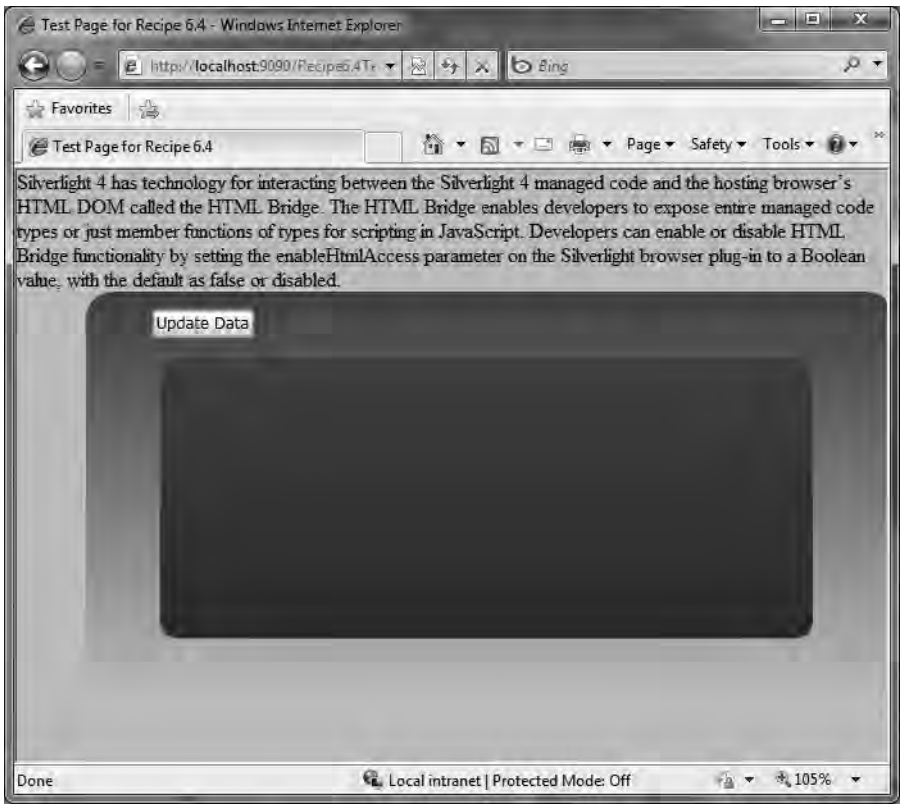


Figure 6-6. *Recipe 6-4's initial UI*

Listing 6-6. *Recipe 6-4's MainPage.xaml File*

```
<UserControl x:Class="Ch06_BrowserIntegration.Recipe6_4.MainPage"
    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"
    mc:Ignorable="d" Width="600" Height="300"
    d:DesignHeight="300" d:DesignWidth="600">
  <Grid Background="#FFAFC6FE">
    <Border x:Name="LayoutRootBorder" CornerRadius="20,20,20,20" >
      <Border.Background>
```

```
    <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
      <GradientStop Color="#FF443EE1" Offset="0.0040000001899898052"/>
      <GradientStop Color="#FFAFC6FE" Offset="1"/>
    </LinearGradientBrush>
  </Border.Background>
  <Grid x:Name="LayoutRoot" Margin="12,12,12,12" Background="{x:Null}">
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.058*"/>
      <ColumnDefinition Width="0.878*"/>
      <ColumnDefinition Width="0.065*"/>
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
      <RowDefinition Height="0.097*"/>
      <RowDefinition Height="0.83*"/>
      <RowDefinition Height="0.073*"/>
    </Grid.RowDefinitions>
    <Button Height="Auto" HorizontalAlignment="Left" Margin="4,0,0,4"
   VerticalAlignment="Bottom" Width="Auto" Grid.Column="1"
   Content="Update Data"
   x:Name="UpdateDataButton" Click="UpdateDataButton_Click"/>
    <Border Grid.Column="1" Grid.Row="1" CornerRadius="13,13,13,13"
      Margin="10,10,10,10" >
      <Border.Background>
        <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
          <GradientStop Color="#FF4B4897"/>
          <GradientStop Color="#FF2F2AAA" Offset="1"/>
        </LinearGradientBrush>
      </Border.Background>
      <ListBox  x:Name="BookListBox" Margin="8,8,8,8" Background="{x:Null}"
   BorderBrush="{x:Null}"
   Foreground="#FF4EBA61" >
        <ListBox.ItemTemplate>
          <DataTemplate>
            <StackPanel Margin="2,2,2,2">
              <TextBlock Text="{Binding Path=ISBN}" Margin="0,0,0,2"/>
              <TextBlock Text="{Binding Path=Title}" Margin="0,0,0,2"/>
              <TextBlock Width="550" Text="{Binding Path=Description}"
                   TextWrapping="Wrap" Margin="0,0,0,10"/>
            </StackPanel>
          </DataTemplate>
        </ListBox.ItemTemplate>
      </ListBox>
    </Border>
  </Grid>
</Border>
```

```
  </Grid>
</UserControl>
```

Listing 6-7. *Recipe 6-4's MainPage.xaml.cs File*

```
using System.Windows;
using System.Windows.Browser;
using System.Windows.Controls;
using System.Windows.Data;
using System.Windows.Media;

namespace Ch06_BrowserIntegration.Recipe6_4
{
  public partial class MainPage : UserControl
  {
    HtmlDocument doc;

    public MainPage()
    {
      InitializeComponent();
      Loaded += new RoutedEventHandler(Page_Loaded);
    }

    void Page_Loaded(object sender, RoutedEventArgs e)
    {
      doc = HtmlPage.Document;
      doc.SetProperty("bgColor", GetColor());
      doc.GetElementById("silverlightControlHost").
                  SetStyleAttribute("width", this.Width.ToString());
      doc.GetElementById("silverlightControlHost").
                  SetStyleAttribute("height", this.Height.ToString());

      //Make scriptable type available to JavaScript
      HtmlPage.RegisterScriptableObject(“MainPage”, this);
    }

    private string GetColor()
    {
      GradientBrush gb = LayoutRootBorder.Background as GradientBrush;
      //Set background color to second gradient stop
      GradientStop gs = gb.GradientStops[1];
      //Remove alpha component from brush since it doesn't work for html
      //elements when setting background color.  ToString("X2") formats the
      //byte value as a hexidecimal value forcing 2 digits each if there are
      // not two digits for each component, it will cause an  error.
```

```
      return gs.Color.R.ToString("X2") + gs.Color.G.ToString("X2") +
                                         gs.Color.B.ToString("X2");
    }

    private void UpdateDataButton_Click(object sender, RoutedEventArgs e)
    {
      HtmlPage.Window.Invoke("getDataUsingJavaScriptAjaxAsync");
    }

    [ScriptableMember]
    public void SetBookXMLData(string data)
    {
      ApressBooks books = new ApressBooks(data);
      Binding b = new Binding("ApressBookList");
      b.Source = books.ApressBookList;
      BookListBox.ItemsSource = books.ApressBookList;
    }
  }
}
```

Now, let's see the JavaScript method created for this recipe that is called from Silverlight. You put all of your scripts into a `js` folder in the `TestWeb` web application. For the default test pages, download the Microsoft AJAX Library and add a script reference to bring it into the web page:

```
  <script type="text/javascript"
          src="js/System.Web.Extensions/1.0.61025.0/MicrosoftAjax.js"/>
```

■ **Note** Download the Microsoft AJAX Library from `http://www.asp.net/ajaxlibrary/download.ashx` We use the Microsoft AJAX Library as a convenient way to make a web request call that is abstracted from the browser, whether it's Internet Explorer, Firefox, or Safari. Listing 6-8 has the source code for the asynchronous Java web request call.

Listing 6-8. *Recipe6.4.js File*

```
///<reference name="MicrosoftAjax.js"
function getDataUsingJavaScriptAjaxAsync() {
    ///<summary>This method makes a web request to obtain an XML file</summary>
    ///<returns type="String" />
    var req = new Sys.Net.WebRequest();
    req.set_url("http://localhost:9090/xml/ApressBooks.xml");
    req.set_httpVerb("GET");
    req.set_userContext("user's context");
    req.add_completed(OnWebRequestCompleted);
```

```
    req.invoke();
}

function OnWebRequestCompleted(executor, eventArgs) {
    if (executor.get_responseAvailable()) {
        var xmlString = executor.get_responseData();
        //Call Managed Code method to pass back data - Covered in Recipe 6.6
        document.getElementById("Xaml1").Content.MainPage.SetBookXMLData(xmlString);
    }
}
```

Although this book does not focus on ASP.NET AJAX, we will cover the highlights of Listing 6-8. The first line (with the `<reference name..>` element commented out with three slashes) is the equivalent of a `using` in C#, and it brings in the Microsoft AJAX Library script file. The `Sys.Net.WebRequest` JavaScript class is used to make the web request asynchronously. When `getDataUsingJavaScriptAjaxAsync` is invoked in the Silverlight application's `UpdateDataButton_Click` event handler, the data is not immediately returned to the Silverlight application when this event handler executes:

```
private void UpdateDataButton_Click(object sender, RoutedEventArgs e)
{
      HtmlPage.Window.Invoke("getDataUsingJavaScriptAjaxAsync");
    }
```

Instead, the web request asynchronously retrieves the data, which is returned via the `OnWebRequestCompleted` JavaScript method. The `OnWebRequestCompleted` JavaScript method shown in Listing 6-8 invokes a scriptable method called `SetBookXMLData()` located in the Silverlight application in order to return the data. A scriptable method is a managed code method that is made available in JavaScript. We cover how to call managed code in Recipe 6-6 in detail.

To summarize, when the Silverlight Update Data `Button` is clicked, the event handler invokes the JavaScript method `getDataUsingJavaScriptAjaxAsync` to initiate the asynchronous call and immediately return—that is, the UI thread is not blocking. When the `ApressBooks.xml` data is returned to the browser, the `OnWebRequestCompleted` JavaScript method passes the data back to Silverlight, where it is parsed by the class named `ApressBooks` using LINQ to XML. (This LINQ to XML functionality was covered in Recipe 2-5, so we don't show the listing here.) The only difference is that the data binding that happens in XAML without any C# code in Recipe 2-5 is now handled via this method in the `Page` class codebehind file:

```
[ScriptableMember]
public void SetBookXMLData(string data)
{
  ApressBooks books = new ApressBooks(data);
  Binding b = new Binding("ApressBookList");
  b.Source = books.ApressBookList;
  BookListBox.ItemsSource = books.ApressBookList;
}
```

Figure 6-7 shows the final UI when the button is clicked.

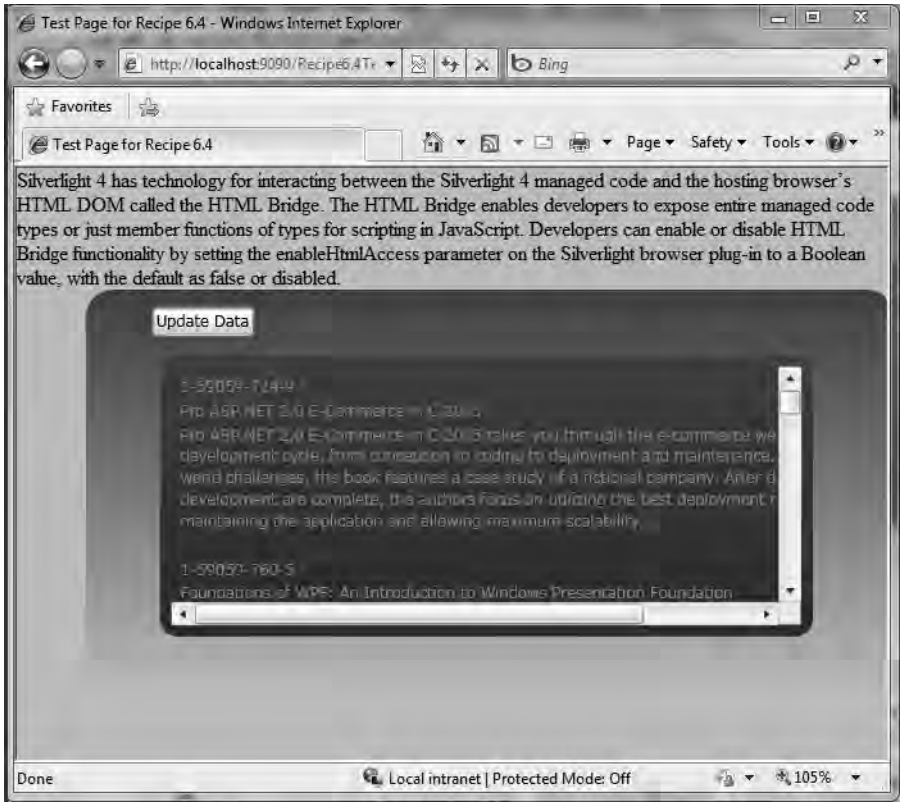


Figure 6-7*. The final UI when the button is clicked*

6-5. Calling a Managed Code Method from JavaScript

Problem

You prefer to write complex operations in managed code but need to call the method from JavaScript as part of integrating Silverlight with a web site.

Solution

To make a managed code operation available in the browser, mark member functions with the `ScriptableMember` attribute. Next, make the scriptable type available on the HTML DOM by registering an instance of the scriptable object by calling `HtmlPage.RegisterScriptableObject`.

How It Works

There will be scenarios where a Silverlight application needs to be tightly integrated with web content such as when you have a robust existing web application where you are introducing Silverlight into the user experience. Cases where a web application needs to perform complex client-side calculations that would be better handled by managed code are great scenarios where the integration capabilities can prove valuable.

Developers can enable or disable HTML Bridge functionality by setting the `enableHtmlAccess` parameter on the Silverlight browser plug-in to a Boolean value, with the default `false`, which disables the HTML Bridge.

For the default test page, add the following `<param>` to the `<object>` tag that instantiates the Silverlight plug-in:

```
<param name="enableHtmlAccess" value="true" />
```

Once this step is complete, it is possible to interact between managed code and the HTML DOM. For more information on the HTML Bridge security settings, see `msdn.microsoft.com/en-us/library/cc645023(VS.96).aspx`

Managed types can be passed as parameters to JavaScript functions and objects, and managed types can be returned from JavaScript functions. You can also assign managed types as event handlers for JavaScript as well as call JavaScript event handlers from managed types. Refer to this site for more information on how to map types between the technologies: `msdn.microsoft.com/en-us/library/cc645079(VS.96).aspx`

To make an entire type available for scripting, mark it with the `ScriptableType` attribute. To mark individual methods as scriptable, apply the `ScriptableMember` to the individual methods. Both attributes reside in the `System.Windows.Browser` namespace.

To call a managed code method from JavaScript, you first declare the method and then decorate it with the `ScriptableMember` attribute as shown here:

```
[ScriptableMember]
public string MyMethod()
{
}
```

The next step is to make the object and its scriptable method available to JavaScript via the HTML Bridge by making this call in either `App.Startup` or `Page.Load` events. Here is an example for this step:

```
HtmlPage.RegisterScriptableObject("foo", RootVisual); //App_Startup
HtmlPage.RegisterScriptableObject("foo", this); //Page_Load
```

If you need to pass a parameter to the managed scriptable method, you obtain a reference to an instance of the managed type with JavaScript code similar to this example below:

```
var MyList =
 slPlugin.Content.BarObject.createManagedObject("List<string>");
```

You can then populate the variable reference in JavaScript using the corresponding JavaScript type's methods.

The final step is to call the scriptable method from JavaScript. The JavaScript code can be anywhere in the test page such as `document.load`, `Silverlight.onLoad` or an event handler such as a button click. The HTML Bridge provides access to the managed code events via the Silverlight plug-

in's Content property to make the call. Based on the example RegisterScriptableObject() and your scriptable method MyMethod, this line of JavaScript code shows how to make the call:

```
strVariable = document.getElementById("Xaml1").Content.foo.MyMethod();
```

When you register the object that has the scriptable methods, the first parameter passed into RegisterScriptableObject() is called the scriptKey. The value passed in as the scriptKey, in this case foo, is appended to Content after using getElementById() to find the Silverlight plug-in in the DOM. You can then call method names using Content.foo.MethodName as shown above.

You can also wire up a managed code event handler directly to a JavaScript event such as an HTML Button click. First, create an event handler in the Silverlight application that follows this method signature:

```
[ScriptableMember]
private void MyJavaScriptEventHandler(object o, EventArgs e)
{
  // Code goes here…
}
```

Next, find the HTML element where the managed code event handler should be attached and attach the event handler to the desired JavaScript event referencing the Silverlight application with the "this" parameter, like so:

```
doc.GetElementById("Button1").AttachEvent("click",
  new EventHandler(this.MyJavaScriptEventHandler));
```

When the HTML button Button1 is clicked on the web page, the managed code event MyJavaScriptEventHandler() will execute.

The Code

This recipe implements the concepts to show the rich integration possible between Silverlight and the HTML DOM. The first step is to set the enableHtmlAccess parameter to true so that the HTML Bridge is available in both the HTML and ASPX test page following the steps listed earlier. For the HTML page, there is only one way to build it: with plain old HTML and JavaScript by adding a <script> tag to bring in a separate JavaScript file in the js folder named Recipe6.5.js.

First, you call a managed scriptable method with parameters. As mentioned in the previous section, you create a reference to a managed object that can then be populated using JavaScript code:

```
var MyList =
slPlugin.Content.BarObject.createManagedObject("List<string>");
MyList.push("Rob","Jit","Harry");
slPlugin.Content.BarObject.Foo(MyList);
```

The preceding code in onSilverlightLoaded creates a list object, populates it with some values and then passes it in to the Foo method. If you set a breakpoint in the Foo method, you will see that the method is successfully called and the values passed in. One other item to note is that you use this line of code in Page_Loaded to make the Bar class available in JavaScript:

```
HtmlPage.RegisterScriptableObject("BarObject", new Bar());
```

You could pass in a signature that uses a constructor that takes a parameter as well as the default constructor signature. Next, you want to grab the background color of the Silverlight control's main `Grid` control and apply it to the HTML page and a text input HTML element. For the HTML page, after enabling the HTML Bridge, you create an `onSilverlightLoaded` JavaScript event that you wire to the Silverlight plug-in's `OnLoad` event handler. You also change the following line of code to transparent instead of white in the Silverlight plug-in parameter list because you want the application to configure the background at runtime:

```
<param name="background" value="transparent />
```

The next step is to create the Silverlight managed code method on the `Page` class that you want to call from JavaScript. You name the method `GetMyBackGroundColor()` because it determines the color of the `LayoutRoot Grid` control and returns the color value as a red, green, blue (RGB) hexadecimal value. If the `Grid.Background` points to a `GradientBrush`, you grab the color value of the first `GradientStop` and pass that color back as the return value on the `GetMyBackgroundColor` method. Here is the line of code from `Page_Load` to make the entire `MainPage` class and its method like the `GetMyBackGroundColor` method available in JavaScript:

```
HtmlPage.RegisterScriptableObject("MainPage", this);
```

In the `onSilverlightLoaded` JavaScript event, you access the `GetMyBackgroundColor()` method with the following line of code:

```
colorRGB = document.getElementById("Xaml1").Content.MainPage.
GetMyBackgroundColor();
```

Once you have the color, you use the following to assign it to the text input control's `backgroundColor` property and to the `document.bgColor` property as well:

```
txt1 = document.getElementById("Text1");
txt1.value = colorRGB;
txt1.style.backgroundColor = colorRGB;
document.bgColor = colorRGB;
```

You set the `width` style attribute on the `<div>` containing Silverlight to equal the width of the Silverlight content from managed code in the `Page.SizeChanged` event. If you didn't do this, the `document.bgColor` value would not be visible. Otherwise, the default setting for the `<div>` in the generated test pages is to take over the entire browser screen height, and the background color set on the HTML page is not visible for most of the page.

To set the `Width` from managed code, you configure an ID on the HTML `<div>` tag to `silverlightControlHost`, which matches the name automatically generated in the HTML test page. In managed code, you attach an event handler to the `Page`'s `SizeChanged` event and execute the following code:

```
HtmlDocument doc = HtmlPage.Document;
doc.GetElementById("silverlightControlHost").
  SetStyleAttribute("width", this.Width.ToString());
```

This code calls `SetStyleAttribute()` for the `width` attribute on the `<div>` and configures it with the `Width` configured on the managed code `Page` object. Figure 6-7 shows the results.

The Silverlight control is on the left side in Figure 6-8 just below the HTML `Button`, the "Color from Silverlight" text, and the text input HTML control with the RGB value returned by the `GetMyBackgroundColor()` method.

The Silverlight control in Figure 6-8 has a gradient that runs from top to bottom; the first gradient stop at the top matches the background color for the rest of the web page. Because you set the `<div>` `width` to match the Silverlight content `Width`, the light blue appears to wrap around the Silverlight plug-in. The light blue does not appear below the Silverlight plug-in because the `height` attribute remains set at `100%` for the `<div>` containing the Silverlight plug-in.

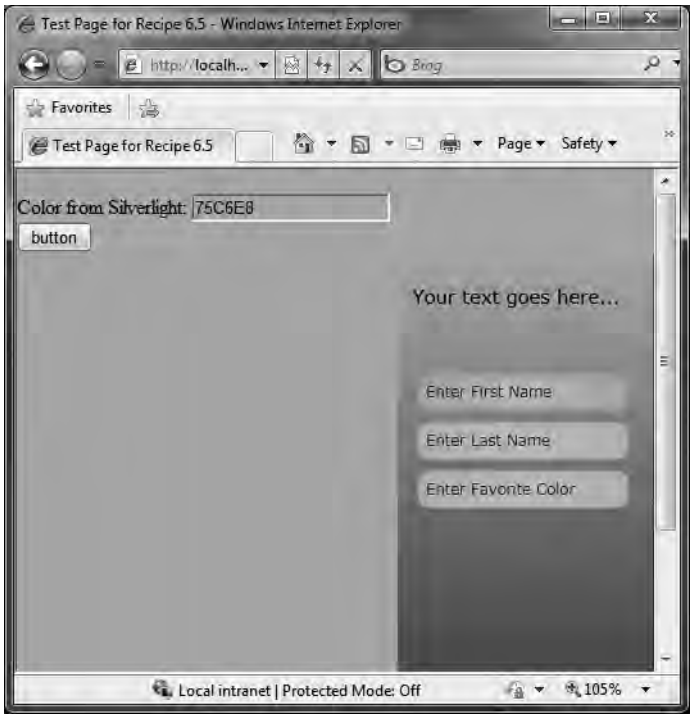


Figure 6-8. *Setting the web page background color from managed code*

The other custom code that you implement maps a managed code event handler to an HTML button `Click` event on the web page. The managed code method name is `InvokedFromHtmlButtonClick()` with this code:

```
private void InvokedFromHtmlButtonClick(object o, EventArgs e)
{
  MessageTextBlock.Text = "HTML button clicked at " + DateTime.Now.ToString();
}
```

You attach the managed code to the HTML button with this code in the `Page_Load` event handler:

```
HtmlDocument doc = HtmlPage.Document;
```

```
doc.GetElementById("Button1").AttachEvent("click",
 new EventHandler(this.InvokedFromHtmlButtonClick));
```

When you click the button in the UI shown in Figure 6-8, Figure 6-9 is the resulting UI.

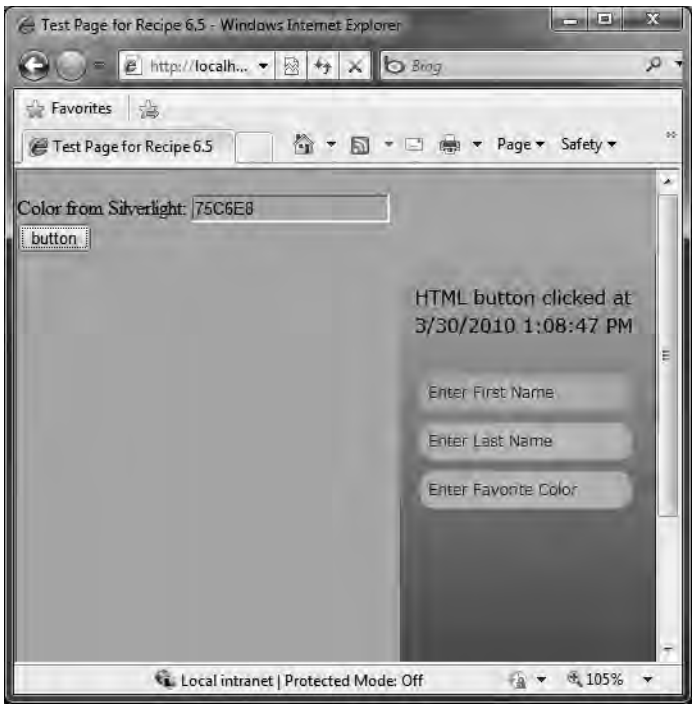


Figure 6-9. *Updated text with date and time displayed*

Since an ASP.NET `Button` server control always performs postback by default, you use an HTML input button on the `.aspx` page. It is possible to prevent the postback using client-side JavaScript; however, you want to call a Silverlight managed code method instead. Listing 6-9 shows the `MainPage.xaml` file; Listing 6-10 shows the `MainPage.xaml.cs` file.

Listing 6-9. *Recipe 6-5's MainPage.xaml File*

```
<UserControl x:Class="Ch06_BrowserIntegration.Recipe6_5.MainPage"
    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"
    mc:Ignorable="d"
    d:DesignHeight="300" d:DesignWidth="400">
  <Grid x:Name="LayoutRoot">
```

```
<Grid.Background>
  <LinearGradientBrush EndPoint="0.5,1" StartPoint="0.5,0">
    <GradientStop Color="#FF75C6E8"/>
    <GradientStop Color="#FF2828AA" Offset="1"/>
  </LinearGradientBrush>
</Grid.Background>

<Grid.RowDefinitions>
  <RowDefinition Height="13*"/>
  <RowDefinition Height="43*"/>
  <RowDefinition Height="244*"/>
</Grid.RowDefinitions>
<Grid.ColumnDefinitions>
  <ColumnDefinition Width="0.035*"/>
  <ColumnDefinition Width="0.91*"/>
  <ColumnDefinition Width="0.055*"/>
</Grid.ColumnDefinitions>
<TextBlock x:Name="MessageTextBlock" HorizontalAlignment="Left"
   Margin="4,4,0,0" VerticalAlignment="Top" Grid.Column="1" Grid.Row="1"
   Text="Your text goes here..." TextWrapping="Wrap"
   d:LayoutOverrides="HorizontalAlignment, VerticalAlignment, GridBox"
   FontSize="14" Width="194.999"/>
<StackPanel Margin="4" Grid.Row="2" Grid.Column="1" >
  <Border Height="Auto" Width="Auto" CornerRadius="10,10,10,10"
       Margin="4">
    <Border.Background>
      <RadialGradientBrush SpreadMethod="Pad">
        <GradientStop Color="#FFD0CDAF"/>
        <GradientStop Color="#FF69E247" Offset="1"/>
      </RadialGradientBrush>
    </Border.Background>
    <TextBox Background="{x:Null}" Height="Auto" x:Name="TextFirstName"
       Width="Auto" Foreground="#FF0000FF" Text="Enter First Name"
       TextWrapping="Wrap" TabIndex="0" BorderBrush="{x:Null}" Margin="2"/>
  </Border>
  <Border Height="Auto" CornerRadius="10,10,10,10" Width="Auto"
      Margin="4">
    <Border.Background>
      <RadialGradientBrush SpreadMethod="Pad">
        <GradientStop Color="#FFD0CDAF"/>
        <GradientStop Color="#FF94E247" Offset="1"/>
      </RadialGradientBrush>
    </Border.Background>
    <TextBox Background="{x:Null}" Height="Auto" x:Name="TextLastName"
       Width="Auto" Foreground="#FF0000FF" Text="Enter Last Name"
```

```
          TextWrapping="Wrap" TabIndex="1" BorderBrush="{x:Null}" Margin="2"/>
      </Border>
      <Border Height="Auto" CornerRadius="10,10,10,10" Width="Auto"
         Margin="4">
        <Border.Background>
          <RadialGradientBrush SpreadMethod="Pad">
            <GradientStop Color="#FFD0CDAF"/>
            <GradientStop Color="#FF94E247" Offset="1"/>
          </RadialGradientBrush>
        </Border.Background>
        <TextBox Background="{x:Null}" x:Name="TextFavoriteColor"
           Width="Auto" Foreground="#FF0000FF" Text="Enter Favorite Color"
           TextWrapping="Wrap" TabIndex="2" BorderBrush="{x:Null}" Margin="2"/>
      </Border>
    </StackPanel>
  </Grid>
</UserControl>
```

Listing 6-10. *Recipe 6-5's MainPage.xaml.cs File*

```
using System;
using System.Windows;
using System.Windows.Browser;
using System.Windows.Controls;
using System.Windows.Media;

namespace Ch06_BrowserIntegration.Recipe6_5
{
  public partial class MainPage : UserControl
  {
    public MainPage()
    {
      InitializeComponent();
      Loaded += new RoutedEventHandler(Page_Loaded);
      SizeChanged += new SizeChangedEventHandler(Page_SizeChanged);
    }

    void Page_Loaded(object sender, RoutedEventArgs e)
    {
      //Make scriptable type available to JavaScript
      HtmlPage.RegisterScriptableObject(“MainPage”, this);
      HtmlPage.RegisterScriptableObject("BarObject", new Bar());

      HtmlDocument doc = HtmlPage.Document;
      doc.GetElementById("Button1").AttachEvent("click",
```

```
    new EventHandler(this.InvokedFromHtmlButtonClick));
}

void Page_SizeChanged(object sender, SizeChangedEventArgs e)
{
  //Set width of Div containing the SilverlightControl to width
  //of Silverlight content so that the HTML background displays
  //along side of the Silverlight control.  Otherwise the Silverlight
  //control will take up the entire page based on the html in the
  //default test pages that are created.
  HtmlDocument doc = HtmlPage.Document;
  doc.GetElementById("silverlightControlHost").SetStyleAttribute("width",
                                                 this.Width.ToString());
}

[ScriptableMember]
public string GetMyBackgroundColor()
{
  Brush b = LayoutRoot.Background;
  if (b is SolidColorBrush)
  {
    SolidColorBrush scb = b as SolidColorBrush;
    //Remove alpha component from brush since it doesn't work for
    //html elements when setting background color.
    //ToString("X2") formats the byte value as a hexidecimal value
    //forcing 2 digits each if there are not two digits for each
    //component, it will cause a JavaScript error.
    return scb.Color.R.ToString("X2") + scb.Color.G.ToString("X2") +
           scb.Color.B.ToString("X2");
  }
  else if (b is GradientBrush)
  {
    GradientBrush gb = b as GradientBrush;
    //Arbitrarily pick the color of first gradient stop as the color
    //to pass back as the returned value.
    GradientStop gs = gb.GradientStops[0];
    //Remove alpha component from brush since it doesn't work for html
    //elements when setting background color.  ToString("X2") formats the
    //byte value as a hexidecimal value forcing 2 digits each. If there
    // are not two digits for each component, it will cause a JavaScript
     //error.
      return gs.Color.R.ToString("X2") + gs.Color.G.ToString("X2") +
                                       gs.Color.B.ToString("X2");
  }
  else
```

```
        return "#FFFFFF";
    }

    private void InvokedFromHtmlButtonClick(object o, EventArgs e)
    {
      MessageTextBlock.Text = "HTML button clicked at " +
         DateTime.Now.ToString();
    }
  }

  [ScriptableType]
  public class Bar
  {
    [ScriptableMember]
    public void Foo(List<string> param)
    { //Set a breakpoint
    }
  }
}
```

6-6. Exchanging Data Among Multiple Plug-ins

Problem

You have more than one Silverlight plug-in in your web page hosting content and you need to exchange data among the plug-ins.

Solution

Use the HTML Bridge covered in Recipes 6-5 and 6-6 to expose methods from Silverlight to JavaScript using the `ScriptableMethodAttribute`. Call the methods as JavaScript methods using `HtmlPage.Window.Invoke()`.

How It Works

We cover the details on working with the HTML Bridge in Recipes 6-5 and 6-6. This recipe focuses on using the HTML Bridge to implement communication between multiple instances of the same Silverlight application.

This recipe implements communication via the HTML Bridge, which means that the data passed via the HTML Bridge must be JavaScript compatible. Refer to this site for more information on how to map types between the technologies: `msdn.microsoft.com/en-us/library/cc645079(VS.96).aspx`

In this example, you implement pushing data as well as requesting data between two instances of the same Silverlight application. You establish a convention of naming the JavaScript methods with the name of the Silverlight plug-in ID as a prefix to the method name.

The Silverlight plug-in supports initialization parameters in the form of key/value pairs in a string like "Key1=Value1;Key2=Value2;Key3=Value3", providing support for multiple initialization parameters. In your case, you have one parameter that you pass in on the <object> tag in the .html page; this parameter is the other Silverlight plug-in you want to work with:

```
<param name="initParams" value="PartnerControl=Xaml2" />
```

This code parses the initParams in Page_Loaded but you could also place this code in App_Startup as well:

```
//Get passed parameter for partner control
 string initParams = HtmlPage.Plugin.GetProperty("initParams").ToString();
 string[] paramsArray = initParams.Split(';');
 string[] KeyValue = paramsArray[0].Split('=');
  _partnerControlID = KeyValue[1];
```

You pass in the parameter so that you know which control to talk to. The correct control is chosen by calling JavaScript methods that are prefixed with the partner control's name. So when sending data to the partner control, you make this call:

```
HtmlPage.Window.Invoke(_partnerControlID + "DoReceive", args);
```

In the DoReceive JavaScript functions, you pass in data from the control from a button click initiated by the user, calling the managed code function ReceiveData() from JavaScript, and passing in the data.

When requesting data, you make this call:

```
string str = (string)HtmlPage.Window.Invoke(_partnerControlID + "RequestData");
```

In the RequestData JavaScript functions, you invoke the managed code RequestData() method via the JavaScript method. The managed code RequestData() method returns the data, which is then returned to the calling application via the HTML Bridge.

This simple convention provides an easy means of communicating between multiple Silverlight plug-ins within the same web page.

The Code

In this recipe's sample code, you modify the default test web pages, adding an additional instance of the Silverlight plug-in of the same Silverlight application, so both plug-in instances point to the Ch06_BrowserIntegration.Recipe6_6.xap file. In both the .aspx and .html pages, you ensure that both Silverlight plug-in controls as well as their parent containers have unique IDs in the page.

You also modify the test pages so that the height and width on all of the controls isn't set to 100% in order to keep the two plug-in instances visible and near each other to facilitate testing. You set the <object> tags hosting the Silverlight plug-in to 100% for Height and Width. You create the four JavaScript functions to implement data-push and data-request in Recipe6.6.js located in the js folder. Listing 6-11 has the four JavaScript functions.

Listing 6-11. *Recipe 6-6's JavaScript File*

```
function Xaml1DoReceive(data)
{
    document.getElementById("Xaml1").Content.MainPage.ReceiveData(data);
}

function Xaml1RequestData()
{
    return document.getElementById("Xaml1").Content.MainPage.RequestData();
}

function Xaml2DoReceive(data)
{
    document.getElementById("Xaml2").Content.MainPage.ReceiveData(data);
}

function Xaml2RequestData(data)
{
    return document.getElementById("Xaml2").Content.MainPage.RequestData();
}
```

The XAML markup has a `TextBlock` at the top of the UI where the ID of the control instance is displayed. The ID is retrieved and set to the `Text` value of the `TextBlock` using this code:

```
ControlID.Text = HtmlPage.Plugin.Id;
```

The UI also has two buttons that make the calls to the appropriate JavaScript method with the Send Data button making the following call to push data to the other application hosted in a separate Silverlight plug-in on the same page:

```
HtmlPage.Window.Invoke(_partnerControlID + "DoReceive", args);
```

The _args parameter is an object array that contains one entry. The other button, Request Data, makes this call to pull data from the other Silverlight application hosted on the page:

```
string str = (string)HtmlPage.Window.
  Invoke(_partnerControlID + "RequestData");
```

There is a `TextBox` control so that the user can type data to send at the upper-right part of the UI. There are two `TextBox` controls on the lower-right part of the UI where pushed data is received and requested data is loaded, as shown in Figure 6-10. Listings 6-12 and 6-13 have the XAML and codebehind file for this recipe.

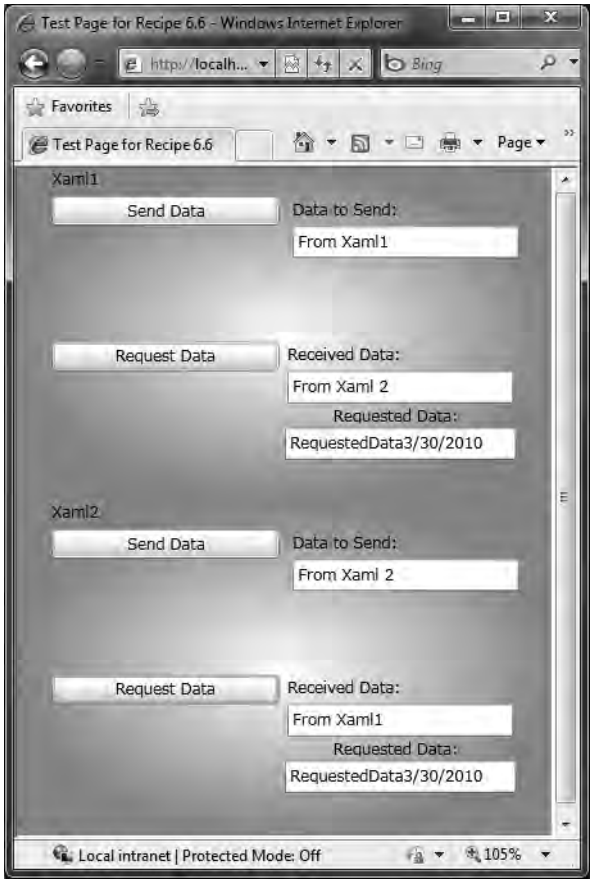


Figure 6-10. *Recipe 6-6's user interface*

Listing 6-12. *Recipe 6-6's MainPage.xaml File*

```
<UserControl x:Class="Ch06_BrowserIntegration.Recipe6_6.MainPage"
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"
    mc:Ignorable="d"
    Width="400" Height="250"
    d:DesignHeight="300" d:DesignWidth="400">
    <Grid x:Name="LayoutRoot">
      <Grid.Background>
        <RadialGradientBrush>
          <GradientStop Color="#FFFFFFFF"/>
          <GradientStop Color="#FFB98585" Offset="1"/>
```

```
        </RadialGradientBrush>
      </Grid.Background>
      <Grid.RowDefinitions>
        <RowDefinition Height="0.067*"/>
        <RowDefinition Height="0.433*"/>
        <RowDefinition Height="0.43*"/>
        <RowDefinition Height="0.07*"/>
      </Grid.RowDefinitions>
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="0.055*"/>
        <ColumnDefinition Width="0.442*"/>
        <ColumnDefinition Width="0.45*"/>
        <ColumnDefinition Width="0.052*"/>
      </Grid.ColumnDefinitions>
      <Button x:Name="SendDataButton" Height="Auto" Margin="4,4,4,0"
       Click="SendDataButton_Click" Grid.Column="1" Grid.Row="1"
       VerticalAlignment="Top" Content="Send Data"/>
      <StackPanel Margin="4,4,4,4" Grid.Column="2" Grid.Row="1">
        <TextBlock Height="Auto" Width="Auto" Text="Data to Send:"
         TextWrapping="Wrap" Margin="2,2,2,2"/>
        <TextBox Height="24" Width="Auto" Text="" TextWrapping="Wrap"
         Margin="2,2,2,2" x:Name="DataToSend"/>
      </StackPanel>
      <Button x:Name="RequestDataButton" Height="Auto" Margin="4,4,4,0"
       Click="RequestDataButton_Click" Grid.Column="1" Grid.Row="2"
       VerticalAlignment="Top" Content="Request Data" />
      <StackPanel Margin="0,4,8,4" Grid.Column="2" Grid.Row="2">
        <TextBlock Height="Auto" Margin="2,2,2,2" Width="Auto"
         Text="Received Data:" TextWrapping="Wrap"/>
        <TextBox Height="24" Margin="2,2,2,2" Width="Auto"
         Text="" TextWrapping="Wrap" x:Name="ReceivedData"/>
        <TextBlock Height="16" Width="101"
          Text="Requested Data:" TextWrapping="Wrap"/>
        <TextBox Height="24" Width="Auto"
          Text="" TextWrapping="Wrap" x:Name="RequestedData"/>
      </StackPanel>

      <TextBlock HorizontalAlignment="Left" Margin="4,0,0,4" Width="102"
       Grid.Column="1" Text="TextBlock" TextWrapping="Wrap"
       d:LayoutOverrides="HorizontalAlignment" x:Name="ControlID"/>
    </Grid>
</UserControl>
```

Listing 6-13. *Recipe 6-6's MainPage.xaml.cs File*

```
using System;
using System.Windows;
using System.Windows.Browser;
using System.Windows.Controls;

namespace Ch06_BrowserIntegration.Recipe6_6
{
  public partial class MainPage : UserControl
  {
    private string _partnerControlID;
    public MainPage()
    {
      InitializeComponent();
      Loaded += new RoutedEventHandler(Page_Loaded);
    }

    void Page_Loaded(object sender, RoutedEventArgs e)
    {
      //Make scriptable type available to JavaScript
      //Enable call to ReceiveData from JavaScript
      HtmlPage.RegisterScriptableObject("MainPage", this);
      //Get the ID of the Silverlight Plug-in Control Parent
      string parentId = HtmlPage.Plugin.Parent.Id;
      //Get the ID of the Silverlight Plug-in Control
      ControlID.Text = HtmlPage.Plugin.Id;
      //Obtain a reference to the DOM
      HtmlDocument doc = HtmlPage.Document;
      //Set height and width on parent div so
      //that the control displays properly
      doc.GetElementById(parentId).
              SetStyleAttribute("width", this.Width.ToString());
      doc.GetElementById(parentId).
                  SetStyleAttribute("height", this.Height.ToString());
      //Get passed parameter for partner control
      string initParams =
         HtmlPage.Plugin.GetProperty("initParams").ToString();
      string[] paramsArray = initParams.Split(';');
      string[] KeyValue = paramsArray[0].Split('=');
      _partnerControlID = KeyValue[1];
    }

    [ScriptableMember]
    public void ReceiveData(object receivedData)
```

```
    {
      ReceivedData.Text = (string)receivedData;
    }

    [ScriptableMember]
    public string RequestData()
    {
      if (DateTime.Now.Millisecond < 500)
        return "RequestedData" + DateTime.Now.ToString();
      else
        return null;
    }

    private void SendDataButton_Click(object sender, RoutedEventArgs e)
    {
      object[] args = new object[1];
      args[0] = DataToSend.Text ;
      HtmlPage.Window.Invoke(_partnerControlID + "DoReceive",args);
    }

    private void RequestDataButton_Click(object sender, RoutedEventArgs e)
    {
      string str = (string)HtmlPage.Window.
        Invoke(_partnerControlID + "RequestData");
      if (str != null)
        RequestedData.Text = str;
      else
        RequestedData.Text = "no data";
    }
  }
}
```

6-7. Layering HTML over the Silverlight Plug-in

Problem

You need to blend the UI of a Silverlight application with HTML such that the HTML can overlay the Silverlight control when running within the browser.

Solution

Configure the Silverlight plug-in hosting the Silverlight UI so that it supports HTML overlaying the Silverlight content.

How It Works

By default, the Silverlight plug-in runs within its own Window such that HTML content can flow around it or is hidden behind the control if absolutely positioning HTML content. Recipe 6-8 covers how to host HTML content when running Out-of-Browser, however, the WebBrowser control doesn't run when running within the browser. For the in-browser scenario, you can follow the steps in this recipe to try to match the UI of an OOB application by more closely integrating the HTML with the plug-in content.

You can configure the Silverlight plug-in to allow HTML content to flow over the Silverlight UI. To do so, set the background parameter to a value of transparent, set the windowless parameter to true, and configure the `z-index` for the `div` hosting the plug-in to zero. These three steps configure the plug-in to have HTML text overlay it. The last step is to create HTML to overlay the control that is positioned over the top of the plugin and has style settings to make the `background` `transparent` and a `z-index` of greater than what is configured on the plug-in (in your case, greater than 1, which is set on the plug-in as the z_index).

The Code

For this project, you create a simple Silverlight application that contains a rectangle and some Silverlight text that overlays it as shown in Figure 6-11.

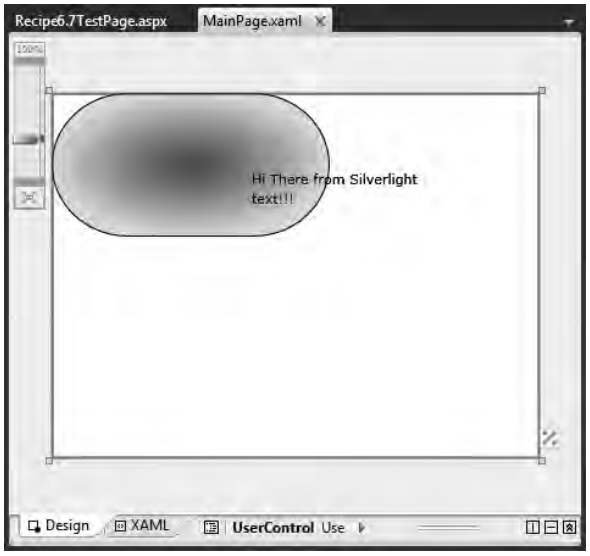


Figure 6-11. *Recipe 6-7's design-time user interface*

Next, turn to the HTML page to configure the Silverlight plug-in HTML and to create a simple piece of HTML to overlay the plug-in. You configure the div hosting the plug-in to have a z-index of 0. You also enable windowless mode and set the background on the plug-in to transparent as shown here:

```
<div id="silverlightControlHost"
style="width: 400px; height: 300px; position: absolute;z-index: 0">
```

```
  <object data="data:application/x-silverlight-2," type="application/x-silverlight-2"
    width="100%" height="100%">
    <param name="source" value="ClientBin/Ch06_BrowserIntegration.Recipe6_7.xap" />
    <param name="onError" value="onSilverlightError" />
    <param name="background" value="transparent" />
    <param name="minRuntimeVersion" value="4.0.50401.0" />
    <param name="autoUpgrade" value="true" />
    <param name="windowless" value="true" />
    <a href="http://go.microsoft.com/fwlink/?LinkID=149156&v=4.0.50401.0" style="text-
decoration: none">
      <img src="http://go.microsoft.com/fwlink/?LinkId=161376" alt="Get Microsoft
Silverlight"
        style="border-style: none" />
    </a>
  </object>
  <iframe id="_sl_historyFrame" style="visibility: hidden; height: 0px;
    width: 0px; border: 0px"></iframe>
</div>
```

Windowless mode causes the browser to render the Silverlight content instead of a separate Window handling the rendering. This can have performance implications for a UI that is heavy with animations so please keep that in mind.

Next, create a little bit of HTML to partially render over the Silverlight plug-in:

```
<div style="background: transparent;
  color: Green; z-index: 1; position: absolute">
  Hi There in HTML!
</div>
```

Note that the `style` on the `div` is configured to have a `transparent` background, `absolute` positioning, and a z-index of 1 to overlay the plug-in. This results in this UI at runtime as shown in Figure 6-12.

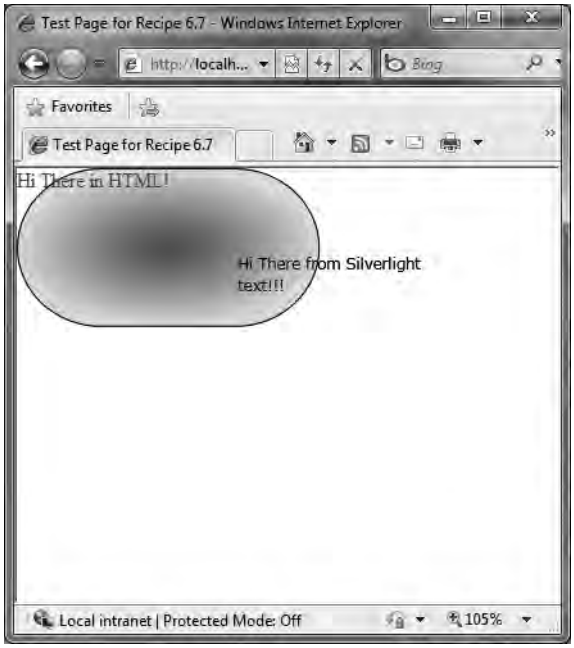


Figure 6-12. *Recipe 6-7's final user interface at runtime*

Note the HTML text that overlays the Silverlight plug-in. Without the configuration you performed on the hosting web page, the plug-in would have simply rendered under the HTML text. To layer the HTML over the plug-in, you could have left the background as white. However, the point was to demonstrate how to layer HTML over the plug-in and vice-versa; configuring the background to transparent demonstrated both scenarios.

6-8. Hosting HTML in a Silverlight Application

Problem

You need to host HTML including ActiveX controls such as the Adobe Flash player within your Silverlight application.

Solution

Use the WebBrowser control in an Out-of-Browser Silverlight 4 application.

How It Works

Silverlight 4 supports embedding a browser control within an Out-of-Browser Silverlight application that matches the browser available on the platform such as Safari on Mac. The `WebBrowser` control is not supported and is disabled when viewing the application in the browser.

■ **Note** Out-of-Browser applications are covered in Chapter 8.

It is very easy to use the `WebBrowser` control. Just drag and drop it onto your Silverlight UI and configure one of its properties to either load local content such as HTML downloaded as part of an RSS feed or navigate to a full web page such as xbox.com or YouTube.com.

The `WebBrowser.Navigate` method loads a `URI` object such as a full HTTP link. You can use `WebBrowser.NavigateToString` method to render a string of HTML content. You can also set the `WebBrowser.Source` property directly. The `WebBrowser.LoadCompleted` event is helpful if you need to alter the UI once the `WebBrowser` control loads its content. As background, the `WebBrowser` control wraps Internet Explorer 7 in terms of HTML rendering capabilities

The Code

For the code, you follow the process described in Recipe 8-1 to create an Out-of-Browser Silverlight application, since that is required in order to leverage the `WebBrowser` control. You create a simple application that includes a `TextBox`, a `Button`, and the `WebBrowser` control. Here's a snippet of the XAML:

```
<Grid>
  <WebBrowser x:Name="BrowserControl" Margin="8,38,58,8" />
  <StackPanel Height="26" Margin="4,8,4,4" Orientation="Horizontal"
    VerticalAlignment="Top" d:LayoutOverrides="Width">
    <TextBox HorizontalAlignment="Left" x:Name="textBox1"
      Width="333" Margin="2,2,2,0" Background="{x:Null}"
      Foreground="LightGray" SelectionForeground="#FF1B1B1B"
      Text="http://youtube.com" />
    <Button Content="Go" Margin="7,2,2,2" x:Name="button1"
      Width="36" Click="button1_Click" />
  </StackPanel>
</Grid>
```

Figure 6-13 shows the UI at design time.

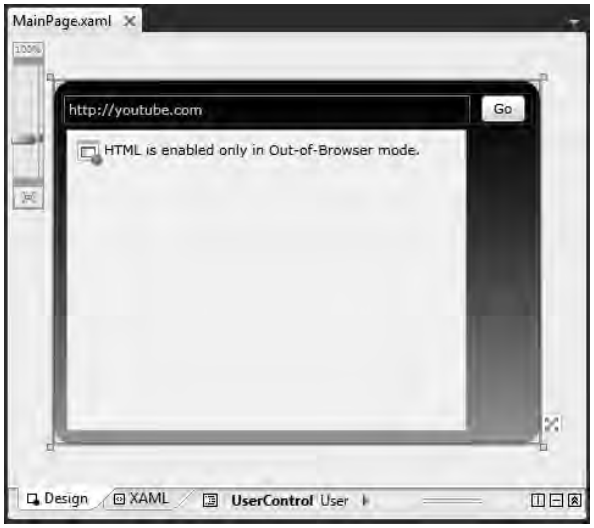


Figure 6-13. *Recipe 6-8's user interface at design time*

When a user clicks the Go button, this line of code fires:

```
BrowserControl.Navigate(new Uri(textBox1.Text));
```

In order to run the application, right-click on the Silverlight plug-in and select Install this application. After installing the application as outlined in Recipe 8-1, run it from the desktop by clicking on the 6-8 icon link located on the pc desktoop. Figure 6-14 shows a screenshot of the UI at runtime with You Tube loaded and playing Adobe Flash video.

Figure 6-14. *Recipe 6-8's user interface at runtime*

We don't show the full listing because most of the code is generated via working in Expression Blend 4. All of the relevant code is discussed above.

6-9. Painting a Silverlight Element with HTML

Problem

You are building an Out-of-Browser application that incorporates the `WebBrowser` control and would like to incorporate the web page contents as part of your user experience.

Solution

Use the `WebBrowserBrush` brush to paint Silverlight elements with the contents of the `WebBrowser` control.

How It Works

The `WebBrowserBrush` has a SetSource property that takes a `WebBrowser` control for a value. When you apply a `WebBrowserBrush` to a XAML element such as a `Rectangle`, the element is painted with the assigned `WebBrowser` control's content. This is useful if you want to create a reflection of the contents of the browser control or use the `WebBrowser` control content in an animation.

The Code

For this recipe, grab the code from Recipe 6-8 as a start and update the Out-of-Browser icons. (Please refer to Recipe 8-1 if you are unsure how to create an Out-of-Browser application.)

In Expression Blend, adjust the UI to make space for a `Rectangle` element to the right of and below the `WebBrowser` control. Add a `Rectangle` to the right of the `WebBrowser` control and another Rectangle over the top of the `WebBrowser` Control. Name the `Rectangle` over top `ReflectionRect` and apply a transform to it by moving its center of rotation to just below the WebBrowser control and rotate it 180 degrees. You should apply a `Skew` of 20 to the `X` component and an `OpacityMask` brush to enhance the reflection appearance. Figure 6-15 shows the UI at design time in Expression Blend.

Figure 6-15. *Recipe 6-9's user interface in Blend*

For the codebehind, the Go button performs the same task as in Recipe 6-8 of loading up the content. You hook into the `WebBrowser.LoadCompleted` event to apply the `WebBrowser` content to the WebBrowserBrush objects for both `Rectangles` as shown here:

```
private void BrowserControl_LoadCompleted(object sender,
System.Windows.Navigation.NavigationEventArgs e)
{
  ((WebBrowserBrush)rectangle1.Fill).SetSource(BrowserControl);
  ((WebBrowserBrush)ReflectionRect.Fill).SetSource(BrowserControl);

  AnimateRectangle.Begin();
}
```

You also animate the rectangle on the right side just to demonstrate possibilities. Figure 6-16 shows the final UI.

Figure 6-16. *Recipe 6-9's user interface at runtime*

6-10. Taking Advantage of the Navigation Framework

Problem

You want to add navigation to your Silverlight application, including support for the browser Back and Forward buttons and URI mapping, and you want the ability to interact with the browser history journal. You would like to have custom URI mappings as well as the ability to programmatically navigate to Silverlight pages using query parameters.

Solution

Take advantage of the Navigation Framework introduced in Silverlight 3 with the new Silverlight Navigation Application project template.

How It Works

In Silverlight 2, providing an application that easily navigated between XAML pages was difficult for developers. In Silverlight 3 and later, Microsoft introduced the Navigation Framework and the new Silverlight Navigation Application project template that allows users to easily navigate between pages. This application template provides support for the browser Back and Forward buttons as well as providing the user with the ability to bookmark a page in a Silverlight application.

When you create a new application with the Silverlight Navigation Application template, more than the usual user interface is created. Figure 6-17 shows the initial project layout.

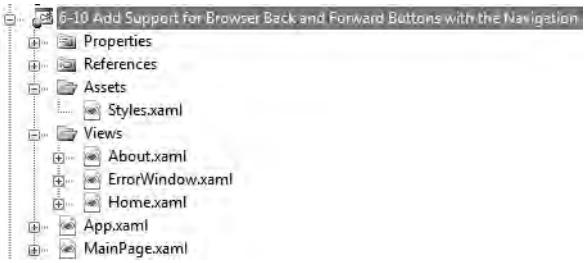


Figure 6-17. *The Silverlight Navigation Application initial project layout*

The additional user interface capabilities help demonstrate how to plug into the framework to speed adoption. You can, of course, completely change the user interface to suite your needs and still take advantage of the navigation framework.

In Figure 6-17, you see the familiar `App.xaml` and `MainPage.xaml` files. In this project template, `MainPage.xaml` acts as a container for the views listed in the `Views` folder. The `Assets` folder is a convenient place to locate additional styles and other resources that are part of an application.

When you run the initial application without making changes, you see the application shown in Figure 6-18.

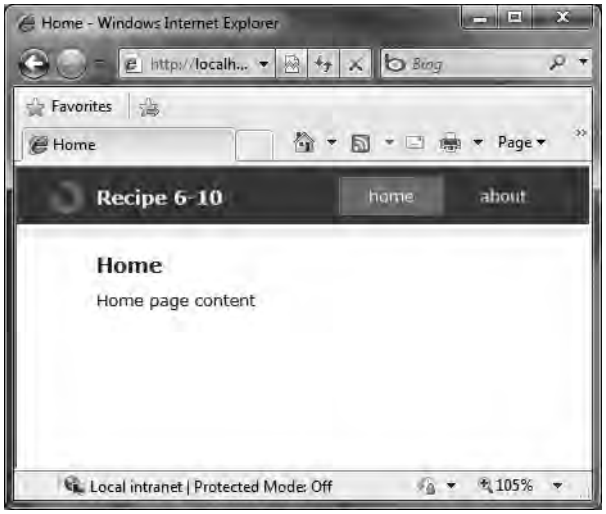


Figure 6-18. *Silverlight Navigation Application initial application UI at runtime*

The full URL is shown here:

```
http://localhost:9090/Recipe6.10TestPage.aspx#/Home
```

Next, click the about button to shift the application to the About view located at `/Views/About.xaml` in the project setup files, resulting in a similar display as in Figure 6-17 but with the text "About page content" and the following URL:

```
http://localhost:9090/Recipe6.10TestPage.aspx#/About
```

Each page results in a navigation entry in the browser history, as you would expect. However, with the Silverlight Navigation Application template, it is possible to bookmark the About view directly by adding the URL `http://localhost:9090/Recipe6.10TestPage.aspx#/About` to the favorites in the web browser or as a shortcut.

The `System.Windows.Controls.Navigation` namespace includes the key controls that provide the navigation application functionality, specifically the `Frame` and `Page` classes.

The `UserControl` class is the type for the `MainPage` object when the Navigation Application template creates a new project. The project contains a `Frame` object named `ContentFrame` by default. The `Frame` class acts as a host for the views that are part of a Navigation Application project. The individual view objects inherit from the `System.Windows.Controls.Page` class. The `Page` class is very similar to the `UserControl` class but adds the capability to be hosted in a `Frame` object. The `Page` class also adds the `Title` property, which is set as the title of the page in the web browser, as shown in Figure 6-18 (above Home in the browser title bar caption).

The `Frame` class integrates with the browser history by default via the `JournalOwnership` property, which can take one of three values:

- `Automatic`: Whether or not this `Frame` will create and use its own journal depends on its parent. If the parent or browser allows it, the navigation will be recorded in the browser journal.
- `OwnsJournal`: The `Frame` maintains its own journal tied into the Browser journal.
- `UsesParentJournal`: The `Frame` object uses the journal of the next available navigation host up the XAML content tree, if one exists. Otherwise, navigation history is not maintained for the `Frame` object if a journal is not available on a parent control.

Figure 6-19 shows the browser journaling after navigating several times between the Home and About pages.

Figure 6-19. *Silverlight Navigation Application project browser journaling integration*

The Code

For this recipe, you add a couple of views by right-clicking the View folder, selecting Add | New Item, and then selecting Silverlight Page in the list. Name the new view items `ItemList` and `ItemDetails`. You want to make the new `Page` object available in the UI, so you add two new `HyperlinkButton` objects to the `LinksStackPanel` object in MainPage.xaml:

```
<HyperlinkButton x:Name="Link2" Style="{StaticResource LinkStyle}"
          NavigateUri="/ItemList"
          TargetName="ContentFrame" Content="item list"/>
<Rectangle x:Name="Divider2" Style="{StaticResource DividerStyle}"/>
<HyperlinkButton x:Name="Link3" Style="{StaticResource LinkStyle}"
          NavigateUri="/ItemDetails" TargetName="ContentFrame"
          Content="item details"/>
<Rectangle x:Name="Divider3" Style="{StaticResource DividerStyle}"/>
```

The important property is `NavigateUri`, where you set the value to the XAML page name without the `.xaml` extension and that it must be prefixed with a forward slash. `Content` is the title for the hyperlink when displayed in the UI. This results in the UI shown in Figure 6-20.

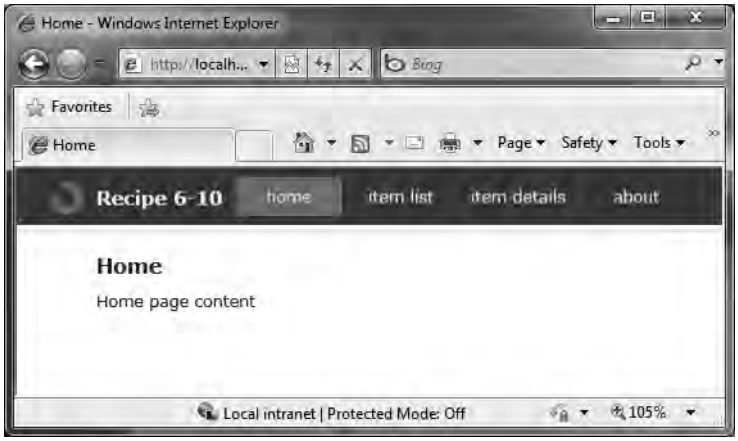


Figure 6-20. *The updated UI with additional menu items*

You can navigate to the new pages just as before, and the navigation will be journaled in the browser history.

You probably noticed that the application is fairly well styled when compared to the normal Silverlight Application template. This helps you visualize the application right away. Conveniently, all of the styles are defined separately in a `ResourceDictionary` in `App.xaml` under the `Assets` project folder:

```
<ResourceDictionary Source="Assets/Styles.xaml"/>
```

This centralizes the styles location for easy editing. It is important to note that the default application layout is not mandatory. For example, you can change the navigation to the left and stack the buttons vertically in a Microsoft Outlook type of layout.

We have not yet covered how to create custom URI mappings or how to pass query parameters when navigating programmatically in code. When the recipe application is initially loaded, the following URL loads:

```
http://localhost:9090/Recipe6.10TestPage.html#/Home
```

The portion of the URL after the hash, `/Home`, is mapped to the `Home.Xaml` page by markup located in `MainPage.xaml`, shown in Listing 6-14, for the `Frame.UriMapper` object.

Listing 6-14. *Recipe 6-10's Main Page.xaml File*

```
<UserControl
    x:Class="Ch06_BrowserIntegration.Recipe6_14.MainPage"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    xmlns:navigation=
     "clr-namespace:System.Windows.Controls;
      assembly=System.Windows.Controls.Navigation"
    xmlns:uriMapper=
    "clr-namespace:System.Windows.Navigation;
     assembly=System.Windows.Controls.Navigation"
    xmlns:d="http://schemas.microsoft.com/expression/blend/2008"
    xmlns:mc="http://schemas.openxmlformats.org/markup-compatibility/2006"
    mc:Ignorable="d" d:DesignWidth="640" d:DesignHeight="480">

  <Grid x:Name="LayoutRoot" Style="{StaticResource LayoutRootGridStyle}">
    <Border x:Name="ContentBorder" Style="{StaticResource ContentBorderStyle}">
      <navigation:Frame x:Name="ContentFrame"
        Style="{StaticResource ContentFrameStyle}"
        Source="/Home" Navigated="ContentFrame_Navigated"
        NavigationFailed="ContentFrame_NavigationFailed">
        <navigation:Frame.UriMapper>
          <uriMapper:UriMapper>
            <uriMapper:UriMapping Uri="/ItemDetails/{lastName}"
                      MappedUri="/Views/ItemDetails.xaml?lastName={lastName}"/>
            <uriMapper:UriMapping Uri="" MappedUri="/Views/Home.xaml"/>
            <uriMapper:UriMapping Uri="/{pageName}"
                      MappedUri="/Views/{pageName}.xaml"/>
            <uriMapper:UriMapping Uri="foo" MappedUri="/Views/About.xaml"/>
          </uriMapper:UriMapper>
        </navigation:Frame.UriMapper>
      </navigation:Frame>
    </Border>
    <Grid x:Name="NavigationGrid" Style="{StaticResource NavigationGridStyle}">
      <Border x:Name="BrandingBorder" Style="{StaticResource BrandingBorderStyle}">
        <StackPanel x:Name="BrandingStackPanel"
```

```
                Style="{StaticResource BrandingStackPanelStyle}">
        <ContentControl Style="{StaticResource LogoIcon}"/>
        <TextBlock x:Name="ApplicationNameTextBlock"
          Style="{StaticResource ApplicationNameStyle}" Text="Application Name"/>
      </StackPanel>
    </Border>
    <Border x:Name="LinksBorder" Style="{StaticResource LinksBorderStyle}">
      <StackPanel x:Name="LinksStackPanel"
                Style="{StaticResource LinksStackPanelStyle}">
        <HyperlinkButton x:Name="Link1" Style="{StaticResource LinkStyle}"
                NavigateUri="/Home" TargetName="ContentFrame" Content="home"/>
        <Rectangle x:Name="Divider1" Style="{StaticResource DividerStyle}"/>
        <HyperlinkButton x:Name="Link2" Style="{StaticResource LinkStyle}"
                NavigateUri="/ItemList"
                TargetName="ContentFrame" Content="item list"/>
        <Rectangle x:Name="Divider2" Style="{StaticResource DividerStyle}"/>
        <HyperlinkButton x:Name="Link3" Style="{StaticResource LinkStyle}"
                NavigateUri="/ItemDetails" TargetName="ContentFrame"
                Content="item details"/>
        <Rectangle x:Name="Divider3" Style="{StaticResource DividerStyle}"/>
        <HyperlinkButton x:Name="Link4" Style="{StaticResource LinkStyle}"
                NavigateUri="/About" TargetName="ContentFrame"
                Content="about"/>
      </StackPanel>
    </Border>
  </Grid>
 </Grid>
</UserControl>
```

Find the `UriMapper` object in the listing, and you will see this automatically generated `UriMapping` as well as the default mapping that points to `Home.xaml`:

```
<uriMapper:UriMapping Uri="/{pageName}"
MappedUri="/Views/{pageName}.xaml"/>
```

The `{pageName}` value is a substitution variable such that when `/Home` is passed in as a URI, the `Home` is translated to load `/Views/Home.xaml` as the Silverlight `Page` object to load in the `Frame`. There is another URI mapping for this URL:

```
http://localhost:9090/Recipe6.10TestPage.html#foo
```

If you change `/Home` to `foo` and run the page, `About.xaml` will load. This URI mapping makes it happen:

```
<uriMapper:UriMapping Uri="foo" MappedUri="/Views/About.xaml"/>
```

Here, you do not append a slash (`/`) to the front so `foo` is appended directly at the end of the URL right after the hash to load the mapped URI. Note that the full URL with `#foo` at the end can be bookmarked, and the bookmark will load the application with the `About.xaml` page displayed.

The last bit of code allows you to programmatically navigate from one page to another page within a Silverlight Navigation Application project. As mentioned, you added two pages named `ItemList.xaml` and `ItemDetails.xaml` as view items for the application. The `ItemList` view contains a simple `DataGrid` pointing to automatically generated sample data in Expression Blend 3, which was covered in Chapter 2. The `ItemDetails` view contains a text box where you will display the passed-in query string value containing the fictitious last name generated in the sample data. We don't include the XAML listings for these files because the action is in the codebehind files shown in Listings 6-15 and 6-16.

Listing 6-15. *Recipe 6-10's ItemList.Xaml.cs Code File*

```
using System;
using System.Windows.Controls;
using System.Windows.Navigation;
using Expression.Blend.SampleData.SampleDataSource;

namespace Ch06_BrowserIntegration.Recipe6_2.Views
{
  public partial class ItemList : Page
  {
    public ItemList()
    {
      InitializeComponent();
    }

    // Executes when the user navigates to this page.
    protected override void OnNavigatedTo(NavigationEventArgs e)
    {
    }

    private void DataGrid_SelectionChanged(object sender,
      SelectionChangedEventArgs e)
    {

      //Navigate with parameters
      string lastName = ((Item)itemsDataGrid.SelectedItem).LastName;
      this.NavigationService.Navigate(
        new Uri(String.Format("/ItemDetails/{0}", lastName.ToString()),
        UriKind.Relative));
    }
  }
}
```

Listing 6-16. *Recipe 6-10's ItemDetails.Xaml.cs Code File*

```
using System.Windows.Controls;
using System.Windows.Navigation;

namespace Ch06_BrowserIntegration.Recipe6_2.Views
{
  public partial class ItemDetails : Page
  {
    public ItemDetails()
    {
      InitializeComponent();
    }

    // Executes when the user navigates to this page.
    protected override void OnNavigatedTo(NavigationEventArgs e)
    {
      if (this.NavigationContext.QueryString.ContainsKey("lastName"))
      itemDetails.Text = "'lastName' query parameter equals "+
        this.NavigationContext.QueryString["lastName"];
    }
  }
}
```

As shown in Listing 6-16 the `ItemListcontains` a `DataGrid` that has a `DataGrid_SelectionChanged` event attached that fires when an item is selected in the ItemList control. This event programmatically navigates to the `ItemDetails` page using the NavigationService.Navigate method:

```
string lastName = ((Item)itemsDataGrid.SelectedItem).LastName;
this.NavigationService.Navigate(
new Uri(String.Format("/ItemDetails/{0}", lastName.ToString()),
UriKind.Relative));
```

To comply with the URI template in `MainPage.xaml`, append the query parameter, the `LastName` field from the selected record, to the end of the URI, which replaces the {0} in the URI string. The `UriMapper` in `MainPage.xaml` loads the `ItemDetails` view with the passed-in `LastName` value as a query parameter like this:

```
/Views/ItemDetails.xaml?lastName=passedInLastName"
```

In the `ItemDetails.xaml.cs` file's `OnNavigatedTo` event handler, you process the query string with the NavigationContext object:

```
if (this.NavigationContext.QueryString.ContainsKey("lastName"))
itemDetails.Text = "'lastName' query parameter equals "+
  this.NavigationContext.QueryString["lastName"];
```

This code results in the UI as shown in Figure 6-21.

Figure 6-21. *The UI showing captured query parameters*

The functionality just covered allows developers to pass parameters or state between navigation `Page` objects for a more unified UI. However, if you look at Figure 6-22 closely, you'll notice that the item details button is not highlighted as expected, as it is when you manually click between tabs. The issue is the default URI comparison logic in `MainPage.xaml.cs` shown here:

```
if (hb.NavigateUri.ToString().Equals(e.Uri.ToString()))
```

When you programmatically navigate between tabs, you append parameters to `Uri`, which is the `Uri` value on `e.Uri` in the `ContentFrame_Navigated` event in `MainPage.xaml.cs`. When this value is compared to the configured `NavigateUri` on all of the navigation `Hyperlink` buttons, the comparison will fail. So change the logic to perform this check instead:

```
if (e.Uri.ToString().Contains(hb.NavigateUri.ToString()))
```

With this update, the URI that is being navigated to is checked to see if it contains the configured `NavigateUri` of any of the `Hyperlink` buttons. If the check passes, the highlighted state is set on the hyperlink, as shown in Figure 6-22.

Figure 6-22. *The UI showing captured query parameters with correct visual state*

6-11. Embedding Silverlight within a Windows Gadget

Problem

You want to build a gadget for the Windows Sidebar that includes the Silverlight 4 plug-in control for both Windows Vista and Windows 7.

Solution

The Windows Sidebar hosts gadgets that are based on an HTML and `JavaScript` programming model. As such, gadgets can host ActiveX controls such as the Silverlight plug-in.

How It Works

Windows Sidebar gadgets are meant to be visually appealing and focused on performing a single task well, such as tracking stock quotes, tracking system resource utilization, reporting internal training status, and so forth. Given the ability to create rich user interfaces for web pages in Silverlight, it is a very interesting scenario to host Silverlight in a Windows Sidebar gadget.

■ **Note** Windows Sidebar gadgets that include Silverlight 4 can only be hosted in 32-bit Sidebar process.

Windows Sidebar gadgets generally have small user interfaces in order to fit in the Sidebar. MSDN has sizing guidelines of 130 pixels in height when docked, which includes 5 pixels of drop shadow—2 pixels on the left, and 3 pixels on the right.

Gadgets can be detached from the Windows Sidebar. In Windows 7, gadgets are free floating by default. When detached or floating, the recommended size is 400 pixels by 400 pixels. Gadgets can have an options dialog box with a client area of 278 pixels wide and no more than 400 pixels high. For more information on Windows Sidebar gadgets interface guidelines, see `msdn.microsoft.com/en-us/library/aa974179.aspx`

Now that you know the basics on the UI for gadgets, here are the three simple steps to create a Windows Sidebar gadget:

1. Create a development folder for all of the gadget files.
2. Add the HTML pages, CSS, and JavaScript files to the development folder.
3. Create a manifest file, and add it to the development folder.

For the first step, create a web site project named `SilverlightRecipesGadget` in the file system under the `Code\Ch06_BrowserIntegration folder` in the sample code. Remove the `App_Data` folder, `Default.aspx` file, and `web.config` file from the project, since you don't need them.

For the second step, add three HTML files named `DockedUndockedView.html`, `FlyoutView.html`, and `SettingsView.html`, as well as four folders: a js folder for JavaScript files, a css folder for CSS files, a img folder for images, and a ClientBin folder for the Silverlight `.xap` file. Add `Silverlight.js` to your project in the js folder and create placeholder JavaScript and CSS files in their respective folders. You obtain `Silverlight.js` from this folder in the files system:

```
%ProgramFiles%\Microsoft SDKs\Silverlight\v2.0\Tools
```

Figure 6-23 shows the initial layout of your Silverlight gadget web project in the Visual Studio Solution Explorer tool window.

Figure 6-23. *Recipe 6-11's initial Silverlight gadget web project layout*

Go to the project properties for the `SilverlightRecipesGadget` project, and add the "6-11 Embedding Silverlight within a Windows Gadget" project to the Silverlight tab. You do not create test pages in the Add Silverlight Application wizard because you don't need them in this project. Completing the wizard will automatically copy the output from your Silverlight application to the `ClientBin` folder for the gadget each time the application is compiled.

For the third step, add an XML file to the web project and name it `Gadget.xml`. This file defines the startup HMTL page, title, authors, and so on for the gadget. For more information about the format of `Gadget.xml`, see `msdn.microsoft.com/en-gb/library/bb508509(VS.85).aspx`

Essentially, you code gadgets as you would code HTML files. The gadget runs in an Internet Explorer window that doesn't have any of the browser chrome. You can manipulate the DOM, make AJAX calls, and access system resources.

There are several views available for a gadget: docked, undocked, flyout, and settings. Figure 6-24 shows the different views available for a gadget.

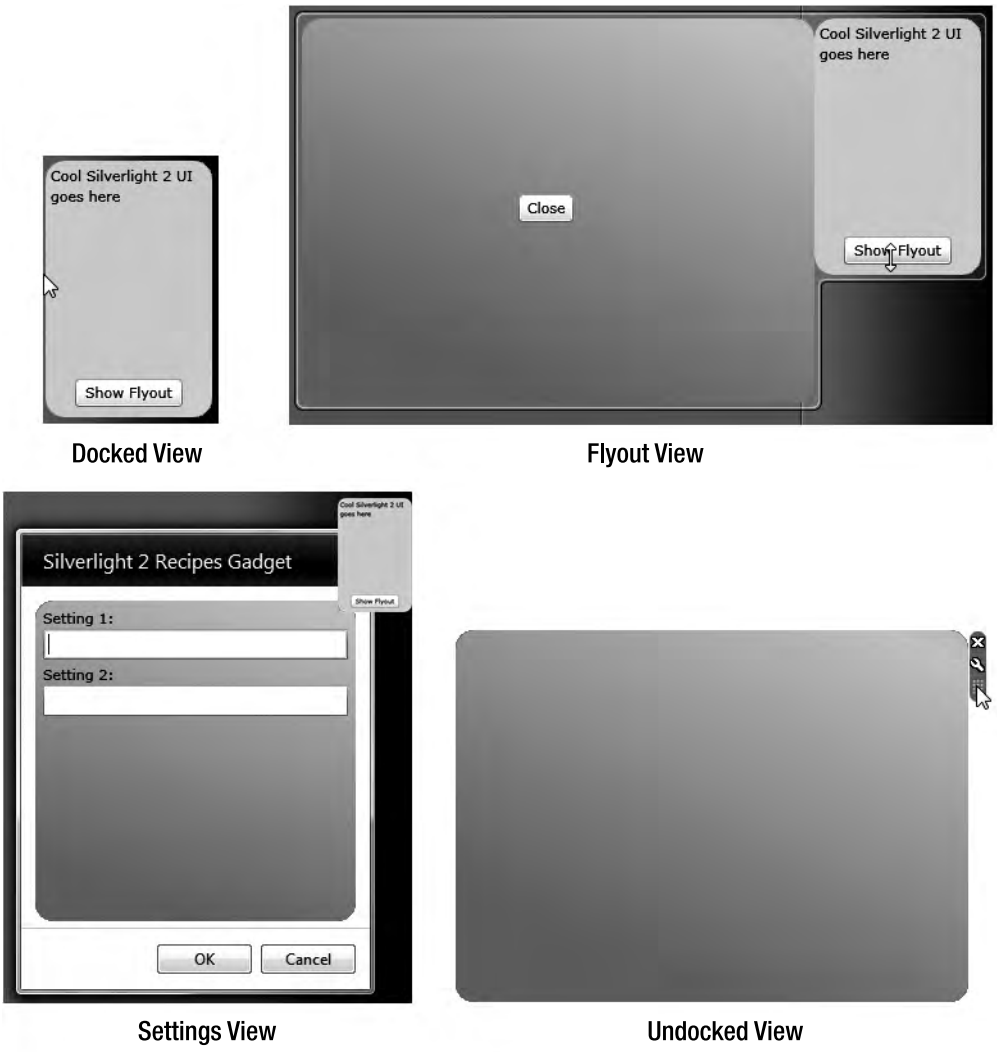


Figure 6-24. *Available gadget views*

As mentioned, gadgets consist of HTML pages. Your gadget has the following HMTL pages to provide all of the views listed in Figure 6-24:

- `DockedUndockedView.html`: Displays the docked and undocked views for the gadget and defines the startup HTML view specified in the `Gadget.xml` manifest
- `FlyoutView.html`: Displays the flyout view for the gadget
- `SettingsView.html`: Displays the settings view for the gadget

In general, when you first create a Silverlight application, it includes an `Application` object named `App` located in the `Application.xaml` file and a single `UserControl` object named `Page` located in `MainPage.xaml`. The `Page UserControl` is defined as the startup UI and configured as the `App.RootVisual` for the `Application` object in the `Application_Startup` method located in `App.xaml.cs`.

For your Silverlight 4 gadget, your goal is to handle all of the UI views shown in Figure 6-24 with the same Silverlight application. You do this by including additional Silverlight `UserControl` objects to handle the various views:

- `DockedView.xaml`: Displays the Silverlight UI when the gadget is in a docked state and serves as the startup view in `DockedUndockedView.html` (originally the `Page UserControl` that you just renamed to `DockedView`)
- `UndockedView.xaml`: Displays the Silverlight UI when the gadget is in an undocked state or floating on the Windows desktop
- `FlyoutView.xaml`: Displays the Silverlight UI when the gadget displays the flyout view in `FlyoutView.html`
- `SettingsView.xaml`: Displays the Silverlight UI when the gadget displays the settings view in `SettingsView.html`

The UI connection point between the hosting HTML pages and corresponding `UserControl` objects is the Silverlight plug-in installation. You take advantage of the initialization parameter functionality on the Silverlight plug-in to tell the Silverlight application which `UserControl` to display.

The gadget development model is based on HTML and `JavaScript`. The programming connection point between gadget programmability and the Silverlight application is the HTML Bridge functionality that enables Silverlight to access `JavaScript` methods as well as enables JavaScript to access managed code methods.

When a user manipulates a gadget to show the flyout view, undock the gadget, or display settings, the gadget API fires JavaScript events. Your approach is to have the JavaScript stub method that receives the gadget API event call the appropriate method in the Silverlight application to update the UI, save settings, and so forth. This puts most of the actual application logic into the Silverlight application, which is where you want it so that you can take advantage of the managed programming model.

There are additional options and considerations, such as multilanguage support, involved in developing a gadget that are not cover here. Refer to the MSDN documentation to learn more about building a Windows Sidebar gadget: `msdn.microsoft.com/en-us/library/bb456468.aspx`

The final step is packaging up the gadget, which is simple: just zip up the contents and change the `.zip` extension `.gadget`. For your example, navigate to the `Code\Ch06_BrowserIntegration\SilverlightRecipesGadget` folder, select all of the contents, right-click one of the files, and select Send to | Compressed (zipped) Folder. It will want to name one of the files or folders with a `.zip` extension. Simply rename it to whatever you like but change the extension to `.gadget`. Double-clicking the `.gadget` file results in the UI shown in Figure 6-25.

Figure 6-25. *Installing the Silverlight recipes gadget*

Gadgets can also be deployed as a `.cab` file, which can be signed to avoid the prompt shown in Figure 6-25, but once you click the Install button shown in Figure 6-25, the gadget will display in the Windows Sidebar unless you are on a 64-bit version of Windows, in which case you need to run the 32-bit version of Sidebar.exe.

■ **Note** When testing a new gadget, you can delete the installation files from this location: `%userprofile%\AppData\Local\Microsoft\Windows Sidebar\Gadgets`.

While automated debugging of code running in the Windows Sidebar is not available, you can still attach the debugger to the sidebar and step through breakpoints for both the Silverlight and JavaScript code. When debugging, deploy the gadget with a debug build of the Silverlight application, package it in a ZIP file, and change the extension to `.gadget`. Once the gadget is installed, attach the debugger using the Visual Studio 2008 Debug ➤ Attach to Process dialog box, as shown in Figure 6-26.

You can enable script debugging in Visual Studio for gadgets as well by following the steps at msdn.microsoft.com/en-us/library/bb456467(VS.85).aspx We recommend that you take advantage of Silverlight and JavaScript debugging support to speed development. When we tried both JavaScript and Silverlight debugging with breakpoints in the Silverlight code and JavaScript code, JavaScript debugging worked fine, but breakpoints set in Silverlight were not hit. Disabling JavaScript debugging in Internet Explorer and restarting the Windows Sidebar allowed Silverlight breakpoints to function as expected.

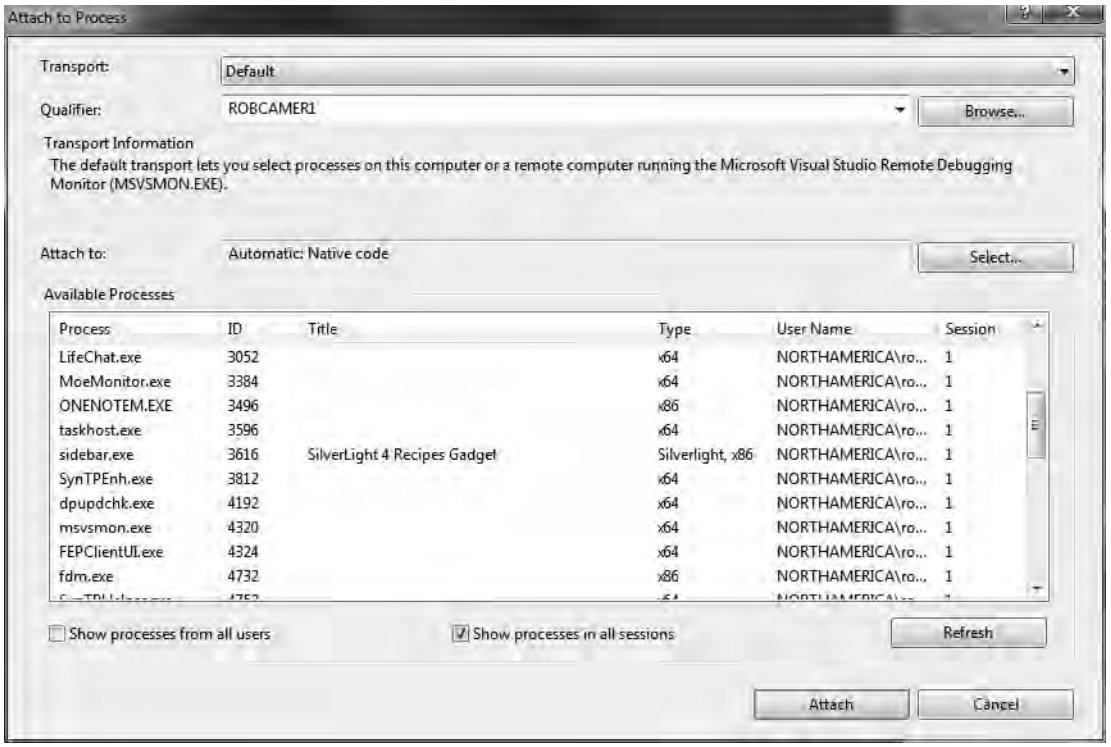


Figure 6-26. *The Visual Studio 2010 Attach to Process dialog box*

The sample code for this recipe is meant to be a gadget template to help you get started with developing your own gadgets. The Silverlight UI portions are simply placeholders for building a more useful gadget, but using this recipe as a template will greatly speed gadget development.

To get started building gadgets with Silverlight 4, a separate solution is included with the source code contained in `SLforGadgetSolution.zip` located in the `\Code\Ch06_BrowserIntegration` folder. This solution contains a bare-bones implementation of the Silverlight project with docking and undocking, flyout menus, and settings support in a simple two-project Visual Studio solution.

The Code

Since you use the same Silverlight application or `.xap` file for all of the gadget project web pages, you need a method to load the correct view into the Silverlight application depending on the `.html` page hosting the Silverlight application as described in this recipe's "How It Works" section. Take advantage of the `initParams` parameter available on the Silverlight plug-in control, which was first demonstrated in Recipe 6-6. For example, in the `DockedUndockedView.html` page, you have this value configured or the Silverlight plug-in control:

```
<param name ="initParams" value="View=DockedUndocked" />
```

The three HTML pages named `DockedUndockedView.html`, `FlyoutView.html`, and `SettingsView.html` all follow this pattern. Listing 6-17 shows the source code for `DockedUndockedView.html`.

Listing 6-17. *DockedUndockedView.html File*

```
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
  <title>Silverlight 4 Recipes</title>
  <link href="css/DockedUndockedView.css" rel="stylesheet" type="text/css" />
  <script language="javascript" type="text/javascript"
  src="/js/Silverlight.js"></script>
  <script language="javascript" type="text/javascript"
  src="/js/Shared.js"></script>
  <script language="javascript" type="text/javascript"
  src="/js/DockedUndockedView.js"></script>

</head>
<body onload="loadGadget();">
  <div id="errorLocation" style="font-size: small; color: Gray;">
  </div>
  <div id="silverlightControlHost">
    <object data="data:application/x-silverlight-2,"
      type="application/x-silverlight-2"
      width="100%" height="100%" id="XamlGadget">
      <param name="source"
        value="x-gadget:///ClientBin/Ch06_BrowserIntegration.Recipe6_11.xap" />
      <param name="onerror" value="onSilverlightError" />
      <param name="minRuntimeVersion" value="4.0.50401.0" />
      <param name="autoUpgrade" value="true" />
      <param name="enableHtmlAccess" value="true" />
      <param name="windowless" value="true" />
      <param name="background" value="transparent" />
      <param name="initParams" value="View=DockedUndocked" />
      <param name="onload" value="onSilverlightLoad" />
      <a href="http://go.microsoft.com/fwlink/?LinkID=149156&v
       =4.0.50401.0" style="text-decoration:none">
      <img src="http://go.microsoft.com/fwlink/?LinkId=161376"
       alt="Get Microsoft Silverlight" style="border-style:none"/>
      </a>
    </object>
    <g:background src="/img/transparentDocked.png"
     mce_src="/img/transparentDocked.png"
     id="transparentBackground" style="width: 130px;
     height: 200px; z-index: -1" />
  </div>
</body>
</html>
```

The HTML page in Listing 6-17 pulls in three JavaScript files: `Silverlight.js`, `Shared.js`, and `DockedUndocked.js`. You pull in `Silverlight.js` in case you need it. `Shared.js` has a common `onSilverlightLoad` handler for all three pages that sets focus to the gadget in HTML. `DockedUndocked.js` is covered next.

For the gadget UI, you want to have rounded corners for all views. Listing 6-18 shows the XAML for `DockedView.xaml`, which is the `UserControl` displayed when the gadget is docked.

Listing 6-18. *DockedView.xaml File*

```
<UserControl x:Class="Ch06_BrowserIntegration.Recipe6_11.DockedView"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    Width="130" Height="200" Background="#00FFFFFF"
    HorizontalAlignment="Left" VerticalAlignment="Top">
  <Grid Background="#00FFFFFF" >
    <Border CornerRadius="15,15,15,15">
      <Border.Background>
        <LinearGradientBrush EndPoint="-0.227,0.337"
        StartPoint="1.227,0.663">
          <GradientStop Color="#FFB9D4C6" Offset="0.397"/>
          <GradientStop Color="#FF65E8A5" Offset="1"/>
          <GradientStop Color="#FF65E8A5"/>
          <GradientStop Color="#FFB9D4C6" Offset="0.554"/>
          <GradientStop Color="#FFB9D4C6" Offset="0.482"/>
        </LinearGradientBrush>
      </Border.Background>
      <Grid x:Name="LayoutRoot" Margin="4" Background="{x:Null}">
        <TextBlock Text="Cool Docked Silverlight 4 UI goes here"
          TextWrapping="Wrap"/>
      </Grid>
    </Border>
  </Grid>
</UserControl>
```

In Listing 6-18, you set the `UserControl` and outer `Grid` control to a transparent background. You also ensure that the Silverlight plug-in in the HTML page is configured with a transparent background. Even after setting `CornerRadius` to 15 for all corners, a white background was visible at the rounded corners in the UI. So you follow these steps to allow a transparent background at the corners: Create a transparent `.png` using Paint.NET (or your favorite drawing tool). In Paint.NET, create a new 130-pixel-wide by 200-pixel-high image for the docked dimensions of the gadget. Next, chose Layers | Layer Properties and set Opacity to 0. Then, save the image to the `img` folder as `transparentDocked.png`.

The gadget JavaScript API provides additional functionality, such as setting the gadget background with the `g:background` tag. Add this HTML to the `DockedUndockedView.html` file inside the `<div>` hosting the Silverlight control to configure the background to provide rounded corners to your gadget:

```
<g:background src="/img/transparentDocked.png"
mce_src="/img/transparentDocked.png"
id="transparentBackground" style="width:130px;height:200px;z-index:-1"/>
```

This code results in the rounded corners being transparent; however, a slight magenta color can be seen at the corners. This is an artifact of having two transparent objects overlapping within Internet Explorer, which is the rendering engine in the Windows Sidebar.

An additional step is required when displaying the docked or undocked view, because they are both hosted in the same HTML page, `DockedUndockedView.html`. To handle this, you wire up events in `DockedUndockedView.js`, shown in Listing 6-19.

Each page has a `loadGadget` event hooked into the HTML body tag's `onload` event. `loadGadget` is the same name for all three HTML pages, but each one does something different specific to the view. Listing 6-19 shows `DockedUndockedView.js`.

Listing 6-19. *DockedUndockedView.js File*

```
function loadGadget() {
    System.Gadget.onDock = dockStateChanged;
    System.Gadget.onUndock = dockStateChanged;

    System.Gadget.Flyout.file = "FlyoutView.html";
    System.Gadget.settingsUI = "SettingsView.html";
}

function dockStateChanged() {
    //change size depending on state
    if (System.Gadget.docked) {
        document.body.style.width = "130px";
        document.body.style.height = "200px";
        document.getElementById("XamlGadget").Content.
          GadgetApp.DockGadget(true);
    }
    else {
        document.body.style.width = "400px";
        document.body.style.height = "290px";
        document.getElementById("XamlGadget").Content.
          GadgetApp.DockGadget(false);
    }
}
```

In `loadGadget` for the Docked/Undocked view, you assign the event handler `dockStateChanged` to the gadget events `onDock` and `onUndock` by passing in `true` to dock it or `false` to undock. When this `JavaScript` event handler fires, it sets the dimensions on the `<body>` tag to fit the UI and then switches between the Silverlight docked or undocked UI via the HTML Bridge with this call:

```
document.getElementById("XamlGadget").Content.GadgetApp.DockGadget(false);
```

To allow the UI to change, you need to take an additional step to switch between the `DockedView.xaml` and `UndockedView.xaml` `UserControl` objects depending on the gadget's current state of being docked or undocked. Here is the typical `Application_Startup` method for a Silverlight application:

```
private void Application_Startup(object sender, StartupEventArgs e)
{
```

```
  this.RootVisual = new MainPage();
}
```

For your Silverlight application, you have additional logic in `GadgetApp.xaml.cs` to choose which `UserControl` to configure for `Application.RootVisual`. In your `Application_Startup`, you first determine which view is requested by obtaining the initialization parameters specified in the hosting HTML page:

```
  //Get passed parameter to choose the view.
  string initParams =
     HtmlPage.Plugin.GetProperty("initParams").ToString();
  string[] paramsArray = initParams.Split(';');
  string[] KeyValue = paramsArray[0].Split('=');
```

Next, use the value for `KeyValue[1]` in a switch statement to select which view to display. You cannot simply switch the value configured on `Application.RootVisual` as it will not work. You set an empty `Grid` as `RootVisual` and then add the necessary `UserControl` as a child to the `Grid` configured as `RootVisual`:

```
switch (KeyValue[1])
{                 //For DockedUndocked, we set Grid as root
                  //so that we can switch user controls later
                 //at runtime for docked and undocked states.
  case "DockedUndocked": _rootControl = new Grid();
                  this.RootVisual = _rootControl;
                  _dockedView = new DockedView();
                  _rootControl.Children.Clear();
                  _rootControl.Children.Add(_dockedView); break;
  case "Flyout":  this.RootVisual = new FlyoutView(); break;
  case "Settings": this.RootVisual = new SettingsView(); break;
}
```

Since the docked and undocked views are hosted in the same HTML page, `DockedUndockedView.html`, you need to take additional steps so that you can switch the UI depending on whether the gadget is docked or floating. First, declare three private reference variables at the top of the `GadgetApp Application` instance:

```
//Use this as root control so that the user controls
//can be switched from docked to undocked
private Grid _rootControl;
//Hold references to Docked and Undocked Views
private DockedView _dockedView ;
private UndockedView _unDockedView ;
```

You configure `Application.RootVisual` to point to a `Grid` control referenced by `_rootControl` and add the `DockedView` and `UndockedView` instances as the child to the root `Grid` control depending on the docked or undocked state. Listing 6-20 shows the full source code for `GadgetApp.xaml.cs`.

Listing 6-20. *GadgetApp.xaml.cs File*

```
using System;
using System.Windows;
using System.Windows.Browser;
using System.Windows.Controls;

namespace Ch06_BrowserIntegration.Recipe6_11
{
  public partial class GadgetApp : Application
  {
    //Use this as root control so that the user controls
    //can be switched from docked or undocked
    private Grid _rootControl;
    //Hold references to Docked and Undocked Views
    private DockedView _dockedView;
    private UndockedView _unDockedView;

    public GadgetApp()
    {
      this.Startup += this.Application_Startup;
      this.Exit += this.Application_Exit;
      this.UnhandledException += this.Application_UnhandledException;

      InitializeComponent();
    }

    private void Application_Startup(object sender, StartupEventArgs e)
    {
      //Get passed parameter for partner control
      string initParams =
         HtmlPage.Plugin.GetProperty("initParams").ToString();
      string[] paramsArray = initParams.Split(';');
      string[] KeyValue = paramsArray[0].Split('=');
      switch (KeyValue[1])
      {
         //For DockedUndocked, we set Grid as root
        //so that we can switch user controls later
        //at runtime for docked and undocked states.
        case "DockedUndocked": _rootControl = new Grid();
          this.RootVisual = _rootControl;
          _dockedView = new DockedView();
          _rootControl.Children.Clear();
          _rootControl.Children.Add(_dockedView);
```

```
            break;
        case "Flyout": this.RootVisual = new FlyoutView();
            break;
        case "Settings": this.RootVisual = new SettingsView();
            break;
      }
      //Make GadgetApp instance available so that script
      //can call DockGadget method from JavaScript
      HtmlPage.RegisterScriptableObject("GadgetApp", this);
    }

    private void Application_Exit(object sender, EventArgs e)
    {

    }

    private void Application_UnhandledException(object sender,
    ApplicationUnhandledExceptionEventArgs e)
    {
      if (!System.Diagnostics.Debugger.IsAttached)
      {
        e.Handled = true;
        Deployment.Current.Dispatcher.BeginInvoke(
          delegate { ReportErrorToDOM(e); });
      }
    }

    private void ReportErrorToDOM(ApplicationUnhandledExceptionEventArgs e)
    {
      try
      {
        string errorMsg = e.ExceptionObject.Message +
                          e.ExceptionObject.StackTrace;
        errorMsg = errorMsg.Replace('"', '\'').Replace("\r\n", @"\n");

        System.Windows.Browser.HtmlPage.Window.Eval(
        "throw new Error(\"Unhandled Error in Silverlight 4 Application " +
        errorMsg + "\");");
      }
      catch (Exception)
      {
      }
    }

    [ScriptableMember]
```

```
    public void DockGadget(Boolean state)
    {
      switch (state)
      {
        case true: _rootControl.Children.Clear();
          _rootControl.Children.Add(_dockedView); break;
        //First time undocking, create undocked view
        case false: if (null == _unDockedView)
            _unDockedView = new UndockedView();
          //Switch to undocked view when gadget undocked
          _rootControl.Children.Clear();
          _rootControl.Children.Add(_unDockedView); break;
      }
    }
  }
}
```

The DockGadget method in Listing 6-20 is located in GadgetApp.xaml.cs and called by the JavaScript code to switch from the docked to undocked view for the Silverlight application. If true is passed in from JavaScript, the DockGadget method clears the children on the rootControl and adds the saved dockedView instance as the child control to the root Grid. If false is passed in, the UndockedView is created and a reference saved and added as the child control of the root Grid.

Setting the enableHtmlAccess parameter on the Silverlight plug-in to true and calling the below line of code in Application_Startup in GadgetApp.xaml.cs makes the ScriptableMember GadgetApp.DockGadget method available in the JavaScript code:

```
HtmlPage.RegisterScriptableObject("GadgetApp", this);
```

There is a button in the DockedView UI that, when clicked, shows the flyout using this line of code that calls the gadget API:

```
HtmlPage.Window.Eval(@"System.Gadget.Flyout.show = true;");
```

For the flyout view, a simple button closes the flyout when clicked, using this line of code that calls into the gadget API:

```
HtmlPage.Window.Eval(@"System.Gadget.Flyout.show = false;");
```

We don't list the code for FlyoutView and UndockedView, since they are mostly placeholders for content that expands when a user hovers over a particular element or clicks a button; they just provide more information.

The additional core gadget functionalities you implement are saving and retrieving settings for the gadget in the SettingsView UserControl. These gadget functions include the ability to persist settings for the gadget. As an example, the Weather Gadget included with Windows has a setting that allows a user to pick location for weather information. In JavaScript, these are the two methods to read and write settings:

```
System.Gadget.Settings.Read(key);
System.Gadget.Settings.Write(key,value);
```

For your Silverlight 4 gadget, you try to execute as much of the application as possible within Silverlight 4 in the SettingsView control, but you still need code in JavaScript to wire up the Silverlight code with the gadget functionality. As an example, the previous settings' API functions are called from the SettingsView.xaml UserControl code in the LoadGadgetSettings and SaveGadgetSettings methods. Listings 6-21 and 6-22 show the code for the SettingsView UserControl.

Listing 6-21. *SettingsView.xaml File*

```
<UserControl x:Class="Ch06_BrowserIntegration.Recipe6_8.SettingsView"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    Width="250" Height="250">
  <Grid >
    <Border CornerRadius="15,15,15,15">
      <Border.Background>
        <LinearGradientBrush EndPoint="0.5,1" StartPoint="1.164,-1.028">
          <GradientStop Color="#FF808080"/>
          <GradientStop Color="#FF808080" Offset="1"/>
          <GradientStop Color="#FF96D7A8" Offset="0.504000000810623169"/>
        </LinearGradientBrush>
      </Border.Background>
      <Grid x:Name="LayoutRoot"  Margin="4">
        <StackPanel Margin="0">
          <TextBlock Margin="2,2,2,0" Text="Setting 1:" TextWrapping="Wrap"/>
          <TextBox x:Name="Setting1" Margin="2,0,2,2" TextWrapping="Wrap"/>
          <TextBlock Text="Setting 2:" Margin="2,2,2,0" TextWrapping="Wrap"/>
          <TextBox x:Name="Setting2" Margin="2,0,2,2" TextWrapping="Wrap"/>
        </StackPanel>
      </Grid>
    </Border>
  </Grid>
</UserControl>
```

Listing 6-22. *SettingsView.xaml.cs File*

```
using System;
using System.Windows.Browser;
using System.Windows.Controls;

namespace Ch06_BrowserIntegration.Recipe6_8
{
  public partial class SettingsView : UserControl
  {
    public SettingsView()
    {
      InitializeComponent();
```

```
      HtmlPage.RegisterScriptableObject("SettingsView", this);
      //Load settings for gadget
      LoadGadgetSettings();
    }

    private void LoadGadgetSettings()
    {
      try
      {
        //Textbox control name is also Setting name in this example.
        Setting1.Text = (HtmlPage.Window.Eval("System.Gadget.Settings") as
        ScriptObject).Invoke("read", Setting1.Name) as string;
        Setting2.Text = (HtmlPage.Window.Eval("System.Gadget.Settings") as
       ScriptObject).Invoke("read", Setting2.Name) as string;
      }
      catch (Exception err)
      {
        //do something with exception here
      }
    }

    [ScriptableMember]
    public void SaveGadgetSettings()
    {
      try
      {
        (HtmlPage.Window.Eval("System.Gadget.Settings") as ScriptObject).
         Invoke("write", Setting1.Name, Setting1.Text);
        (HtmlPage.Window.Eval("System.Gadget.Settings") as ScriptObject).
         Invoke("write", Setting2.Name, Setting2.Text);
      }
      catch (Exception err)
      {
        //do something with exception here
      }
    }
  }
}
```

The LoadGadgetSettings and SaveGadgetSettings methods are called from JavaScript events located in SettingsView.js that are wired up in Listing 6-23.

Listing 6-23. *SettingsView.js File*

```
function loadSettingsView()
```

```
{
    System.Gadget.onSettingsClosed = settingsViewClosed;
    System.Gadget.onSettingsClosing = settingsViewClosing;
}

function settingsViewClosed(event) {
}

function settingsViewClosing(event) {
    document.getElementById("XamlGadget").Content.
      SettingsView.SaveGadgetSettings();

    if (event.closeAction == event.Action.commit)
    {
        //call Method to save settings in the SettingsView UserControl
        document.getElementById("XamlGadget").
          Content.SettingsView.SaveGadgetSettings();
    }

    // Allow the Settings dialog to close.
    event.cancel = false;
}
```

The JavaScript function `loadSettingsView` is called when the `<body>` tag loads in `SettingsView.html`. This function wires up two JavaScript events to `onSettingsClosed` and `onSettingsClosing`. The `settingsViewClosed` JavaScript event is not used in your code, but leave it as a placeholder. The `settingsViewClosing` JavaScript makes the call into the `SettingsView` Silverlight `UserControl` in this line of code:

```
document.getElementById("XamlGadget").Content.
  SettingsView.SaveGadgetSettings();
```

This pattern of implementing the logic in Silverlight but wiring up the events in JavaScript is the approach you take to implement the gadget functionality code as much as possible.

The last file is the XML file, the manifest file for your gadget, shown in Listing 6-24.

Listing 6-24. *Gadget.xml File*

```
<?xml version="1.0" encoding="utf-8" ?>
<gadget>
  <name>Silverlight 4 Recipes Gadget</name>
  <namespace>Ch06_BrowserIntegration</namespace>
  <version>1.0</version>
  <author name="Rob Cameron and Jit Ghosh">
  </author>
  <copyright>2008</copyright>
  <description>Testing Silverlight in a Gadget</description>
```

```
  <icons>
  </icons>
  <hosts>
    <host name="sidebar">
      <base type="HTML" apiVersion="1.0.0"
            src="DockedUndockedView.html" />
      <permissions>full</permissions>
      <platform minPlatformVersion="1.0" />
    </host>
  </hosts>
</gadget>
```

■ **Note** If you're using Notepad or some other text editor to create the file, be sure to save the manifest file as `Gadget.xml` with encoding as UTF-8; otherwise, it will not be recognized as a valid gadget.

6-12. Embedding Silverlight in an Internet Explorer 8 Web Slice

Problem

You need to host Silverlight 4 content in an Internet Explorer 8 Web Slice.

Solution

Internet Explorer 8 (IE8) Web Slices are based on an HTML and JavaScript programming model. As such, IE8 Web Slices can host ActiveX controls, such as the Silverlight plug-in.

How It Works

An IE8 Web Slice is a new browser feature that allows web site users to subscribe to a portion of a web page. Web Slices are based on the `hAtom` and `hSlice` microformats. It is very easy to create a web slice in an existing web page by simply annotating the HTML with class names for title, entry content as well as other properties. For more information regarding Web Slices, go to the Web Slices link on MSDN at msdn.microsoft.com/en-us/library/cc956158(VS.85).aspx.

The Code

In order to create your web slice, first you reduce the test pages to just the code necessary to create a web slice. Listing 6-25 has the source code for the `.html` page.

Listing 6-25. *Recipe 6-12's Test Page .html File*

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
  <title>Test Page for Recipe 6.12/title>
</head>
<body>
  <form id="form1" runat="server" style="height: 100%">
  <div id="Recipe6.12WebSlice" class=hslice><!--Web Slice class -->
    <H3 class=entry-title>Recipe6.12 WebSlice Title</H3> <!--Web Slice Title class -->
      <a rel="entry-content" href=
       "http://localhost:9090/Recipe6.12WebSlice.aspx" style="display:none;"></a>
  </div>
  </form>
</body>
</html>
```

You can certainly put more content into this page, but this is reduced to just what is necessary to demonstrate a Web Slice. The updated test pages do two things: identify the Web Slice content and bootstrap installation with the help of IE8. Essentially, a Web Slice is a container HTML control, such as a `<div>`, that has a particular class attribute applied to it. In your case, the `<div>` with the `id` of `Recipe6.9WebSlice` has the `class` value of `hslice` on it to identify that it is a Web Slice container. You can add a title to the Web Slice by assigning an HTML element the `class` value of `entry-title`, which you do on an `<h3>` tag. The text contained in the HTML element with the entry-title class is also the text that is used to represent the title of the Web Slice in IE8's Favorites bar. Configuring these classes in HTML causes IE to display the Install a Web Slice button when the user mouses over the `<div>` tag, as shown in Figure 6-27.

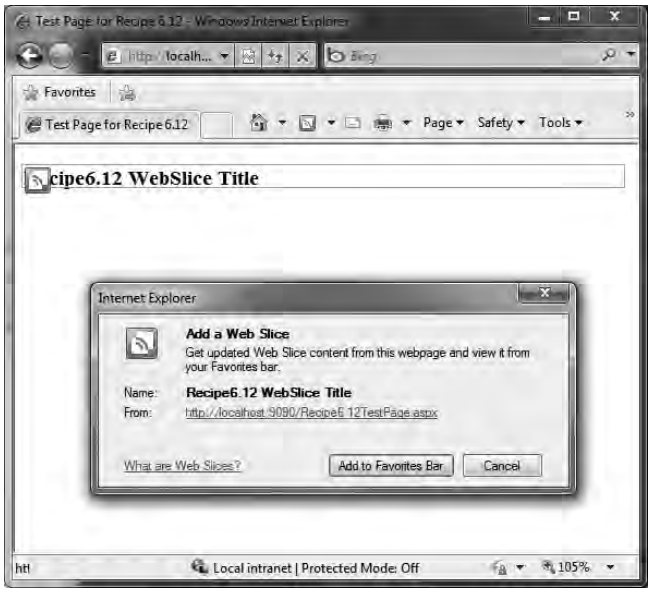


Figure 6-27. *The Add a Web Slice button and dialog*

When you move the mouse over the Web Slice `<div>`, the green button appears over the `<div>` text. When you click the green button, it displays the Add a Web Slice dialog box. This adds the Web Slice to the Favorites section in IE8, as shown in Figure 6-28.

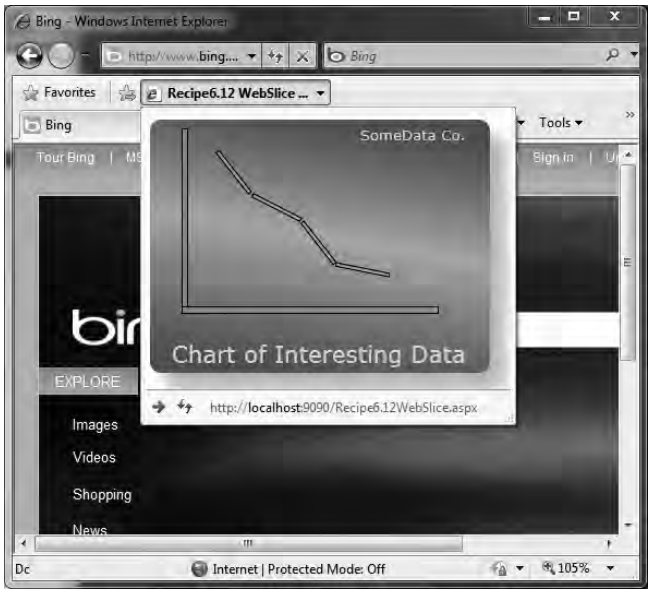


Figure 6-28. *The installed Web Slice*

After installation, the user can navigate to any web site and still be able to bring up the Web Slice by clicking the link in the Favorites section of IE8. In your case, the Web Slice displays a fictitious graph for a fictitious company, but you can display anything in a Web Slice that you can create in Silverlight.

So far, we have not explained where, exactly, the Silverlight content is loaded from. As noted previously, the `<a>` tag in Listing 6-26 is part of the Web Slice, which in your case points to a file named `Recipe6.9WebSlice.aspx`:

```
<a rel="entry-content" style="display:none;"
href="http://localhost:9090/Recipe6.12WebSlice.aspx" ></a>
```

We first tried putting the Silverlight `<object>` tag directly in the same page as the test page by adding the `entry-content` class to a `<div>` where the Silverlight control is instantiated, but that did not work. We note this as background in case you wish to build a Web Slice that does not use Silverlight and want to keep the Web Slice content in the same page.

Listing 6-26 has the code for the Web Slice.

Listing 6-26. *Recipe 6-12's Web Slice .aspx*

```
<%@ Page Language="C#" AutoEventWireup="true" %>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
 "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head runat="server">
  <title>Test Page for Recipe 6.12</title>
  <style type="text/css">
    html, body
    {
      height: 100%;
      width: 100%;
    }
    body
    {
      padding: 0;
      margin: 0;
    }
    #silverlightControlHost
    {
      height: 100%;
      width: 100%;
      text-align: center;
    }
  </style>
  <script type="text/javascript" src="Silverlight.js"></script>

  <script type="text/javascript">
    function onSilverlightError(sender, args) {
      var appSource = "";
```

```
      if (sender != null && sender != 0) {
        appSource = sender.getHost().Source;
      }

      var errorType = args.ErrorType;
      var iErrorCode = args.ErrorCode;

      if (errorType == "ImageError" || errorType == "MediaError") {
        return;
      }

      var errMsg = "Unhandled Error in Silverlight Application " + appSource + "\n";

      errMsg += "Code: " + iErrorCode + "    \n";
      errMsg += "Category: " + errorType + "       \n";
      errMsg += "Message: " + args.ErrorMessage + "     \n";

      if (errorType == "ParserError") {
        errMsg += "File: " + args.xamlFile + "     \n";
        errMsg += "Line: " + args.lineNumber + "     \n";
        errMsg += "Position: " + args.charPosition + "     \n";
      }
      else if (errorType == "RuntimeError") {
        if (args.lineNumber != 0) {
          errMsg += "Line: " + args.lineNumber + "     \n";
          errMsg += "Position: " + args.charPosition + "     \n";
        }
        errMsg += "MethodName: " + args.methodName + "     \n";
      }

      throw new Error(errMsg);
    }
  </script>

</head>
<body>
  <form id="form1" runat="server" style="height:100%; width:100%">
  <div id="silverlightControlHost">
    <object data="data:application/x-silverlight-2," type=
             "application/x-silverlight-2"
      width="100%" height="100%">
      <param name="source" value=
                "ClientBin/Ch06_BrowserIntegration.Recipe6_12.xap" />
      <param name="onError" value="onSilverlightError" />
      <param name="background" value="white" />
```

```
      <param name="minRuntimeVersion" value="3.0.40613.0" />
      <param name="autoUpgrade" value="true" />
      <a href="http://go.microsoft.com/fwlink/?LinkID=149156&v=3.0.40613.0"
        style="text-decoration: none">
        <img src="http://go.microsoft.com/fwlink/?LinkId=108181"
          alt="Get Microsoft Silverlight" style="border-style: none" />
      </a>
    </object>
    <iframe id="_sl_historyFrame" style="visibility: hidden; height:
      0px; width: 0px; border: 0px"></iframe>
  </div>
  </form>
</body>
</html>
```

This page has some minor modifications related to styles that differ from the typical test page; these deviations prevent scroll bars from appearing when the Web Slice preview is displayed in the IE8 Favorites toolbar. So, add `style="height:100%; width:100%"` to the form page. Also, add the same values to the CSS style for `#silverlightControlHost` and for the `<html>` and `<body>` tags. Lastly, remove the `overflow: auto;` attribute. This results in the nice clean Web Slice display shown in Figure 6-28.

CHAPTER 7

Networking and Web Service Integration

In modern, well-architected, loosely coupled systems, a common practice is to expose application processing logic and server-resident data as a set of services. The term *service* is used fairly generically in this context—a service can be anything that has a known endpoint accessible over a standard web protocol like HTTP, offering information exchange capabilities using a standard format like SOAP, plain XML, or JavaScript Object Notation (JSON).

For a server-side UI framework like ASP.NET or a desktop application built using .NET, you can use the full power of the .NET Framework's web service stack to consume these services from the presentation layer of your application.

In the same vein, if you are developing Silverlight-based user experiences, you will often need to consume these services directly from your client-side Silverlight code. The Silverlight .NET libraries include networking APIs that allow you to do just that. The Silverlight network programming stack lets you take advantage of the following high-level features:

- Communicating over HTTP or HTTPS with web services
- Seamlessly integrating with Windows Communication Foundation–based services
- Exchanging plain old XML (POX) or JSON-formatted data to communicate with services
- Enabling TCP-based communication through TCP sockets
- Responding to network availability state changes from locally installed applications
- Enabling local communication between multiple Silverlight applications on the same web page

Note that Silverlight only supports communication with WS-I Basic Profile 1.1–compliant endpoints for SOAP 1.1 over HTTP(S) style message exchange.

Some of the more modern web service standards, such as the WS-* family of protocols, offer a standardized way of enabling advanced distributed computing features in a service-oriented architecture (SOA). Most of these standards are meant for complex SOAs where many services interact with one another across various server platform implementations. Some examples are

- Reliable message delivery using WS-ReliableMessaging
- Atomic transactions across services using WS-AtomicTransactions
- Advanced distributed, cross-platform security mechanisms using WS-Security that go beyond the traditional point-to-point Secure Sockets Layer (SSL) usage

These standards are typically implemented in a layered fashion on top of the basic SOAP standard mentioned earlier, and any client framework enabled for these standards needs client-side implementation. A full implementation of these standards, however, would have meant a significant increase in the size of the runtime and libraries that the Silverlight plug-in contains. To keep a small footprint and provide the efficient, responsive, cross-platform user experience of Silverlight, a decision was made to not support the WS-* standards at this point.

Also of note is the increased use of Representational State Transfer (REST)-styled services in Web 2.0–type web applications, which seems to be a continuing trend. REST is a way of accessing resources over HTTP, where every resource thus accessible is identifiable with a URI. RESTful services typically use either plain XML or other lightweight formats like JSON to exchange messages over HTTP; operations on such services are equivalent to either acquiring or sending such resources to specified endpoints. These techniques are well supported in Silverlight, as you will see in this chapter.

■ **Note** In the recipes, we have chosen to use Windows Communication Foundation (WCF) to implement the HTTP-based services. As needed, we highlight the specific WCF-related requirements for the services to be usable by Silverlight, but a detailed treatment of WCF is beyond the scope of this book. We also use LINQ and LINQ to XML queries in several of the recipes in this chapter. For more details about WCF, LINQ, and LINQ to XML, refer to the appropriate documentation in the MSDN library at `msdn.microsoft.com/en-us/library/default.aspx`. You can also refer to *Pro LINQ: Language Integrated Query in C# 2008* (Apress, 2007) and *Pro WCF: Practical Microsoft SOA Implementation* (Apress, 2007) for in-depth treatments.

A Quick Word about the Samples

The WCF web services in the sample code for this chapter are created as file-system web projects. This is to avoid a dependency on Microsoft Internet Information Services (IIS) and to ensure that you can run all the code samples on your machine without needing IIS. However, keep in mind that we did this purely to reduce the effort in getting the book samples up and running after they are downloaded. For all practical purposes, you should consider a state-of-the-art, industry-leading web application server like IIS for your mission-critical sites and services, whether in a development, test, or production environment.

Also note that file-system web projects are debugged using a development web server built into Visual Studio. When you are in debug mode, Visual Studio takes care of starting up the necessary services. However, if you are running the client from outside Visual Studio or browsing to the test page from inside Visual Studio, the services and development web server are not started automatically. The best way to start them manually is to browse to your `.svc` page for the service project from within the Visual Studio Solution Explorer.

In addition, the Visual Studio development web server randomly picks a port for applications. This is not desirable, especially for web services, because you need to specify the URI for the service in your client code or configuration. You can instruct Visual Studio to always use a fixed port on a per-project basis, from the project's Debug properties page. We have done so in the sample projects already. Take care not to specify the same port on services that need to run together.

7-1. Consuming a WCF Service

Problem

Your Silverlight application needs to communicate with a WCF service.

Solution

Add a reference to the WCF service to your Silverlight application, and use the generated proxy classes to invoke the service.

How It Works

From the context menu of the Silverlight project in Solution Explorer, select Add Service Reference. This brings up the dialog shown in Figure 7-1.

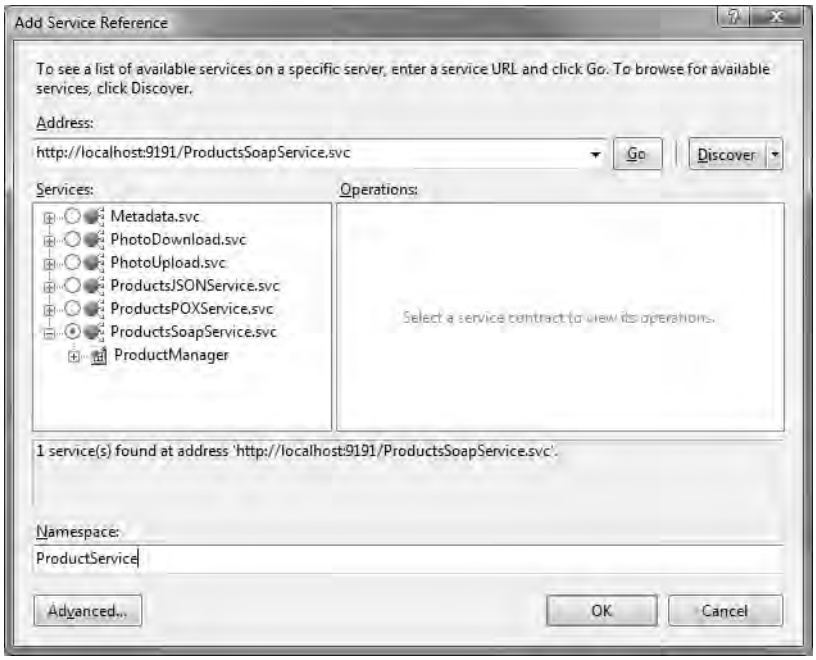


Figure 7-1. *Visual Studio 2008 Add Service Reference dialog*

You have the option of entering the URL of the service endpoint or, if the service project is part of your solution, of clicking Discover to list those services. After the service(s) are listed, select the appropriate service and click OK to add a reference to the service to your application, which generates a set of proxy classes. You can change the namespace in which the generated proxy lives by changing the default namespace specified by the dialog.

Additionally, you have the option to further customize the generated proxy by clicking the Advanced button. This brings up the dialog shown in Figure 7-2, where you can specify, among other options, the collection types to be used by the proxy to express data collections and dictionaries being exchanged with the service.

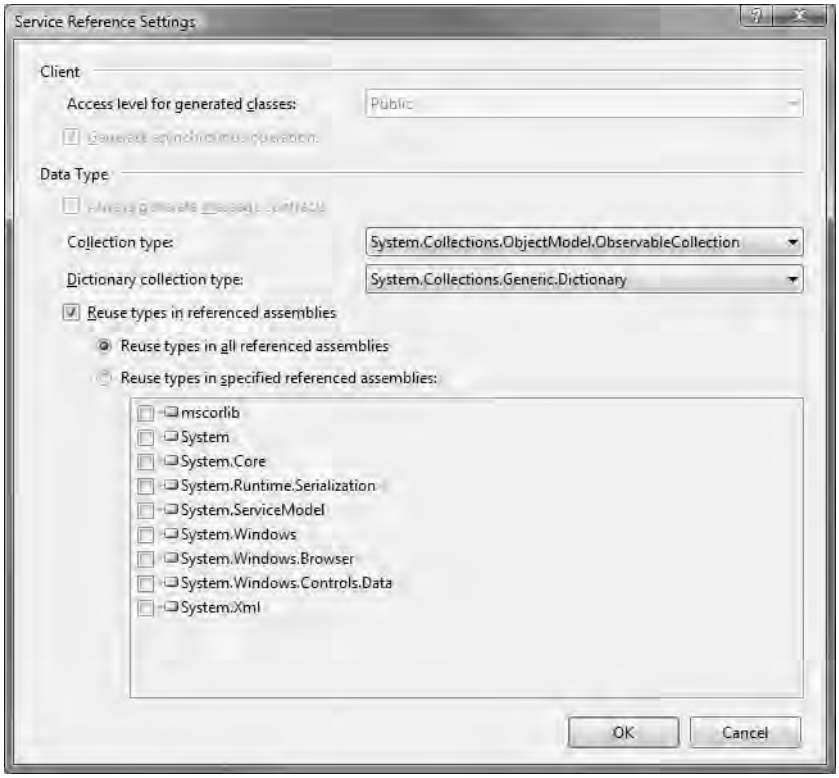


Figure 7-2. *Visual Studio 2008 Service Reference Settings dialog*

To display the generated proxy files, select the proxy node under the Service References node in your project tree, and then click the Show All Files button on the top toolbar on the Visual Studio Solution Explorer. The proxy node has the same name as the service for which you generated the proxy. You can find the generated proxy code in the `Reference.cs` file under the `Reference.svcmap` node in the project, as shown in Figure 7-3.

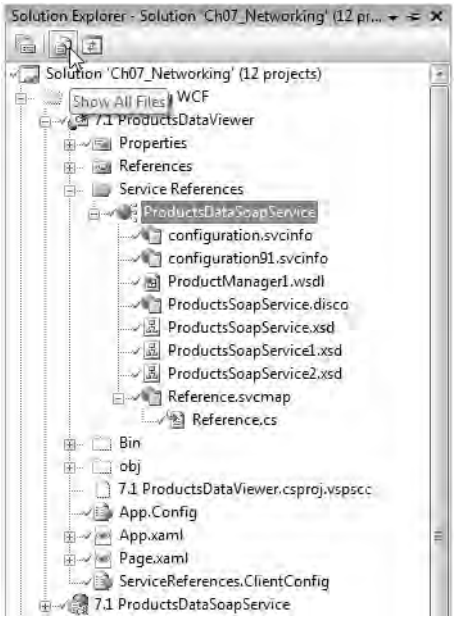


Figure 7-3. *Visual Studio 2008 generated service proxy*

Invoking a Service Operation

Assuming a service named `ProductManager` exists, `Reference.cs` contains a client proxy class for the service named `ProductManagerClient`. It also contains the data-contract types exposed by the service.

Silverlight uses an asynchronous invoke pattern—all web-service invocations are offloaded to a background thread from the local thread pool, and control is returned instantly to the executing Silverlight code. The proxy-generation mechanism implements this by exposing an *xxx*`Async()` method and *xxx*`Completed` event pair on the client proxy, where *xxx* is an operation on the service. To invoke the service operation from your Silverlight code, you execute the *xxx*`Async()` method and handle the *xxx*`Completed` event, in which you can extract the results returned by the service call from the event arguments. Note that although the service-invocation code executes on a background thread, the framework switches context to the main UI thread before invoking the completion event handler so that you do not have to worry about thread safety in your implementation of the handler.

Listing 7-1 shows such a pair from the generated proxy code for a service operation named `GetProductHeaders`.

Listing 7-1. *Generated proxy code for a service operation*

```
public event System.EventHandler<GetProductHeadersCompletedEventArgs>
GetProductHeadersCompleted;

public partial class GetProductHeadersCompletedEventArgs :
    System.ComponentModel.AsyncCompletedEventArgs
{
```

```
private object[] results;

  public GetProductHeadersCompletedEventArgs(object[] results,
      Exception exception, bool cancelled, object userState) :
      base(exception, cancelled, userState)
  {
    this.results = results;
  }

  public List<ProductHeader> Result
  {
    get
    {
      base.RaiseExceptionIfNecessary();
      return ((System.Collections.Generic.List<ProductHeader>)(this.results[0]));
    }
  }
}

public void GetProductDetailAsync(ushort ProductId) {
            this.GetProductDetailAsync(ProductId, null);
  }
```

Note the custom event argument type named `GetProductHeadersCompletedEventArgs` in Listing 7-1. Silverlight creates one of these for every unique operation in your service. Each exposes a `Result` property as shown, which is strongly typed (in this case, to a `List<ProductHeader>`) to help you avoid any casting or conversion in retrieving the result of the service call.

Configuring a WCF Service for Silverlight

As indicated in the introduction to this chapter, Silverlight requires a SOAP/HTTP-based service to be WS-I Basic Profile 1.1 compliant. In WCF terms, that means using `BasicHttpBinding` on the service endpoint. Listing 7-2 shows a sample configuration section of a service that uses `BasicHttpBinding`.

Listing 7-2. *WCF Service Configuration in Web.config*

```
<system.serviceModel>
    <bindings>
      <basicHttpBinding>
        <binding name="LargeMessage_basicHttpBinding"
                 maxReceivedMessageSize="1048576" />
      </basicHttpBinding>
    </bindings>
    <serviceHostingEnvironment aspNetCompatibilityEnabled="True"/>
    <services>
```

```
      <service behaviorConfiguration="ServiceBehavior"
          name="Recipe7_1.ProductsDataSoapService.ProductManager">
        <endpoint address="" binding="basicHttpBinding"
        bindingConfiguration="LargeMessage_basicHttpBinding"
        contract=
"Recipe7_1.ProductsDataSoapService.IProductManager" />
        <endpoint address="mex" binding="mexHttpBinding"
                  contract="IMetadataExchange" />
      </service>
    </services>
    <behaviors>
      <serviceBehaviors>
        <behavior name="ServiceBehavior">
          <serviceMetadata httpGetEnabled="true" />
          <serviceDebug includeExceptionDetailInFaults="false" />
        </behavior>
      </serviceBehaviors>
    </behaviors>
  </system.serviceModel>
```

The additional endpoint utilizing `mexHttpBinding` is required to expose service-contract metadata, which is needed for the client proxy generation described earlier in this section. Note the setting of the `maxReceivedMessageSize` property on the binding to about 1 MB (defined in bytes). This increases it from its default value of about 65 KB, because you anticipate the messages in the code sample to be larger than that limit.

Also note that similar configuration settings are needed on the Silverlight client to initialize the proxy and consume the service. When you generate the proxy, this is automatically generated for you and stored in a file called `ServiceReferences.ClientConfig`. This file is packaged into the resulting `.xap` file for your Silverlight application, and the settings are automatically read in when you instantiate a service proxy.

The Code

The code sample for this recipe builds a simple master-detail style UI over product inventory data exposed by a WCF service. Listing 7-3 shows the service contract for the WCF service.

Listing 7-3. *Service contract for the service in ServiceContract.cs*

```
using System.Collections.Generic;
using System.ServiceModel;

namespace Recipe7_1.ProductsDataSoapService
{
  [ServiceContract]
  public interface IProductManager
  {
    [OperationContract]
```

```
    List<ProductHeader> GetProductHeaders();
    [OperationContract]
    void UpdateProductHeaders(List<ProductHeader> Updates);

    [OperationContract]
    ProductDetail GetProductDetail(ushort ProductId);

    [OperationContract]
    void UpdateProductDetail(ProductDetail Update);
  }
}
```

A service contract models the external interface that the service exposes to the world. You can represent the service contract in a common language runtime (CLR) programming language of your choice (C# in this case). The contract itself is an interface, with the operations defined as method signatures in the interface. The attribution of the interface with `ServiceContractAttribute`, and that of the operations with `OperationContractAttribute`, indicates to the WCF runtime that this interface is representative of a service contract. When you try to generate a proxy (or model it by hand) using Visual Studio, the Web Service Definition Language (WSDL) that is returned by the service and used to model the proxy also maps to this service contract.

The service contract in Listing 7-3 is implemented as an interface named `IProductManager`, allows retrieval of a collection of all `ProductHeader` objects through `GetProductHeaders()`, and accepts batched `ProductHeader` changes through `UpdateProductHeaders()`. It also lets you retrieve `ProductDetail` using `GetProductDetail()` for a specific product, in addition to allowing updates to `ProductDetail` information for a product using `UpdateProductDetail()` in a similar fashion.

Listing 7-4 shows the data contracts used in the service.

Listing 7-4. *Data contracts for the service in DataContracts.cs*

```
namespace Recipe7_1.ProductsDataSoapService
{
  [DataContract]
  public partial class ProductHeader
  {
    private ushort? productIdField;
    private decimal? listPriceField;
    private string nameField;
    private string sellEndDateField;
    private string sellStartDateField;

    [DataMember]
    public ushort? ProductId
    {
      get { return this.productIdField; }
      set { this.productIdField = value; }
    }
    [DataMember]
```

```
  public decimal? ListPrice
  {
    get { return this.listPriceField; }
    set { this.listPriceField = value; }
  }
  [DataMember]
  public string Name
  {
    get { return this.nameField; }
    set { this.nameField = value; }
  }
  [DataMember]
  public string SellEndDate
  {
    get { return this.sellEndDateField; }
    set { this.sellEndDateField = value; }
  }
  [DataMember]
  public string SellStartDate
  {
    get { return this.sellStartDateField; }
    set { this.sellStartDateField = value; }
  }
}

[DataContract]
public partial class ProductDetail
{

  private ushort? productIdField;
  private string classField;
  private string colorField;
  private byte? daysToManufactureField;
  private string discontinuedDateField;
  private string finishedGoodsFlagField;
  private string makeFlagField;
  private string productLineField;
  private string productNumberField;
  private ushort? reorderPointField;
  private ushort? safetyStockLevelField;
  private string sizeField;
  private decimal? standardCostField;
  private string styleField;
  private string weightField;
```

```
[DataMember]
public ushort? ProductId
{
  get { return this.productIdField; }
  set { this.productIdField = value; }
}
[DataMember]
public string Class
{
  get { return this.classField; }
  set { this.classField = value; }
}
[DataMember]
public string Color
{
  get { return this.colorField; }
  set { this.colorField = value; }
}
[DataMember]
public byte? DaysToManufacture
{
  get { return this.daysToManufactureField; }
  set { this.daysToManufactureField = value; }
}
[DataMember]
public string DiscontinuedDate
{
  get { return this.discontinuedDateField; }
  set { this.discontinuedDateField = value; }
}
[DataMember]
public string FinishedGoodsFlag
{
  get { return this.finishedGoodsFlagField; }
  set { this.finishedGoodsFlagField = value; }
}
[DataMember]
public string MakeFlag
{
  get { return this.makeFlagField; }
  set { this.makeFlagField = value; }
}
[DataMember]
public string ProductLine
{
```

```
  get { return this.productLineField; }
  set { this.productLineField = value; }
}
[DataMember]
public string ProductNumber
{
  get { return this.productNumberField; }
  set { this.productNumberField = value; }
}
[DataMember]
public ushort? ReorderPoint
{
  get { return this.reorderPointField; }
  set { this.reorderPointField = value; }
}
[DataMember]
public ushort? SafetyStockLevel
{
  get { return this.safetyStockLevelField; }
  set { this.safetyStockLevelField = value; }
}
[DataMember]
public string Size
{
  get { return this.sizeField; }
  set { this.sizeField = value; }
}
[DataMember]
public decimal? StandardCost
{
  get { return this.standardCostField; }
  set { this.standardCostField = value; }
}
[DataMember]
public string Style
{
  get { return this.styleField; }
  set { this.styleField = value; }
}
[DataMember]
public string Weight
{
  get { return this.weightField; }
  set { this.weightField = value; }
}
```

```
  }
}
```

Any custom CLR type that you define in your application and use in your service operations needs to be explicitly known to the WCF runtime. This is so that it can be serialized to/deserialized from the wire format (SOAP/JSON, and so on) to your application code format (CLR type). To provide this information to WCF, you must designate these types as data contracts. The `DataContractAttribute` is applied to the type, and each property member that you may want to expose is decorated with the `DataMemberAttribute`. Leaving a property undecorated does not serialize it, and neither is it included in the generated proxy code.

In this case, you define data contracts for the `ProductHeader` and the `ProductDetail` types that you use in the service contract. Note that WCF inherently knows how to serialize framework types such as primitive types and collections. Therefore, you do not need specific contracts for them.

Listing 7-5 shows the full implementation of the service in the `ProductManager` class, implementing the service contract `IProductManager`.

Listing 7-5. *Service implementation in ProductManager.cs*

```
using System;
using System.Collections.Generic;
using System.IO;
using System.Linq;
using System.ServiceModel.Activation;
using System.Web;
using System.Xml.Linq;

namespace Recipe7_1.ProductsDataSoapService
{
  [AspNetCompatibilityRequirements(
    RequirementsMode = AspNetCompatibilityRequirementsMode.Required)]
  public class ProductManager : IProductManager
  {
    public List<ProductHeader> GetProductHeaders()
    {
      //open the local XML data file for products
      StreamReader stmrdrProductData = new StreamReader(
        new FileStream(HttpContext.Current.Request.MapPath(
          "App_Data/XML/Products.xml"), FileMode.Open));
      //create a Linq To XML Xdocument and load the data
      XDocument xDocProducts = XDocument.Load(stmrdrProductData);
      //close the stream
      stmrdrProductData.Close();
      //transform the XML data to a collection of ProductHeader
      //using a Linq To XML query
      IEnumerable<ProductHeader> ProductData =
       from elemProduct in xDocProducts.Root.Elements()
       select new ProductHeader
```

```
    {
      Name = elemProduct.Attribute("Name") != null ?
       elemProduct.Attribute("Name").Value : null,
      ListPrice = elemProduct.Attribute("ListPrice") != null ?
                  new decimal?(Convert.ToDecimal(
                    elemProduct.Attribute("ListPrice").Value))
                  : null,
      ProductId = elemProduct.Attribute("ProductId") != null ?
                  new ushort?(Convert.ToUInt16(
                    elemProduct.Attribute("ProductId").Value)) :
                  null,
      SellEndDate = elemProduct.Attribute("SellEndDate") != null ?
       elemProduct.Attribute("SellEndDate").Value : null,
      SellStartDate = elemProduct.Attribute("SellStartDate") != null ?
       elemProduct.Attribute("SellStartDate").Value : null
    };
  //return a List<ProductHeader>
  return ProductData.ToList();
}

public void UpdateProductHeaders(List<ProductHeader> Updates)
{
  //open the local data file and load into an XDocument
  StreamReader stmrdrProductData = new StreamReader(
    new FileStream(HttpContext.Current.Request.MapPath(
      "App_Data/XML/Products.xml"), FileMode.Open));
  XDocument xDocProducts = XDocument.Load(stmrdrProductData);
  stmrdrProductData.Close();
  //for each of the ProductHeader instances
  foreach (ProductHeader Prod in Updates)
  {
    //find the corresponding XElement in the loaded XDocument
    XElement elemTarget =
     (from elemProduct in xDocProducts.Root.Elements()
      where Convert.ToUInt16(elemProduct.Attribute("ProductId").Value)
      == Prod.ProductId
      select elemProduct).ToList()[0];
    //and updates the attributes with the changes
    if (elemTarget.Attribute("Name") != null)
      elemTarget.Attribute("Name").SetValue(Prod.Name);
    if (elemTarget.Attribute("ListPrice") != null
            && Prod.ListPrice.HasValue)
      elemTarget.Attribute("ListPrice").SetValue(Prod.ListPrice);
    if (elemTarget.Attribute("SellEndDate") != null)
      elemTarget.Attribute("SellEndDate").SetValue(Prod.SellEndDate);
```

```
    if (elemTarget.Attribute("SellStartDate") != null)
      elemTarget.Attribute("SellStartDate").SetValue(Prod.SellStartDate);
  }
  //save the XDocument with the changes back to the data file
  StreamWriter stmwrtrProductData = new StreamWriter(
    new FileStream(HttpContext.Current.Request.MapPath(
      "App_Data/XML/Products.xml"), FileMode.Truncate));
  xDocProducts.Save(stmwrtrProductData);
  stmwrtrProductData.Close();

}

public ProductDetail GetProductDetail(ushort ProductId)
{
  StreamReader stmrdrProductData = new StreamReader(
    new FileStream(
      HttpContext.Current.Request.MapPath("App_Data/XML/Products.xml"),
      FileMode.Open));

  XDocument xDocProducts = XDocument.Load(stmrdrProductData);
  stmrdrProductData.Close();

  IEnumerable<ProductDetail> ProductData =
    from elemProduct in xDocProducts.Root.Elements()
    where elemProduct.Attribute("ProductId").Value == ProductId.ToString()
    select new ProductDetail
    {
  Class = elemProduct.Attribute("Class") != null ?
       elemProduct.Attribute("Class").Value : null,
      Color = elemProduct.Attribute("Color") != null ?
       elemProduct.Attribute("Color").Value : null,
      DaysToManufacture = elemProduct.Attribute("DaysToManufacture") != null ?
       new byte?(
         Convert.ToByte(elemProduct.Attribute("DaysToManufacture").Value))
         : null,
      DiscontinuedDate = elemProduct.Attribute("DiscontinuedDate") != null ?
       elemProduct.Attribute("DiscontinuedDate").Value : null,
      FinishedGoodsFlag = elemProduct.Attribute("FinishedGoodsFlag") != null ?
       elemProduct.Attribute("FinishedGoodsFlag").Value : null,

      MakeFlag = elemProduct.Attribute("MakeFlag") != null ?
       elemProduct.Attribute("MakeFlag").Value : null,
      ProductId = elemProduct.Attribute("ProductId") != null ?
       new ushort?(
         Convert.ToUInt16(elemProduct.Attribute("ProductId").Value))
```

```
          : null,
        ProductLine = elemProduct.Attribute("ProductLine") != null ?
         elemProduct.Attribute("ProductLine").Value : null,
        ProductNumber = elemProduct.Attribute("ProductNumber") != null ?
         elemProduct.Attribute("ProductNumber").Value : null,
        ReorderPoint = elemProduct.Attribute("ReorderPoint") != null ?
         new ushort?(
           Convert.ToUInt16(elemProduct.Attribute("ReorderPoint").Value))
           : null,
        SafetyStockLevel = elemProduct.Attribute("SafetyStockLevel") != null ?
         new ushort?(
           Convert.ToUInt16(elemProduct.Attribute("SafetyStockLevel").Value))
           : null,
        StandardCost = elemProduct.Attribute("StandardCost") != null ?
         new decimal?(Convert.ToDecimal(
           elemProduct.Attribute("StandardCost").Value))
         : null,
        Style = elemProduct.Attribute("Style") != null ?
         elemProduct.Attribute("Style").Value : null

    };

  return ProductData.ToList()[0];
}
public void UpdateProductDetail(ProductDetail Update)
{
  StreamReader stmrdrProductData = new StreamReader(
    new FileStream(
      HttpContext.Current.Request.MapPath("App_Data/XML/Products.xml"),
      FileMode.Open));
  XDocument xDocProducts = XDocument.Load(stmrdrProductData);
  stmrdrProductData.Close();

  XElement elemTarget =
    (from elemProduct in xDocProducts.Root.Elements()
       where Convert.ToUInt16(elemProduct.Attribute("ProductId").Value)
       == Update.ProductId
       select elemProduct).ToList()[0];

  if (elemTarget.Attribute("Class") != null)
    elemTarget.Attribute("Class").SetValue(Update.Class);
  if (elemTarget.Attribute("Color") != null)
    elemTarget.Attribute("Color").SetValue(Update.Color);
  if (elemTarget.Attribute("DaysToManufacture") != null
    && Update.DaysToManufacture.HasValue)
```

```
        elemTarget.Attribute("DaysToManufacture").
          SetValue(Update.DaysToManufacture);
      if (elemTarget.Attribute("DiscontinuedDate") != null)
        elemTarget.Attribute("DiscontinuedDate").
          SetValue(Update.DiscontinuedDate);
      if (elemTarget.Attribute("FinishedGoodsFlag") != null)
        elemTarget.Attribute("FinishedGoodsFlag").
          SetValue(Update.FinishedGoodsFlag);
      if (elemTarget.Attribute("MakeFlag") != null)
        elemTarget.Attribute("MakeFlag").
          SetValue(Update.MakeFlag);
      if (elemTarget.Attribute("ProductLine") != null)
        elemTarget.Attribute("ProductLine").
          SetValue(Update.ProductLine);
      if (elemTarget.Attribute("ProductNumber") != null)
        elemTarget.Attribute("ProductNumber").
          SetValue(Update.ProductNumber);
      if (elemTarget.Attribute("ReorderPoint") != null
        && Update.ReorderPoint.HasValue)
        elemTarget.Attribute("ReorderPoint").
          SetValue(Update.ReorderPoint);
      if (elemTarget.Attribute("SafetyStockLevel") != null
        && Update.SafetyStockLevel.HasValue)
        elemTarget.Attribute("SafetyStockLevel").
          SetValue(Update.SafetyStockLevel);
      if (elemTarget.Attribute("StandardCost") != null
        && Update.StandardCost.HasValue)
        elemTarget.Attribute("StandardCost").
          SetValue(Update.StandardCost);
      if (elemTarget.Attribute("Style") != null)
        elemTarget.Attribute("Style").
          SetValue(Update.Style);

      StreamWriter stmwrtrProductData =
        new StreamWriter(
          new FileStream(
            HttpContext.Current.Request.MapPath("App_Data/XML/Products.xml"),
            FileMode.Truncate));

      xDocProducts.Save(stmwrtrProductData);
      stmwrtrProductData.Close();
    }
  }
}
```

We discuss the operations for handling product headers briefly. The ones to handle product details are implemented in a similar fashion and should be easy to follow.

All the data for this service is stored in a local data file named `Products.xml`. In the `GetProductHeaders()` method, you open the file and read the XML data into an `XDocument` instance. A LINQ query is used to navigate the `XDocument` and transform the XML data into a collection of `ProductHeader` instances. In `UpdateProductHeaders()`, the `XElement` instance corresponding to each product is updated with the changes in the `ProductHeader` instance, and the changes are saved to the same data file.

Note the use of the `AspNetCompatibilityRequirementsAttribute` setting on the service class, indicating that support to be required. In order to get to the data files on the file system, you map the incoming HTTP request to a server path in the code. And the `HttpContext` type that makes the current request available to you is available only if ASP.NET support is enabled this way. This setting needs the corresponding configuration setting

```
<serviceHostingEnvironment aspNetCompatibilityEnabled="True"/>
```

already shown in Listing 7-2.

Figure 7-4 shows the Silverlight application's UI, and Listing 7-6 lists the XAML for the page.

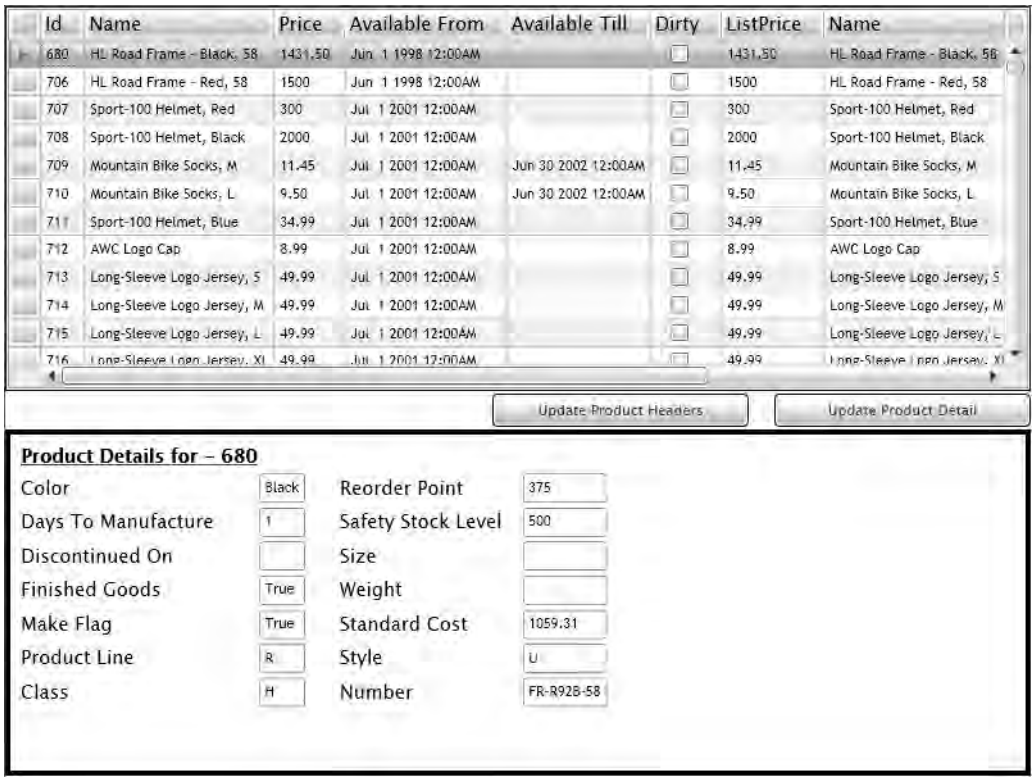


Figure 7-4. *The UI consuming products data from a WCF service*

Listing 7-6. *XAML for the page in MainPage.xaml*

```
<UserControl x:Class="Recipe7_1.ProductsDataViewer.MainPage"
  xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
  xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
  xmlns:DataControls=
    "clr-namespace:System.Windows.Controls;assembly=System.Windows.Controls.Data"
  Width="800" Height="600">

  <Grid x:Name="LayoutRoot" Background="White">
    <Grid.RowDefinitions>
      <RowDefinition Height="50*" />
      <RowDefinition Height="5*" />
      <RowDefinition Height="45*" />
    </Grid.RowDefinitions>
    <!-- Top Data Grid -->
    <DataControls:DataGrid
      HorizontalAlignment="Stretch"
      VerticalAlignment="Stretch"
      x:Name="ProductHeaderDataGrid"
      Grid.Row="0"
      SelectionChanged="ProductHeaderDataGrid_SelectionChanged"
      CurrentCellChanged="ProductHeaderDataGrid_CurrentCellChanged"
      BeginningEdit="ProductHeaderDataGrid_BeginningEdit">
      <DataControls:DataGrid.Columns>
        <DataControls:DataGridTextColumn
          Header="Id"
          Binding="{Binding ProductId}" />
        <DataControls:DataGridTextColumn
          Header="Name"
          Binding="{Binding Name, Mode=TwoWay}" />
        <DataControls:DataGridTextColumn
          Header="Price"
          Binding="{Binding ListPrice, Mode=TwoWay}" />
        <DataControls:DataGridTextColumn
          Header="Available From"
          Binding="{Binding SellStartDate, Mode=TwoWay}" />
        <DataControls:DataGridTextColumn
          Header="Available Till"
          Binding="{Binding SellEndDate, Mode=TwoWay}" />
      </DataControls:DataGrid.Columns>
    </DataControls:DataGrid>
    <!-- Butons -->
    <StackPanel Orientation="Horizontal"
                HorizontalAlignment="Right"
```

```
            VerticalAlignment="Center" Grid.Row ="1">
  <Button x:Name="Btn_SendHeaderUpdates" Content="Update Product Headers"
        Width="200" Click="Click_Btn_SendHeaderUpdates" Margin="0,0,20,0"/>
  <Button x:Name="Btn_SendDetailUpdates" Content="Update Product Detail"
        Width="200" Click="Click_Btn_SendDetailUpdate"/>
</StackPanel>
<Rectangle Stroke="Black" StrokeThickness="4" Grid.Row="2" />
<!-- Data entry form -->
<Grid Grid.Row="2" x:Name="ProductDetailsGrid" Margin="10,10,10,10">
  <Grid.RowDefinitions>
    <RowDefinition Height="Auto" />
    <RowDefinition Height="Auto"/>
    <RowDefinition Height="Auto"/>
    <RowDefinition Height="Auto"/>
    <RowDefinition Height="Auto"/>
    <RowDefinition Height="Auto"/>
    <RowDefinition Height="Auto"/>
    <RowDefinition Height="Auto"/>
  </Grid.RowDefinitions>
  <Grid.ColumnDefinitions>
    <ColumnDefinition Width="Auto"/>
    <ColumnDefinition Width="Auto"/>
    <ColumnDefinition Width="Auto"/>
    <ColumnDefinition Width="Auto"/>
  </Grid.ColumnDefinitions>
  <StackPanel Orientation="Horizontal"
              Grid.Row="0"
              HorizontalAlignment="Left"
              VerticalAlignment="Top"
              Margin="2,0,0,0">
    <TextBlock Text="Product Details for - "
               FontWeight="Bold"
               TextDecorations="Underline"/>
    <TextBlock Text="{Binding ProductId}"
               FontWeight="Bold"
               TextDecorations="Underline"/>
  </StackPanel>
  <TextBlock Text="Color" Grid.Row="1" Grid.Column="0"
             Margin="2,2,15,2" />
  <TextBlock Text="Days To Manufacture" Grid.Row="2" Grid.Column="0"
             Margin="2,2,15,2" />
  <TextBlock Text="Discontinued On" Grid.Row="3" Grid.Column="0"
             Margin="2,2,15,2" />
  <TextBlock Text="Finished Goods" Grid.Row="4" Grid.Column="0"
             Margin="2,2,15,2" />
```

```
<TextBlock Text="Make Flag" Grid.Row="5" Grid.Column="0"
           Margin="2,2,15,2" />
<TextBlock Text="Product Line" Grid.Row="6" Grid.Column="0"
           Margin="2,2,15,2" />
<TextBlock Text="Class" Grid.Row="7" Grid.Column="0"
           Margin="2,2,15,2"/>
<TextBlock Text="Reorder Point" Grid.Row="1" Grid.Column="2"
           Margin="2,2,15,2" />
<TextBlock Text="Safety Stock Level" Grid.Row="2" Grid.Column="2"
           Margin="2,2,15,2" />
<TextBlock Text="Size" Grid.Row="3" Grid.Column="2"
           Margin="2,2,15,2" />
<TextBlock Text="Weight" Grid.Row="4" Grid.Column="2"
           Margin="2,2,15,2" />
<TextBlock Text="Standard Cost" Grid.Row="5" Grid.Column="2"
           Margin="2,2,15,2" />
<TextBlock Text="Style" Grid.Row="6" Grid.Column="2"
           Margin="2,2,15,2" />
<TextBlock Text="Number" Grid.Row="7" Grid.Column="2"
           Margin="2,2,15,2" />
<TextBox Text="{Binding Color,Mode=TwoWay}"
         Grid.Row="1" Grid.Column="1" Margin="2,2,25,2" />
<TextBox Text="{Binding DaysToManufacture,Mode=TwoWay}"
         Grid.Row="2" Grid.Column="1" Margin="2,2,25,2" />
<TextBox Text="{Binding DiscontinuedDate,Mode=TwoWay}"
         Grid.Row="3" Grid.Column="1" Margin="2,2,25,2" />
<TextBox Text="{Binding FinishedGoodsFlag,Mode=TwoWay}"
         Grid.Row="4" Grid.Column="1" Margin="2,2,25,2" />
<TextBox Text="{Binding MakeFlag,Mode=TwoWay}"
         Grid.Row="5" Grid.Column="1" Margin="2,2,25,2" />
<TextBox Text="{Binding ProductLine,Mode=TwoWay}"
         Grid.Row="6" Grid.Column="1" Margin="2,2,25,2" />
<TextBox Text="{Binding Class,Mode=TwoWay}"
         Grid.Row="7" Grid.Column="1" Margin="2,2,25,2"/>
<TextBox Text="{Binding ReorderPoint,Mode=TwoWay}"
         Grid.Row="1" Grid.Column="3" Margin="2,2,25,2" />
<TextBox Text="{Binding SafetyStockLevel,Mode=TwoWay}"
         Grid.Row="2" Grid.Column="3" Margin="2,2,25,2" />
<TextBox Text="{Binding Size,Mode=TwoWay}"
         Grid.Row="3" Grid.Column="3" Margin="2,2,25,2" />
<TextBox Text="{Binding Weight,Mode=TwoWay}"
         Grid.Row="4" Grid.Column="3" Margin="2,2,25,2" />
<TextBox Text="{Binding StandardCost,Mode=TwoWay}"
         Grid.Row="5" Grid.Column="3" Margin="2,2,25,2" />
<TextBox Text="{Binding Style,Mode=TwoWay}"
```

```
            Grid.Row="6" Grid.Column="3" Margin="2,2,25,2" />
      <TextBox Text="{Binding ProductNumber,Mode=TwoWay}"
            Grid.Row="7" Grid.Column="3" Margin="2,2,25,2" />
    </Grid>
  </Grid>
</UserControl>
```

The preceding XAML uses a `DataGrid` named `ProductHeaderDataGrid` to display the `ProductHeader` properties. For each selected `ProductHeader`, to display the related details in a master-detail fashion, you further bind the `ProductDetail` properties to controls in a `Grid` named `ProductDetailsGrid`, which uses `TextBlocks` for labels and appropriately bound `TextBoxes` for property values, to create a data-entry form for the bound `ProductDetail`.

You also include two `Buttons` inside a `StackPanel` to provide the user with a way to submit updates to `ProductHeaders` or a `ProductDetail`.

Listing 7-7 shows the codebehind for the `MainPage`.

Listing 7-7. *Codebehind for MainPage in MainPage.xaml.cs*

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Windows;
using System.Windows.Controls;
using Recipe7_1.ProductsDataViewer.ProductsDataSoapService;

namespace Recipe7_1.ProductsDataViewer
{
  public partial class MainPage : UserControl
  {
    ProductsDataSoapService.ProductManagerClient client = null;
    bool InEdit = false;
    public MainPage()
    {
      InitializeComponent();
      //create a new instance of the proxy
      client = new ProductsDataSoapService.ProductManagerClient();
      //add a handler for the GetProductHeadersCompleted event
      client.GetProductHeadersCompleted +=
        new EventHandler<GetProductHeadersCompletedEventArgs>(
          client_GetProductHeadersCompleted);
      //add a handler for the UpdateProductHeadersCompleted event
      client.UpdateProductHeadersCompleted +=
        new EventHandler<System.ComponentModel.AsyncCompletedEventArgs>(
          client_UpdateProductHeadersCompleted);
      //add a handler for GetProductDetailCompleted
      client.GetProductDetailCompleted +=
```

```
    new EventHandler<GetProductDetailCompletedEventArgs>(
      client_GetProductDetailCompleted);
  //invoke the GetProductHeaders() service operation
  client.GetProductHeadersAsync();
}

void ProductHeaderDataGrid_SelectionChanged(object sender, EventArgs e)
{
  if (ProductHeaderDataGrid.SelectedItem != null)
    //invoke the GetProductDetails() service operation,
    //using the ProductId of the currently selected ProductHeader
    client.GetProductDetailAsync(
      (ProductHeaderDataGrid.SelectedItem as
      ProductsDataSoapService.ProductHeader).ProductId.Value);
}

void client_GetProductDetailCompleted(object sender,
  GetProductDetailCompletedEventArgs e)
{
  //set the datacontext of the containing grid
  ProductDetailsGrid.DataContext = e.Result;
}
void client_UpdateProductHeadersCompleted(object sender,
  System.ComponentModel.AsyncCompletedEventArgs e)
{
  client.GetProductHeadersAsync();
}

void client_GetProductHeadersCompleted(object sender,
  GetProductHeadersCompletedEventArgs e)
{
  //bind the data of form List<ProductHeader> to the ProductHeaderDataGrid
  ProductHeaderDataGrid.ItemsSource = e.Result;
}

void ProductHeaderDataGrid_CurrentCellChanged(object sender,
  EventArgs e)
{
  //changing the dirty flag on a cell edit for the ProductHeader data grid
  if (InEdit && (sender as DataGrid).SelectedItem != null)
  {
    ((sender as DataGrid).SelectedItem as ProductHeader).Dirty = true;
    InEdit = false;
  }
}
```

```
    private void ProductHeaderDataGrid_BeginningEdit(object sender,
     DataGridBeginningEditEventArgs e)
    {
      InEdit = true;
    }

    void Click_Btn_SendHeaderUpdates(object Sender, RoutedEventArgs e)
    {
      //get all the header items
      List<ProductHeader> AllItems =
        ProductHeaderDataGrid.ItemsSource as List<ProductHeader>;
      //use LINQ to filter out the ones with their dirty flag set to true
      List<ProductHeader> UpdateList =
          new List<ProductHeader>
          (
            from Prod in AllItems
            where Prod.Dirty == true
            select Prod
          );
      //send in the updates
      client.UpdateProductHeadersAsync(UpdateList);
    }

    void Click_Btn_SendDetailUpdate(object Sender, RoutedEventArgs e)
    {
      //send the ProductDetail update
      client.UpdateProductDetailAsync(ProductDetailsGrid.DataContext as
        ProductsDataSoapService.ProductDetail);
    }


  }
}
```

To fetch and bind the initial `ProductHeader` data, in the constructor of the `MainPage`, you create an instance of the `ProductService.ProductManagerClient` type, which is the proxy class created by adding the service reference to the Silverlight project. You then invoke the `GetProductHeaders()` operation on the service. Handle the `GetProductHeadersCompleted` event, and, in it, bind the data to the `DataGrid`. The data is made available to you in the `Results` property of the `GetProductHeadersCompletedEventArgs` type.

Handle the row-selection change for the `DataGrid` in `ProductHeaderDataGrid_SelectionChanged()`, and fetch and bind the appropriate product details information similarly.

To reduce the amount of data sent in updates, you send only the data that has changed. As shown in Listing 7-8, you extend the partial class for the `ProductHeader` data contract to include a `Dirty` flag so that you can track only the `ProductHeader` instances that have changed.

Listing 7-8. *Extension to ProductHeader type to include a dirty flag*

```
namespace Recipe7_1.ProductsDataViewer.ProductsDataSoapService
{
  public partial class ProductHeader
  {
    //dirty flag
    public bool Dirty { get; set; }
  }
}
```

Referring back to Listing 7-7, you see that to use the `Dirty` flag appropriately, you handle the `BeginningEdit` event on the `ProductHeaderDataGrid`. This event is raised whenever the user starts to edit a cell. In the handler, you set a flag named `InEdit` to indicate that an edit process has started. You also handle the `CurrentCellChanged` event, which is raised whenever the user navigates away from a cell to another one. In this handler, you see if the cell was in edit mode by checking the `InEdit` flag. If it was, you get the current `ProductHeader` data item from the `SelectedItem` property of the `DataGrid` and set its `Dirty` flag appropriately.

You handle the `Click` event of the button `Btn_SendHeaderUpdates` to submit the `ProductHeader` updates. Using a LINQ query on the currently bound collection of `ProductHeaders`, you filter out the changed data based on the `Dirty` flag, and you pass on the changed data set via `UpdateProductHeadersAsync()`. To update a `ProductDetail`, pass on the currently bound `ProductDetail` instance to `UpdateProductDetailAsync()`.

7-2. Exchanging XML Messages over HTTP

Problem

Your Silverlight application needs to exchange POX messages with an HTTP endpoint.

Solution

Use the `HttpWebRequest`/`HttpWebResponse` pair of types in `System.Net` to exchange POX messages with an HTTP endpoint.

How It Works

POX-style message exchange can be an attractive alternative to the more structured SOAP-based message exchange. It does not impose any of the specific format requirements of SOAP, and there is much more freedom regarding how messages are structured. Consequently, it requires fewer infrastructural requirements, benefits from more implementation options, and can be consumed by almost any XML-aware runtime environment.

The downside of such loose-format messaging, however, is that very often, client frameworks do not have the luxury of tool-based assistance like Visual Studio's service proxy-generation features. Also, client APIs that consume such services are somewhat lower level—in most cases, they implement some sort of request/response mechanism over HTTP, with support for HTTP-related features, like choice of verbs or Multipurpose Internet Mail Extensions (MIME) types.

Using HttpWebRequest/HttpWebResponse in Silverlight

The HttpWebRequest/HttpWebResponse types implement an API that allows Silverlight clients to send requests and receive responses from HTTP endpoints in an asynchronous fashion.

HttpWebRequest and HttpWebResponse are abstract classes and hence are not directly constructable. To use the API, you start by invoking the static Create() method on the HttpWebRequest type, supplying the URL of the endpoint you wish to interact with. What is returned to you is an instance of WebRequest—the base class for HttpWebRequest. You have the option of setting the desired HTTP verb to use through the HttpWebRequest.Method property—HttpWebRequest supports GET and POST. The default value of the Method property on a newly created web request is GET. You really only need to set it if you are going to use POST.

You also have the option of setting the MIME type using the ContentType property.

Using GET

The GET verb is typically used to request a web resource from an endpoint. The request is represented as the URI of the resource, with optional additional query string parameters. You invoke a GET request using the BeginGetResponse() method on the WebRequest instance. Pass a delegate of the form AsyncResult around a handler that you implement. This handler gets called back when the async request operation completes. In the handler, call EndGetResponse() to access any response information returned in the form of a WebResponse instance. You can then call WebResponse.GetResponseStream() to access the returned content.

Using POST

If you need to submit content back to an HTTP endpoint for processing, and you want to include the data in the body of the request, you must use the POST verb. To POST content, you need to write the content to be posted into the request stream. To do this, first call BeginGetRequestStream(), again passing in an AsyncResult delegate. In the handler, call EndGetRequestStream() to acquire a stream to the request's body, and write the content you intend to POST to that stream. Then, call BeginGetResponse() using the same pattern outlined earlier.

Handling Asynchronous Invocation

The methods discussed here follow an asynchronous invocation pattern. The BeginGetResponse() and BeginGetRequestStream() methods dispatch the execution to a randomly allocated background thread, returning control to your main application thread right away. The AsyncResult handlers that you pass in as callbacks are invoked on these background threads. If you want to access any parts of your object model created on the main thread—such as the controls on the page or any types that you instantiate elsewhere in your code—from one of these handlers, you cannot do it in the normal fashion, because doing so causes a cross-thread access violation. You need to first switch context to the thread that owns the object you are trying to access. To do this, you must use a type called Dispatcher.

The Dispatcher type is designed to manage work items for a specific thread. More specifically, in this context, a Dispatcher exposes methods that allow you to execute a piece of code in the context of the thread that owns the Dispatcher. The DependencyObject type, and hence all derived types, exposes a Dispatcher instance, which is associated with the thread that creates the type. One of the easiest instances you can get hold of is exposed on the Page itself.

To use the Dispatcher, use the static BeginInvoke() function, passing in a delegate to the method that you want to execute on the Dispatcher's thread, regardless of which thread it is called from. Dispatcher ensures a proper thread-context switch to execute the targeted method on its owning thread. For instance, if you want to access some element on the Page from a background thread, you use the Page's Dispatcher as described.

■ **Note** Although we chose POX messages as the first example of demonstrating this API, the types are a general-purpose means of HTTP communication from Silverlight. You can exchange other kinds of information over HTTP using these as well. We show you another example using JSON in Recipe 7-3.

Configuring WCF to Use Non-SOAP Endpoints

Although the Silverlight techniques demonstrated in this API can be used with any HTTP endpoint that accepts and responds with POX messages, we have chosen to implement the POX/HTTP endpoint using WCF.

WCF by default uses SOAP-based message exchange, but it also enables a web programming model that allows non-SOAP endpoints over HTTP to be exposed from WCF services. This allows REST-style services to use formats like POX or JSON to exchange messages with clients.

To enable web-style, URI-based invocation of operations on these services, apply one of the `WebGetAttribute` or `WebInvokeAttribute` types found in `System.ServiceModel.Web` to the operations. The `WebGetAttribute` mandates use of the HTTP GET verb to acquire a resource; hence the only way to pass in parameters to such an operation is through query string parameters on the client that are mapped by the WCF runtime to parameters in the operation. As an example, here is the declaration of a GET-style operation:

```
[OperationContract]
[WebGet()]
Information GetSomeInformation(int Param);
```

You can invoke this operation by sending an HTTP GET request to an URI endpoint, formatted like so:

```
http://someserver/someservice.svc/GetSomeInformation?Param=50
```

`WebInvokeAttribute` defaults to the use of the POST verb but can also be specified to accept the PUT or DELETE verb. If you are using POST, the message body is expected to be in the POST body content, whereas you can continue to use query-string style parameters with a verb like PUT. However, keep in mind that Silverlight only allows the use of POST, not PUT or DELETE.

In addition to using these attributes to decorate your WCF operations, you also need to specify the appropriate binding and behavior. To use POX messaging over HTTP, you must use `WebHttpBinding` for the endpoint. Here is a snippet from a WCF config file that shows this:

```
<endpoint address="" binding="webHttpBinding" contract="IProductManager" />
```

The Code

The code sample for this recipe reuses the example used in Recipe 7-1. To illustrate the concept, change the WCF service to use POX messages over HTTP, and implement the client using the `HttpWebRequest/HttpWebResponse` API.

Listing 7-9 shows the service contract for the WCF service adapted for POX exchange over HTTP.

Listing 7-9. *Service contract for the POX Service in ServiceContract.cs*

```
using System.ServiceModel;
using System.ServiceModel.Web;
using System.Xml;

namespace Recipe7_2.ProductsDataPOXService
{
  [ServiceContract]
  public interface IProductManager
  {
    [OperationContract]
    [XmlSerializerFormat()]
    [WebGet()]
    XmlDocument GetProductHeaders();

    [OperationContract]
    [XmlSerializerFormat()]
    [WebInvoke()]
    void UpdateProductHeaders(XmlDocument Updates);

    [OperationContract]
    [XmlSerializerFormat()]
    [WebGet()]
    XmlDocument GetProductDetail(ushort ProductId);

    [OperationContract]
    [XmlSerializerFormat()]
    [WebInvoke()]
    void UpdateProductDetail(XmlDocument Update);
  }
}
```

POX messages are just blocks of well-formed XML. Consequently, you use the `System.Xml.XmlDocument` type to represent the messages being exchanged. Because `XmlDocument` does not have the WCF `DataContractAttribute` applied to it, WCF cannot use the default data-contract serialization to serialize these messages. So, you also apply `System.ServiceModel.XmlSerializerFormatAttribute()` to the service operations to use XML serialization.

Listing 7-10 shows the implementation of the `GetProductHeaders()` and the `UpdateProductHeaders()` operations.

Listing 7-10. *Service implementation for POX service in ProductManager.cs*

```
using System.IO;
using System.Linq;
using System.ServiceModel.Activation;
```

```
using System.Web;
using System.Xml;
using System.Xml.Linq;

namespace Recipe7_2.ProductsDataPOXService
{
  [AspNetCompatibilityRequirements(
    RequirementsMode = AspNetCompatibilityRequirementsMode.Required)]
  public class ProductManager : IProductManager
  {
    public XmlDocument GetProductHeaders()
    {
      //open the local data file
      StreamReader stmrdrProductData =
        new StreamReader(
          new FileStream(
            HttpContext.Current.Request.MapPath("App_Data/XML/Products.xml"),
            FileMode.Open));
      //create and load an XmlDocument
      XmlDocument xDoc = new XmlDocument();
      xDoc.LoadXml(stmrdrProductData.ReadToEnd());
      stmrdrProductData.Close();

      //return the document
      HttpContext.Current.Response.Cache.SetCacheability(HttpCacheability.NoCache);
      return xDoc;
    }

    public void UpdateProductHeaders(XmlDocument Updates)
    {
      //load the XmlDocument containing the updates into a LINQ XDocument
      XDocument xDocProductUpdates = XDocument.Parse(Updates.OuterXml);
      //load the local data file
      StreamReader stmrdrProductData =
        new StreamReader(
          new FileStream(
            HttpContext.Current.Request.MapPath("App_Data/XML/Products.xml"),
            FileMode.Open));
      XDocument xDocProducts = XDocument.Load(stmrdrProductData);
      stmrdrProductData.Close();
      //for each of the updated records, find the matching record in the local data
      //using a LINQ query
      //and update the appropriate fields
      foreach (XElement elemProdUpdate in xDocProductUpdates.Root.Elements())
      {
```

```
    XElement elemTarget =
      (from elemProduct in xDocProducts.Root.Elements()
       where elemProduct.Attribute("ProductId").Value ==
       elemProdUpdate.Attribute("ProductId").Value
       select elemProduct).ToList()[0];
    if (elemTarget.Attribute("Name") != null)
      elemTarget.Attribute("Name").
        SetValue(elemProdUpdate.Attribute("Name").Value);
    if (elemTarget.Attribute("ListPrice") != null)
      elemTarget.Attribute("ListPrice").
        SetValue(elemProdUpdate.Attribute("ListPrice").Value);
    if (elemTarget.Attribute("SellEndDate") != null)
      elemTarget.Attribute("SellEndDate").
        SetValue(elemProdUpdate.Attribute("SellEndDate").Value);
    if (elemTarget.Attribute("SellStartDate") != null)
      elemTarget.Attribute("SellStartDate").
        SetValue(elemProdUpdate.Attribute("SellStartDate").Value);
  }
  //save the changes
  StreamWriter stmwrtrProductData =
    new StreamWriter(
      new FileStream(
        HttpContext.Current.Request.MapPath("App_Data/XML/Products.xml"),
        FileMode.Truncate));
  xDocProducts.Save(stmwrtrProductData);
  stmwrtrProductData.Close();
}

public XmlDocument GetProductDetail(ushort ProductId)
{
  StreamReader stmrdrProductData =
    new StreamReader(
      new FileStream(
        HttpContext.Current.Request.MapPath("App_Data/XML/Products.xml"),
        FileMode.Open));
  XDocument xDocProducts = XDocument.Load(stmrdrProductData);
  XDocument xDocProdDetail = new XDocument(
    (from xElem in xDocProducts.Root.Elements()
      where xElem.Attribute("ProductId").Value == ProductId.ToString()
      select xElem).ToList()[0]);

  XmlDocument xDoc = new XmlDocument();
  xDoc.LoadXml(xDocProdDetail.ToString());
  stmrdrProductData.Close();
```

```
    HttpContext.Current.Response.Cache.SetCacheability(HttpCacheability.NoCache);
    return xDoc;
  }
  public void UpdateProductDetail(XmlDocument Update)
  {
    XDocument xDocProductUpdates = XDocument.Parse(Update.OuterXml);
    XElement elemProdUpdate = xDocProductUpdates.Root;
    StreamReader stmrdrProductData =
      new StreamReader(
        new FileStream(
          HttpContext.Current.Request.MapPath("App_Data/XML/Products.xml"),
          FileMode.Open));

    XDocument xDocProducts = XDocument.Load(stmrdrProductData);
    stmrdrProductData.Close();

    XElement elemTarget =
      (from elemProduct in xDocProducts.Root.Elements()
       where elemProduct.Attribute("ProductId").Value ==
       elemProdUpdate.Attribute("ProductId").Value
       select elemProduct).ToList()[0];

    if (elemTarget.Attribute("Class") != null)
      elemTarget.Attribute("Class").
        SetValue(elemProdUpdate.Attribute("Class").Value);
    if (elemTarget.Attribute("Color") != null)
      elemTarget.Attribute("Color").
        SetValue(elemProdUpdate.Attribute("Color").Value);
    if (elemTarget.Attribute("DaysToManufacture") != null)
      elemTarget.Attribute("DaysToManufacture").
        SetValue(elemProdUpdate.Attribute("DaysToManufacture").Value);
    if (elemTarget.Attribute("DiscontinuedDate") != null)
      elemTarget.Attribute("DiscontinuedDate").
        SetValue(elemProdUpdate.Attribute("DiscontinuedDate").Value);
    if (elemTarget.Attribute("FinishedGoodsFlag") != null)
      elemTarget.Attribute("FinishedGoodsFlag").
        SetValue(elemProdUpdate.Attribute("FinishedGoodsFlag").Value);
    if (elemTarget.Attribute("MakeFlag") != null)
      elemTarget.Attribute("MakeFlag").
        SetValue(elemProdUpdate.Attribute("MakeFlag").Value);
    if (elemTarget.Attribute("ProductLine") != null)
      elemTarget.Attribute("ProductLine").
        SetValue(elemProdUpdate.Attribute("ProductLine").Value);
    if (elemTarget.Attribute("ProductNumber") != null)
      elemTarget.Attribute("ProductNumber").
```

```
            SetValue(elemProdUpdate.Attribute("ProductNumber").Value);
        if (elemTarget.Attribute("ReorderPoint") != null)
          elemTarget.Attribute("ReorderPoint").
            SetValue(elemProdUpdate.Attribute("ReorderPoint").Value);
        if (elemTarget.Attribute("SafetyStockLevel") != null)
          elemTarget.Attribute("SafetyStockLevel").
            SetValue(elemProdUpdate.Attribute("SafetyStockLevel").Value);
        if (elemTarget.Attribute("StandardCost") != null)
          elemTarget.Attribute("StandardCost").
            SetValue(elemProdUpdate.Attribute("StandardCost").Value);
        if (elemTarget.Attribute("Style") != null)
          elemTarget.Attribute("Style").
            SetValue(elemProdUpdate.Attribute("Style").Value);

        StreamWriter stmwrtrProductData = new StreamWriter(new FileStream(HttpContext.
Current.Request.MapPath("App_Data/XML/Products.xml"), FileMode.Truncate));
        xDocProducts.Save(stmwrtrProductData);
        stmwrtrProductData.Close();
      }
    }
}
```

Because `GetProductHeaders()` returns a POX message, you open the local data file, load the XML content into an `XmlDocument` instance, and return the `XmlDocument` instance. The `XmlSerializerFormatAttribute` on the operation ensures that the XML content is formatted as it is on the wire.

In `UpdateProductHeaders()`, you receive the updates as a POX message. You parse the content of the message and load it into an instance of the `XDocument` type so that it can participate in a LINQ to XML query. You use the query to find the matching records in the local XML data, also loaded in an `XDocument`, and copy over the updates before you save the local data back to its file store.

The `GetProductDetail()` and `UpdateProductDetail()` methods follow the same implementation pattern.

Note the call to `SetCacheability()` to set the cache policy to `NoCache` before you return data from the `GetProductHeaders()` and `GetProductDetail()` methods. The Silverlight network stack relies on the browser's network stack, and the default behavior has the browser look for the data requested in its own cache first. Setting this in the server response causes the browser to never cache the returned data, so that every time the client calls the service operation, the operation is invoked and current data is returned. This is important for data that can be changed between requests, as in this case with the update operations. For purely lookup data that seldom changes, you may want to leave the browser cache on, and possibly stipulate an expiration. You can refer to more information about controlling the browser-caching policy from the server on MSDN at `msdn.microsoft.com/en-us/library/system.web.httpresponse.cache.aspx`.

Now, let's look at the client code in the codebehind class. Because the complete code listing is repetitive between the product header- and product detail-related functionality, we list only the code pertaining to the acquiring and updating product headers. You can access the book's sample code to get the full implementation.

Listing 7-11 shows the product header-related functionality.

Listing 7-11. *Partial listing of the codebehind in MainPage.xaml.cs*

```
using System;
using System.Collections.Generic;
using System.IO;
using System.Linq;
using System.Net;
using System.Windows;
using System.Windows.Controls;
using System.Xml.Linq;
namespace Recipe7_2.POXProductsDataViewer
{
  public partial class MainPage : UserControl
  {
    private const string ServiceUri =
        "http://localhost:9292/ProductsPOXService.svc";
    bool InEdit = false;

    public MainPage()
    {
      InitializeComponent();

      RequestProductHeaders();
    }


    private List<ProductHeader> DeserializeProductHeaders(string HeaderXml)
    {
      //load into a LINQ to XML Xdocument
      XDocument xDocProducts = XDocument.Parse(HeaderXml);
      //for each Product Xelement, project a new ProductHeader
      List<ProductHeader> ProductList =
        (from elemProduct in xDocProducts.Root.Elements()
         select new ProductHeader
         {
           Name = elemProduct.Attribute("Name") != null ?
             elemProduct.Attribute("Name").Value : null,
           ListPrice = elemProduct.Attribute("ListPrice") != null ?
             new decimal?(
               Convert.ToDecimal(elemProduct.Attribute("ListPrice").
               Value)) : null,
           ProductId = elemProduct.Attribute("ProductId") != null ?
             new ushort?(Convert.ToUInt16(elemProduct.Attribute("ProductId").
               Value)) : null,
           SellEndDate = elemProduct.Attribute("SellEndDate") != null ?
```

```
            elemProduct.Attribute("SellEndDate").Value : null,
          SellStartDate = elemProduct.Attribute("SellStartDate") != null ?
            elemProduct.Attribute("SellStartDate").Value : null

        }).ToList();
    //return the list
    return ProductList;
  }

  private void RequestProductHeaders()
  {
    //create and initialize an HttpWebRequest
    WebRequest webReq = HttpWebRequest.Create(
      new Uri(string.Format("{0}/GetProductHeaders", ServiceUri)));

    //GET a response, passing in OnProductHeadersReceived
    //as the completion callback, and the WebRequest as state
    webReq.BeginGetResponse(
      new AsyncCallback(OnProductHeadersReceived), webReq);
  }

  private void OnProductHeadersReceived(IAsyncResult target)
  {
    //reacquire the WebRequest from the passed in state
    WebRequest webReq = target.AsyncState as WebRequest;
    //get the WebResponse
    WebResponse webResp = webReq.EndGetResponse(target);

    //get the response stream, and wrap in a StreamReader for reading as text
    StreamReader stmReader = new StreamReader(webResp.GetResponseStream());
    //read the incoming POX into a string
    string ProductHeadersXml = stmReader.ReadToEnd();
    stmReader.Close();

    //use the Dispatcher to switch context to the main thread
    //deserialize the POX into a Product Header collection,
//and bind to the DataGrid
    Dispatcher.BeginInvoke(new Action(delegate
    {
      ProductHeaderDataGrid.ItemsSource =
        DeserializeProductHeaders(ProductHeadersXml);
    }), null);

  }
  private void UpdateProductHeaders()
```

```
{
  //create and initialize an HttpWebRequest
  WebRequest webReq = HttpWebRequest.Create(
    new Uri(string.Format("{0}/UpdateProductHeaders", ServiceUri)));
  //set the VERB to POST
  webReq.Method = "POST";
  //set the MIME type to send POX
  webReq.ContentType = "text/xml";
  //begin acquiring the request stream
  webReq.BeginGetRequestStream(
    new AsyncCallback(OnProdHdrUpdReqStreamAcquired), webReq);
}

private void OnProdHdrUpdReqStreamAcquired(IAsyncResult target)
{
  //get the passed in  WebRequest
  HttpWebRequest webReq = target.AsyncState as HttpWebRequest;
  //get the request stream, wrap in a writer
  StreamWriter stmUpdates =
    new StreamWriter(webReq.EndGetRequestStream(target));
  Dispatcher.BeginInvoke(new Action(delegate
    {
      //select all the updated records
      List<ProductHeader> AllItems =
        ProductHeaderDataGrid.ItemsSource as List<ProductHeader>;
      List<ProductHeader> UpdateList = new List<ProductHeader>
                                  (
                                    from Prod in AllItems
                                    where Prod.Dirty == true
                                    select Prod
                                  );

      //use LINQ to XML to transform to XML
      XElement Products = new XElement("Products",
        from Prod in UpdateList
        select new XElement("Product",
           new XAttribute("Name", Prod.Name),
           new XAttribute("ListPrice", Prod.ListPrice),
           new XAttribute("ProductId", Prod.ProductId),
           new XAttribute("SellEndDate", Prod.SellEndDate),
           new XAttribute("SellStartDate", Prod.SellStartDate)));

      //write the XML into the request stream
      Products.Save(stmUpdates);
      stmUpdates.Close();
```

```
      //start acquiring the response
      webReq.BeginGetResponse(
        new AsyncCallback(OnProdHdrsUpdateCompleted), webReq);
    }));

}

private void OnProdHdrsUpdateCompleted(IAsyncResult target)
{
  HttpWebRequest webResp = target.AsyncState as HttpWebRequest;
  HttpWebResponse resp =
    webResp.EndGetResponse(target) as HttpWebResponse;
  //if response is OK, refresh the grid to
  //show that the changes actually happened on the server

  if (resp.StatusCode == HttpStatusCode.OK)
    RequestProductHeaders();
}
void ProductHeaderDataGrid_SelectionChanged(object sender, EventArgs e)
{
  if (ProductHeaderDataGrid.SelectedItem != null)
  {

    //invoke the GetProductDetails() service operation,
    //using the ProductId of the currently selected ProductHeader
    RequestProductDetail(
      (ProductHeaderDataGrid.SelectedItem
      as ProductHeader).ProductId.Value);
  }
}
void ProductHeaderDataGrid_CurrentCellChanged(object sender,
 EventArgs e)
    {
      //changing the dirty flag on a cell edit for the ProductHeader data grid
      if (InEdit && (sender as DataGrid).SelectedItem != null)
      {
        ((sender as DataGrid).SelectedItem as ProductHeader).Dirty = true;
        InEdit = false;
      }
    }
private void ProductHeaderDataGrid_BeginningEdit(object sender,
 DataGridBeginningEditEventArgs e)
{
  InEdit = true;
}
```

```
    void Click_Btn_SendHeaderUpdates(object Sender, RoutedEventArgs e)
    {
      UpdateProductHeaders();
    }
    void Click_Btn_SendDetailUpdate(object Sender, RoutedEventArgs e)
    {
      UpdateProductDetail();
    }

    //Product detail functionality omitted -
    //please refer to sample code for full listing
  }
}
```

In the `RequestProductHeaders()` method, you create the `HttpWebRequest` and submit it asynchronously using `BeginGetResponse()`. Note the passing of the `WebRequest` instance as the state parameter to `BeginGetResponse()`. On completion of the async call, when the supplied callback handler `OnProductHeadersReceived()` is called back, you need access to the `WebRequest` instance in order to complete the call by calling `EndGetResponse()` on it. Passing it in as the state parameter provides access to it in a thread-safe way, inside the handler executing on a background thread.

In `OnProductHeadersReceived()`, you obtain the `WebRequest` from the `IAsyncResult.AsyncState` parameter and then obtain the `WebResponse` using the `EndGetResponse()` method on the `WebRequest`. Open the response stream using `WebResponse.GetResponseStream()`, read the POX message from that stream, and bind the data to the `ProductHeaderDataGrid` after deserializing it into a suitable collection of `ProductHeaders` using `DeserializeProductHeaders()`. `DeserializeProductHeaders()` uses a LINQ to XML query to transform the POX message to an instance of `List<ProductHeader>`.

To send updates back to the service, you use the `UpdateProductHeaders()` method. Set the `Method` property of the request to POST, with the MIME type appropriately set to `text/XML`. Then, asynchronously acquire the request stream with a call to `BeginGetRequestStream()`.

When `BeginGetRequestStream()` is completed, the `OnProdHdrUpdReqStreamAcquired()` callback occurs on a background thread. In the handler, switch thread context back to the main thread using `Dispatcher.Invoke()`. In the delegate passed to `Invoke()`, filter out the updated records and transform the records to XML using LINQ to XML, and then serialize the resulting XML to the request stream. After closing the stream, submit the POST calling `BeginGetResponse()`. After the POST completes, you have the ability to check the `StatusCode` property to decide on your course of action. If the code is `HttpStatusCode.OK`, refresh the data from the server by calling `RequestProductDetail()` again. The only other possible value is `HttpStatusCode.NotFound`, which indicates a problem with the service call and can be used to display a suitable error message.

Also shown in Listing 7-11 is the handling of the dirty flag, row edits, and button-click handlers for submitting updates, which remain the same as in Recipe 7-1 and hence are not discussed here.

The UI for this sample, and therefore the XAML, remain exactly the same as in Recipe 7-1.

7-3. Using JSON Serialization over HTTP

Problem

Your Silverlight application needs to exchange JavaScript Object Notation (JSON) messages with an HTTP endpoint.

Solution

Use the `HttpWebRequest/HttpWebResponse` pair of types to exchange JSON messages with the HTTP endpoint. Use `DataContractJsonSerializer` to serialize/deserialize JSON data.

How It Works

The techniques used in this recipe are largely similar to the ones in Recipe 7-2, so we will highlight the differences.

JSON

JSON is a very lightweight format that can be applied to data exchanged on the wire between computers. JSON is textual, like XML, and is based on a subset of the JavaScript programming language, borrowing those portions of the JavaScript syntax that are needed to represent data structures and collections. JSON has gained a lot of popularity of late as a serialization format of choice, especially for Ajax web applications, where objects and collections need to be serialized to and from JavaScript code. For more on the format specification, and a more detailed introduction, visit `www.json.org`.

Listing 7-12 shows the JSON serialized representation of an instance of the `ProductDetail` class (which we use in the past recipes and continue to use here), for `ProductId` of value 680.

Listing 7-12. *JSON representation of a ProductDetail instance*

```
{"Class":"H",
"Color":"Black",
"DaysToManufacture":1,
"DiscontinuedDate":"",
"FinishedGoodsFlag":"True",
"MakeFlag":"True",
"ProductId":680,
"ProductLine":"R ",
"ProductNumber":"FR-R92B-58",
"ReorderPoint":375,
"SafetyStockLevel":500,
"Size":null,
"StandardCost":1059.31,
"Style":"U ",
"Weight":null}
```

It is easy to note that the serialized format does not contain any details about the actual CLR type or even the data types of the properties being serialized—it is a collection of named properties and their values. It is the job of an appropriate JSON serializer on both ends of the wire to take this textual format and convert it into an instance of a class.

Part of JSON's popularity is based on the fact that it is much more compact than XML in most cases—although both are textual, JSON is less verbose. However, JSON has some disadvantages as well. It was designed to be a serialization format and therefore is not meant to be used in a stand-alone way. In other words, the serialized textual format shown earlier is not much use until you turn it back into an object. XML, on the other hand, enjoys facilities that can be used to operate on the XML itself, such as XPath, XQuery, XSL transformations, and LINQ to XML, whereby the serialized XML can be useful to you without having to be deserialized into an object structure.

If you must choose formats, and you have control on both ends of the wire, JSON is preferable if you never intend to operate directly on the serialized form; XML is preferable otherwise. If you do not have control on both ends, the choice may already be made for you.

Using the DataContractJsonSerializer Type

Silverlight provides the `DataContractJsonSerializer` type in `System.Runtime.Serialization.Json`. It lets you serialize or deserialize JSON data to and from CLR types decorated with the `DataContract` attribute.

To use `DataContractSerializer`, create a new instance of it, and initialize it with the type of the CLR object you want to serialize:

```
DataContractJsonSerializer jsonSer = new
  DataContractJsonSerializer(typeof(List<ProductHeader>));
```

To deserialize some JSON data, pass in a reference to the stream containing the JSON data to the `ReadObject()` method, and cast the returned object to the desired type:

```
List<ProductHeader> productList =
jsonSer.ReadObject(jsonStream ) as List<ProductHeader>;
```

`DataContractJsonSerializer` supports object trees with nested objects, and `ReadObject()` returns to you the object at the root of the tree.

To serialize objects to JSON, use the `WriteObject()` method, passing in a destination stream, and the root object in the object tree that you want serialized:

```
jsonSer.WriteObject(jsonStream,rootObject);
```

Configuring WCF to Use JSON

We continue to use the WCF service from the previous recipes, but let's configure it this time to use JSON formatting on the messages exchanged.

`WebGetAttribute` and `WebInvokeAttribute` expose two properties that let you control this formatting: `RequestFormat` and `ResponseFormat`. Both properties are of type `WebMessageFormat`, which is an enum. You need to set `RequestFormat` to `WebMessageFormat.Json` to enable the service to accept JSON-formatted requests; set `ResponseFormat` identically to send JSON-formatted responses from the service.

You must also configure your WCF service endpoint to specify the use of a JSON serializer. To do this, you apply a custom behavior to the endpoint. Define a behavior named `ScriptBehavior`; the `webHttp` element in it enforces the use of JSON:

```
<endpointBehaviors>
  <behavior name="ScriptBehavior">
    <webHttp/>
  </behavior>
</endpointBehaviors>
```

You can apply the behavior to an endpoint as shown here:

```
<endpoint address="" behaviorConfiguration="ScriptBehavior" binding="webHttpBinding"
          contract="IProductManager" />
```

The Code

The code for this sample is virtually identical to that from Recipe 7-2. Listing 7-13 shows the service contract modified to use JSON.

Listing 7-13. *Service contract modified for JSON in ServiceContract.cs*

```
using System.Collections.Generic;
using System.ServiceModel;
using System.ServiceModel.Web;

namespace Recipe7_3.ProductsDataJSONService
{
  [ServiceContract]
  public interface IProductManager
  {
    [OperationContract]
    [WebGet(ResponseFormat = WebMessageFormat.Json)]
    List<ProductHeader> GetProductHeaders();

    [OperationContract]
    [WebInvoke(RequestFormat = WebMessageFormat.Json)]
    void UpdateProductHeaders(List<ProductHeader> Updates);

    [OperationContract]
    [WebGet(ResponseFormat = WebMessageFormat.Json)]
    ProductDetail GetProductDetail(ushort ProductId);

    [OperationContract]
    [WebInvoke(RequestFormat = WebMessageFormat.Json)]
    void UpdateProductDetail(ProductDetail Update);
```

```
  }
}
```

You specify the `RequestFormat` and the `ResponseFormat` properties of the `WebGet` and `WebInvoke` attributes to use JSON. In this case, in the methods `GetProductHeaders()` and `GetProductDetail()`, you only need to specify `ResponseFormat`, because the query is performed using a GET. In case of the update methods, you do not expect a response back from the POST, so only the `RequestFormat` is set to use JSON; thus the data sent to the service is formatted appropriately. However, when using POST, you may encounter scenarios where you are both sending and receiving data, in which case you need to specify both properties in `WebInvokeAttribute`.

Because almost all of the codebehind for the `MainPage` in this sample is identical to that in Recipe 7-2, we highlight the differences in Listing 7-14. The only real difference is in the way you serialize and deserialize the messages.

Listing 7-14. *Codebehind for JSON serialization and deserialization in MainPage.xaml.cs*

```
private List<ProductHeader> DeserializeProductHeaders(Stream HeaderJson)
{
    //create and initialize a new DataContractJsonSerializer
    DataContractJsonSerializer jsonSer =
      new DataContractJsonSerializer(typeof(List<ProductHeader>));
    //Deserialize - root object returned and cast
    List<ProductHeader> ProductList =
      jsonSer.ReadObject(HeaderJson) as List<ProductHeader>;
    return ProductList;
}
private void OnProdHdrUpdReqStreamAcquired(IAsyncResult target)
{
  HttpWebRequest webReq = target.AsyncState as HttpWebRequest;
  Stream stmUpdates = webReq.EndGetRequestStream(target);
  Dispatcher.BeginInvoke(new Action(delegate
    {
      List<ProductHeader> AllItems =
        ProductHeaderDataGrid.ItemsSource as List<ProductHeader>;

      List<ProductHeader> UpdateList =
        new List<ProductHeader>
        (
          from Prod in AllItems
          where Prod.Dirty == true
          select Prod
        );
      //create and initialize a DataContractJsonSerializer
      DataContractJsonSerializer jsonSer =
        new DataContractJsonSerializer(typeof(List<ProductHeader>));
      //write object tree out to the stream
      jsonSer.WriteObject(stmUpdates, UpdateList);
```

```
      stmUpdates.Close();

      webReq.BeginGetResponse(
        new AsyncCallback(OnProductHeadersUpdateCompleted), webReq);
    }));
}
private ProductDetail DeserializeProductDetails(Stream DetailJson)
{

    DataContractJsonSerializer jsonSer =
      new DataContractJsonSerializer(typeof(ProductDetail));
    ProductDetail Detail =
      jsonSer.ReadObject(DetailJson) as ProductDetail;
    return Detail;
}
private void OnProductDetailUpdateRequestStreamAcquired(IAsyncResult target)
{
  HttpWebRequest webReq =
    (target.AsyncState as object[])[0] as HttpWebRequest;
  Stream stmUpdates = webReq.EndGetRequestStream(target);


  ProductDetail Detail =
    (target.AsyncState as object[])[1] as ProductDetail;

  DataContractJsonSerializer jsonSer =
    new DataContractJsonSerializer(typeof(ProductDetail));
  jsonSer.WriteObject(stmUpdates, Detail);
  stmUpdates.Close();
  webReq.BeginGetResponse(
new AsyncCallback(OnProductDetailsUpdateCompleted), webReq);
}
```

The `DeserializeProductHeaders()` method uses a `DataContractJsonSerializer` to deserialize JSON data from a stream to a `List<ProductHeader>`. You create a new instance of `DataContractJsonSerializer`, passing in the targeted CLR type. You then call the `ReadObject()` method, passing in the stream containing the serialized object tree. This deserializes the object and returns it to you as an `Object`, which you must cast appropriately. Note that if an object tree is serialized into the stream, on deserialization the entire tree is reconstructed and the root object of the tree is returned to you.

In `OnProdHdrUpdReqStreamAcquired()`, you switch to the main thread using `Dispatcher.Invoke()`. Prior to sending an update to a `ProductHeader`, you serialize a `List<ProductHeader>` containing the updates to a stream as JSON. After you filter out the collection of `ProductHeaders` containing the updates using LINQ, you again use a newly constructed `DataContractJsonSerializer` instance, this time initializing it with the type of `List<ProductHeader>`. You then call the `WriteObject()` method on it, passing in the target stream and the `List<ProductHeader>` instance containing the updates that you want to serialize.

`DeserializeProductDetails()` and `OnProductDetailUpdateRequestStreamAcquired()` are implemented following the same pattern and should be self-explanatory.

Note that `DataContractJsonSerializer` needs the data types that are serialized to be declared as `DataContracts`, as in Recipe 7-1. Consequently, the data model used is identical to that in Recipe 7-1.

Also note that while sending POST requests that contain JSON-formatted data, you must set the MIME type appropriately by setting the `ContentType` property on the request to the string "application/json" like so:

```
WebRequest webReq = HttpWebRequest.Create
  (new Uri(string.Format("{0}/UpdateProductHeaders",ServiceUri)));
webReq.Method = "POST";
webReq.ContentType = "application/json";
```

The rest of the application, including its UI logic and the remainder of the codebehind, is identical to Recipe 7-2.

7-4. Accessing Resources over HTTP

Problem

You need to access resources located at a remote HTTP endpoint from your Silverlight application. You may need to read from or write to remote streams or have to download/upload resources over HTTP.

Solution

Use the `WebClient` API to read from or write to remote resources, or download or upload resources.

How It Works

The `WebClient` type has a convenient collection of methods that let you access resources over HTTP. You can use the `WebClient` class in two basic modes: uploading/downloading resources as strings and reading from or writing to streams, both over HTTP.

Downloading/Uploading Resources

You can use the `DownloadStringAsync()` method to asynchronously download any resource over HTTP as the long as the resource is (or can be converted to) a string. `DownloadStringAsync()` accepts a URI to the resource and raises the `DownloadStringProgressChanged` event to report download progress. Download completion is signaled when the `DownloadStringCompleted` event is raised. The `DownloadStringCompletedEventArgs.Result` property exposes the downloaded string resource.

The `UploadStringAsync()` method similarly accepts the upload endpoint URI. It also accepts the string resource to upload and reports completion by raising the `UploadStringCompleted` event.

Both methods accept a user-supplied state object, which is made available in the progress change and the completion event handlers through the `UserState` property on the

`DownloadProgressChangedEventArgs`, `DownloadStringCompletedEventArgs`, or `UploadStringCompletedeventArgs` parameter.

Reading/Writing Remote Streams

The `OpenReadAsync()` method accepts a remote HTTP URI and attempts to download the resource and make it available as a locally readable stream. Download progress is reported using the `DownloadProgressChanged` event, as mentioned earlier. The completion of the asynchronous read is signaled by the runtime by raising the `OpenReadCompleted` event. In the handler for `OpenReadCompleted`, the `OpenReadCompletedEventArgs.Result` property exposes the resource stream.

The `OpenWriteAsync()` method behaves slightly differently. Before it tries to access the remote resource, it raises the `OpenWriteCompleted` event synchronously. In the handler for this event, you are expected to write to the `OpenWriteCompletedEventArgs.Result` stream the data you want to save to the remote resource. After this stream is written and closed, and the handler returns, the runtime attempts to asynchronously send the data to the remote endpoint.

WebClient and HTTP Endpoints

In previous recipes, we outline the use of the `HttpWebRequest`/`HttpWebResponse` APIs with POX- or JSON-enabled web services. Although the `WebClient` API is primarily meant for accessing remote resources, its `DownloadStringAsync()` and `UploadStringAsync()` APIs can be effectively used for similar web-service communication as well, where POX or JSON messages formatted as strings are exchanged using this API set. Additionally, `WebClient` can work with other HTTP endpoints such as ASP.NET web pages. The code samples use a mix of WCF services and ASP.NET pages to illustrate this.

Canceling Long-Running Operations

Depending on the size of the resource being accessed, the available network bandwidth, and similar factors, download operations can be long-running, and it is desirable to provide application users with a way to cancel an operation should they choose to do so. The `WebClient` type exposes a property called `IsBusy`, which when `true` indicates that the `WebClient` instance is currently performing a background operation. Calling `CancelAsync()` on a `WebClient` instance attempts to cancel any such running operation. Note that because the operation is on a background thread, if `CancelAsync()` succeeds, the completion handler is invoked on the main thread, just as it would be on a successful completion. In the handler, you can check the `Cancelled` property on the event argument parameter to see if the operation was canceled or if it was a normal completion.

We show the use of all these in the following sample for this recipe.

The Code

The sample used here implements a simple photo-management application. The UI for the application is shown in Figure 7-5.

Figure 7-5. *The photo-management application UI*

The application downloads a ZIP file on start and displays image thumbnails contained in the ZIP. When you select a specific thumbnail, the full-resolution image is downloaded. Additional custom metadata can be associated with the image and saved to the server. Clicking the Upload button allows the user to select and upload a locally available JPEG image file.

The back-end functionality is divided into three sets of operations related to metadata management, photo downloads, and photo uploads, and is implemented across two WCF services and a pair of ASP.NET pages.

Listing 7-15 shows the service and data contracts for the various services.

Listing 7-15. *Service and data contracts for the WCF services in Contracts.cs*

```
using System;
using System.Collections.Generic;
using System.IO;
using System.Runtime.Serialization;
```

```
using System.ServiceModel;
using System.ServiceModel.Web;

namespace Recipe7_4.PhotoService
{
  [ServiceContract]
  public interface IPhotoDownload
  {
    [OperationContract]
    [WebGet()]
    //get the zip file containing the thumbnails
    Stream GetThumbs();

    [OperationContract]
    [WebGet(UriTemplate = "Photos?Name={PhotoName}")]
    //get a full resolution image
    byte[] GetPhoto(string PhotoName);
  }

  [ServiceContract]
  public interface IMetadata
  {
    [OperationContract]
    [WebGet(ResponseFormat = WebMessageFormat.Json)]
    //get the names of all the JPEG images available for download
    List<string> GetPhotoFileNames();

    [OperationContract]
    [WebGet(UriTemplate = "PhotoMetadata?Id={PhotoId}",
ResponseFormat = WebMessageFormat.Json)]
    //get the metadata for a specific image
    PhotoMetaData GetPhotoMetaData(string PhotoId);

  }

  [DataContract]
  public class PhotoMetaData
  {
    [DataMember]
    public string Id { get; set; }
    [DataMember]
    public string Name { get; set; }
    [DataMember]
    public string Description { get; set; }
    [DataMember]
```

```
    public string Location { get; set; }
    [DataMember]
    public int? Rating { get; set; }
    [DataMember]
    public DateTime? DateTaken { get; set; }
  }
}
```

The sample code for this recipe contains the full implementation of two WCF services, `Metadata.svc` and `PhotoDownload.svc`, that implement the `IMetadata` and `IPhotoDownload` contracts respectively, as shown in Listing 7-15. They handle the tasks of downloading metadata and photos. Because the implementation of the WCF services is similar in structure to the implementations described in previous recipes in this chapter, we do not discuss it here. You are encouraged to look at the sample code for this book.

Listing 7-16 shows the codebehind for `MetadataUpload.aspx`. The page markup contains nothing of relevance because the page does not render anything; it is used purely as an endpoint to which some data is posted by a `WebClient` instance.

Listing 7-16. *MetadataUpload.aspx page codebehind in MetadataUpload.aspx.cs*

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Runtime.Serialization.Json;

namespace Recipe7_4.PhotoService
{
  public partial class MetadataUpload : System.Web.UI.Page
  {
    protected void Page_Load(object sender, EventArgs e)
    {
      if (Request.HttpMethod == "POST")
      {
        DataContractJsonSerializer jsonSer =
          new DataContractJsonSerializer(typeof(PhotoMetaData));
        SetPhotoMetaData(
          jsonSer.ReadObject(Request.InputStream) as PhotoMetaData);
        Response.SuppressContent = true;
      }
    }

    public void SetPhotoMetaData(PhotoMetaData MetaData)
    {
      PhotoStoreDataContext dcPhoto = new PhotoStoreDataContext();
      List<PhotoData> pds = (from pd in dcPhoto.PhotoDatas
                             where pd.PhotoId == MetaData.Id
                             select pd).ToList();
```

```
      if (pds.Count == 0)
      {
        dcPhoto.PhotoDatas.InsertOnSubmit(new PhotoData {
          PhotoId = MetaData.Id, Name = MetaData.Name,
          Location = MetaData.Location, DateTaken = MetaData.DateTaken,
          Description = MetaData.Description, Rating = MetaData.Rating });
      }
      else
      {
        pds[0].Name = MetaData.Name;
        pds[0].DateTaken = MetaData.DateTaken;
        pds[0].Description = MetaData.Description;
        pds[0].Location = MetaData.Location;
        pds[0].Rating = MetaData.Rating;
      }
      dcPhoto.SubmitChanges();
    }
  }
}
```

As you can see in Listing 7-16, you check for an incoming POST request in the `Page_Load` handler of the ASPX page and deserialize the JSON stream into a `PhotoMetadata` object. You then pass the `PhotoMetadata` instance to `SetPhotoMetadata()`, which uses LINQ to SQL to update the database. Before you return from the `Page_Load` handler, you set `Response.SuppressContent` to `true`. This ensures that there is no HTML markup response from the page, because you need none.

Listing 7-17 shows the implementation of `PhotoUpload.aspx`, which is structured in a similar fashion.

Listing 7-17. *PhotoUpload.aspx codebehind in PhotoUpload.aspx.cs*

```
using System;
using System.IO;
using System.Web;

namespace Recipe7_4.PhotoService
{
  public partial class PhotoUpload1 : System.Web.UI.Page
  {
    protected void Page_Load(object sender, EventArgs e)
    {
      if (Request.HttpMethod == "POST")
      {
        AddPhoto(Request.InputStream);
        Response.SuppressContent = true;
      }
    }
```

```
    public void AddPhoto(Stream PhotoStream)
    {
      //get the file name for the photo
      string PhotoName =
        HttpContext.Current.Request.Headers["Image-Name"];
      if (PhotoName == null) return;
      //open a file stream to store the photo
      FileStream fs = new FileStream(
        HttpContext.Current.Request.MapPath
        (string.Format("APP_DATA/Photos/{0}", PhotoName)),
        FileMode.Create, FileAccess.Write);
      //read and store
      BinaryReader br = new BinaryReader(PhotoStream);
      BinaryWriter bw = new BinaryWriter(fs);

      int ChunkSize = 1024 * 1024;
      byte[] Chunk = null;
      do
      {
        Chunk = br.ReadBytes(ChunkSize);
        bw.Write(Chunk);
        bw.Flush();
      } while (Chunk.Length == ChunkSize);

      br.Close();
      bw.Close();
    }
  }
}
```

Note that the images and the ZIP file containing the thumbnails are stored on the server file system, under the `App_Data` folder of the ASP.NET web application hosting the WCF services. The metadata for each image, however, is stored in a SQL Server database. For the samples, we use SQL Server 2008 Express version, which you can download for free from `www.microsoft.com/express/sql/download/default.aspx`. When you install the product, take care to name the server SQLEXPRESS. This is the default name that the SQL 2008 installer uses, and so does the code sample. If you change it, visit the `web.config` files for the web service project named "7.4 PhotoService" in the sample code for this recipe, and change the database-connection strings to reflect your chosen server name. The following snippet shows the configuration entry in `web.config`:

```
<connectionStrings>
 <add name="SLBook_recipe_7_4_dbConnectionString"
 connectionString="Data Source=.\SQLEXPRESS;Initial Catalog=Recipe_7_4_db;
Integrated Security=True" providerName="System.Data.SqlClient"/>
</connectionStrings>
```

After SQL 2008 is installed, you need to create a database named Recipe_4_7_db and run the Recipe_7_4_db.sql file included with the sample code to create the necessary data model. We also include a database backup file named Recipe_4_7_db.bak, which you can restore into your SQL 2008 instance in lieu of creating the database and running the queries yourself.

Listing 7-18 shows some of the data types used in the client application.

Listing 7-18. *Data types used in the client application in DataTypes.cs*

```
using System;
using System.ComponentModel;
using System.Runtime.Serialization;
using System.Windows;
using System.Windows.Media.Imaging;

namespace Recipe7_4.PhotoClient
{
  public class WrappedImage : INotifyPropertyChanged
  {
    //bound to the thumbnail
    public BitmapImage Small { get; set; }
    //bound to the full res image
    public BitmapImage Large { get; set; }
    //Metadata
    private PhotoMetaData _Info = null;
    public PhotoMetaData Info
    {
      get { return _Info; }
      set
      {
        _Info = value;
        if (PropertyChanged != null)
          PropertyChanged(this, new PropertyChangedEventArgs("Info"));
      }
    }
    //Download Progress
    private double _PercentProgress;
    public double PercentProgress
    {
      get { return _PercentProgress; }
      set
      {
        _PercentProgress = value;
        if (PropertyChanged != null)
          PropertyChanged(this, new PropertyChangedEventArgs("PercentProgress"));
      }
```

```
}
//show the progress bar
private Visibility _ProgressVisible = Visibility.Collapsed;
public Visibility ProgressVisible
{
  get { return _ProgressVisible; }
  set
  {
    _ProgressVisible = value;
    if (PropertyChanged != null)
      PropertyChanged(this, new PropertyChangedEventArgs("ProgressVisible"));
  }
}
//parts removed for brevity

//download completed - show the image
private Visibility _ImageVisible = Visibility.Collapsed;
public Visibility ImageVisible
{
  get { return _ImageVisible; }
  set
  {
    _ImageVisible = value;
    if (PropertyChanged != null)
      PropertyChanged(this, new PropertyChangedEventArgs("ImageVisible"));
  }
}
//name of the thumbnail file
private string _ThumbName;
public string ThumbName
{
  get { return _ThumbName; }
  set
  {
    _ThumbName = value;
    if (PropertyChanged != null)
      PropertyChanged(this, new PropertyChangedEventArgs("ThumbName"));
  }
}
//name of the image file
private string _FileName;
public string FileName
{
  get { return _FileName; }
  set
```

```
    {
      _FileName = value;
      if (PropertyChanged != null)
        PropertyChanged(this, new PropertyChangedEventArgs("FileName"));
    }
  }

  public event
    PropertyChangedEventHandler PropertyChanged;

}
[DataContract]
public class PhotoMetaData : INotifyPropertyChanged
{
  //a unique Id for the image file - the file name
  private string _Id;
  [DataMember]
  public string Id
  {
    get { return _Id; }
    set
    {
      _Id = value;
      if (PropertyChanged != null)
        PropertyChanged(this, new PropertyChangedEventArgs("Id"));
    }
  }
  //a user supplied friendly name
  private string _Name;
  [DataMember]
  public string Name
  {
    get { return _Name; }
    set
    {
      _Name = value;
      if (PropertyChanged != null)
        PropertyChanged(this, new PropertyChangedEventArgs("Name"));
    }
  }
  private string _Description;
  [DataMember]
  public string Description
  {
    get { return _Description; }
```

```
    set
    {
      _Description = value;
      if (PropertyChanged != null)
        PropertyChanged(this, new PropertyChangedEventArgs("Description"));
    }
  }
  private string _Location;
  [DataMember]
  public string Location
  {
    get { return _Location; }
    set
    {
      _Location = value;
      if (PropertyChanged != null)
        PropertyChanged(this, new PropertyChangedEventArgs("Location"));
    }
  }
  private int? _Rating;
  [DataMember]
  public int? Rating
  {
    get { return _Rating; }
    set
    {
      _Rating = value;
      if (PropertyChanged != null)
        PropertyChanged(this, new PropertyChangedEventArgs("Rating"));
    }
  }
  private DateTime? _DateTaken;
  [DataMember]
  public DateTime? DateTaken
  {
    get { return _DateTaken; }
    set
    {
      _DateTaken = value;
      if (PropertyChanged != null)
        PropertyChanged(this, new PropertyChangedEventArgs("DateTaken"));
    }
  }

  public event PropertyChangedEventHandler PropertyChanged;
```

```
  }
}
```

The `WrappedImage` type, as shown in Listing 7-18, is used to wrap an image and its metadata. It implements `INotifyPropertyChange` to facilitate data binding to XAML elements in the UI. For more about data binding and property-change notifications, refer to Chapter 4.The `WrappedImage` type contains individual `BitmapImage` instances for the thumbnail and the high-resolution image, and a few other properties that relate to download-progress reporting and visibility of different parts of the UI.

Also shown is the `PhotoMetadata` data-contract type used to transfer metadata to and from the WCF services. The difference between the client implementation of `PhotoMetadata` shown here and the one used in the service shown in Listing 7-15 is that you add property-change notification code to each property in the client-side implementation.

Listing 7-19 shows the XAML for `MainPage`. The XAML for this page is fairly extensive, so we discuss only pertinent portions briefly.

Listing 7-19. *XAML for MainPage in MainPage.xaml.cs*

```
<UserControl x:Class="Recipe7_4.PhotoClient.MainPage"
  xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
  xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
  FontFamily="Trebuchet MS" FontSize="11"
  Width="800" Height="700"
  xmlns:Controls
  ="clr-namespace:System.Windows.Controls;assembly=System.Windows.Controls"
  xmlns:vsm="clr-namespace:System.Windows;assembly=System.Windows">
  <UserControl.Resources>

    <DataTemplate x:Key="dtProgressMessage">
      <StackPanel Orientation="Horizontal">
        <TextBlock Text="Processing" Margin="0,0,5,0" Foreground="Red"/>
        <TextBlock Text="{Binding}" Margin="0,0,2,0" Foreground="Red"/>
        <TextBlock Text="%" Foreground="Red"/>
      </StackPanel>
    </DataTemplate>

    <DataTemplate x:Key="dtThumbnail">
      <Grid>
        <Image Width="100" Height="75"
               Source="{Binding '', Mode=OneWay, Path=Small}"
               Stretch="Fill" Margin="5,5,5,5"/>
      </Grid>
    </DataTemplate>

    <DataTemplate x:Key="dtLargePhoto">
      <Grid VerticalAlignment="Top" HorizontalAlignment="Stretch" Height="Auto">
        <Grid.RowDefinitions>
```

```
        <RowDefinition Height="0.8*"/>
        <RowDefinition Height="0.2*"/>
      </Grid.RowDefinitions>
      <Image  HorizontalAlignment="Stretch"
              VerticalAlignment="Stretch"
              Source="{Binding '', Mode=OneWay, Path=Large}"
              Stretch="Uniform" Grid.Row="0"
              Margin="0,0,0,0"
              Visibility="{Binding Mode=OneWay, Path=ImageVisible}"/>
      <CheckBox Content="{Binding '',Mode=OneWay, Path=FileName}"
                Grid.Row="1" HorizontalAlignment="Center"
                VerticalAlignment="Center"
                Foreground="Black"
                Margin="0,0,0,0" FontSize="16" FontWeight="Bold"
                x:Name="btnMeta" Checked="btnMeta_Checked"
                Unchecked="btnMeta_Unchecked" />
      <ProgressBar
        Maximum="100" Minimum="100" Width="290" Foreground="Red" Height="30"
        Value="{Binding Mode=OneWay, Path=PercentProgress}"
        Visibility="{Binding Mode=OneWay, Path=ProgressVisible}"
        HorizontalAlignment="Center" VerticalAlignment="Center"/>
    </Grid>
  </DataTemplate>

  <DataTemplate x:Key="dtPhotoMetaData">
    <Grid>
      <Grid.RowDefinitions>
        <RowDefinition Height="0.15*"/>
        <RowDefinition Height="0.15*"/>
        <RowDefinition Height="0.15*"/>
        <RowDefinition Height="0.15*"/>
        <RowDefinition Height="0.15*"/>
        <RowDefinition Height="0.15*"/>
        <RowDefinition Height="0.10*"/>
      </Grid.RowDefinitions>
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="0.5*" />
        <ColumnDefinition Width="0.5*" />
      </Grid.ColumnDefinitions>
      <TextBlock Grid.Row="0" Grid.Column="0"
                 Grid.ColumnSpan="2" Text="Edit Metadata"
                 HorizontalAlignment="Center"
                 VerticalAlignment="Center" Margin="3,3,3,3"/>
      <TextBlock Grid.Row="1" Grid.Column="0"
                 Text="Name:" Margin="3,3,3,3" />
```

```
    <TextBlock Grid.Row="2" Grid.Column="0"
               Text="Description:" Margin="3,3,3,3" />
    <TextBlock Grid.Row="3" Grid.Column="0"
               Text="Location:" Margin="3,3,3,3" />
    <TextBlock Grid.Row="4" Grid.Column="0"
               Text="Rating:" Margin="3,3,3,3" />
    <TextBlock Grid.Row="5" Grid.Column="0"
               Text="Date Taken:" Margin="3,3,3,3" />
    <TextBox Grid.Row="1" Grid.Column="1"
             Text="{Binding Mode=TwoWay,Path=Info.Name}"
             Width="275" Margin="3,3,3,3" />
    <TextBox Grid.Row="2" Grid.Column="1"
             Text="{Binding Mode=TwoWay,Path=Info.Description}"
             Width="275" Margin="3,3,3,3" TextWrapping="Wrap"
             AcceptsReturn="True" />
    <TextBox Grid.Row="3" Grid.Column="1"
             Text="{Binding Mode=TwoWay,Path=Info.Location}"
             Width="275" Margin="3,3,3,3" TextWrapping="Wrap"
             AcceptsReturn="True" />
    <TextBox Grid.Row="4" Grid.Column="1"
             Text="{Binding Mode=TwoWay,Path=Info.Rating}"
             Width="275" Margin="3,3,3,3" />
    <Controls:DatePicker Grid.Row="5" Grid.Column="1"
                    SelectedDate="{Binding Mode=TwoWay,Path=Info.DateTaken}"
                    Width="275" Margin="3,3,3,3"/>
    <Button Content="Save Changes" x:Name="btnSaveMetaData"
            Grid.Row="6" Grid.ColumnSpan="2" HorizontalAlignment="Center"
            VerticalAlignment="Center" Height="30" Width="100"
            Margin="10,10,10,10" Click="btnSaveMetaData_Click"/>
  </Grid>
</DataTemplate>

<ControlTemplate x:Key="ctThumbnailListBoxItem" TargetType="ListBoxItem">
  <Grid>
    <vsm:VisualStateManager.VisualStateGroups>
      <vsm:VisualStateGroup x:Name="CommonStates">
        <vsm:VisualState x:Name="Normal">
          <Storyboard/>
        </vsm:VisualState>
        <vsm:VisualState x:Name="MouseOver">
          <Storyboard>
            <ColorAnimationUsingKeyFrames
              BeginTime="00:00:00"
              Duration="00:00:00.0010000"
              Storyboard.TargetName="brdrHover"
```

```
            Storyboard.TargetProperty=
            "(Border.BorderBrush).(SolidColorBrush.Color)">
            <SplineColorKeyFrame
              KeyTime="00:00:00" Value="#FF0748BD"/>
          </ColorAnimationUsingKeyFrames>
        </Storyboard>
      </vsm:VisualState>
    </vsm:VisualStateGroup>
    <vsm:VisualStateGroup x:Name="SelectionStates">
      <vsm:VisualState x:Name="Unselected"/>
      <vsm:VisualState x:Name="Selected">
        <Storyboard>
          <ColorAnimationUsingKeyFrames
            BeginTime="00:00:00"
            Duration="00:00:00.0010000"
            Storyboard.TargetName="brdrSelect"
            Storyboard.TargetProperty=
            "(Border.Background).(SolidColorBrush.Color)">
            <SplineColorKeyFrame
              KeyTime="00:00:00" Value="#FF0748BD"/>
          </ColorAnimationUsingKeyFrames>
        </Storyboard>
      </vsm:VisualState>
      <vsm:VisualState x:Name="SelectedUnfocused"/>
    </vsm:VisualStateGroup>
    <vsm:VisualStateGroup x:Name="FocusStates">
      <vsm:VisualState x:Name="Unfocused"/>
      <vsm:VisualState x:Name="Focused"/>
    </vsm:VisualStateGroup>
  </vsm:VisualStateManager.VisualStateGroups>
  <Border HorizontalAlignment="Stretch"
          VerticalAlignment="Stretch"
          x:Name="brdrHover" BorderBrush="#FF000000"
          BorderThickness="5" CornerRadius="3,3,3,3"
          Margin="3,3,3,3" >
    <Border  CornerRadius="3,3,3,3" Padding="7,7,7,7"
             Background="Transparent">
      <Border x:Name="brdrSelect" Background="#FF9AE1F5"
              CornerRadius="3,3,3,3" Padding="3,3,3,3"  >
        <ContentPresenter
          Content="{TemplateBinding Content}"
          ContentTemplate="{TemplateBinding ContentTemplate}"
          HorizontalAlignment="Left"
           />
      </Border>
```

```
        </Border>
      </Border>
    </Grid>
  </ControlTemplate>
  <Style x:Key="styleThumbnailListBoxItem" TargetType="ListBoxItem">
    <Setter Property="IsEnabled" Value="true" />
    <Setter Property="Foreground" Value="#FF000000" />
    <Setter Property="HorizontalContentAlignment" Value="Left" />
    <Setter Property="VerticalContentAlignment" Value="Top" />
    <Setter Property="FontSize" Value="12" />
    <Setter Property="Background" Value="White" />
    <Setter Property="Padding" Value="2,0,0,0" />
    <Setter Property="Template" Value="{StaticResource ctThumbnailListBoxItem}"/>
  </Style>
</UserControl.Resources>

<Grid Background="BurlyWood">
  <Grid.ColumnDefinitions>
    <ColumnDefinition Width="*"/>
    <ColumnDefinition Width="Auto"/>
  </Grid.ColumnDefinitions>
  <Grid.RowDefinitions>
    <RowDefinition Height="150"/>
    <RowDefinition Height="*"/>
    <RowDefinition Height="Auto"/>
  </Grid.RowDefinitions>
  <ListBox HorizontalAlignment="Stretch"
           Margin="5,5,5,5"
           Width="Auto"
           SelectionChanged="lbxThumbs_SelectionChanged"
           ItemTemplate="{StaticResource dtThumbnail}"
           x:Name="lbxThumbs"
           ItemContainerStyle="{StaticResource styleThumbnailListBoxItem}"
           Grid.ColumnSpan="2" Visibility="Collapsed">
    <ListBox.ItemsPanel>
      <ItemsPanelTemplate>
        <StackPanel Orientation="Horizontal"/>
      </ItemsPanelTemplate>
    </ListBox.ItemsPanel>
  </ListBox>
  <StackPanel x:Name="visualThumbZipDownload" Margin="0,20,0,0">
    <ProgressBar
      Maximum="100" Minimum="0" Height="30" Foreground="Red"
      Width="290" x:Name="pbarThumbZipDownload"
      Visibility="Visible" HorizontalAlignment="Center"
```

```
        VerticalAlignment="Center"/>
      <Button x:Name="btnZipDownloadCancel"
              Content="Cancel"
              Click="btnZipDownloadCancel_Click"
              HorizontalAlignment="Center" Width="125" />
    </StackPanel>

    <ContentControl x:Name="contentctlLargeImage"
                    HorizontalAlignment="Stretch"
                    VerticalAlignment="Stretch"
                    Grid.Row="1" Margin="8,8,8,8"
                    ContentTemplate="{StaticResource dtLargePhoto}"
                    Grid.RowSpan="1"/>
    <ContentControl x:Name="contentctlImageInfo"
                    HorizontalAlignment="Stretch"
                    VerticalAlignment="Stretch"
                    Grid.Row="1" Grid.Column="1"
                    Margin="8,0,8,0"
                    ContentTemplate="{StaticResource dtPhotoMetaData}"
                    Grid.RowSpan="1" Visibility="Collapsed"/>
    <Grid HorizontalAlignment="Stretch" Margin="8,8,8,8"
          VerticalAlignment="Stretch" Grid.Row="2">
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="0.5*"/>
        <ColumnDefinition Width="0.5*"/>
      </Grid.ColumnDefinitions>
      <Button HorizontalAlignment="Right"
              VerticalAlignment="Stretch" Content="Previous"
              Margin="8,0,8,0"   Height="32.11" x:Name="btnPrevious"
              Width="99.936"
              Click="btnPrev_Click"/>
      <Button Margin="8,0,8,0" VerticalAlignment="Stretch"
              Content="Next" HorizontalAlignment="Left"
              Height="31.11" x:Name="btnNext"
              Grid.Column="1" Width="99.936"
              Click="btnNext_Click"/>
      <Button HorizontalAlignment="Left" Margin="0,0,0,0"
              Width="100" Content="Upload" x:Name="btnUpload"
              Click="btnUpload_Click"/>
    </Grid>
  </Grid>
</UserControl>
```

The main UI is made up of a `ListBox` named `lbxThumbs` and two `ContentControls` named `contentctlLargeImage` and `contentctlImageInfo`. A `ProgressBar` control is also used on `MainPage`, as well

as Buttons for image navigation (btnPrevious and btnNext), a Button to cancel the thumbnail ZIP download (btnZipDownloadCancel), and a Button to upload a local image to the server (btnUpload).

You apply a custom Panel to the ListBox lbxThumbs to change its orientation to display the thumbnail items horizontally from left to right. You also apply a custom control template to each ListBoxItem, using the ItemContainerStyle property of the ListBox, to change the default look and feel of a ListBoxItem. Custom Panels and ControlTemplates are discussed in more detail in Chapter 5.

The dtLargePhoto data template is used to display a selected image and is made up of an Image control, a CheckBox control that can be used to toggle the visibility of the image's metadata, and a ProgressBar that displays the download progress of an image. The Image is bound to the Large property on the WrappedImage type. dtLargePhoto is applied to the ContentControl contentctlLargeImage in the main UI, using its ContentTemplate property.

The dtPhotoMetaData data template creates a data-entry form for image metadata. It has edit controls data-bound to properties in the PhotoMetadata data contract and is applied to the ContentControl contentctlImageInfo in the main UI again, with initial Visibility of the ContentControl set to Collapsed.

The dtThumbnail data template is applied to the ListBox lbxThumbnails through its ItemTemplate property. dtThumbnail also contains an Image control, bound to WrappedImage.Small.

Now, let's look at how the WebClient is used in this MainPage's codebehind to access resources and interact with web services. Listing 7-20 shows the codebehind for MainPage.

Listing 7-20. *Codebehind for the PhotoClient application page in MainPage.xaml.cs*

```
using System;
using System.Collections.Generic;
using System.Collections.ObjectModel;
using System.IO;
using System.Net;
using System.Runtime.Serialization.Json;
using System.Text;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Media.Imaging;
using System.Windows.Resources;
using System.Xml.Linq;

namespace Recipe7_4.PhotoClient
{
  public partial class Page : UserControl
  {

    private const string MetadataDownloadUri =
      "http://localhost:9494/MetaData.svc";
    private const string MetadataUploadUri =
      "http://localhost:9494/MetaDataUpload.aspx";
    private const string PhotoDownloadUri =
      "http://localhost:9494/PhotoDownload.svc";
    private const string PhotoUploadUri =
      "http://localhost:9494/PhotoUpload.aspx";
```

```
ObservableCollection<WrappedImage> ImageSources =
  new ObservableCollection<WrappedImage>();
WebClient wcThumbZip = new WebClient();
public Page()
{
  InitializeComponent();
  lbxThumbs.ItemsSource = ImageSources;
  contentctlLargeImage.Content = new WrappedImage();
  GetImageNames();
}

private void GetImageNames()
{
  //create a WebClient
  WebClient wcImageNames = new WebClient();
  //attach a handler to the OpenReadCompleted event
  wcImageNames.OpenReadCompleted +=
    new OpenReadCompletedEventHandler(
      delegate(object sender, OpenReadCompletedEventArgs e)
      {
        //initialize a JSON Serializer
        DataContractJsonSerializer jsonSer =
          new DataContractJsonSerializer(typeof(List<string>));
        //deserialize the returned Stream to a List<string>
        List<string> FileNames =
          jsonSer.ReadObject(e.Result) as List<string>;
        //start loading the thumbnails
        LoadThumbNails(FileNames);
      });
  //Start reading the remote resource as a stream
  wcImageNames.OpenReadAsync(
    new Uri(string.Format("{0}/GetPhotoFileNames", MetadataDownloadUri)));

}

private void LoadThumbNails(List<string> ImageFileNames)
{
  wcThumbZip.OpenReadCompleted +=
    new OpenReadCompletedEventHandler(wcThumbZip_OpenReadCompleted);
  wcThumbZip.DownloadProgressChanged +=
    new DownloadProgressChangedEventHandler
      (
        delegate(object Sender, DownloadProgressChangedEventArgs e)
        {
```

```
          //set the progress bar value to the reported progress percentage
          pbarThumbZipDownload.Value = e.ProgressPercentage;
        }
      );
  //start reading the thumbnails zip file as a stream,
  //pass in the ImageFileNames List<string> as user state
  wcThumbZip.OpenReadAsync(
    new Uri(
      string.Format("{0}/GetThumbs", PhotoDownloadUri)), ImageFileNames);
}

void wcThumbZip_OpenReadCompleted(object sender,
  OpenReadCompletedEventArgs e)
{
  //if operation was cancelled, return.
  if (e.Cancelled) return;
  //grab the passed in user state from
  //e.UserState, and cast it appropriately
  List<string> FileNames = e.UserState as List<string>;
  //create a StreamResourceInfo wrapping the returned stream,
  //with content type set to .PNG
  StreamResourceInfo resInfo = new StreamResourceInfo(e.Result, "image/png");
  //for each file name
  for (int i = 0; i < FileNames.Count; i++)
  {
    //create and initialize a WrappedImage instance
    WrappedImage wi =
      new WrappedImage
      {
        Small = new BitmapImage(),
        Large = null,
        FileName = FileNames[i] + ".jpg",
        ThumbName = FileNames[i] + ".png"
      };
    try
    {
      //Read the thumbnail image from the returned stream (the zip file)
      Stream ThumbStream = Application.GetResourceStream(
        resInfo, new Uri(wi.ThumbName, UriKind.Relative)).Stream;
      //and save it in the WrappedImage instance
      wi.Small.SetSource(ThumbStream);
      //and bind it to the thumbnail listbox
      ImageSources.Add(wi);
    }
    catch
```

```
    {
    }
  }
  //hide the progress bar and show the ListBox
  visualThumbZipDownload.Visibility = Visibility.Collapsed;
  lbxThumbs.Visibility = Visibility.Visible;
}
private void btnZipDownloadCancel_Click(object sender, RoutedEventArgs e)
{
  //if downloading thumbnail zip , issue an async request to cancel
  if (wcThumbZip != null && wcThumbZip.IsBusy)
    wcThumbZip.CancelAsync();
}

//thumbnail selection changed
private void lbxThumbs_SelectionChanged(object sender,
  SelectionChangedEventArgs e)
{
  //get the WrappedImage bound to the selected item
  WrappedImage wi = (e.AddedItems[0] as WrappedImage);
  //bind it to the large image display, as well to the metadata display
  contentctlLargeImage.Content = wi;
  contentctlImageInfo.Content = wi;
  //if the large image has not been downloaded
  if (wi.Large == null)
  {
    //display the progress bar and hid the large image control
    wi.ProgressVisible = Visibility.Visible;
    wi.ImageVisible = Visibility.Collapsed;
    //initialize the BitmapImage for the large image
    wi.Large = new BitmapImage();
    //new web client
    WebClient wcLargePhoto = new WebClient();
    //progress change handler
    wcLargePhoto.DownloadProgressChanged +=
      new DownloadProgressChangedEventHandler(
        delegate(object Sender, DownloadProgressChangedEventArgs e1)
        {
          //update value bound to progress bar
          wi.PercentProgress = e1.ProgressPercentage;
        });
    //completion handler
    wcLargePhoto.DownloadStringCompleted +=
      new DownloadStringCompletedEventHandler(
        wcLargePhoto_DownloadStringCompleted);
```

```
    //download image bytes as a string, pass
    //in WrappedImage instance as user supplied state
    wcLargePhoto.DownloadStringAsync(
      new Uri(string.Format("{0}/Photos?Name={1}",
        PhotoDownloadUri, wi.FileName)), wi);
  }
}
//large image download completed
void wcLargePhoto_DownloadStringCompleted(object sender,
  DownloadStringCompletedEventArgs e)
{
  //get the WrappedImage instance from user supplied state
  WrappedImage wi = (e.UserState as WrappedImage);
  //parse XML formatted response string into an XDocument
  XDocument xDoc = XDocument.Parse(e.Result);
  //grab the root, and decode the default base64
  //representation into the image bytes
  byte[] Buff = Convert.FromBase64String((string)xDoc.Root);
  //wrap in a memory stream, and
  MemoryStream ms = new MemoryStream(Buff);
  wi.Large.SetSource(ms);
  wi.ProgressVisible = Visibility.Collapsed;
  wi.ImageVisible = Visibility.Visible;
  GetPhotoMetadata(wi);
}

private void btnPrev_Click(object sender, RoutedEventArgs e)
{
  if (lbxThumbs.SelectedIndex == 0) return;
  lbxThumbs.SelectedIndex = lbxThumbs.SelectedIndex - 1;
}

private void btnNext_Click(object sender, RoutedEventArgs e)
{
  if (lbxThumbs.SelectedIndex == lbxThumbs.Items.Count - 1) return;
  lbxThumbs.SelectedIndex = lbxThumbs.SelectedIndex + 1;
}

private void btnMeta_Checked(object sender, RoutedEventArgs e)
{
  contentctlImageInfo.Visibility = Visibility.Visible;
}

private void btnMeta_Unchecked(object sender, RoutedEventArgs e)
{
```

```
    contentctlImageInfo.Visibility = Visibility.Collapsed;
  }

  private void GetPhotoMetadata(WrappedImage wi)
  {

    WebClient wcMetadataDownload = new WebClient();
    wcMetadataDownload.DownloadStringCompleted +=
      new DownloadStringCompletedEventHandler(
        delegate(object sender, DownloadStringCompletedEventArgs e)
        {
          DataContractJsonSerializer JsonSer =
            new DataContractJsonSerializer(typeof(PhotoMetaData));
          //decode UTF8 string to byte[], wrap in a memory string and
          //deserialize to PhotoMetadata using DatacontractJsonSerializer
          PhotoMetaData pmd = JsonSer.ReadObject(
            new MemoryStream(new UTF8Encoding().GetBytes(e.Result)))
            as PhotoMetaData;
          //data bind
          (e.UserState as WrappedImage).Info = pmd;
        });
    wcMetadataDownload.DownloadStringAsync(
      new Uri(string.Format("{0}/PhotoMetadata?Id={1}",
        MetadataDownloadUri,
        wi.FileName)), wi);
  }

  private void btnSaveMetaData_Click(object sender, RoutedEventArgs e)
  {
    SetPhotoMetadata(contentctlImageInfo.Content as WrappedImage);
  }
  //upload metadata
  private void SetPhotoMetadata(WrappedImage wi)
  {
    //new WebClient
    WebClient wcMetadataUpload = new WebClient();
    //serialize the metadata as JSON
    DataContractJsonSerializer JsonSer =
      new DataContractJsonSerializer(typeof(PhotoMetaData));
    MemoryStream ms = new MemoryStream();
    JsonSer.WriteObject(ms, wi.Info);
    //convert serialized form to a string
    string SerOutput = new UTF8Encoding().
      GetString(ms.GetBuffer(), 0, (int)ms.Length);
    ms.Close();
```

```
      //upload string
      wcMetadataUpload.UploadStringAsync(
        new Uri(MetadataUploadUri), "POST",
       SerOutput);
    }


    //upload local image file
    private void btnUpload_Click(object sender, RoutedEventArgs e)
    {
      //open a file dialog and allow the user to select local image files
      OpenFileDialog ofd = new OpenFileDialog();
      ofd.Filter = "JPEG Images|*.jpg;*.jpeg";
      ofd.Multiselect = true;
      if (ofd.ShowDialog() == false) return;
      //for each selected file
      foreach (FileInfo fdfi in ofd.Files)
      {
        //new web client
        WebClient wcPhotoUpload = new WebClient();
        //content type
        //wcPhotoUpload.Headers["Content-Type"] = "image/jpeg";
        //name of the file as a custom property in header
        wcPhotoUpload.Headers["Image-Name"] = fdfi.Name;
        wcPhotoUpload.OpenWriteCompleted +=
          new OpenWriteCompletedEventHandler(wcPhotoUpload_OpenWriteCompleted);
        //upload image file - pass in the image file stream as user supplied state
        wcPhotoUpload.OpenWriteAsync(new Uri(PhotoUploadUri),
          "POST", fdfi.OpenRead());
      }
    }

    void wcPhotoUpload_OpenWriteCompleted(object sender,
OpenWriteCompletedEventArgs e)
    {
      //get the image file stream from the user supplied state
      Stream imageStream = e.UserState as Stream;
      //write the image file out to the upload stream available in e.Result
      int ChunkSize = 1024 * 1024;
      int ReadCount = 0;
      byte[] Buff = new byte[ChunkSize];
      do
      {
        ReadCount = imageStream.Read(Buff, 0, ChunkSize);
        e.Result.Write(Buff, 0, ReadCount);
```

```
      } while (ReadCount == ChunkSize);
      //close upload stream and return - framework will upload in the background
      e.Result.Close();
    }
  }
}
```

The `GetImageNames()` method uses `WebClient.OpenReadAsync()` to acquire a list of names for all the image files available to you for download. In the operation contract for `IMetaData.GetPhotoFileNames()` in Listing 7-15, notice that the response format is specified as JSON. In the `WebClient.OpenReadCompleted` event handler (implemented using the C# anonymous delegate feature), you use the `DataContractJsonSerializer` to deserialize content from the returned stream into a `List<string>` of the file names. You then call the `LoadThumbnails()` method, passing in the list of file names.

The `LoadThumbnails()` method uses the `WebClient.OpenReadAsync()` method again to start downloading the thumbnail ZIP file. In the `WebClient.DownloadProgressChanged` event handler, the `ProgressBar` control `pbarThumbZipDownload` is updated with the percentage of progress. In case of a long download, a Cancel button is provided. You handle the cancellation in `btnZipDownloadCancel_Click()`, where you check to see if the `WebClient` is currently downloading using the `IsBusy` property, and if so, issue a cancellation request. The UI for thumbnail ZIP download and cancellation is shown in Figure 7-6.

Figure 7-6. *Thumbnail ZIP download*

The `OpenReadCompleted` handler `wcThumbZip_OpenReadCompleted()` first checks to see if the operation was canceled. If not, the file name list is retrieved from the user state, and each thumbnail is retrieved from the ZIP file using the `Application.GetResourceStream()` method. This method can read individual streams compressed inside a ZIP, as long as the correct content type (in this case, `image/png`) is provided using the `StreamResourceInfo` type parameter. The returned stream from `GetResourceStream()` is the thumbnail file, which is data-bound to the UI via a new instance of a `WrappedImage`. You create the `WrappedImage`, initialize its `Small` property to the thumbnail image, set its `FileName` and `ThumbName` properties, and then add it to the `ImageSources` collection. The `ImageSources` collection was already bound to `lbxThumbs` as its `ItemsSource` in the constructor of the page.

Now, let's look at downloading the full image and its metadata. In the `SelectionChanged` handler `lbxThumbs_SelectionChanged()` for the thumbnails `ListBox`, you acquire the `WrappedImage` instance bound to the current thumbnail and bind it to the `ContentControl contentctlLargeImage` as well. You then determine whether the image corresponding to that thumbnail has been downloaded already by checking the `WrappedImage.Large` property for `null`. If it is null, you use the `DownloadStringAsync()` method to download the image. The operation contract of the `IPhotoDownload.GetPhoto()` in Listing 7-15 shows you that the image is being returned from the service as an array of bytes, but the default WCF `DataContractSerializer` knows how to serialize the `byte[]` to a Base64-encoded string. The message returned from `GetPhoto()` in the completion handler `wcLargePhoto_DownloadStringCompleted()` is an XML fragment, containing only one element: the Base64-encoded string representing the image. You access the result as an `XDocument` instance, parsing it using the `XDocument.Parse()` method. You then decode the root of this `XDocument` instance back to an array of bytes. You wrap it into a temporary memory stream, set it as the source for the `BitmapImage` bound to the large image control, and proceed to fetch the metadata.

The PhotoMetadata is returned from the service formatted as JSON. The GetPhotoMetadata() method also uses DownloadStringAsync() to acquire the metadata, decodes the downloaded string from its UTF8 string form to the constituent byte array, deserializes the byte array using the DataContractJasonSerializer, and then binds the resulting PhotoMetadata instance to the metadata UI through the WrappedImage.Info property.

In the SetPhotoMetadata() method, the PhotoMetadata instance is serialized to JSON and then encoded to a UTF8 string, which is then uploaded using the UploadStringAsync() method. Note that the upload uses the MetadataUpload.aspx page as the endpoint. This code sample does not handle the upload-completion event, but you can do so to check for any upload errors.

The last piece of this solution is the image-upload logic. In the click handler btnUpload_Click() for the Upload button, you use the OpenFileDialog to allow the user to select one or more local image files. You can learn more about the OpenFileDialog class in Chapter 2. Each image file is then uploaded using OpenWriteAsync(). Note that the Content-Type HTTP header is set to the image/jpeg MIME type to ensure proper encoding. Also note the use of the custom header property Image-Name to upload the name of the image file. As shown in Listing 7-17, this is extracted and used in the codebehind of the PhotoUpload.aspx page to name the image file on the server, after it has been uploaded.

As mentioned earlier, OpenWriteAsync() immediately calls the completion handler wcPhotoUpload_OpenWriteCompleted(), where you write the image file to the upload stream made available through the OpenWriteCompletedEventArgs.Result property. When the stream is closed and the handler returns, the framework uploads the file asynchronously.

■ **Note** You may have noticed the absence of any upload-progress notification handlers. Silverlight does not supply any upload-progress notifications, although future versions may.

7-5. Using Sockets to Communicate over TCP

Problem

You need a Silverlight application to communicate with server-side applications using TCP sockets.

Solution

Use the System.Net.Sockets.Socket type and related types to connect and exchange data with a server-side TCP socket.

How It Works

Silverlight supports socket communication through the System.Net.Sockets.Socket type. This class exposes an API to connect to a TCP endpoint at a specified IP address/port combination, send data to that endpoint, and receive data from that endpoint.

However, the Socket type in Silverlight is slightly different from the equivalent type in the desktop and server versions of the .NET Framework; it supports only the client behavior and has no server abilities. In other words, unlike the desktop or the server version, the Silverlight version does not expose the ability to go into a listen mode and accept incoming connections. Therefore, although

Silverlight applications can easily use TCP sockets to exchange data with server applications, a Silverlight application cannot act as a socket-based server.

The Sockets API in Silverlight

All socket functionality in Silverlight works asynchronously, thus avoiding any blocking calls that would prevent the main thread from blocking execution while waiting for any such call completion. This is in line with other networking and web services APIs that you have studied in earlier recipes in this chapter. However, the design pattern for the `Socket`'s asynchronous APIs is somewhat different from the previously discussed Begin-End pattern, as you see in a moment.

The life of a socket connection begins by creating a new instance of a `Socket` and calling the `ConnectAsync()` method on the socket instance. The call to `ConnectAsync()` is nonblocking and returns immediately. To be notified on completion of the connection process, you can attach a handler to the `Completed` event of the `SocketAsyncEventArgs` parameter, which then is called back by the runtime. The following code excerpt shows a sample of this:

```
//create a new socket
Socket ClientSocket = new Socket(AddressFamily.InterNetwork,
                                 SocketType.Stream,
                                 ProtocolType.Tcp);
//create a new SocketEventArgs
SocketAsyncEventArgs sockEvtArgs = new SocketAsyncEventArgs {
  RemoteEndPoint = new IPEndPoint(IPAddress.Parse("192.168.0.10"), 4502),
  UserToken = MyData };
//connect a completion handler
sockEvtArgs.Completed += new EventHandler<SocketAsyncEventArgs>(
    delegate(object sender, SocketAsyncEventArgs e)
    {
      if (e.SocketError == SocketError.Success)
      {

        //connection succeeded - do something
      }
    });
//connect asynchronously
ClientSocket.ConnectAsync(sockEvtArgs);
```

As you can see, the `Socket` construction parameters let you specify the following:

- The type of addressing scheme used between IPv4 or IPv6 (which also enables IPv4) using the `AddressFamily` enumeration. To specify an IPv4 addressing scheme, use `AddressFamily.InterNetwork`; for IPv6, use `AddressFamily.InterNetworkV6`.
- The `SocketType` (the only available value is `Stream`).
- The `ProtocolType` (the only supported protocol is TCP).

Alternatively, you can set all the enumeration values to `unspecified`, and the values are inferred at runtime.

The endpoint being connected to is specified as the `RemoteEndPoint` property of the `SocketEventArgs` parameter. You can set it to an instance of `IPEndPoint` if you know the exact IP address or that of a `DnsEndPoint` if you have a hostname and want the DNS system to translate it to an IP address for you. Additionally, you need to supply the port. You can also supply any user state in the `UserToken` parameter.

When the connection is made, the `Completed` event handler is called, and further information is made available to you through the `SocketAsyncEventArgs` instance passed into the handler. The `SocketError` property gives you a success status or the type of error that was encountered, and the `UserToken` parameter can be used to extract any supplied user state.

There is a static version of `ConnectAsync()`, which behaves similarly. Because you do not explicitly create a `Socket` instance to use the static version, a connected `Socket` instance is made available to you through the `ConnectSocket` property on the `SocketEventArgs` instance in the `Completed` handler.

After you are connected, you can begin sending and receiving data. To send data, you can use the `SendAsync()` method. The data to be sent must be represented as a `byte[]` and can be copied to the `SocketAsynceventArgs.Buffer` using the `SetBuffer()` method, as shown here:

```
SocketAsyncEventArgs sockEvtArgsSend = new SocketAsyncEventArgs();
sockEvtArgsSend.SetBuffer(MyData, 0, MyData.Length);
sockEvtArgsSend.Completed +=
  new EventHandler<SocketAsyncEventArgs>(SendRequest_Completed);
ClientSocket.SendAsync(sockEvtArgsSend);
```

Receiving data uses a similar implementation. To receive data, you allocate a `byte[]` and assign it using the `SocketAsyncEventargs.SetBuffer()` method as the receiving buffer, followed by a call to `ReceiveAsync()`. Note that the Silverlight socket implementation gives you no indication when you are about to receive data from a remote endpoint; nor can you poll the socket from time to time. Consequently, when the call to `ReceiveAsync()` returns in the `Completed` handler, you may want to execute the code to receive again, thus keeping your client socket in a continuous receive mode. The following code shows such an arrangement:

```
private void ReceiveMessage()
{
  //allocate memory
  byte[] ReceiveBuffer = new Byte[1024];
  SocketAsyncEventArgs sockEvtArgsReceive = new SocketAsyncEventArgs();
  //set the receive buffer
  sockEvtArgsReceive.SetBuffer(ReceiveBuffer, 0, 1024);
  sockEvtArgsReceive.Completed +=
    new EventHandler<SocketAsyncEventArgs>(Receive_Completed);
  //receive
  ClientSocket.ReceiveAsync(sockEvtArgsReceive);
}
void Receive_Completed(object sender, SocketAsyncEventArgs e)
{
  if (e.SocketError == SocketError.Success)
  {
    //switch context
    ParentPage.Dispatcher.BeginInvoke(new Action(delegate
```

```
    {
      //access the received data
      byte[] Message = new byte[e.BytesTransferred];
      Array.Copy(e.Buffer, 0, Message, 0, e.BytesTransferred);
      //do something to process the received message

      //keep receiving
      ReceiveMessage();
    }));
  }
}
```

■ **Note** The `Completed` handlers are called on a background thread, necessitating a context switch using `Dispatcher`, before you can invoke code running on the main UI thread. For more about `Dispatcher`, refer to Recipe 7-2 in this chapter or to Chapter 2.

Cross-Domain Policy and Port Requirements

Silverlight applications using sockets have to satisfy cross-domain policy requirements to access remote socket servers. Cross-domain policies for both HTTP and TCP communications are discussed in greater detail in Recipe 7-6. There is also a restriction on the range of ports that a Silverlight client can connect to—the port must be within the inclusive range of 4502 to 4534.

The Code

The code sample for this recipe builds a simple one-to-one chat application that consists of a server program that acts as the listener and the gateway for exchanging text-based messages between Silverlight clients.

Running the Sample Code

To start the whole environment, you must first start up the sockets server and the policy server. Both of these are console programs and can be started either from the command line or from inside Visual Studio if you intend to start them in debug mode. The sockets server, which is named `ChatBroker.exe`, accepts one parameter on the command line: the port number you want it to listen on. Ensure that this is within the allowed port range of 4502 to 4534, inclusive. If you are debugging this from within Visual Studio, you can specify the parameter in your project's Debug properties page. The policy server is called `PolicyServer.exe` and does not need any startup parameters.

When you have the server instances up and running, you can then start (either in debug mode or by browsing to the page) the client. Figure 7-7 shows the various states of the Silverlight client.

Figure 7-7. *Various states of the Silverlight chat client*

You can specify the IP address and the port at which the sockets server is listening, as well as a name that you want to use in the conversation. After the user logs in, the client displays a list of all other participants currently connected to the server. You can click a participant and start a conversation. To simulate multiple participants, open multiple instances of the client and log in with multiple names.

The Client

The Silverlight client communicates with the server program using TCP sockets. The messages exchanged by the Silverlight client and the server program are expressed as data contracts, and you use JSON as the serialization format. You further convert the JSON-formatted messages to byte arrays before you can use them with sockets.

The applicable data contracts are shown in Listing 7-21.

Listing 7-21. *Data contracts to represent various messages in MessageTypes.cs*

```
using System.Collections.Generic;
using System.IO;
using System.Runtime.Serialization;
using System.Runtime.Serialization.Json;

[DataContract]
[KnownType(typeof(ConnectionDisconnectionRequest))]
[KnownType(typeof(ConnectionReply))]
[KnownType(typeof(ConnectionDisconnectionNotification))]
```

```
[KnownType(typeof(TextMessage))]
[KnownType(typeof(ChatEndNotification))]
// a wrapper message that contains the actual message,
// facilitating easy serialization and deserialization
public class MessageWrapper
{
  [DataMember]
  public object Message { get; set; }

  //Deserialize a byte[] into a MessageWrapper
  public static MessageWrapper DeserializeMessage(byte[] Message)
  {
    MemoryStream ms = new MemoryStream(Message);
    DataContractJsonSerializer dcSer =
      new DataContractJsonSerializer(typeof(MessageWrapper));
    MessageWrapper mw = dcSer.ReadObject(ms) as MessageWrapper;
    return mw;
  }
  //serialize a MessageWrapper into a MemoryStream
  public static MemoryStream SerializeMessage(MessageWrapper Message)
  {
    MemoryStream ms = new MemoryStream();
    DataContractJsonSerializer dcSer =
      new DataContractJsonSerializer(typeof(MessageWrapper));
    dcSer.WriteObject(ms, Message);
    return ms;
  }
}

//a request from a client to the server for either a connection or a disconnection
[DataContract]
public class ConnectionDisconnectionRequest
{
  [DataMember]
  public string From { get; set; }
  [DataMember]
  public bool Connect { get; set; }

}
//a reply from the server on successful connection
[DataContract]
public class ConnectionReply
{
  [DataMember]
  public List<string> Participants;
```

```
}
//a broadcast style notification to all connected clients about a
//specific client's connection/disconnection activity
[DataContract]
public class ConnectionDisconnectionNotification
{
  [DataMember]
  public string Participant { get; set; }
  [DataMember]
  public bool Connect { get; set; }
}
//a notification from a client to the server that it has ended a chat
[DataContract]
public class ChatEndNotification
{
  [DataMember]
  public string From { get; set; }
  [DataMember]
  public string To { get; set; }
}
//a chat message
[DataContract]
public class TextMessage
{
  [DataMember]
  public string From { get; set; }
  [DataMember]
  public string To { get; set; }
  [DataMember]
  public string Body { get; set; }
}
```

You use `DataContractJsonSerializer` to serialize and deserialize the message types shown in Listing 7-21. For more details about JSON serialization and `DataContractJsonSerializer`, refer to Recipe 7-3.

Because you have to deserialize from a `byte[]` to a CLR type on receiving a message, you face the challenge of not knowing the actual type information to pass on to `DataContractJsonSerializer`. To resolve this problem, you introduce a wrapper type named `MessageWrapper`, as shown in Listing 7-19, with a `Body` property of type `object` that contains the instance of the specific message you want to send. All messages are wrapped in this type before they are serialized to be sent out through the socket.

The `KnownTypeAttributes` applied to `MessageWrapper` ensures that the serializer uses the correct CLR type for the contained message while serializing the `MessageWrapper` instance to JSON, even though the `Body` property is of type `object`. It also allows you to specify `typeof(MessageWrapper)` as the parameter to the `DataContractJsonSerializer` instance for deserialization, ensuring that the correct type is used to deserialize the contained message. You define two static methods, `DeserializeMessage()` and `SerializeMessage()`, on the `MessageWrapper` type that encapsulates this logic.

Before you move into the sockets code, let's quickly look at the XAML UI. Listing 7-22 lists the XAML for `MainPage`.

Listing 7-22. *XAML for the chat client page in MainPage.xaml*

```
<UserControl x:Class="Recipe7_5.ChatClient.MainPage"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    Width="308" Height="550"
    xmlns:d="http://schemas.microsoft.com/expression/blend/2008"
    xmlns:mc="http://schemas.openxmlformats.org/markup-compatibility/2006"
    mc:Ignorable="d"
    xmlns:vsm="clr-namespace:System.Windows;assembly=System.Windows">
  <UserControl.Resources>
    <ControlTemplate x:Key="ctTalkButton" TargetType="Button">
      <Grid>
        <Image Source="SpeechMicHS.png"/>
      </Grid>
    </ControlTemplate>
    <DataTemplate x:Key="dtConversation">
      <Grid Width="Auto" Height="Auto">
        <Grid.RowDefinitions>
          <RowDefinition Height="0.191*"/>
          <RowDefinition Height="0.809*"/>
        </Grid.RowDefinitions>
        <TextBlock Text="{Binding From}"
                   TextWrapping="Wrap"
                   HorizontalAlignment="Left"
                   VerticalAlignment="Top"
                   Foreground="#FF1C2E7C"/>
        <TextBlock Text="{Binding Body}"
                   TextWrapping="Wrap"
                   HorizontalAlignment="Stretch"
                   VerticalAlignment="Top"
                   d:LayoutOverrides="VerticalAlignment"
                   Grid.Row="1"
                   Margin="8,8,8,8"
                   FontSize="12"
                   FontFamily="Georgia"
                   FontWeight="Normal"/>
      </Grid>
    </DataTemplate>
    <ControlTemplate x:Key="ct_lbxConversationItem" TargetType="ListBoxItem">
      <Grid Background="{TemplateBinding Background}">
        <Grid.RowDefinitions>
          <RowDefinition Height="*"/>
          <RowDefinition Height="Auto"/>
        </Grid.RowDefinitions>
```

```
      <ContentPresenter
        HorizontalContentAlignment="{TemplateBinding HorizontalContentAlignment}"
        Padding="{TemplateBinding Padding}"
        VerticalContentAlignment="{TemplateBinding VerticalContentAlignment}"
        HorizontalAlignment="Stretch" Content="{TemplateBinding Content}"
        ContentTemplate="{TemplateBinding ContentTemplate}"
        TextAlignment="{TemplateBinding TextAlignment}"
        TextDecorations="{TemplateBinding TextDecorations}"
        TextWrapping="Wrap"/>
    </Grid>
  </ControlTemplate>
  <Style x:Key="style_lbxitemConversation" TargetType="ListBoxItem">
    <Setter Property="IsEnabled" Value="true"/>
    <Setter Property="Foreground" Value="#FF000000"/>
    <Setter Property="HorizontalContentAlignment" Value="Left"/>
    <Setter Property="VerticalContentAlignment" Value="Top"/>
    <Setter Property="Cursor" Value="Arrow"/>
    <Setter Property="TextAlignment" Value="Left"/>
    <Setter Property="TextWrapping" Value="Wrap"/>
    <Setter Property="FontSize" Value="12"/>
    <Setter Property="Background" Value="White"/>
    <Setter Property="Padding" Value="2,0,0,0"/>
    <Setter Property="Template"
                Value="{StaticResource ct_lbxConversationItem}"/>
  </Style>

</UserControl.Resources>
<Grid x:Name="LayoutRoot" Background="White">
  <Grid.RowDefinitions>
    <RowDefinition Height="Auto"/>
    <RowDefinition Height="Auto"/>
    <RowDefinition Height="Auto"/>
  </Grid.RowDefinitions>
  <Border Padding="4,4,4,4" BorderBrush="Black"
          Background="LightBlue" BorderThickness="4"
          Grid.RowSpan="3"/>
  <Grid Visibility="Visible" x:Name="viewLogin" Width="300" Height="550">
    <Grid.RowDefinitions>
      <RowDefinition Height="0.364*"/>
      <RowDefinition Height="0.086*"/>
      <RowDefinition Height="0.1*"/>
      <RowDefinition Height="0.1*"/>
      <RowDefinition Height="0.35*"/>
    </Grid.RowDefinitions>
    <Grid.ColumnDefinitions>
```

```
        <ColumnDefinition Width="0.3*"/>
        <ColumnDefinition Width="0.43*"/>
        <ColumnDefinition Width="0.27*"/>
      </Grid.ColumnDefinitions>
      <TextBlock Text="IP" Grid.Row="0" Grid.Column="1" VerticalAlignment="Bottom"
                 HorizontalAlignment="Center" Margin="0,0,0,3" FontFamily="Arial"
                 FontSize="12" />
      <TextBlock Text="Port" Grid.Row="0" Grid.Column="2"
                 VerticalAlignment="Bottom"
                 HorizontalAlignment="Center" Margin="0,0,0,3"
                 FontFamily="Arial" FontSize="12" />
      <TextBlock Text="Server :" Grid.Row="1" Grid.Column="0"
                 VerticalAlignment="Center" HorizontalAlignment="Left"
                 Margin="0,0,0,0" Width="82" FontSize="12"
                 FontFamily="Arial" TextAlignment="Right" />
      <TextBlock Text="Your Name :" Grid.Row="2" Grid.Column="0"
                 VerticalAlignment="Center"
                 HorizontalAlignment="Left"
                 Margin="0,0,0,0"  Width="82" FontSize="12"
                 FontFamily="Arial" TextAlignment="Right" />
      <TextBox FontSize="16" x:Name="tbxIPAddress"
               Text="{Binding IP, Mode=TwoWay}"
               HorizontalContentAlignment="Center" HorizontalAlignment="Stretch"
               Grid.Row="1" Grid.Column="1"  Margin="4,0,4,0"
               VerticalAlignment="Center" TextWrapping="NoWrap"
               VerticalScrollBarVisibility="Disabled" Height="25" />
      <TextBox FontSize="16" x:Name="tbxPort" Text="{Binding Port, Mode=TwoWay}"
               HorizontalContentAlignment="Center" Width="Auto"
               HorizontalAlignment="Stretch" Grid.Row="1" Grid.Column="2"
               Margin="4,0,4,0" VerticalAlignment="Center" TextWrapping="NoWrap"
               VerticalScrollBarVisibility="Disabled" Height="25" />
      <TextBox FontSize="16" x:Name="tbxParticipantName" Text
               ="{Binding Me, Mode=TwoWay}"
               HorizontalContentAlignment="Center" Width="Auto"
               HorizontalAlignment="Stretch" Grid.Row="2" Grid.Column="1"
               Grid.ColumnSpan="2"  Margin="4,0,4,0" VerticalAlignment="Center"
               TextWrapping="NoWrap" VerticalScrollBarVisibility="Disabled"
               Height="25" />
      <HyperlinkButton FontFamily="Arial" FontSize="16"
                       HorizontalAlignment="Center" Margin="0,8,0,0"
                       x:Name="btnJoin" VerticalAlignment="Top" Grid.Row="3"
                       Grid.Column="1" Grid.ColumnSpan="1"
                       Content="Click here to join" Click="btnJoin_Click"/>
    </Grid>
    <Grid HorizontalAlignment="Stretch" VerticalAlignment="Stretch"
```

```
        Grid.Row="1" Visibility="Collapsed"
        x:Name="viewParticipants" Width="300" Height="550">
  <Grid.RowDefinitions>
    <RowDefinition Height="0.1*"/>
    <RowDefinition Height="0.9*"/>
  </Grid.RowDefinitions>
  <ListBox HorizontalAlignment="Stretch" Margin="8,8,8,8"
           VerticalAlignment="Stretch" Grid.Row="1"
           x:Name="lbxParticipants"
           ItemsSource="{Binding Participants, Mode=TwoWay}">
    <ListBox.ItemTemplate>
      <DataTemplate>
        <Grid VerticalAlignment="Stretch" HorizontalAlignment="Stretch">
          <Grid.ColumnDefinitions>
            <ColumnDefinition Width="0.854*"/>
            <ColumnDefinition Width="0.146*"/>
          </Grid.ColumnDefinitions>
          <TextBlock FontSize="12" Text="{Binding}" TextAlignment="Left"
                        TextWrapping="Wrap" HorizontalAlignment="Stretch"
                        Margin="5,5,5,5" VerticalAlignment="Stretch"/>
          <Button Template="{StaticResource ctTalkButton}"
                      HorizontalAlignment="Right" Margin="8,8,8,8"
                      Grid.Column="1" Content="Button" Click="btnTalk_Click"
                      Tag="{Binding}"/>
        </Grid>
      </DataTemplate>
    </ListBox.ItemTemplate>
  </ListBox>
  <HyperlinkButton HorizontalAlignment="Right" VerticalAlignment="Center"
                   Content="Click to Logoff" Margin="8,8,8,8" FontSize="14"
                   x:Name="btnLogoff" Click="btnLogoff_Click" />
</Grid>
<Grid HorizontalAlignment="Stretch" VerticalAlignment="Stretch" Grid.Row="2"
      Visibility="Collapsed" x:Name="viewChat" Width="300" Height="550">
  <Grid.RowDefinitions>
    <RowDefinition Height="0.053*"/>
    <RowDefinition Height="0.607*"/>
    <RowDefinition Height="0.284*"/>
    <RowDefinition Height="0.056*"/>
  </Grid.RowDefinitions>
  <ListBox HorizontalAlignment="Stretch" VerticalAlignment="Stretch"
           Margin="8,8,8,8" x:Name="lbxConversation" Grid.Row="1"
           ItemTemplate="{StaticResource dtConversation}"
           ItemsSource="{Binding Conversation, Mode=TwoWay}"
           ItemContainerStyle="{StaticResource style_lbxitemConversation}"/>
```

```
      <TextBox HorizontalAlignment="Stretch" VerticalAlignment="Stretch"
               Text="{Binding MessageBody, Mode=TwoWay}" TextWrapping="Wrap"
               Grid.Row="2" Margin="8,8,8,8" VerticalScrollBarVisibility="Auto"
               FontFamily="Courier New" Foreground="#FF0B356A"
               x:Name="tbxMessage"/>
      <HyperlinkButton HorizontalAlignment="Center" VerticalAlignment="Center"
                       Content="Click to Send" Grid.Row="3"
                       Margin="0,0,0,0" FontSize="14" x:Name="btnSend"
                       Click="btnSend_Click"/>
      <HyperlinkButton FontSize="14" HorizontalAlignment="Right" Margin="0,0,8,8"
                       x:Name="btnEndChat" VerticalAlignment="Stretch"
                       Content="End Chat" Click="btnEndChat_Click"/>
    </Grid>
  </Grid>
</UserControl>
```

The XAML is pretty simple. The UI is broken into three views, contained in three corresponding `Grids`: `viewLogin`, `viewParticipants`, and `viewChat`.

`viewLogin` exposes the login UI, made up of `TextBoxes` to accept the IP address, the server port, and the participant name. The fields are bound to properties on the `ClientConnectionManager` class, which we discuss momentarily. It also contains a `HyperlinkButton`, which when clicked initiates the login process.

`viewParticipants` contains a `ListBox` named `lbxParticipants` that displays the currently joined participants, except for the participant logged in through this client instance. `lbxParticipants` is bound to the `ClientConnectionManager.Participants` property. The data template for each item consists of a `TextBlock` showing the participant name, and a custom templated `Button` displaying an icon, which when clicked initiates a conversation with the corresponding participant. Another `HyperlinkButton` lets the user log off.

`viewChat` contains a `ListBox` named `lbxConversation` that displays the conversation history, bound to the `ClientConnectionManager.Conversation` property, and a `TextBox` that lets the user type in a message, bound to `ClientConnectionManager.MessageBody`. It also contains two more `HyperlinkButtons` to send a message and to end a chat.

`viewParticipants` and `viewChat` are initially hidden and are made visible depending on the state of the application.

Let's now look at the codebehind for `MainPage` in Listing 7-23.

Listing 7-23. *Codebehind for the MainPage in MainPage.xaml.cs*

```
using System.Windows;
using System.Windows.Controls;

namespace Recipe7_5.ChatClient
{
  public partial class MainPage : UserControl
  {
    public ClientConnectionManager ConnManager { get; set; }

    public MainPage()
```

```
{
  InitializeComponent();
  //initialize the ClientConnectionManager
  ConnManager = new ClientConnectionManager { ParentPage = this };
  //set the data context to the ClientConnetionManager
  LayoutRoot.DataContext = ConnManager;
}

private void btnJoin_Click(object sender, RoutedEventArgs e)
{
  ConnManager.Join();
}
private void btnLogoff_Click(object sender, RoutedEventArgs e)
{
  ConnManager.Disconnect();
}

private void btnTalk_Click(object sender, RoutedEventArgs e)
{
  //get the participant name from the Button.Tag
  //which was bound to the name at data binding
  ConnManager.TalkingTo = (sender as Button).Tag as string;
  ShowChatView();
}

private void btnSend_Click(object sender, RoutedEventArgs e)
{
  ConnManager.SendTextMessage();
}

private void btnEndChat_Click(object sender, RoutedEventArgs e)
{
  ConnManager.SendChatEnd();
}
internal void ShowParticipantsView()
{
  viewParticipants.Visibility = Visibility.Visible;
  viewLogin.Visibility = Visibility.Collapsed;
  viewChat.Visibility = Visibility.Collapsed;
}
internal void ShowChatView()
{
  viewParticipants.Visibility = Visibility.Collapsed;
  viewLogin.Visibility = Visibility.Collapsed;
  viewChat.Visibility = Visibility.Visible;
```

```
    }
    internal void ShowLoginView()
    {
      viewParticipants.Visibility = Visibility.Collapsed;
      viewLogin.Visibility = Visibility.Visible;
      viewChat.Visibility = Visibility.Collapsed;
    }
  }
}
```

The MainPage constructor creates a new instance of the ClientConnectionManager named ConnManager, initializing its ParentPage property with this Page instance. This is done so that in the ClientConnectionManager implementation, you have access to MainPage and its UI elements to effect various state changes. You also set the DataContext of the topmost Grid named LayoutRoot to ConnManager so that all the bindings to various properties of ClientConnectionManager that you saw in the XAML can be put into effect.

The various Button click handlers are self-explanatory; corresponding functions in the ClientConnectionManager are invoked from them. The ShowLoginView(), ShowParticipantsView(), and ShowChatView() methods toggle between views and are used from within the ClientConnectionManager, as you see next.

We have encapsulated all the client-side sockets–based communication and message processing in ClientConnectionManager. Listing 7-24 shows the ClientConnectionManager class.

Listing 7-24. *ClientConnectionManager in ConnectionManager.cs*

```
using System;
using System.Collections.Generic;
using System.Collections.ObjectModel;
using System.ComponentModel;
using System.IO;
using System.Net;
using System.Net.Sockets;

namespace Recipe7_5.ChatClient
{
  public class ClientConnectionManager : INotifyPropertyChanged
  {
    public event PropertyChangedEventHandler PropertyChanged;

    //create a new socket
    Socket ClientSocket = new Socket(AddressFamily.InterNetwork,
      SocketType.Stream, ProtocolType.Tcp);
    //reference to the parent page
    public Page ParentPage { get; set; }
    //participants collection
    private ObservableCollection<string> _Participants;
    public ObservableCollection<string> Participants
```

```
{
  get { return _Participants; }
  set
  {
    _Participants = value;
    if (PropertyChanged != null)
      PropertyChanged(this, new PropertyChangedEventArgs("Participants"));
  }
}
//collection of all messages exchanged in a particular conversation
private ObservableCollection<TextMessage> _Conversation;
public ObservableCollection<TextMessage> Conversation
{
  get { return _Conversation; }
  set
  {
    _Conversation = value;
    if (PropertyChanged != null)
      PropertyChanged(this, new PropertyChangedEventArgs("Conversation"));
  }
}
//IP Address of the server connected to
private string _IP;
public string IP
{
  get { return _IP; }
  set
  {
    _IP = value;
    if (PropertyChanged != null)
      PropertyChanged(this, new PropertyChangedEventArgs("IP"));
  }
}
//Port connected to
private string _Port;
public string Port
{
  get { return _Port; }
  set
  {
    _Port = value;
    if (PropertyChanged != null)
      PropertyChanged(this, new PropertyChangedEventArgs("Port"));
  }
}
```

```
//name of the person logged in
private string _Me;
public string Me
{
  get { return _Me; }
  set
  {
    _Me = value;
    if (PropertyChanged != null)
      PropertyChanged(this, new PropertyChangedEventArgs("Me"));

  }
}
//the other person in a conversation
private string _TalkingTo;
public string TalkingTo
{
  get { return _TalkingTo; }
  set
  {
    _TalkingTo = value;
    if (PropertyChanged != null)
      PropertyChanged(this, new PropertyChangedEventArgs("TalkingTo"));
  }
}
//the body of a conversation message
private string _MessageBody;
public string MessageBody
{
  get { return _MessageBody; }
  set
  {
    _MessageBody = value;
    if (PropertyChanged != null)
      PropertyChanged(this, new PropertyChangedEventArgs("MessageBody"));
  }
}
//buffer used to receive messages
private const int RECEIVEBUFFERSIZE = 10 * 1024;
private byte[] ReceiveBuffer = new Byte[RECEIVEBUFFERSIZE];
//constructor
public ClientConnectionManager()
{
  //initialize the collections
  Participants = new ObservableCollection<string>();
```

```
  Conversation = new ObservableCollection<TextMessage>();
}
//called when the login button is clicked
public void Join()
{
  //create a new SocketEventArgs, specify the remote endpoint details
  SocketAsyncEventArgs sockEvtArgs =
    new SocketAsyncEventArgs
    {
      RemoteEndPoint = new IPEndPoint(IPAddress.Parse(IP),
        Convert.ToInt32(Port)),
      UserToken = Me
    };
  //connect a completion handler
  sockEvtArgs.Completed +=
    new EventHandler<SocketAsyncEventArgs>(Connection_Completed);
  //connect asynchronously
  ClientSocket.ConnectAsync(sockEvtArgs);

}
//connection completion handler
void Connection_Completed(object sender, SocketAsyncEventArgs e)
{
  //connected successfully, send a
  //ConnectionDisconnectionRequest with Connect=true
  if (e.SocketError == SocketError.Success)
  {
    SocketAsyncEventArgs sockEvtArgs =
      new SocketAsyncEventArgs { UserToken = e.UserToken };
    //serialize a new ConnectionDisconnectionMessage into a MemoryStream
    MemoryStream SerializedStream =
      MessageWrapper.SerializeMessage(
      new MessageWrapper
      {
        Message = new ConnectionDisconnectionRequest
        {
          From = e.UserToken as string,
          Connect = true
        }
      });
    //set buffer to the contents of the memorystream
    sockEvtArgs.SetBuffer(SerializedStream.GetBuffer(),
      0, (int)SerializedStream.Length);
    sockEvtArgs.Completed +=
      new EventHandler<SocketAsyncEventArgs>(ConnectionRequestSend_Completed);
```

```
    //send
    ClientSocket.SendAsync(sockEvtArgs);
  }
}
//ConnectionDisconnectionRequest send completion handler
void ConnectionRequestSend_Completed(object sender, SocketAsyncEventArgs e)
{
  //sent successfully
  if (e.SocketError == SocketError.Success)
  {
    //start receiving messages
    ReceiveMessage();
    //switch context
    ParentPage.Dispatcher.BeginInvoke(new Action(delegate
    {
      //switch view to participants
      ParentPage.ShowParticipantsView();
    }));
  }
}
//receive a message
private void ReceiveMessage()
{
  SocketAsyncEventArgs sockEvtArgsReceive = new SocketAsyncEventArgs();
  sockEvtArgsReceive.SetBuffer(ReceiveBuffer, 0, RECEIVEBUFFERSIZE);
  sockEvtArgsReceive.Completed +=
    new EventHandler<SocketAsyncEventArgs>(Receive_Completed);
  ClientSocket.ReceiveAsync(sockEvtArgsReceive);
}
//receive completion handler
void Receive_Completed(object sender, SocketAsyncEventArgs e)
{
  if (e.SocketError == SocketError.Success)
  {
    ParentPage.Dispatcher.BeginInvoke(new Action(delegate
    {
      //copy the message to a temporary buffer - this is
      //because we reuse the same buffer for all SocketAsyncEventArgs,
      //and message lengths may vary
      byte[] Message = new byte[e.BytesTransferred];
      Array.Copy(e.Buffer, 0, Message, 0, e.BytesTransferred);
      //process the message
      ProcessMessage(Message);
      //keep receiving
      ReceiveMessage();
```

```
    }));
  }
}
//process a message
internal void ProcessMessage(byte[] Message)
{
  //deserialize the message into the wrapper
  MessageWrapper mw = MessageWrapper.DeserializeMessage(Message);
  //check type of the contained message
  //correct type resolution is ensured through the
  //usage of KnownTypeAttribute on the MessageWrapper
  //data contract declaration
  if (mw.Message is TextMessage)
  {
    //receiving a text message from someone -
    //switch to chat view if not there already
    ParentPage.ShowChatView();
    //remember the other party in the conversation
    if (this.TalkingTo == null)
      this.TalkingTo = (mw.Message as TextMessage).From;
    //data bind the text of the message
    Conversation.Add(mw.Message as TextMessage);
  }
  //someone has ended an ongoing chat
  else if (mw.Message is ChatEndNotification)
  {
    //reset
    this.TalkingTo = null;
    //reset
    Conversation.Clear();
    //go back to participants list
    ParentPage.ShowParticipantsView();
  }
  //server has sent a reply to your connection request
  else if (mw.Message is ConnectionReply)
  {
    //reset
    Participants.Clear();
    //get the list of the other participants
    List<string> ReplyList = (mw.Message as ConnectionReply).Participants;
    //data bind
    foreach (string s in ReplyList)
      Participants.Add(s);

  }
```

```
    //someone has connected or disconnected
    else if (mw.Message is ConnectionDisconnectionNotification)
    {
      ConnectionDisconnectionNotification notif =
        mw.Message as ConnectionDisconnectionNotification;
      //if it is a connection
      if (notif.Connect)
        //add to participants list
        Participants.Add(notif.Participant);
      else
      {
        //remove from participants list
        Participants.Remove(notif.Participant);
        //if you were in a conversation with this person,
        //go back to the participants view
        if (notif.Participant == TalkingTo)
        {
          ParentPage.ShowParticipantsView();
        }
      }
    }
  }
  //send a text message
  internal void SendTextMessage()
  {
    //package the From, To and Text of the message
    //into a TextMessage, and then into a wrapper
    MessageWrapper mwSend =
      new MessageWrapper
      {
        Message = new TextMessage {
          From = Me, To = TalkingTo, Body = MessageBody }
      };
    //serialize
    MemoryStream SerializedStream = MessageWrapper.SerializeMessage(mwSend);
    SocketAsyncEventArgs sockEvtArgsSend =
      new SocketAsyncEventArgs { UserToken = mwSend.Message };
    //grab the byte[] and set the buffer
    sockEvtArgsSend.SetBuffer(
      SerializedStream.GetBuffer(), 0, (int)SerializedStream.Length);
    //attach handler
    sockEvtArgsSend.Completed +=
      new EventHandler<SocketAsyncEventArgs>(SendTextMessage_Completed);
    //send
    ClientSocket.SendAsync(sockEvtArgsSend);
```

```
}
//send completed
void SendTextMessage_Completed(object sender, SocketAsyncEventArgs e)
{
  //success
  if (e.SocketError == SocketError.Success)
  {
    //switch context
    ParentPage.Dispatcher.BeginInvoke(new Action(delegate
    {
      //send was successful, add message to ongoing conversation
      Conversation.Add(e.UserToken as TextMessage);
      //reset edit box
      MessageBody = "";
    }));
  }
}
//disconnect
internal void Disconnect()
{
  SocketAsyncEventArgs sockEvtArgs = new SocketAsyncEventArgs();
  //package a ConnectionDisconnectionRequest with Connect=false
  MemoryStream SerializedStream =
    MessageWrapper.SerializeMessage(
    new MessageWrapper
    {
      Message = new ConnectionDisconnectionRequest
      {
        From = Me,
        Connect = false
      }
    });
  sockEvtArgs.SetBuffer(
    SerializedStream.GetBuffer(), 0, (int)SerializedStream.Length);
  sockEvtArgs.Completed +=
    new EventHandler<SocketAsyncEventArgs>(DisconnectRequest_Completed);
  ClientSocket.SendAsync(sockEvtArgs);
}
//disconnect completed
void DisconnectRequest_Completed(object sender, SocketAsyncEventArgs e)
{
  //success
  if (e.SocketError == SocketError.Success)
  {
    //reset my identity
```

```
        this.Me = null;
        //clear all participants
        Participants.Clear();
        //show login screen
        ParentPage.ShowLoginView();
      }
    }
    //end a chat
    internal void SendChatEnd()
    {
      MessageWrapper mwSend =
        new MessageWrapper
        {
          Message = new ChatEndNotification { From = Me, To = TalkingTo }
        };
      MemoryStream SerializedStream =
        MessageWrapper.SerializeMessage(mwSend);
      SocketAsyncEventArgs sockEvtArgsSend =
        new SocketAsyncEventArgs { UserToken = mwSend.Message };
      sockEvtArgsSend.SetBuffer(
        SerializedStream.GetBuffer(), 0, (int)SerializedStream.Length);
      sockEvtArgsSend.Completed +=
        new EventHandler<SocketAsyncEventArgs>(SendChatEnd_Completed);
      ClientSocket.SendAsync(sockEvtArgsSend);
    }
    //chat ended
    void SendChatEnd_Completed(object sender, SocketAsyncEventArgs e)
    {
      //success
      if (e.SocketError == SocketError.Success)
      {
        //switch context
        ParentPage.Dispatcher.BeginInvoke(new Action(delegate
        {
          //reset identity of the other participant
          this.TalkingTo = null;
          //clear the conversation
          Conversation.Clear();
          //switch back to the participants view
          ParentPage.ShowParticipantsView();
        }));
      }
    }
  }
}
```

As discussed before, ClientConnectionManager is used as the datasource for most of the data bound to the XAML for the client UI, and therefore implements INotifyPropertyChanged; the appropriate property setters raise PropertyChanged events.

After the user specifies the IP address, a port, and a participant name in the initial login screen, you establish a connection to the server. To do this, call the Join() method, which uses the Socket.ConnectAsync() method to establish the server connection. You specify the details of the remote endpoint (IP address and port) in the SocketeventArgs parameter. You also specify Connection_Completed() as the completion handler for ConnectAsync().

When a successful socket connection is established, in Connection_Completed() you send the first application-specific message of type ConnectionDisconnectionRequest to the server, with the ConnectionDisconnectionRequest.Connect property set to True, to indicate a request for connection. You wrap the message in an instance of the MessageWrapper type, serialize it to a MemoryStream, and use the MemoryStream contents to fill the send buffer. Attach ConnectionRequestSend_Completed() as the completion handler, and then call SendAsync() to send the request.

When the send request returns, ConnectionRequestSend_Completed() is invoked; you check for a successful send by checking the SocketAsyncEventArgs.SocketError property. In the event of a successful operation, this property is set to SocketError.Success; a plethora of other values indicate different error conditions. On a successful send, you prepare the client for receiving a message back from the server by calling ReceiveMessage(). You also switch the client UI to display the view with the list of participants by calling ShowParticipantsView() on the Page.

In ReceiveMessage(), you use a preallocated buffer to receive all your messages. You call Socket.ReceiveAsync() to start receiving messages, after attaching the Receive_Completed() completion handler. When a message is successfully retrieved, you copy it out of the message buffer into a temporary one before you process the message and take appropriate action. Note that you call ReceiveMessage() again as soon as you complete processing the previous message in order to keep the socket in a constant receive mode and not miss any incoming messages—albeit on a background thread because of the asynchronous nature of ReceiveAsync().

The ProcessMessage() method is central to the client-side message processing. Incoming messages are deserialized from byte[] to MessageWrapper instances by calling MessageWrapper.DeserializeMessage(), as shown in Listing 7-19. The type of the contained message in MessageWrapper.Body is used to determine the action taken.

The first message a client receives is the server's acknowledgment of the connection, in the form of a ConnectionReply message. The ConnectionReply.Participants collection contains the names of all the other participants logged in; you bind that collection to the participants ListBox on the UI and switch the view by calling ShowParticipantsView() on the page.

For incoming TextMessage instances, if the client is not already in chat mode, you switch the UI appropriately by calling ShowChatView() and then display the message by adding it to the Conversations collection bound to the ListBox used to display a conversation. You also set the ClientConnectionManager.TalkingTo property to the name of the participant from whom you are receiving the message, as indicated by the TextMessage.From property.

Clients can also receive a couple of other types of messages. When you receive a ChatEndNotification, you reset the TalkingTo property, clear the conversation ListBox, and switch to the participants view. For a ConnectionDisconnectionNotification, if the Connect property is True (indicating that a new participant is connecting), you add the participant to the bound Participants property; otherwise, you remove them, and switch views if you were currently in conversation with the disconnecting participant.

The ClientConnectionManager class also implements various methods for sending different types of messages from the client. All of these methods follow the same pattern demonstrated when you sent the first ConnectionDisconnectionRequest earlier: you create and initialize a new message instance of the appropriate message type, serialize it using MessageWrapper.SerializeMessage(), and then send it using Socket.SendAsync().

The Chat Server

The chat server is implemented as a console program. The functionality is divided into two primary classes: `ConnectionListener`, which accepts incoming client connections, hands them over to a `ServerConnectionManager` instance, and continues to listen for more connections; and `ServerConnectionManager`, which manages and processes messages for each connected client and then routes messages between clients.

Listing 7-25 shows the `ConnectionListener` class that you use in the server program to listen and accept incoming connections from clients.

Listing 7-25. *ConnectionListener class in ConnectionListener.cs*

```
using System;
using System.Net;
using System.Net.Sockets;

namespace Recipe7_5.ChatBroker
{
  internal class ConnectionListener
  {
    //the socket used for listening to incoming connections
    Socket ListenerSocket { get; set; }
    SocketAsyncEventArgs sockEvtArgs = null;
    //new server connection manager
    ServerConnectionManager ConnManager = new ServerConnectionManager();
    //run the connection listener
    internal void Run(int Port)
    {
      //create a new IP endpoint at the specific port,
      //and on any available IP address
      IPEndPoint ListenerEndPoint = new IPEndPoint(IPAddress.Any, Port);
      //create the listener socket
      ListenerSocket = new Socket(AddressFamily.InterNetwork,
        SocketType.Stream, ProtocolType.Tcp);
      //bind to the endpoint
      ListenerSocket.Bind(ListenerEndPoint);
      //listen with a backlog of 20
      ListenerSocket.Listen(20);
      Console.WriteLine("Waiting for incoming connection ...");
      //start accepting connections
      AcceptIncoming();
    }
    //accept incoming connections
    internal void AcceptIncoming()
    {
      //pass in the server connection manager
```

```
      sockEvtArgs = new SocketAsyncEventArgs { UserToken = ConnManager };
      sockEvtArgs.Completed += new EventHandler<SocketAsyncEventArgs>(
          delegate(object Sender, SocketAsyncEventArgs e)
          {
            Console.WriteLine("Accepted connection..." +
              "Assigning to Connection Manager...." +
              "Waiting for more connections...");
            //pass the connected socket to the server connection manager
            ConnManager.Manage(e.AcceptSocket);
            //keep listening
            AcceptIncoming();
          });
      //accept an incoming connection
      ListenerSocket.AcceptAsync(sockEvtArgs);
    }
  }
}
```

The `ConnectionListener` class is instantiated and launched by calling its `Run()` method from the server program's `Main()` method. In `Run()`, you create an `IPEndpoint` using the port number passed in as a command-line argument. Specifying `IPAddress.Any` as the `IPAddress` parameter allows the listener to listen on all available IP addresses on the machine, which is especially handy on machines that have multiple active network connections. You then bind the socket to the endpoint and start listening by calling `Socket.Listen()`. The parameter to `Listen()` specifies the size of the backlog of incoming connections that the runtime maintains for you while you process them one at a time. Finally, you call `AcceptIncoming()`.

The `AcceptIncoming()` method uses `Socket.AcceptAsync()` on the listener socket to asynchronously accept an incoming connection. In the `Completed` handler of `SocketAsyncEventArgs`, the connected client socket is available in the `SocketAsyncEventArgs.AcceptSocket` property. You pass this socket on to an instance of the `ServerConnectionManager` type through its `Manage()` method. You then continue to accept more incoming connections.

The `ServerConnectionManager` type is used to manage all connected client sockets. You also define a `Participant` type to represent a specific connected client and its communications. Listing 7-26 shows the code for these two classes.

Listing 7-26. *Implementation for ServerConnectionManager and participant types in MessageProcessing.cs*

```
using System;
using System.Collections.Generic;
using System.IO;
using System.Linq;
using System.Net.Sockets;
using System.Threading;

namespace Recipe7_5.ChatBroker
{
  internal class ServerConnectionManager
```

```
{

  //list of participants
  private List<Participant> _Participants = new List<Participant>();
  internal List<Participant> Participants
  {
    get { return _Participants; }
  }
  //accept and manage a client socket
  internal void Manage(Socket socket)
  {
    //create a new Participant around the client socket
    Participant p = new Participant { ClientSocket = socket, Parent = this };
    //add it to the list
    _Participants.Add(p);
    //start up the participant
    p.StartUp();
  }
  //broadcast a message from a participant to all other participants
  internal void Broadcast(string From, MessageWrapper Message)
  {
    //get a list of all participants other than the one sending the message
    List<Participant> targets = (from p in Participants
                                 where p.Name != From
                                 select p).ToList();
    //iterate and add to the Send queue for each
    foreach (Participant p in targets)
    {
      lock (p.QueueSyncRoot)
      {
        p.SendQueue.Enqueue(Message);
      }
    }
  }
  //send a message to a specific participant
  internal void Send(string To, MessageWrapper Message)
  {
    //get the Participant from the list
    Participant target = (from p in Participants
                          where p.Name == To
                          select p).ToList()[0];
    //add to the send queue for the participant
    lock (target.QueueSyncRoot)
    {
      target.SendQueue.Enqueue(Message);
```

```
    }
  }
}

internal class Participant
{
  //lock target
  internal object QueueSyncRoot = new object();
  //name as specified at the client
  internal string Name { get; set; }
  //the connected client socket
  internal Socket ClientSocket { get; set; }
  //a reference back to the ServerConnectionManager instance
  internal ServerConnectionManager Parent { get; set; }
  //are we currently receiving a message from this participant?
  bool Receiving = false;
  //are we currently sending a message to this participant?
  bool Sending = false;
  //a queue to hold messages being sent to this participant
  private Queue<MessageWrapper> _SendQueue = new Queue<MessageWrapper>();
  internal Queue<MessageWrapper> SendQueue
  {
    get { return _SendQueue; }
    set { _SendQueue = value; }
  }
  //check to see if there are messages in the queue
  private int HasMessage()
  {
    lock (QueueSyncRoot)
    {
      return SendQueue.Count;
    }
  }
  //start the participant up
  internal void StartUp()
  {
    //create the receiver thread
    Thread thdParticipantReceiver = new Thread(new ThreadStart(
      //thread start delegate
        delegate
        {
          //loop while the socket is valid
          while (ClientSocket != null)
          {
            //if there is no data available OR
```

```
            //we are currently receiving, continue
            if (ClientSocket.Available <= 0 || Receiving) continue;
            //set receiving to true
            Receiving = true;
            //begin to receive the next message
            ReceiveMessage();
          }
        }));
    //set thread to background
    thdParticipantReceiver.IsBackground = true;
    //start receiver thread
    thdParticipantReceiver.Start();
    //create the sender thread
    Thread thdParticipantSender = new Thread(new ThreadStart(
      //thread start delegate
        delegate
        {
          //loop while the socket is valid
          while (ClientSocket != null)
          {
            //if there are no messages to be sent OR
            //we are currently sending, continue
            if (HasMessage() == 0 || Sending) continue;
            //set sending to true
            Sending = true;
            //begin sending
            SendMessage();
          }
        }));
    //set thread to background
    thdParticipantSender.IsBackground = true;
    //start sender thread
    thdParticipantSender.Start();
  }
  //receive a message
  private void ReceiveMessage()
  {
    SocketAsyncEventArgs sockEvtArgs = new SocketAsyncEventArgs();
    //allocate a buffer as large as the available data
    sockEvtArgs.SetBuffer(
      new byte[ClientSocket.Available], 0, ClientSocket.Available);
    sockEvtArgs.Completed += new EventHandler<SocketAsyncEventArgs>(
      //completion handler
        delegate(object sender, SocketAsyncEventArgs e)
        {
```

```
        //process the message
        ProcessMessage(e.Buffer);
        //done receiving, thread loop will look for next
        Receiving = false;
      });
  //start receiving
  ClientSocket.ReceiveAsync(sockEvtArgs);
}
internal void ProcessMessage(byte[] Message)
{
  //deserialize message
  MessageWrapper mw = MessageWrapper.DeserializeMessage(Message);
  //if text message
  if (mw.Message is TextMessage)
  {
    //send it to the target participant
    Parent.Send((mw.Message as TextMessage).To, mw);
  }
  //if it is a ConnectionDisconnectionRequest
  else if (mw.Message is ConnectionDisconnectionRequest)
  {
    ConnectionDisconnectionRequest connDisconnReq =
      mw.Message as ConnectionDisconnectionRequest;
    //if connecting
    if (connDisconnReq.Connect)
    {
      this.Name = connDisconnReq.From;
      //broadcast to everyone else
      Parent.Broadcast(this.Name, new MessageWrapper
      {
        Message = new ConnectionDisconnectionNotification
        {
          Participant = this.Name,
          Connect = true
        }
      });
      //send the list of all participants other than
      //the one connecting to the connecting client
      Parent.Send(this.Name, new MessageWrapper
      {
        Message = new ConnectionReply
        {
          Participants =
          (from part in Parent.Participants
           where part.Name != this.Name
```

```
            select part.Name).ToList()
        }
      });
    }
    else //disconnecting
    {
      //remove from the participants list
      Parent.Participants.Remove(this);
      //close socket
      this.ClientSocket.Close();
      //reset
      this.ClientSocket = null;
      //broadcast to everyone else
      Parent.Broadcast(this.Name, new MessageWrapper
      {
        Message = new ConnectionDisconnectionNotification
        {
          Participant = this.Name,
          Connect = false
        }
      });
    }
  }
  //chat end
  else if (mw.Message is ChatEndNotification)
  {
    //send it to the other participant
    Parent.Send((mw.Message as ChatEndNotification).To, mw);
  }
}
//send a message
private void SendMessage()
{
  MessageWrapper mw = null;
  //dequeue a message from the send queue
  lock (QueueSyncRoot)
  {
    mw = SendQueue.Dequeue();
  }
  SocketAsyncEventArgs sockEvtArgs =
    new SocketAsyncEventArgs { UserToken = mw };
  //serialize and pack into the send buffer
  MemoryStream SerializedMessage =
    MessageWrapper.SerializeMessage(mw);
  sockEvtArgs.SetBuffer(
```

```
        SerializedMessage.GetBuffer(), 0, (int)SerializedMessage.Length);
      sockEvtArgs.Completed += new EventHandler<SocketAsyncEventArgs>(
        //completion handler
          delegate(object sender, SocketAsyncEventArgs e)
          {
            //not sending anymore
            Sending = false;
          });
      //begin send
      ClientSocket.SendAsync(sockEvtArgs);
    }
  }
}
```

An instance of a `Participant` is created and stored in a list when the `ServerConnectionManager` receives a connected client socket through the `Manage()` method. The `Participant.Startup()` method starts two background threads—one each for receiving and sending messages, each of which continue as long as the client socket for that `Participant` is valid.

The receive thread calls the `ReceiveMessage()` method, provided that there is data to be read (as determined by the `Socket.Available` property) and that the `Receiving` boolean flag is set to `false`. The flag is set to `true` prior to calling `ReceiveMessage()` and is reset after `ReceiveMessage()` returns so that the socket is always ready to receive the next message as soon as it arrives.

`ReceiveMessage()` uses the `ProcessMessage()` method to process and act on a received message. `ProcessMessage()` is structured similarly to the one in the Silverlight client in that it deserializes a message and looks at the type of the contained `Body` property to determine the course of action. For messages that are intended to be delivered to other participants, `ProcessMessage` delivers it to that participant either through `ServerConnectionManager.Broadcast()`, which delivers a message to all participants except for the one sending it, or by `ServerConnectionManager.Send()`, which delivers it to a single targeted participant. Delivery of a message in this case is achieved by adding the message to a send queue of type `Queue<MessageWrapper>` defined in each participant.

The send thread continously checks the `Sending` flag (used similarly to the `Receiving` flag) and the presence of messages in the queue of the owning participant using `Participant.HasMessage()`. When a message is found, `SendMessage()` is called, which then serializes the message and sends it out through the participant's socket.

The Policy Server

The policy server is similarly implemented as a console program that listens on all available IP addresses, bound to a well-known port 943. Listing 7-27 shows the code for the policy server.

Listing 7-27. *Implementation for the PolicyServer type in PolicyListener.cs*

```
using System;
using System.IO;
using System.Net;
using System.Net.Sockets;
using System.Text;
```

```
namespace Recipe7_5.PolicyServer
{

  internal class PolicyListener
  {
    Socket ListenerSocket { get; set; }
    SocketAsyncEventArgs sockEvtArgs = null;
    //valid policy request string
    public static string ValidPolicyRequest = "<policy-file-request/>";

    public PolicyListener()
    {
      //bind to all available addresses and port 943
      IPEndPoint ListenerEndPoint =
        new IPEndPoint(IPAddress.Any, 943);
      ListenerSocket =
        new Socket(AddressFamily.InterNetwork, SocketType.Stream, ProtocolType.Tcp);
      ListenerSocket.Bind(ListenerEndPoint);
      ListenerSocket.Listen(20);
    }
    internal void ListenForPolicyRequest()
    {
      sockEvtArgs = new SocketAsyncEventArgs();
      sockEvtArgs.Completed += new EventHandler<SocketAsyncEventArgs>(
          delegate(object Sender, SocketAsyncEventArgs e)
          {
            //process this request
            ReadPolicyRequest(e.AcceptSocket);
            //go back to listening
            ListenForPolicyRequest();
          });
      ListenerSocket.AcceptAsync(sockEvtArgs);
    }
    private bool ReadPolicyRequest(Socket ClientSocket)
    {
      SocketAsyncEventArgs sockEvtArgs =
        new SocketAsyncEventArgs { UserToken = ClientSocket };
      sockEvtArgs.SetBuffer(
        new byte[ValidPolicyRequest.Length], 0, ValidPolicyRequest.Length);
      sockEvtArgs.Completed += new EventHandler<SocketAsyncEventArgs>(
          delegate(object Sender, SocketAsyncEventArgs e)
          {
            if (e.SocketError == SocketError.Success)
            {
              //get policy request string
```

```
            string PolicyRequest = new UTF8Encoding().
              GetString(e.Buffer, 0, e.BytesTransferred);
            //check for valid format
            if (PolicyRequest.CompareTo(ValidPolicyRequest) == 0)
              //valid request-send policy
              SendPolicy(e.UserToken as Socket);
          }
        });
      return ClientSocket.ReceiveAsync(sockEvtArgs);
    }
    private void SendPolicy(Socket ClientSocket)
    {
      //read the policy file
      FileStream fs = new FileStream("clientaccesspolicy.xml", FileMode.Open);
      byte[] PolicyBuffer = new byte[(int)fs.Length];
      fs.Read(PolicyBuffer, 0, (int)fs.Length);
      fs.Close();

      SocketAsyncEventArgs sockEvtArgs =
        new SocketAsyncEventArgs { UserToken = ClientSocket };
      //send the policy
      sockEvtArgs.SetBuffer(PolicyBuffer, 0, PolicyBuffer.Length);
      sockEvtArgs.Completed += new EventHandler<SocketAsyncEventArgs>(
          delegate(object Sender, SocketAsyncEventArgs e)
          {
            //close this connection
            if (e.SocketError == SocketError.Success)
              (e.UserToken as Socket).Close();
          });
      ClientSocket.SendAsync(sockEvtArgs);
    }
  }
}
```

After a connection request is accepted by the policy server, it attempts to receive a policy request from the client and checks it for validity by comparing it to the string literal `<policy-file-request/>`. If valid, the policy file is read into memory and sent back to the client through the connected client socket. When the send is completed, the socket connection is closed, and the policy server keeps listening for more policy requests.

7-6. Enabling Cross-Domain Access

Problem

You need your Silverlight client to access resources or services in a domain different from the one from which it originated.

Solution

Create an appropriate cross-domain policy on the target domain.

How It Works

Attacks where malicious code may make unauthorized calls to a remote services domain or flood the network with a large number of calls to effect denial of service are common threats on the Internet. To prevent this, Silverlight requires an explicit opt-in for a target remote domain to allow a Silverlight application to access network resources in that domain. The domain from which the Silverlight application is served is also called the *site of origin*, and a *remote domain* is any network location other than the site of origin.

This opt-in is implemented by way of a policy file that is downloaded by the Silverlight runtime and evaluated for access permissions. The policy file is defined in an XML syntax and must be named `clientaccesspolicy.xml`.

For HTTP-based communication (which includes the WebClient and the other HTTP communication classes, as well as the Silverlight WCF client proxy implementation), the owner of the target domain needs to place such a policy file at the root of the target site. When your Silverlight application makes the first HTTP request to the target domain in question, the Silverlight runtime tries to download the policy file from the site's root. If the download is successful, the runtime then evaluates the policy settings in the file to determine whether appropriate access has been granted to the resources being requested by the client application. On successful evaluation and the presence of appropriate permissions, the application is allowed to continue with the network call. Otherwise, the network call fails. Figure 7-8 shows the sequence of calls for cross-domain access over HTTP.

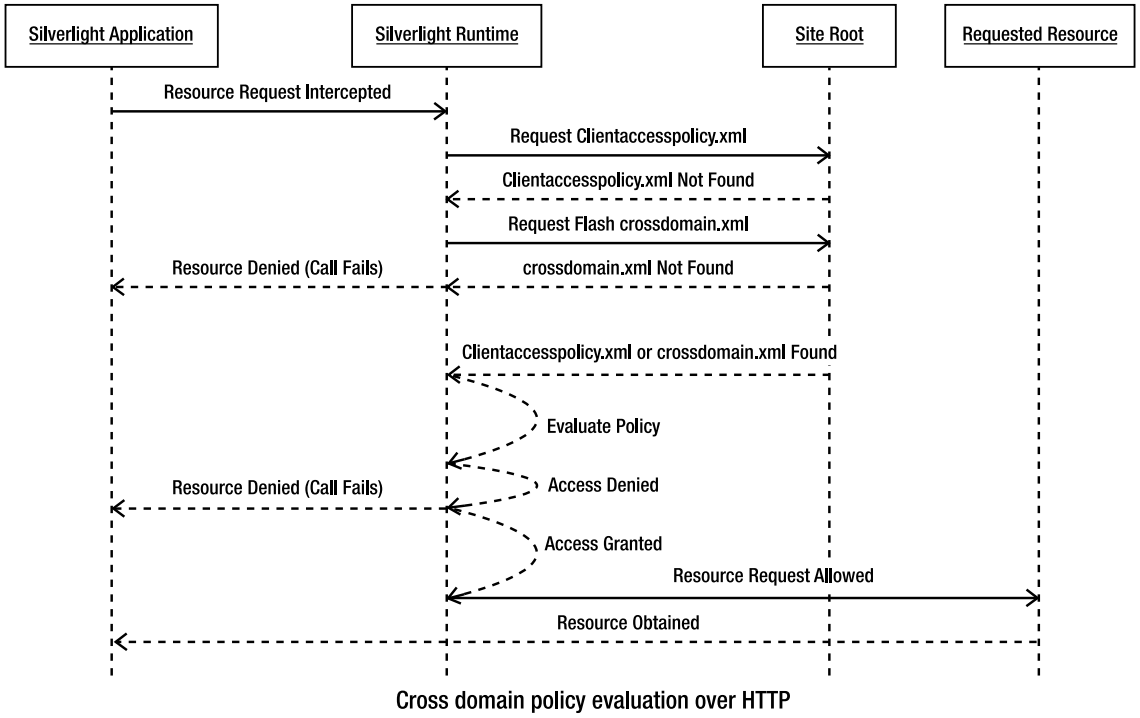


Figure 7-8. *Call sequence for cross-domain access over HTTP*

Also note that Silverlight supports the Flash cross-domain access policy format as well. In the previous scenario, if a `clientaccesspolicy.xml` is not found, the runtime tries to download a Flash policy file named `crossdomain.xml` and base resource access on the policy specified there.

For sockets-based communication, a similar policy file is used, but there are a few more details. For Silverlight applications using sockets, the cross-domain policy requirements apply to cross-domain calls as well as those back to the site of origin. On the first attempt to open a connection to a TCP endpoint from a Silverlight application, the runtime attempts to open another TCP connection to the target server (cross-domain or site of origin) at port 943. If this connection succeeds, the runtime then tries to download the policy file over this connection. If the download succeeds, the connection is closed and the downloaded policy file is used for the rest of the session. Figure 7-9 shows the sequence of calls for cross-domain access over TCP sockets.

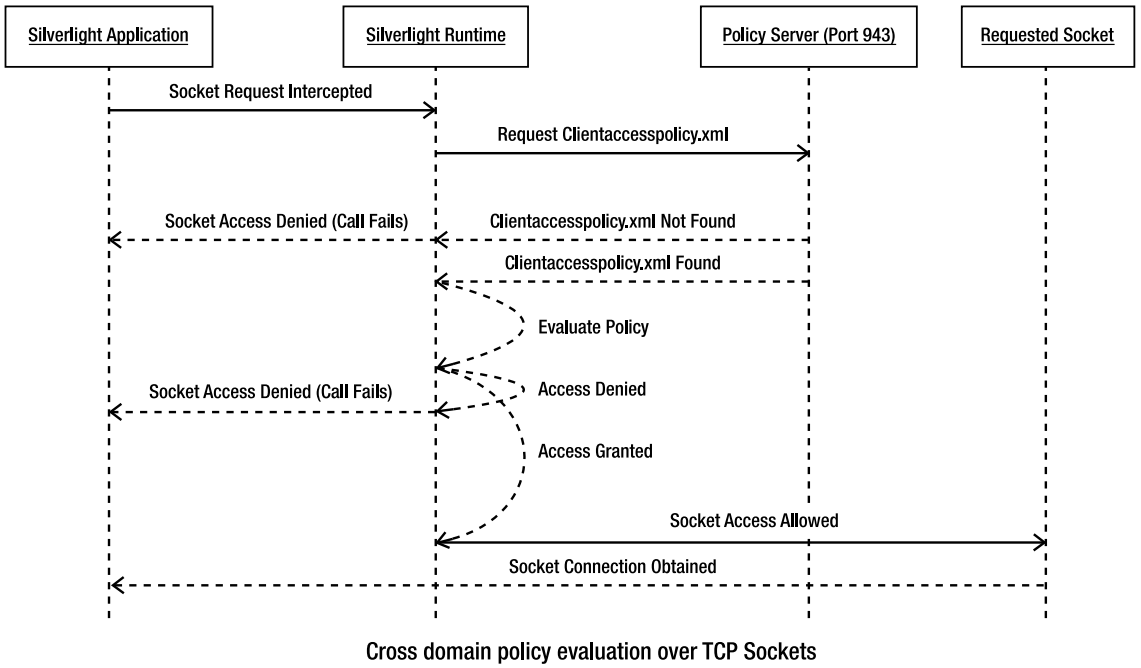


Figure 7-9. *Call sequence for cross-domain access over TCP sockets*

All of this happens behind the scenes as far as your Silverlight code is concerned, so no specific design or code consideration is necessary on the client side for either your HTTP or sockets-based code. However, if you are also implementing the sockets-based server, you need to implement a listener on port 943 and be prepared to serve the policy file when the request comes in. The request is in the form of a special string constant of the value `<policy-file-request/>`.

The Code

Listing 7-28 shows a sample policy file for HTTP resource access.

Listing 7-28. *Sample clientaccesspolicy.xml for HTTP Access*

```
<?xml version="1.0" encoding="utf-8"?>
<access-policy>
  <cross-domain-access>
    <policy>
      <allow-from http-request-headers="MyHeader, X-API-*">
        <domain uri="http://subdomain1.mydomain.com"/>
        <domain uri="http://subdomain2.mydomain.com"/>
        <domain uri="http://mydomain.com:8181"/>
```

```
      </allow-from>
      <grant-to>
        <resource path="/images "/>
        <resource path="/services" include-subpaths="True"/>
      </grant-to>
    </policy>
  </cross-domain-access>
</access-policy>
```

Multiple `domain` entries can be used to specify specific subdomains on a root domain or nonstandard HTTP ports that are allowed to be accessed. If your domain does not have subdomains or nonstandard ports, or if you want to grant access to the entire domain regardless, include one `domain` entry, as shown here:

```
<allow-from>
  <domain uri="*"/>
</allow-from>
```

Each `resource` entry specifies a resource for which access permission is granted, with the `path` property containing the root relative path to the resource. The optional `include-subpaths` defaults to `False` and can be left out. If you want to grant access to subpaths for a specific path as well, set `include-subpaths` to `True`, as shown in Listing 7-28. Specifying one `resource` entry with the path value set to `/` and `include-subpaths` set to `True` allows full access to all resources in the site, as shown here:

```
<grant-to>
  <resource path="/" include-subpaths="True"/>
</grant-to>
```

The optional `http-request-headers` attribute on the `allow-from` element can be a comma-separated list of allowed HTTP request headers, where you can use an asterisk (*) as a part of a header name to indicate a wildcard. You can also replace the entire list and use the * wildcard to allow all possible headers. If the attribute is left out, no HTTP headers are allowed.

Listing 7-29 shows a `clientaccesspolicy.xml` file for sockets-based access.

Listing 7-29. *Sample clientaccesspolicy.xml for sockets-based access*

```
<?xml version="1.0" encoding ="utf-8"?>
<access-policy>
  <cross-domain-access>
    <policy>
      <allow-from>
        <domain uri="*" />
      </allow-from>
      <grant-to>
        <socket-resource port="4502-4534" protocol="tcp" />
      </grant-to>
    </policy>
```

```
  </cross-domain-access>
</access-policy>
```

The difference here is in the use of the `socket-resource` element. The `socket-resource` element has two attributes. The `port` attribute can be used to specify the range of ports allowed, where the range has to be within 4502–4534. The `protocol` attribute allows `tcp` as the only possible value in this version of Silverlight. They are both required attributes.

For complete details on the policy syntax, refer to the related MSDN documentation at `msdn.microsoft.com/en-us/library/cc645032(VS.95).aspx`.

7-7. Exchanging Data between Silverlight Applications

Problem

You have two or more separate Silverlight applications composing parts of your overall web page, and you need these applications to exchange data with each other.

Solution

Use the local connection feature in Silverlight 3 to enable communication channels between these applications and facilitate cross-application data exchange.

How It Works

The local-connection feature in Silverlight 3 enables you to establish communication channels between two or more Silverlight applications on the same web page.

Receiver Registration

In this mode of communication, an application can act as a sender, a receiver, or both. To register itself with the communication system as a receiver, the application has to provide a unique identity, using which messages are directed to it. This identity is a combination of a receiver name (expressed using a string literal) and the application's web domain name, and needs to yield a unique identifier within the scope of the containing page.

To register itself as a receiver, the application can create an instance of the `LocalMessageReceiver` class in `System.Windows.Messaging`, passing in the receiver name as shown here:

```
LocalMessageReceiver ThisReceiver = new LocalMessageReceiver("ThisReceiverName");
```

Using this version of the constructor registers the receiver name as unique in its originating domain—other receivers in the page can have the same receiver name as long as they belong to different domains. Registering in this fashion also allows the receiver to receive messages only from those senders on the page that originate from the same domain as the receiver.

The local-connection API offers granular control over the message receiving heuristics. An overloaded constructor for the `LocalMessageReceiver` class is made available with the following signature:

```
public LocalMessageReceiver(string receiverName,
      ReceiverNameScope nameScope, IEnumerable<string> allowedSenderDomains);
```

The `ReceiverNameScope` enumeration used in the second parameter has two possible values. `ReceiverNameScope.Domain` has the same effect as the previous constructor, requiring that the receiver name be unique within all receivers on the page originating from the same domain. However, `ReceiverNameScope.Global` requires that the receiver name be unique across all receivers on the page, regardless of their originating domain name.

The third parameter, `allowedSenderDomains`, enables extending the list of sender domains from which the receiver can receive messages beyond the receiver's originating domain. Setting it to `LocalMessageReceiver.AnyDomain` allows the receiver to receive messages from any sender on the page, regardless of the sender's originating domain. You can also set `allowedSenderDomains` to a selective list of the domains from which you want to allow message receipt. The following code shows a receiver being registered as unique across all receiver domains on the page, with the abilty to receive messages from senders in two specific domains (`http://www.microsoft.com` and `http://www.silverlight.net`):

```
LocalMessageReceiver ThisReceiver =
     new LocalMessageReceiver("ThisReceiverName",
       ReceiverNameScope.Global, new List<string>{ "http://www.microsoft.com",
         "http://www.silverlight.net"});
```

Receiving Messages

When a receiver has been registered, you need to attach a handler to the `LocalMessageReceiver.MessageReceived` event to receive messages and then call the `LocalMessageReceiver.Listen()` method to start listening for incoming messages asynchronously. Here is an example:

```
ThisReceiver.MessageReceived +=
  new EventHandler<MessageReceivedEventArgs>((s, e) =>
  {
    string Msg = e.Message;

   //do something with the received message
    ...
   //optionally send a response message
   string ResponseMessage = PrepareResponseMessage();
   e.Response = ResponseMessage;

  });
ThisReceiver.Listen();
```

The `MessageReceivedEventArgs.Message` property contains the string message that was sent. When your code has processed the message, you can also send a response message back to the sender in the

`MessageReceivedEventArgs.Response` property. The response message follows the same rules as any other local connection message: it must be a string that is less than 1 MB in size. We talk more about the `Response` property in a bit.

Sending Messages

A sender application has no explicit registration process. To send messages to a receiver, you must construct an instance of `System.Windows.Messaging.LocalMessageSender` as shown here, passing in the receiver name and the receiver domain as parameters:

```
LocalMessageSender ThisSender =
  new LocalMessageSender("SomeReceiver","http://localhost");
```

You can also pass the value `LocalMessageSender.Global` as the second parameter. In that case, the system attempts to deliver the message to all receivers with the specified name on the page, regardless of what domain they belong to.

Local-connection messages are always sent asynchronously using the `LocalMessageSender.SendAsync()` method, as show here:

```
string MyMessage;
//create a message here
ThisSender.SendAsync(MyMessage);
```

As you can see, the message being sent is of type `String`. In the current version of Silverlight, only string messages less than 1 MB can be sent and received using the local-connection system. This may seem limiting initially. But consider that you can express any Silverlight data structure in either JSON or XML strings using the Silverlight-supplied serialization mechanisms like data-contract serialization or LINQ to XML XDocument serialization. With that in mind, this approach allows you to build fairly effective and rich data-exchange scenarios.

After the message has been sent, or an attempt to do so fails, the `LocalMessageSender.SendCompleted` event is raised by the runtime. You need to handle the event to do any error handling or response processing, as shown here:

```
ThisSender.SendCompleted +=
  new EventHandler<SendCompletedEventArgs>((s, e) =>
  {
    if (e.Error != null)
    {
      //we had an error sending the message - do some error reporting here
    }
    else if (e.Response != null)
    {
      //the receiver sent a response - process it here
    }
  });
```

Because the send operation is asynchronous and returns immediately, the local-connection system does not raise a direct exception to the sender if a send operation is unsuccessful.

Consequently, in the SendCompleted event handler, you should check the SendCompletedEventArgs.Error property of type Exception for any exception that may be raised in the event of an unsuccessful send attempt. In case of a send-related error, this may be set to an instance of System.Windows.Messaging.SendFailedException.

If the send was successful, the SendCompletedEventArgs.Response may contain a response message, depending on whether the receiver sent a response back.

Request-Response

The Response property is interesting in that it lets you establish a rudimentary request-response correlation using the local connection.

There are no limitations on an application being both a sender and a receiver at the same time. For an application to be both a sender and a receiver, you must perform the appropriate receiver registration and then create both a LocalMessageSender and a LocalMessageReceiver instance, as shown in the previous sections. One way to send responses from a receiver back to a sender would be a role-reversal strategy, where the receiver acts as a sender and the sender acts as a receiver for the response message path. However, because the order of message delivery is not guaranteed in the current implementation, this puts the onus on you to include additional details in the message body, should you need to correlate a sent message with its response.

The Response properties on the MessageReceivedEventArgs and MessageSentEventArgs types let you circumvent that. MessageReceivedEventArgs also contains a Message property and a SenderDomain property, which let the receiver application accurately pair the right response with the incoming message. MessageSentEventArgs also contains Message and Response properties, in addition to information about the receiver that sent the response through the ReceiverDomain and ReceiverName properties. This allows the sender to accurately pair a receiver response with a specific sent message.

The Code

The code sample for this recipe builds on the sample from Recipe 4-4 in Chapter 4. That recipe has a simple spending analysis application for a family; the expenditures for different categories are maintained in a DataGrid and also graphed in a bar graph as a percentage of the total. The application allows you to change the spending in each category to different values and watch the graph change accordingly. It also lets you drag any bar in the graph using your mouse and watch the corresponding value change in the DataGrid, maintaining the same total.

To adapt that sample to this recipe, you break it into two separate applications. The application named 7.7 HomeExpenseWorksheet encapsulates the DataGrid-based worksheet portion of the sample, whereas the 7.7 HomeExpenseGraph application encapsulates the bar-graph implementation. You then use local-connection-based messaging between the two applications to implement the necessary communication.

Figure 7-10 shows the applications hosted on the same page.

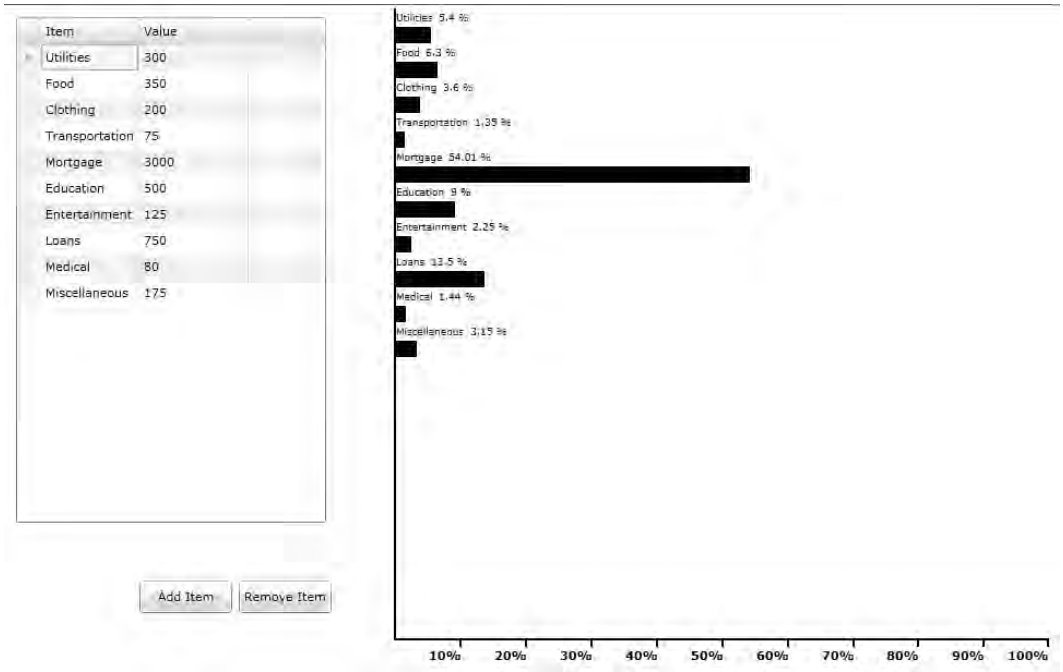


Figure 7-10. *The expense worksheet and the expense graph applications on the same page*

Before we discuss the local-connection-related code changes, let's quickly look at the XAML for the expense worksheet application, shown in Listing 7-30.

Listing 7-30. *XAML for the HomeExpenseWorksheet application in MainPage.xaml*

```
<UserControl x:Class="Recipe7_7.HomeExpenseWorksheet.MainPage"
             xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
             xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
             xmlns:data=
    "clr-namespace:System.Windows.Controls;assembly=System.Windows.Controls.Data"
             Width="300"
             Height="600">

  <Grid x:Name="LayoutRoot"
        Background="White">
    <Grid.RowDefinitions>
      <RowDefinition Height="0.8*" />
      <RowDefinition Height="0.2*" />
    </Grid.RowDefinitions>
    <data:DataGrid HorizontalAlignment="Stretch"
                   Margin="8,8,8,8"
                   VerticalAlignment="Stretch"
```

```
                HeadersVisibility="All"
                Grid.Row="0"
                x:Name="dgSpending"
                AutoGenerateColumns="False"
                CellEditEnded="dgSpending_CellEditEnded">
      <data:DataGrid.Columns>
        <data:DataGridTextColumn Header="Item"
                                 Binding="{Binding Item,Mode=TwoWay}" />
        <data:DataGridTextColumn Header="Value"
                                 Width="100"
                                 Binding="{Binding Amount,Mode=TwoWay}" />
      </data:DataGrid.Columns>
    </data:DataGrid>
    <StackPanel Orientation="Horizontal"
                Grid.Row="1"
                HorizontalAlignment="Right">
      <Button x:Name="btnAddItem"
              Margin="3,3,3,3"
              Height="30"
              Width="85"
              Content="Add Item"
              Click="btnAddItem_Click" />
      <Button x:Name="btnRemoveItem"
              Margin="3,3,3,3"
              Height="30"
              Width="85"
              Content="Remove Item"
              Click="btnRemoveItem_Click" />
    </StackPanel>
  </Grid>
</UserControl>
```

The code in Listing 7-30 shows the only notable changes made to the XAML, as adapted from Recipe 4-4. As you can see, you add two buttons: clicking `btnAddItem` adds a new row to the `DataGrid`, and clicking `btnRemoveItem` removes the currently selected item from the `DataGrid`. You also attach a handler to the `CellEditEnded` event of the `DataGrid`. We cover the details of the implementations of these handlers later in this section.

The XAML for the HomeExpenseGraph application remains largely the same as the comparable part in Recipe 4-4. We do not cover it again here, but we urge you to refer back to the code samples or to Recipe 4-4.

To start with the local-connection implementation, recall that messages are string based. However, strings are cumbersome to work with, so you define the application messages as a custom CLR type named `Message` and then resort to serialization to convert `Message` instances to string representations before sending them. Listing 7-31 shows the `Message` type.

Listing 7-31. *The Message custom type in Messages.cs*

```
using System.Collections.Generic;
using System.IO;
using System.Runtime.Serialization;
using System.Text;

namespace Recipe7_7.SD
{
  public enum MessageType
  {
    ItemRemoved,
    ItemsValueChanged
  }

  [DataContract]
  public class Message
  {
    [DataMember]
    public MessageType MsgType { get; set; }
    [DataMember]
    public List<Spending> Items { get; set; }
    public static string Serialize(Message Msg)
    {
      DataContractSerializer dcSer = new DataContractSerializer(typeof(Message));
      MemoryStream ms = new MemoryStream();
      dcSer.WriteObject(ms, Msg);
      ms.Flush();
      string RetVal = Encoding.UTF8.GetString(ms.GetBuffer(), 0, (int)ms.Length);
      ms.Close();
      return RetVal;
    }

    public static Message Deserialize(string Msg)
    {
      DataContractSerializer dcSer = new DataContractSerializer(typeof(Message));
      MemoryStream ms = new MemoryStream(Encoding.UTF8.GetBytes(Msg));
      Message RetVal = dcSer.ReadObject(ms) as Message;
      ms.Close();
      return RetVal;
    }
  }
}
```

You handle two kinds of messages in the local connection implementation between the worksheet and the graph applications, as defined in the `MessageType` enumeration. The `MessageType.ItemRemoved` value indicates a message that communicates the removal of one or more items; it is sent from the worksheet to the graph only when rows are removed from the worksheet. The `MessageType.ItemsValueChanged` typed message can be sent in either direction when the values of one or more items change—either in the worksheet for an existing item or a newly added item through user edits, or in the graph when the user drags a bar to resize it.

The `Message` class contains the `MessageType` and a list of `Items` with changed values or a list of `Items` that were removed. It also defines two static methods that use `DataContractSerialization` to serialize and deserialize instances of the `Message` type to and from a string representation. Note that you have the `Message` class attributed as a `DataContract` with the `Mistyped` and `Items` properties attributed as `DataMember`.

An individual data item for the application is defined as a class named `Spending`, and a custom class named `SpendingCollection` deriving from `ObservableCollection<Spending>` defines the data collection that initially populates the worksheet and the graph. These classes are not changed much from Recipe 4-4, so we do not cover them in detail. Listing 7-32 shows these classes.

Listing 7-32. *Data classes in DataClasses.cs*

```
using System.Collections.ObjectModel;
using System.ComponentModel;
using System.Linq;
using System.Runtime.Serialization;
namespace Recipe7_7.SD
{
  public class SpendingCollection : ObservableCollection<Spending>
  {
    public SpendingCollection()
    {
      this.Add(new Spending
      {
        ParentCollection = this,
        ID = 1,
        Item = "Utilities",
        Amount = 300
      });
      this.Add(new Spending
      {
        ParentCollection = this,
        ID = 2,
        Item = "Food",
        Amount = 350
      });
      this.Add(new Spending
      {
        ParentCollection = this,
        ID = 3,
```

```
    Item = "Clothing",
    Amount = 200
  });
  this.Add(new Spending
  {
    ParentCollection = this,
    ID = 4,
    Item = "Transportation",
    Amount = 75
  });
  this.Add(new Spending
  {
    ParentCollection = this,
    ID = 5,
    Item = "Mortgage",
    Amount = 3000
  });
  this.Add(new Spending
  {
    ParentCollection = this,
    ID = 6,
    Item = "Education",
    Amount = 500
  });
  this.Add(new Spending
  {
    ParentCollection = this,
    ID = 7,
    Item = "Entertainment",
    Amount = 125
  });
  this.Add(new Spending
  {
    ParentCollection = this,
    ID = 8,
    Item = "Loans",
    Amount = 750
  });
  this.Add(new Spending
  {
    ParentCollection = this,
    ID = 9,
    Item = "Medical",
    Amount = 80
  });
```

```
    this.Add(new Spending
    {
      ParentCollection = this,
      ID = 10,
      Item = "Miscellaneous",
      Amount = 175
    });
  }

  public double Total
  {
    get
    {
      return this.Sum(spending => spending.Amount);
    }
  }
}

[DataContract]
public class Spending : INotifyPropertyChanged
{

  public event PropertyChangedEventHandler PropertyChanged;
  internal void RaisePropertyChanged(PropertyChangedEventArgs e)
  {
    if (PropertyChanged != null)
    {
      PropertyChanged(this, e);
    }
  }

  public override int GetHashCode()
  {
    return ID.GetHashCode();
  }

  public override bool Equals(object obj)
  {
    return (obj is Spending) ? this.ID.Equals((obj as Spending).ID) : false;
  }

  SpendingCollection _ParentCollection = null;

  public SpendingCollection ParentCollection
  {
```

```
    get { return _ParentCollection; }
    set
    {
      _ParentCollection = value;
      if (ParentCollection != null)
      {
        foreach (Spending sp in ParentCollection)
          sp.RaisePropertyChanged(new PropertyChangedEventArgs("Amount"));
      }
    }
  }

  private int _ID = default(int);
  [DataMember]
  public int ID
  {
    get
    {
      return _ID;
    }

    set
    {
      if (value != _ID)
      {
        _ID = value;
        if (PropertyChanged != null)
          PropertyChanged(this, new PropertyChangedEventArgs("ID"));
      }
    }
  }

  private string _Item;
  [DataMember]
  public string Item
  {
    get { return _Item; }
    set
    {
      string OldVal = _Item;
      if (OldVal != value)
      {
        _Item = value;
        RaisePropertyChanged(new PropertyChangedEventArgs("Item"));
```

```
        }
      }
    }

    private double _Amount;
    [DataMember]
    public double Amount
    {
      get { return _Amount; }
      set
      {
        double OldVal = _Amount;
        if (OldVal != value)
        {
          _Amount = value;

          if (ParentCollection != null)
          {
            foreach (Spending sp in ParentCollection)
              sp.RaisePropertyChanged(new PropertyChangedEventArgs("Amount"));
          }
        }
      }
    }
  }
}
```

The only changes worth noting are the addition of an `ID` property to the `Spending` class to uniquely identify it in a collection, and the overrides for `GetHashCode()` and `Equals()` to facilitate locating or comparing spending instances based on their IDs. The changes are noted in bold in Listing 7-32.

Now, let's look at the application code. Listing 7-33 lists the codebehind for the worksheet application.

Listing 7-33. *The MainPage codebehind in MainPage.xaml.cs for the HomeExpenseWorksheet application*

```
using System;
using System.Collections.Generic;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Messaging;
using Recipe7_7.SD;

namespace Recipe7_7.HomeExpenseWorksheet
{
  public partial class MainPage : UserControl
  {
```

```
//data source
SpendingCollection SpendingList = new SpendingCollection();
//create a sender
LocalMessageSender WorksheetSender =
  new LocalMessageSender("SpendingGraph",
    LocalMessageSender.Global);
//create a receiver
LocalMessageReceiver WorksheetReceiver =
  new LocalMessageReceiver("SpendingWorksheet",
    ReceiverNameScope.Global, LocalMessageReceiver.AnyDomain);

public MainPage()
{
  InitializeComponent();

  //bind data
  dgSpending.ItemsSource = SpendingList;

  //handle message receipt
  WorksheetReceiver.MessageReceived+=
    new EventHandler<MessageReceivedEventArgs>((s,e) =>
  {
    //deserialize message
    Message Msg = Message.Deserialize(e.Message);
    //if item value changed
    if (Msg.MsgType == MessageType.ItemsValueChanged)
    {
      //for each item for which value has changed
      foreach (Spending sp in Msg.Items)
      {
        //find the corrsponding item in the data source and replace value
        SpendingList[SpendingList.IndexOf(sp)] = sp;
      }
    }
  });

  //handle send completion
  WorksheetSender.SendCompleted +=
    new EventHandler<SendCompletedEventArgs>((s, e) =>
  {
    //if error
    if (e.Error != null)
    {
      //we had an error sending the message - do some error reporting here
    }
```

```
    //if there was a response
    else if (e.Response != null)
    {
      //the receiver sent a response - process it here
    }
  });

  //start listening for incoming messages
  WorksheetReceiver.Listen();
}

//handle add row button click
private void btnAddItem_Click(object sender, RoutedEventArgs e)
{
  //add a new Spending instance to the data source
  SpendingList.Add(new Spending() { ParentCollection = SpendingList });
}

//handle a cell edit
private void dgSpending_CellEditEnded(object sender,
  DataGridCellEditEndedEventArgs e)
{
  //send a message
  WorksheetSender.SendAsync(Message.Serialize(
    new Message()
    {
      //message type - Item value changed
      MsgType = MessageType.ItemsValueChanged,
      //the changed Spending instance
      Items = new List<Spending> { e.Row.DataContext as Spending }
    }));
}

//remove the selected item
private void btnRemoveItem_Click(object sender, RoutedEventArgs e)
{
  //if there is a selected row
  if (dgSpending.SelectedItem != null)
  {
    //get the corresponding Spending instance
    Spending target = dgSpending.SelectedItem as Spending;
    //remove it from the data source
    SpendingList.Remove(target);
    //send a message
    WorksheetSender.SendAsync(Message.Serialize(
```

```
        new Message()
        {
          //message type - Item Removed
          MsgType = MessageType.ItemRemoved,
          //the item that was removed
          Items = new List<Spending> { target }
        }));
      }
    }
  }
}
```

As you can see, you start by creating a `LocalMessageSender` and a `LocalMessageReceiver` instance, respectively, named `WorksheetSender` and `WorksheetReceiver`, as members of the codebehind class. `WorksheetSender` is created to let you send messages to a receiver named `SpendingGraph`, which is globally unique across all receivers on the page. `WorksheetReceiver` registers this application as a receiver named `SpendingWorksheet`, again with a global namescope, and prepares to receive incoming messages from senders in any domain.

During construction, you attach handlers to `WorksheetReceiver.MessageReceived` and `WorksheetSender.SendCompleted`. In the `MessageReceived` handler, you deserialize the incoming message and then process it. You only handle messages of type `MessageType.ItemsValueChanged`, because these are the only types of messages the HomeExpenseGraph application can generate. As a part of the processing, if you do receive `Spending` instances that have changed, you replace them accordingly in the expense worksheet datasource. In the `SendCompleted` handler, you show a skeletal set of statements for handling error conditions and response messages—we leave it as an exercise for you to implement error handling and response correlation as needed.

In the `Click` event handler for the `Button` named `btnAddItem`, you add a new `Spending` item to the datasource. However, you do not immediately send a message to the HomeExpenseGraph application, because the `Spending` item still does not have any meaningful data. Instead, you use the `CellEditEnded` event handler to send item-change notifications. In that handler, you construct a new `Message` instance with the changed `Spending` item as the only item in the `Message.Items` collection, and you set the `MsgType` property to `MessageType.ItemsValueChanged`. You then serialize the message and send it through the `WorksheetSender.SendAsync()` method.

In the `Click` handler for `btnRemoveItem`, you first remove the `Spending` instance bound to the selected `DataGrid` row from the datasource collection. Then, you use the same approach to serialize and send a `Message` instance, with the `MsgType` property set to `MessageType.ItemRemoved`.

Let's look at the HomeExpenseGraph application. Listing 7-34 shows the codebehind for the `MainPage` in that application.

Listing 7-34. *The MainPage aodebehind in MainPage.xaml.cs for the HomeExpenseGraph application*

```
using System;
using System.Collections.Generic;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Input;
using System.Windows.Messaging;
using System.Windows.Shapes;
```

```
using Recipe7_7.SD;

namespace Recipe7_7.HomeExpenseGraph
{
  public partial class MainPage : UserControl
  {
    //variables to enable mouse interaction
    private bool MouseLeftBtnDown = false;
    private bool Dragging = false;
    Point PreviousPos;
    //data source
    SpendingCollection SpendingList = null;
    //create a sender
    LocalMessageSender GraphSender =
      new LocalMessageSender("SpendingWorksheet",
        LocalMessageSender.Global);
    //create a receiver
    LocalMessageReceiver GraphReceiver =
     new LocalMessageReceiver("SpendingGraph",
       ReceiverNameScope.Global, LocalMessageReceiver.AnyDomain);

    public MainPage()
    {
      InitializeComponent();

      SpendingList = this.Resources["REF_SpendingList"] as SpendingCollection;
      //handle property changed for each Spending - this is used to send item
      //value changed messages
      foreach (Spending sp in SpendingList)
      {
        sp.PropertyChanged +=
          new System.ComponentModel.
            PropertyChangedEventHandler(Spending_PropertyChanged);
      }
      //handle message receipts
      GraphReceiver.MessageReceived +=
        new EventHandler<MessageReceivedEventArgs>((s, e) =>
      {
        //deserialize message
        Message Msg = Message.Deserialize(e.Message);
        //if value changed
        if (Msg.MsgType == MessageType.ItemsValueChanged)
        {
          //for each changed Spending instance
          foreach (Spending sp in Msg.Items)
```

```
        {
          //if it exists
          if (SpendingList.Contains(sp))
          {
            //replace it with the changed one
            SpendingList[SpendingList.IndexOf(sp)] = sp;
          }
          else
          {
            //add the new one
            SpendingList.Add(sp);
          }
          //handle property changed
          sp.PropertyChanged +=
            new System.ComponentModel.
              PropertyChangedEventHandler(Spending_PropertyChanged);
          //force a recalc of the bars in the graph
          sp.ParentCollection = SpendingList;
        }
      }
      //item removed
      else if (Msg.MsgType == MessageType.ItemRemoved)
      {
        foreach (Spending sp in Msg.Items)
        {
          //unhook the event handler
          SpendingList[SpendingList.IndexOf(sp)].PropertyChanged
            -= Spending_PropertyChanged;
          //remove from data source
          SpendingList.Remove(sp);
        }
        //force a recalc of the bars in the graph
        if (SpendingList.Count > 0)
          SpendingList[0].ParentCollection = SpendingList;

      }
    });

    //start listening for incoming messages
    GraphReceiver.Listen();
  }
  void Spending_PropertyChanged(object sender,
    System.ComponentModel.PropertyChangedEventArgs e)
  {
    //send a message
```

```
  GraphSender.SendAsync(
    Message.Serialize(
        new Message
        {
          //changed item
          Items = new List<Spending> { sender as Spending },
          //message type - item value changed
          MsgType = MessageType.ItemsValueChanged
        }));

}

private void Rectangle_MouseMove(object sender, MouseEventArgs e)
{
  if (MouseLeftBtnDown)
  {
    Rectangle rect = (Rectangle)sender;
    if (Dragging == false)
    {
      Dragging = true;
      rect.CaptureMouse();
    }

    Point CurrentPos = e.GetPosition(sender as Rectangle);
    double Moved = CurrentPos.X - PreviousPos.X;
    if (rect.Width + Moved >= 0)
    {
      rect.Width += Moved;
    }
    PreviousPos = CurrentPos;
  }
}

private void Rectangle_MouseLeftButtonDown(object sender,
  MouseButtonEventArgs e)
{
  MouseLeftBtnDown = true;
  PreviousPos = e.GetPosition(sender as Rectangle);
}

private void Rectangle_MouseLeftButtonUp(object sender,
  MouseButtonEventArgs e)
{
  Rectangle rect = (Rectangle)sender;
  if (Dragging)
```

```
      {
        Dragging = false;
        rect.ReleaseMouseCapture();
      }
      MouseLeftBtnDown = false;
    }
  }
}
```

As before, this application needs to both send and receive messages. As shown in Listing 7-34, you create instances of `LocalMessageSender` and `LocalMessageReceiver` such that this application can receive messages from the worksheet application and send messages to it as well.

In the constructor, after the datasource is bound, you handle the `PropertyChanged` event for each item in the collection. The `PropertyChanged` event is raised whenever the user drags a bar within the graph; if you look at the handler for the `PropertyChanged` event, note that you send a message to the other application indicating thus action.

You also handle the `MessageReceived` event as before. In the handler, you handle messages of both types—where item values are changed and where items are removed.

If an item value changes, you check to see if the item that changed already exists or was newly created in the worksheet application and does not exist in the datasource for this application. If it is an existing item, you replace it with the changed item; if it is a new item, you add it to the collection. You also attach a handler to the `Spending` item so that you can track changes to it in this application. Finally, you set the `Spending.ParentCollection` property to the datasource to which it was added to in which it was replaced. If you look at the definition of the `Spending` type in Listing 7-32, you see that this forces a property-change notification for all the items in the datasource. The bar graph displays the spending as percentages of the total, and this causes the bar graph's bar widths to be recalculated based on the new values.

If an item is removed, you first unattach the `PropertyChanged` event handler from the item that was removed and then remove it from the datasource collection. When the removals are complete, you force a similar recalculation of the bar widths based on the new percentages.

The rest of the code handles mouse events to enable user adjustments of the bars and is covered in Recipe 4-4.

CHAPTER 8

Building Out Of Browser Silverlight Applications

In the default deployment model for Silverlight, an application is delivered through the Silverlight plug-in embedded in a web page and consequently accessed through the user's choice of browser. In this scenario, the user must be connected to the web site that serves up the application.

Silverlight 3 extended that deployment model and introduced support for installing a Silverlight application on your local desktop. After the application is installed, you can use your platform's traditional mechanism to launch and run the application (for example, clicking an icon on the Start menu or desktop in Windows). This model of local installation is commonly known as the Out Of Browser (OOB) activation model for a Silverlight application.

In the process, you are no longer required to navigate to the application's source web site or open a browser window, nor do you have to be connected to a network. The application runs in its own window like any other installed application, providing the standard control mechanisms for the host window (close, minimize, maximize, and so on).

Silverlight 4 extends the OOB model in many ways. There is further control over the application's look and feel; for example, you can control aspects of the application window such as removing the default Windows chrome and supplying your own. You can also stipulate that the application be run with an elevated set of permissions that afford access to the local file system or the ability to interoperate with installed COM libraries through COM automation.

The recipes in this chapter show you how to take advantage of the OOB features of Silverlight, specifically:

- Building an OOB application that can operate both in a connected and an offline mode
- Controlling the application window characteristics and customizing the window chrome
- Accessing the local file system
- Interoperating with system services on Windows through COM Interop
- Notification windows

8-1. Building a Silverlight application to run outside the browser

Problem

You need to give your Silverlight application the ability to be locally installed on a desktop. You also need the application to support execution with or without an available network connection.

Solution

Use the local installation support provided by Silverlight to enable the user to locally install the application. Use the network availability API in Silverlight to adapt your application logic to handle execution in an offline mode.

How It Works

Preparing the Application

The first step in enabling local installation for a Silverlight application is to supply the necessary installation settings in the Silverlight application manifest. Bring up the Project Properties page in Visual Studio for the Silverlight project, and you'll see an Enable running application out of the browser check box (see Figure 8-1). Check that option, and then click the Out-of-Browser Settings button to open the Out-of-Browser Settings dialog for the project (see Figure 8-2).

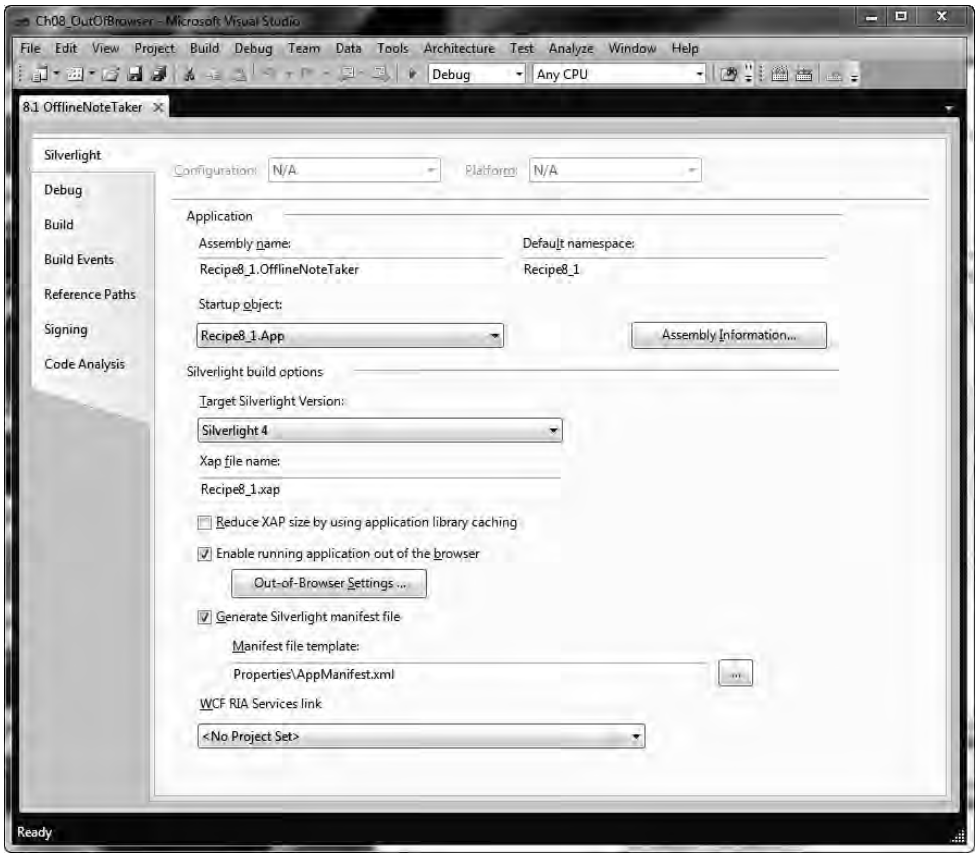


Figure 8-1. *Enabling Out-of-Browser activation in Visual Studio*

Figure 8-2. *The Out-of-Browser Settings dialog*

The Shortcut name field provides a user-friendly name for the application when it's installed on the desktop, and the Application description field provides a more detailed description. The Use GPU Acceleration check box specifies whether the locally installed application uses GPU acceleration (if available).

The installation process also requires that you provide four images, with square dimensions of 16, 32, 48 and 128 pixels each. These must be in PNG image format and must be included in the project with the Content setting specified for each image in Visual Studio. To select the appropriate image, click the adjoining Browse button to select from images included in your project, as shown in Figure 8-3. Note that you can choose not to specify these images, in which case the runtime uses a set of default images.

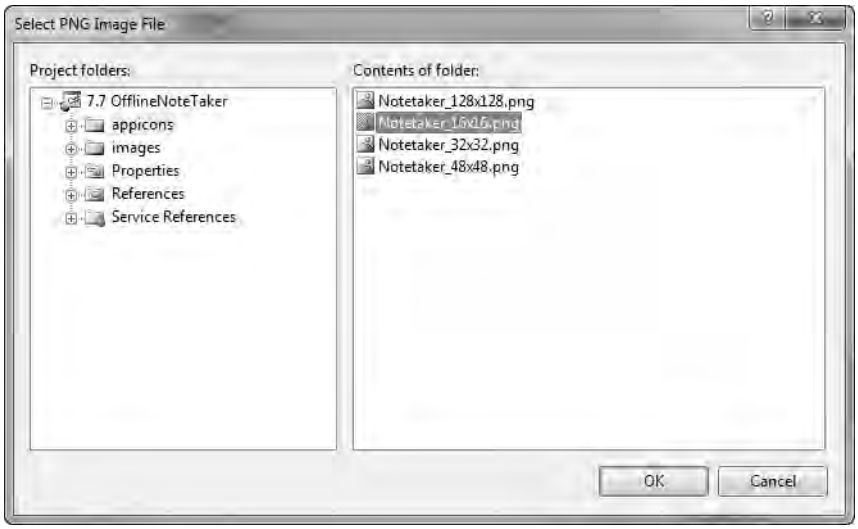


Figure 8-3. *Selecting OOB icons*

You also specify the initial `Width`, `Height`, and the `Window Title` of the host window within which the locally installed application launches. Note that these setting are the initial launch settings only, and the application always launches in a host window of these dimensions. Also note that the default initial location of the application window is centered on the screen, but if you check the Set window location manually option, you can specify the initial `Top` and `Left` coordinates of the application window in screen coordinates. Although the user can resize the host window when the application launches, Silverlight has no built-in facility to remember those settings across launches; however, we will show you in later recipes how to record these settings and control them programmatically. We will also discuss the other options on the dialog in later recipes.

The settings specified in this process are stored as XML in a file named `OutOfBrowserSettings.xml` under the `Properties` folder in your Silverlight project.

Installing the Application

If the installation settings are applied as discussed above, you can bring up the Silverlight context menu on the application running in the browser. You'll see an option to locally install the application, as shown in Figure 8-4.

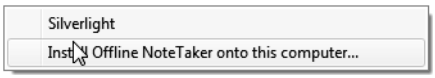


Figure 8-4. *Local installation menu option in the Silverlight context menu*

Selecting this option opens an installation options dialog. Figure 8-5 shows a sample.

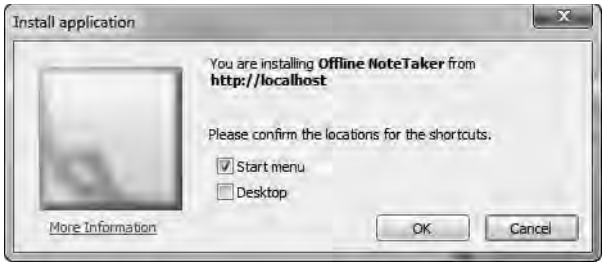


Figure 8-5. *Installation options dialog for local installation of a Silverlight application*

Note the text marked in bold in the dialog box. The title provided in the application identity settings in the application manifest is used to identify the application, and the web URI indicates the application's site of origin (in this case, http://localhost indicates that the application is being delivered from the local web server). The icon used in this dialog is the 128 x 128 pixel image provided in the application manifest.

After the application is installed, you can launch it directly from either the Start menu icon or the desktop shortcut added during the installation process, depending on your selection of the shortcut locations in the install dialog.

To remove a locally installed application, you can to run the application, either locally or in-browser by visiting the application web site, and bring up the Silverlight context menu. When the application is installed locally, the context menu offers an option to remove the application from your machine (see Figure 8-6). In Windows, you can also use Control Panel | Programs and Features to remove the listed application.

Figure 8-6. *Context menu option for local application removal*

Customizing the Installation Flow

The default mechanism of installing a Silverlight application through the context menu option may not always be a desirable choice. You may want to display a more visually appealing and slightly more obvious way of indicating to the user that the application can be locally installed. You may also want to have additional application logic tied to the process of the local installation. The `System.Windows.Application` class exposes some APIs to help control programmatic installation.

With the appropriate installation settings present in the application manifest as described earlier, invoking the static method `Application.Install()` from your application code has the same effect as invoking the context menu option for local installation.

The `Application.InstallState` property also gives you the current install state of the application. It is of the enumeration type `System.Windows.InstallState` and can have the following values:

- `NotInstalled`: The current application has not been locally installed on the machine.
- `Installing`: Either `Application.Install()` has been invoked or the user selected the install option from the context menu, and the application is about to be locally installed.
- `Installed`: The currently running application is installed on the machine.
- `InstallFailed`: An attempt to install the application was made, but the attempt failed.

The ApplicationInstallStateChanged event is raised whenever the value of Application.InstallState changes from one state to another in this list.

Note that the NotInstalled and Installed states are not necessarily indicative of the current application being run in or out of browser. For instance, if you install an application locally but navigate to the same application again on the same machine and load it in-browser from its site of origin, the InstallState of the in-browser application instance reports Installed. To know if your application is being launched locally or in-browser, rely on the Application.IsRunningOutOfBrowser static property of type Boolean; it returns true when the application is running locally and false when it is in-browser.

One obvious use of these APIs is to display different UIs to the user depending on the current install state. As an example, see the XAML in Listings 8-1 and 8-2. Note that we have left some portions out for brevity.

Listing 8-1. *OnlinePage.xaml*

```
<UserControl x:Class="Recipe8_1.OnlinePage"...>
  <Grid>
    ...
    <TextBlock Text="I am running in-browser".../>
    <Button x:Name="btnInstall"
            Content="Install Application"
            Click="btnInstall_Click"/>
  </Grid>
</UserControl>
```

Listing 8-2. *LocalPage.xaml*

```
<UserControl x:Class="Recipe8_1.LocalPage"...>
  <Grid x:Name="LayoutRoot"
        Background="White">
    <TextBlock Text="I am running locally"/>
  </Grid>
</UserControl>
```

Listing 8-1 shows a XAML page named OnlinePage.xaml that you want to display when the application is running in-browser. Listing 8-2 shows LocalPage.xaml, which you want the same application to display when running locally.

To detach the application, add the code shown here into the Click event handler of the Button named btnInstall in Listing 8-1:

```
 private void btnInstall_Click(object sender, RoutedEventArgs e)
{
  if(Application.Current.InstallState == InstallState.NotInstalled)
    Application.Current.Install();
}
```

Check Application.InstallState; if it indicates that the code is currently running in-browser, you invoke the Install() method to locally install the application.

You also make an additional check in the Application.StartUp event handler and load the appropriate page:

```
private void Application_Startup(object sender, StartupEventArgs e)
{
  if (Application.Current.IsRunningOutOfBrowser)
  this.RootVisual = new LocalPage();
 else
  this.RootVisual = new OnlinePage();
}
```

We look at using the `InstallState` property and installation customization in more detail in this recipe's code sample.

Sensing Network Availability

When you are running a locally installed application, you may want to add application logic that allows the application to behave reasonably well in the absence of network connectivity.

Silverlight provides support in the framework for sensing network connectivity. As network state changes during the lifetime of your application, you can handle the static `NetworkAddressChanged` event in the `System.Net.NetworkInformation.NetworkChange` class to receive network-change notifications from the runtime. This event is raised any time any one of your computer's existing network interfaces goes through a network address change.

However, not all such notifications indicate unavailability of a network connection; they may indicate a transition from one valid network address to another. To determine if a valid network connection is available, in the event handler of the `NetworkAddressChanged` event (and anywhere else in your code), you can invoke the static `GetIsNetworkAvailable()` method in the `System.Net.NetworkInformation.NetworkInterface` class. This method returns `true` if an active network connection is available or `false` if not.

Updating Locally Installed Applications

The local installation deployment model also adds support for application-initiated self-updates for application code. The related API lets you check for updates to the application code at the site of origin and asynchronously download the changes.

The `Application.CheckAndDownloadUpdateAsync()` method checks for any updates to the application code at the site of origin. If it finds an updated version, the updated bits are downloaded to the local machine's application cache asynchronously. The `Application.CheckAndDownloadUpdateCompleted` event is raised when the download process completes or if the check reveals no changes. The `CheckAndDownloadUpdatedCompletedEventArgs.UpdateAvailable` property is set to `true` if updates were downloaded or `false` if no updates were available. To apply the updates, the user needs to restart the application.

Listing 8-3 shows a possible use of the application-update feature.

Listing 8-3. *Code to Update an Application with Changes*

```
private void Application_Startup(object sender, StartupEventArgs e)
{
  if(Application.Current.InstallState == InstallState.Installed
    && Application.Current.IsRunningOutOfBrowser &&
```

```
    NetworkInterface.GetIsNetworkAvailable())
  {
    Application.Current.CheckAndDownloadUpdateCompleted+=
      new CheckAndDownloadUpdateCompletedEventHandler((s,args)=>
    {
      if (args.UpdateAvailable)
      {
        MessageBox.Show("New updates are available for this application." +
          "Please restart the application to apply updates.","Update Status",
          MessageBoxButton.OK);
        this.RootVisual = new CheckUpdatePage();
      }
      else
        this.RootVisual = new MainPage();
    });
    Application.Current.CheckAndDownloadUpdateAsync();

  }
  else
    this.RootVisual = new MainPage();
}
```

As shown in Listing 8-3, you check to see if the application is running from a locally installed version out of the browser and has network connectivity. If so, you proceed to invoke `CheckAndDownloadUpdatesAsync()`. In the `CheckAndDownloadUpdateCompleted` handler, you check to see if updates are available. If there are updates, you display an appropriate message and use a different root visual to prevent the main application from running without the updates being applied.

Note that whether you want to enforce the download of an available update depends on application logic specified as shown in Listing 8-3. Should you choose to, you can let the user continue without applying the update, as long as your application can function as an older version without causing any errors.

The Code

The code sample for this recipe builds a simple note-taking application that allows the user to take notes that have a title and a body and stores them on the server categorized by the date the note was taken. The application can also be installed locally; the user can operate the locally installed application even when disconnected from the network by providing a local note store. The user can then synchronize the local note store with the server when network connectivity is restored.

Figure 8-7 shows the application two ways, running in-browser and locally installed.

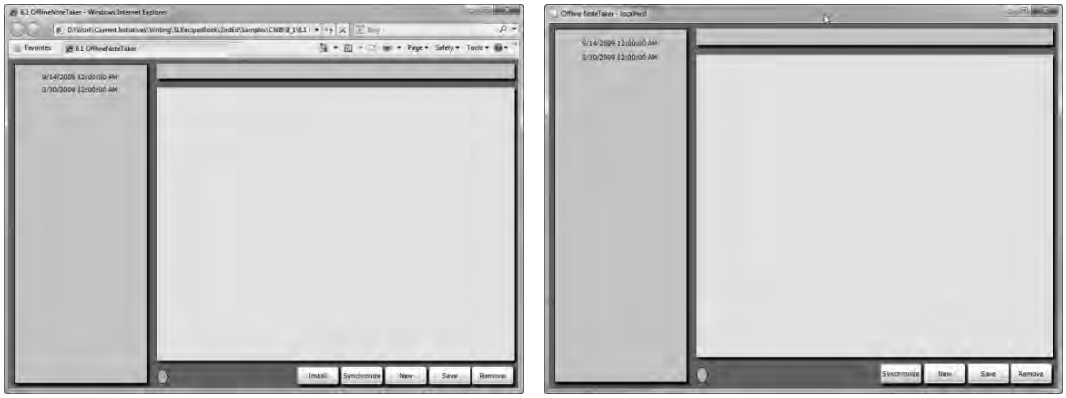


Figure 8-7. *NoteTaker application running in-browser and out of browser*

The application displays the currently stored notes in a `TreeView` control, with the top-level nodes displaying the dates containing individual nodes for each note stored on that date. The user can use the buttons on the UI (from left to right) to install the application locally; synchronize any notes stored offline with the server version of notes data; create a new note; save a note; or remove a selected note, respectively. (Note that when you run the application locally, the install button is not displayed). The small `Ellipse` to the left of the buttons is colored green to indicate network availability and red otherwise.

A WCF service acts as the data source for the application. The WCF service uses the file system to store notes. Each note file is named with the unique ID of the note and is stored in a folder named after the date the note was created, along with other notes that have the same creation date. We do not go through the details of the service implementation in this recipe, but you are encouraged to look at the sample code, as well as Recipe 7.1, for more details of WCF integration with Silverlight.

Listing 8-4 shows the service contract definition as well as the data contract that defines the `Note` type.

Listing 8-4. *Service and Data Contracts for the Note Manager WCF Service in INoteManager.cs*

```
[ServiceContract]
public interface INoteManager
{
  //Get all the dates for which we have notes stored
  [OperationContract]
  List<DateTime> GetDates();

  //Get all the notes for a specific date
  [OperationContract]
  List<Note> GetNotesForDate(DateTime ForDate);

  //Add a note to the note store
  [OperationContract]
  void AddNote(Note note);
```

```
  //Remove a note from the note store
  [OperationContract]
  void RemoveNote(DateTime ForDate, string NoteID);
}

[DataContract]
public class Note
{
  //Unique ID for the note
  [DataMember]
  public string NoteID { get; set; }
  //When was the note created or last modified ?
  [DataMember]
  public DateTime LastModified { get; set; }
  //When was the note last synchronized ?
  [DataMember]
  public DateTime? LastSynchronized { get; set; }
  //Note title
  [DataMember]
  public string Title { get; set; }
  //Note body
  [DataMember]
  public string Body { get; set; }
}
```

Let's look at the UI of the application in XAML before we discuss the code. Listing 8-5 shows relevant portions of the XAML for `MainPage.xaml`.

Listing 8-5. *XAML for the NoteTaker Application UI in MainPage.xaml*

```
<UserControl
  ...
  DataContext="{Binding RelativeSource={RelativeSource Self}}">
  <UserControl.Resources>
    <DataTemplate x:Key="dtNoteItem">
      <Grid>
        ...
        <Image
    Source="/Recipe8_1.OfflineNoteTaker;component/images/Note.png".../>
        <TextBlock Text="{Binding Path=Title}" .../>
      </Grid>
    </DataTemplate>

    <windows:HierarchicalDataTemplate
        ItemsSource="{Binding Path=Notes, Mode=OneWay}"
                                    ItemTemplate="{StaticResource dtNoteItem}"
```

```
                                    x:Key="dtDateItem">
    <Grid>
      ...
      <Image
  Source="/ Recipe8_1.OfflineNoteTaker;component/images/Date.png".../>
      <TextBlock Text="{Binding Path=Date}"... />
    </Grid>
  </windows:HierarchicalDataTemplate>

  <local:BoolToVisibilityConverter x:Key="REF_BoolToVisibilityConverter" />
</UserControl.Resources>

<Grid x:Name="LayoutRoot"...>
  ...
  <Grid ...>
    ...
    <Button x:Name="btnInstall"
            Click="btnInstall_Click"
            Content="Install"
            Visibility="{Binding
      Converter={StaticResource REF_BoolToVisibilityConverter},
      ConverterParameter=reverse, Mode=OneWay, Path=Installed}"...>
      ...
    </Button>
    <Button x:Name="btnSynchronize"
            Click="btnSynchronize_Click"
            Content="Synchronize"
            Visibility="{Binding
      Converter={StaticResource REF_BoolToVisibilityConverter},
      Mode=OneWay, Path=NetworkOn}"...>
      ...
    </Button>
    <Button Content="New"
            x:Name="btnNew"
            Click="btnNew_Click"...>
      ...
    </Button>
    <Button Content="Save"
            x:Name="btnSave"
            Click="btnSave_Click"...>
      ...
    </Button>
    <Button x:Name="btnRemove"
            Click="btnRemove_Click"
            Content="Remove"...>
```

```
        ...
      </Button>
    </Grid>

    <Grid...>
      ...
      <TextBox x:Name="tbxTitle"
               Text="{Binding Path=CurrentNote.Title, Mode=TwoWay}"
               TextWrapping="NoWrap"...>
        ...
      </TextBox>
      <TextBox x:Name="tbxBody"
               Text="{Binding Path=CurrentNote.Body, Mode=TwoWay}"
               TextWrapping="Wrap"
               AcceptsReturn="True"...>
        ...
      </TextBox>
    </Grid>
    <controls:TreeView x:Name="NotesTree"
                       ItemsSource="{Binding Path=NotesByDate, Mode=OneWay}"
                       ItemTemplate="{StaticResource dtDateItem}"...>
      ...
    </controls:TreeView>
    <Grid ...>
      <Ellipse x:Name="signNoNetwork"
               Fill="#FFFF0000"
               Visibility="{Binding Path=NetworkOn,Mode=OneWay,
        Converter={StaticResource REF_BoolToVisibilityConverter},
        ConverterParameter='reverse'}".../>
      <Ellipse x:Name="signNetworkOn"
               Fill="#FF75FF00"
               Visibility="{Binding Path=NetworkOn,Mode=OneWay,
        Converter={StaticResource REF_BoolToVisibilityConverter}}"... />
    </Grid>
  </Grid>
</UserControl>
```

The first thing to note in the XAML in Listing 8-5 is that the `DataContext` for the top level `UserControl` is bound to the `MainPage` code-behind class using the `RelativeSource.Self` enumerated value. This allows the rest of the UI to bind to properties defined directly on the `MainPage` class, without having to resort to defining separate data-class types for the most part. For more details about `RelativeSource` binding, refer to Chapter 4.

The `TreeView` control instance named `NotesTree` displays currently stored notes. `NotesTree.ItemsSource` is bound to a property named `NotesByDate` of type `ObservableCollection<TreeNodeData>`, where `TreeNodeData` is a data class representing a top-level item in the `TreeView`. Listing 8-6 shows the `TreeNodeData` class.

Listing 8-6. *TreeNodeData Data Class in MainPage.xaml.cs*

```
//Represents a top level node (Date) in the tree view
//with children nodes (Note)
public class TreeNodeData : INotifyPropertyChanged
{
  public event PropertyChangedEventHandler PropertyChanged;
  private DateTime _Date = default(DateTime);
  public DateTime Date
  {
    get
    {
      return _Date;
    }
    set
    {
      if (value != _Date)
      {
        _Date = value;
        if (PropertyChanged != null)
          PropertyChanged(this, new PropertyChangedEventArgs("Date"));
      }
    }
  }

  private ObservableCollection<Note> _Notes =
    default(ObservableCollection<Note>);
  public ObservableCollection<Note> Notes
  {
    get
    {
      return _Notes;
    }
    set
    {
      if (value != _Notes)
      {
        _Notes = value;
        if (PropertyChanged != null)
          PropertyChanged(this, new PropertyChangedEventArgs("Notes"));
      }
    }
  }
}
```

Note that the TreeNodeData class is hierarchical in nature, in that each instance contains a Date property that defines the data at that level and a Notes property of type ObservableCollection <Note> that defines the data collection for the sublevel. Referring back to Listing 8-5, observe the use of the HierarchicalDataTemplate type to define the UI for the top-level nodes of NotesTree.

A HierarchicalDataTemplate is an extension of the data-template type meant to be used with hierarchical data sets such as the ones defined by a collection of TreeNodeData instances. It provides for data-template chaining that lets you define a data template for multiple levels of a hierarchical data set. In addition to binding a data item to a HierarchicalDataTemplate, you can set the ItemTemplate and ItemsSource properties of the template. The HierarchicalDataTemplate then applies the data template in the ItemTemplate property to each element in the collection bound to the ItemsSource.

In the example, dtDateItem is a HierarchicalDataTemplate containing the necessary XAML to display the dates as the top-level nodes; it is bound to TreeNodeData, defined in Listing 8-6. The ItemTemplate property on dtDateItem is set to use the dtNoteItem data template, whereas its ItemsSource is bound to the TreeNodeData.Notes property. This causes every Note instance in the Notes collection to use the dtNoteItem data template and be displayed as children to the corresponding date item in the TreeView.

Note that there is no system-enforced limit on this kind of chaining. Unlike in the example, if you need more levels in the hierarchy and you have a data structure that supports such nesting, you can use additional HierarchicalDataTemplates as children. When you reach a level at which you no longer need children items, you can resort to a simple DataTemplate.

The rest of the XAML is self-explanatory. The buttons on the UI serve different functions that we look at a moment when we explore the codebehind. The tbxTitle and tbxBody TextBoxes are bound to the Title and the Body properties of the CurrentNote property of the MainPage class, and the signNoNetwork and signNetworkOn ellipses are colored red and green and are both bound to the MainPage.NetworkOn property to be made visible conditionally depending on the value of the NetworkOn property. A ValueConverter converts bool to the Visibility type for these bindings.

Before we look at the main application codebehind, let's cover one more aspect of the sample. Because the application is designed to work seamlessly even in the absence of a network connection, it needs an interface to store and retrieve note data from local storage when the WCF service cannot be reached. To facilitate that, you create a class called LocalNoteManagerClient, shown in Listing 8-7. This class mirrors the service contract used on the WCF service, but it implements all the note data-management functionality using the isolated storage feature in Silverlight. To learn more about isolated storage, see Chapter 3.

Listing 8-7. *LocalNoteManagerClient Class for Local Note Management*

```
//Manages notes on the local client using Isolated Storage as the backing store
public class LocalNoteManagerClient
{
  //gets all the dates
  public List<DateTime> GetDates()
  {
    IsolatedStorageFile AppStore =
      IsolatedStorageFile.GetUserStoreForApplication();
    //get all the existing folders - each folder represents a date
    //for which notes exist
    string[] val = AppStore.GetDirectoryNames();
    return AppStore.GetDirectoryNames().
      Select((sz) => DateTime.Parse(sz.Replace("_","/"))).ToList();
  }
```

```
//gets all the notes stored in local storage for a specific date
public ObservableCollection<Note> GetNotesForDate(DateTime ForDate)
{
  ObservableCollection<Note> RetVal = new ObservableCollection<Note>();
  IsolatedStorageFile AppStore =
    IsolatedStorageFile.GetUserStoreForApplication();
  //get the folder corresponding to this date
  string DirPath = ForDate.ToShortDateString().Replace("/", "_");
  //if folder exists
  if (AppStore.DirectoryExists(DirPath))
  {
    //get all the files
    string[] FileNames = AppStore.
      GetFileNames(System.IO.Path.Combine(DirPath, "*.note"));
    foreach (string FileName in FileNames)
    {
      //open a file
      IsolatedStorageFileStream fs = AppStore.
        OpenFile(System.IO.Path.Combine(DirPath, FileName), FileMode.Open);
      //deserialize
      DataContractJsonSerializer serNote =
        new DataContractJsonSerializer(typeof(Note));
      //add to returned collection
      RetVal.Add(serNote.ReadObject(fs) as Note);
      //close file
      fs.Close();
    }
  }
  //return collection
  return RetVal;
}
//adds a note to local storage
public void AddNote(Note note)
{
  IsolatedStorageFile AppStore =
    IsolatedStorageFile.GetUserStoreForApplication();
  string DirPath = note.LastModified.ToShortDateString().Replace("/", "_");
  //if a directory for the note date does not exist - create one
  if (AppStore.DirectoryExists(DirPath) == false)
    AppStore.CreateDirectory(DirPath);
  string FilePath = string.Format("{0}\\{1}",
    DirPath, note.NoteID + ".note");
 //create file, serialize and store
    IsolatedStorageFileStream fs = AppStore.
      OpenFile(FilePath, FileMode.Create);
```

```
      DataContractJsonSerializer serNote =
        new DataContractJsonSerializer(typeof(Note));
      serNote.WriteObject(fs, note);
      fs.Close();
  }
  //removes a note from local storage
  public void RemoveNote(DateTime ForDate, string NoteID)
  {
    IsolatedStorageFile AppStore =
      IsolatedStorageFile.GetUserStoreForApplication();
    string FilePath = string.Format("{0}\\{1}",
        ForDate.ToShortDateString().Replace("/", "_"), NoteID + ".note") ;

    if (AppStore.FileExists(FilePath))
      AppStore.DeleteFile(FilePath);
  }
}
```

Now, let's look at the main application functionality, most of which is in the `MainPage.xaml.cs` codebehind class. Listing 8-8 shows the `MainPage` class.

Listing 8-8. *MainPage.xaml.cs Codebehind Class for the Offline NoteTaker*

```
public partial class MainPage : UserControl, INotifyPropertyChanged
{
  public event PropertyChangedEventHandler PropertyChanged;
  //initialize to a blank note
  private Note _CurrentNote = new Note()
  {
    NoteID = Guid.NewGuid().ToString(),
    LastModified = DateTime.Now
  };

  //Tracks the currently selected/displayed note
  public Note CurrentNote
  {
    get { return _CurrentNote; }
    set
    {
      if (value != _CurrentNote)
      {
        _CurrentNote = value;
        if (PropertyChanged != null)
          PropertyChanged(this, new PropertyChangedEventArgs("CurrentNote"));
      }
    }
```

```
}

private ObservableCollection<TreeNodeData> _NotesByDate =
  default(ObservableCollection<TreeNodeData>);
//Collection of TreeNodeData that binds to the TreeView to display saved notes
public ObservableCollection<TreeNodeData> NotesByDate
{
  get
  {
    //initialize to a blank collection
    if (_NotesByDate == null)
      _NotesByDate = new ObservableCollection<TreeNodeData>();
    return _NotesByDate;
  }
  set
  {
    if (value != _NotesByDate)
    {
      _NotesByDate = value;
      if (PropertyChanged != null)
        PropertyChanged(this, new PropertyChangedEventArgs("NotesByDate"));
    }
  }
}

//Indicates if the app is running offline - used to bind to XAML
public bool Installed
{
  get
  {
    return Application.Current.InstallState == InstallState.Installed;
  }
}
//Indicates if network connectivity is available - used to bind to XAML
public bool NetworkOn
{
  get
  {
    return NetworkInterface.GetIsNetworkAvailable();
  }
}

public MainPage()
{
  InitializeComponent();
```

```
    //Refresh notes treeview
    RefreshNotesView();
    //listen for network connection/disconnection events
    NetworkChange.NetworkAddressChanged +=
      new NetworkAddressChangedEventHandler((s, a) =>
      {
        //update XAML bound property
        if (PropertyChanged != null)
          PropertyChanged(this, new PropertyChangedEventArgs("NetworkOn"));
        //refersh the treeview to display remote/local notes appropriately
        RefreshNotesView();
      });
    //handle selection change in the notes treeview
    NotesTree.SelectedItemChanged +=
      new RoutedPropertyChangedEventHandler<object>((s, a) =>
    {
      if (a.NewValue is Note)
      {
        //set the CurrentNote property to the currently selected note
        CurrentNote = a.NewValue as Note;
      }
    });
  }

  //take the application offline
  private void btnInstall_Click(object sender, RoutedEventArgs e)
  {
    Application.Current.Install();
  }
  private void RefreshNotesView()
  {
    //clear current bound collection
    NotesByDate.Clear();
    //reinitialize the CurrentNote
    CurrentNote = new Note()
    {
      NoteID = Guid.NewGuid().ToString(),
      LastModified = DateTime.Now
    };
    //if we have network connectivity
    if (NetworkOn)
    {
      //use the WCF proxy
      NoteManagerClient client = new NoteManagerClient();
      //handle getting all the dates asynchronously
```

```
  client.GetDatesCompleted +=
    new EventHandler<GetDatesCompletedEventArgs>((sender, args) =>
  {

    foreach (DateTime dt in args.Result)
    {
      //create another instance of the WCF proxy
      NoteManagerClient client1 = new NoteManagerClient();
      //handle getting the notes for a date asynchronously
      client1.GetNotesForDateCompleted +=
        new EventHandler<GetNotesForDateCompletedEventArgs>((s, a) =>
      {
        //create a node for the date and add the notes to it
        NotesByDate.Add(
          new TreeNodeData()
          {
            Date = (DateTime)a.UserState,
            Notes = new ObservableCollection<Note>(a.Result)
          });
      });
      //get all the notes on the server for a specific date
      //pass in the date as user state
      client1.GetNotesForDateAsync(dt, dt);
    }
  });
  //get all the dates for which we have notes on the server
  client.GetDatesAsync();
}
else
{
  //create a client for local note management
  LocalNoteManagerClient client = new LocalNoteManagerClient();
  //Get all the dates
  List<DateTime> dates = client.GetDates();
  foreach (DateTime dt in dates)
  {
    //get the notes for that date
    ObservableCollection<Note> notesForDate = client.GetNotesForDate(dt);
    //add to the treeview
    NotesByDate.Add(
      new TreeNodeData()
      {
        Date = dt,
        Notes = notesForDate
      });
```

```
    }
  }
}

//handle the Save button
private void btnSave_Click(object sender, RoutedEventArgs e)
{
  if (NetworkOn)
  {
    //use the WCF proxy
    NoteManagerClient client = new NoteManagerClient();
    client.AddNoteCompleted +=
      new EventHandler<AsyncCompletedEventArgs>((s, a) =>
    {
      //refresh the treeview
      RefreshNotesView();
    });
    //add the new/updated note to the server
    client.AddNoteAsync(CurrentNote);
  }
  else
  {
    //use the local note manager
    LocalNoteManagerClient client = new LocalNoteManagerClient();
    //add the note
    client.AddNote(CurrentNote);
    //refresh the tree view
    RefreshNotesView();
  }
}

//handle the New Button
private void btnNew_Click(object sender, RoutedEventArgs e)
{
  //reinitialize the CurrentNote
  CurrentNote = new Note()
  {
    NoteID = Guid.NewGuid().ToString(),
    LastModified = DateTime.Now
  };
}

//handle Remove button
private void btnRemove_Click(object sender, RoutedEventArgs e)
{
```

```
  //a valid existing note has to be selected
  if (CurrentNote == null ||
    NotesByDate.SelectMany((tnd) => tnd.Notes).
    Where((nt) => nt == CurrentNote).Count() > 0)
    return;

  if (NetworkOn)
  {
    //use the WCF proxy
    NoteManagerClient remoteClient = new NoteManagerClient();
    remoteClient.RemoveNoteCompleted +=
      new EventHandler<AsyncCompletedEventArgs>((s, a) =>
      {
        //refresh tree view
        RefreshNotesView();
      });
    //remove the note
    remoteClient.RemoveNoteAsync(CurrentNote.LastModified, CurrentNote.NoteID);
  }
  else
  {
    //use the local client
    LocalNoteManagerClient localClient = new LocalNoteManagerClient();
    //remove note
    localClient.RemoveNote(CurrentNote.LastModified, CurrentNote.NoteID);
    //refresh tree view
    RefreshNotesView();
  }
}

//handle Synchronize button
private void btnSynchronize_Click(object sender, RoutedEventArgs e)
{
  SynchronizeOfflineStore();
}

private void SynchronizeOfflineStore()
{
  LocalNoteManagerClient localClient = new LocalNoteManagerClient();
  //Notes that are on the server with LastModifiedDate <= LastSynchronizedDate
  //but are missing on the client, must have been deleted on the client
  List<Note> NotesDeletedOnClient =
    NotesByDate.SelectMany((tnd) => tnd.Notes).Distinct().
              Where((nt) => nt.LastSynchronized >= nt.LastModified).
              Except(localClient.GetDates().
```

```
        SelectMany((dt) => localClient.GetNotesForDate(dt)).
        Distinct()).ToList();
//remove the deleted notes from the server
foreach (Note nt in NotesDeletedOnClient)
{
  NoteManagerClient remoteClient = new NoteManagerClient();
  remoteClient.RemoveNoteAsync(nt.LastModified, nt.NoteID);
}
//Notes that are on the client with LastModifiedDate <= LastSynchronizedDate
//but are missing on the server, must have been deleted on the server
List<Note> NotesDeletedOnServer =
  localClient.GetDates().
        SelectMany((dt) => localClient.GetNotesForDate(dt)).Distinct().
        Where((nt) => nt.LastSynchronized >= nt.LastModified).Except(
  NotesByDate.SelectMany((tnd) => tnd.Notes).Distinct()).ToList();
//remove the deleted notes from the client
foreach (Note nt in NotesDeletedOnServer)
  localClient.RemoveNote(nt.LastModified, nt.NoteID);
//get all the notes on the server that have not been synchronized with the
//client. Since we are online, the notes represented in NotesByDate
//constitutes the server state
List<Note> NotesOutOfSyncOnServer =
      NotesByDate.SelectMany((tnd) => tnd.Notes).Distinct().
            Where((nt) => nt.LastSynchronized == null ||
              nt.LastSynchronized < nt.LastModified).ToList();
//add the server side notes to the client
foreach (Note nt in NotesOutOfSyncOnServer)
{
  //set appropriate timestamps
  nt.LastSynchronized = DateTime.Now;
  nt.LastModified = nt.LastSynchronized.Value;
  localClient.AddNote(nt);
}
//get all the notes on the client that have not been synchronized with the
//server.
List<Note> NotesOutOfSyncOnClient =
        localClient.GetDates().
        SelectMany((dt) => localClient.GetNotesForDate(dt)).Distinct().
          Where((nt) => nt.LastSynchronized == null ||
            nt.LastSynchronized < nt.LastModified).ToList();

//add the client side notes to the server
foreach (Note nt in NotesOutOfSyncOnClient)
{
  NoteManagerClient remoteClient = new NoteManagerClient();
```

```
        //timestamps
        nt.LastSynchronized = DateTime.Now;
        nt.LastModified = nt.LastSynchronized.Value;
        remoteClient.AddNoteAsync(nt);
      }
      //refresh
      RefreshNotesView();
    }
}
```

The `MainPage` class defines a few properties that are noteworthy. The `NotesByDate` property of type `ObservableCollection<TreeNodeData>` defines the entire note collection at any point in time, and the `CurrentNote` property defines the currently selected note in the UI. The `Installed` property wraps around `Application.InstallState` and returns `true` if its value is `InstallState.Installed`. The `NetworkOn` property wraps a call to `NetworkInterface.GetIsNetworkAvailable()` to indicate network availability.

You use the `RefreshNotesView()` method to load any existing notes in the constructor of the page. As shown in the definition of `RefreshNotesView()` in Listing 8-8, the `NetworkOn` property determines network availability. If a network connection is available, you use the WCF service proxy to access the note data and populate the `NotesByDate` collection, which in turn displays the data in the `NotesTree` `TreeView`. In the absence of a network connection, you use the `LocalNoteManagerClient` class to access the data from local storage and use it similarly.

■ **Note** To create a network-unavailable state in your system, the easiest option is to turn off your network adapter. If you have multiple adapters on and connected, make sure you turn all of them off.

In the constructor, you also handle a few events. You attach a handler to the `NetworkChange.NetworkAddressChanged` event; in the event of a network state change, you update the UI by raising the `PropertyChanged` event and invoke `RefreshNotesView()` again to acquire the note data from the appropriate storage location. You also handle the `SelectedItemChanged` event on the `NotesTree` `TreeView` control to set the value of the `CurrentNote` property to the currently selected note.

The handlers for the `Click` events on `btnSave`, `btnRemove`, `btnNew`, and `btnInstall` are straightforward. In each of the first three handlers, you again use either the WCF service or local storage, depending on the state of network availability. And `btnInstall_Click()` is a simple wrapper to an invocation of `Application.Install()` that takes you through the local installation process, as described in the previous section.

The last piece of this recipe is the data-synchronization logic. Before we delve into it, note that this is merely a sample and the synchronization logic demonstrated here is implemented from scratch. If you are building a sizeable application, you should investigate other scalable and robust data-synchronization frameworks like the Microsoft Sync Framework. You can find more information about the Sync Framework at `msdn.microsoft.com/en-us/sync/default.aspx`.

The synchronization logic in this sample is invoked through handling the `Click` event of the `btnSynchronize` button on the UI and is encapsulated in the `SynchronizeOfflineStore()` method. Because the `Visibility` property of `btnSynchronize` is tied to network availability through a binding to the `NetworkOn` property, you are assured that this code is invoked only when the network is available.

The synchronization logic in `SynchronizeOfflineStore()` is straightforward. You first use the `LastModifiedDate` and `LastSynchronizedDate` properties on the `Note` instances to look for notes that

have been deleted on one side of storage but still exist on the other side. The logic is simple: if a note exists on one side and has been synchronized more recently than it has been modified, but it does not exist on the other side, then it must have been deleted from the side on which it does not exist. You then delete that note from the side on which it currently exists.

Next, you look for notes on either side with a modification date more recent than the last synchronization date. These notes have been either added or updated, and the changes have not been synchronized. You invoke `AddNote()` on the appropriate storage service contract for these notes. The implementation of `AddNote()` on the WCF service and on `LocalNoteManagerClient` always creates a new note. If the data synchronization required an update of a note with partial changes to its data on one side, the complete note file is written again, but in effect it provides the desired result.

This takes care of propagating all the changes bi-directionally. On completion of this method, both data stores are synchronized.

8-2. Controlling the Application Window

Problem

You want to control various aspects of the application window such as its position, size, chrome, move, and resize behavior.

Solution

Use the properties and methods of the `Window` class, as well as the `WindowState` and `WindowStyle` settings.

How It Works

Window Attributes

When an application is running out of browser, the `Application.Current.MainWindow` property, which is an instance of the `Window` class, represents the running window. The `Window` class exposes several attributes of the running application window that can be programmatically controlled. `Window.Top`, `Window.Left`, `Window.Height` and `Window.Width` expose the top and left coordinates and the height and width of the window, respectively. Recall from recipe 8-1 that initial values of these properties can be set at deployment as well as a part of your out of browser deployment settings.

Additionally the `Window.Topmost` property, when set to true, makes the application window the topmost window in Z-order on the current desktop, and the `Window.WindowState` property can be set to one of the values in the enumerated type `WindowState` that include `WindowState.Maximized`, `WindowState.Minimized` and `WindowState.Normal` to define the various possible states of the window, with WindowState.Normal being the default setting.

The application can also define a specific window style as defined in the `WindowStyle` enumerated type. This attribute can however only be read at runtime through the `Deployment.Current.OutOfBrowserSettings.WindowSettings.WindowStyle` property, and requires that it be set through the out of browser settings at deployment. The `WindowStyle` enumeration defines three `WindowStyle` values: `None`, `SingleBorderWindow`, and `BorderlessRoundCornersWindow`. `WindowStyle.None` and `WindowStyle.BorderlessRoundCornersWindow` both produce borderless windows, with the second

option adding rounded corners. `WindowStyle.SingleBorderWindow` uses the default OS specific chrome. Figure 8-8 shows the Out-of-Browser settings dialog with the window style setting being set.

Figure 8-8. *Window Style setting for OOB deployment*

Note that the `Deployment.Current.OutOfBrowserSettings.WindowSettings` property provides access to other settings information such as the window title, the initial left-top coordinates, initial dimensions etc., but all of these properties are read only. Some of the properties that can be changed at runtime will need to be changed through the Window class, as discussed earlier. Also note that specifying the window style requires that the application be marked to run with elevated trust when run out of the browser. You should be aware that when an OOB application is installed with elevated trust requirements, the install dialog looks a little different. Figure 8-9 shows the install dialog for an OOB application requiring elevated trust.

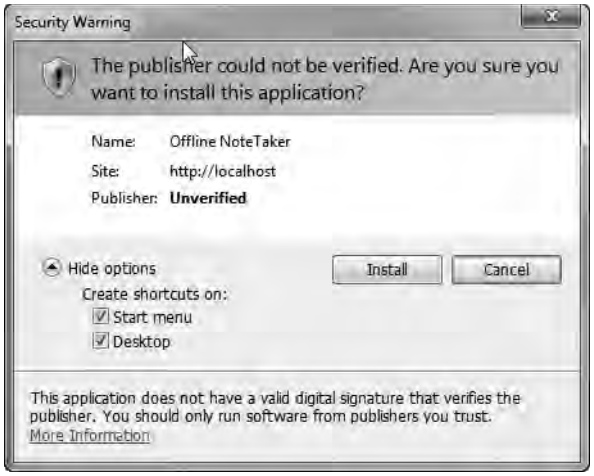


Figure 8-9. *Install dialog for application requiring elevated trust*

Resizing and moving a Window

In addition to the above window attributes, there are a few additional APIs provided to control the resizing and moving of a window. The default OS-supplied window chrome provides you with the necessary means to resize or move the window. But in cases where you set the `WindowStyle` property to one of the values that create a borderless window, you may need to offer alternative means to the user to resize and move the window. The `Window.DragMove()` method can be used to move the window programmatically, especially in response to mouse events. `DragMove()` automatically moves the window in the direction in which the mouse moves, by the amount that the mouse moves by between calls to `DragMove()`. The `Window.DragResize()` method can be called to resize the window. `DragResize()` accepts a single parameter of the enumerated type `WindowResizeEdge`. The `WindowResizeEdge` defines the possible window edge values, one for each edge and one for each corner, such as `WindowResizeEdge.Bottom`, `WindowResizeEdge.BottomLeft`, etc. `DragResize ()` automatically resizes the window by the amount the mouse has moved between calls to `DragResize ()`.Note that both APIs require the application to be installed and running with elevated trust.

The Code

The sample for this recipe extends the note taker application from recipe 8-1 to demonstrate the usage of some of the attributes and APIs discussed above.

You modify the XAML and add three buttons to the top right corner of the `LayoutRoot` grid: a `Button` to minimize the window named `btnMinimize`, a `Button` to toggle between the maximized and the normal view of the window named `btnMaximize`, and a `Button` to close the window named `btnClose`. You then change the out of browser settings for the application and set the Window Style field to "No Border" to deploy it as a borderless window. Since the changes to the XAML are minimal, we do not list them here; you can refer to the `MainPage.xaml` for the code sample to take a look at the changes. Figure 8-10 shows the application running in a borderless window with the three buttons mentioned above.

Figure 8-10. *Offline Note taker application running in a borderless window style*

You centralize the handling of the window resizing and moving functionality as well as the click handlers to the three buttons mentioned above in a single class named `WindowManager`. Listing 8-9 shows the code for the `WindowManager` class.

Listing 8-9. *WindowManager class*

```
public static class WindowManager
{
  private static FrameworkElement ShellRoot;
  //a rect defined on the window determining the hit target that
  //we will use to determine if a mouse drag causes the window to move
  private static Rect MoveHandleRect = default(Rect);
  //the width from the edges of the window determining the hit target
  //we will use to determine if a mouse drag causes a resize
  private static double ResizeHandleWidth = 8;
  //store the old cursor to revert back when necessary
  static Cursor OldCursor = null;
  //current action on the window
  static Action CurrentAction = Action.None;

  //enumeration defining the current action on the window
  private enum Action
  {
```

```
    Moving, Resizing, None
  }
  //register the FrameworkElement whose mouse movements
  //will determine the various window move and resize logic
  public static void RegisterShell(FrameworkElement shellRoot,
    double resizeHandleWidth, Rect moveHandleRect,
    Button btnMinimize, Button btnMaximize, Button btnClose)
  {
    ShellRoot = shellRoot;
    ResizeHandleWidth = resizeHandleWidth;
    MoveHandleRect = moveHandleRect;
    OldCursor = ShellRoot.Cursor;
    //handle the various mouse events
    ShellRoot.MouseEnter += new MouseEventHandler(ShellRoot_MouseEnter);
    ShellRoot.MouseLeave += new MouseEventHandler(ShellRoot_MouseLeave);
    ShellRoot.MouseMove += new MouseEventHandler(ShellRoot_MouseMove);
    ShellRoot.MouseLeftButtonDown +=
      new MouseButtonEventHandler(ShellRoot_MouseLeftButtonDown);
    ShellRoot.MouseLeftButtonUp +=
      new MouseButtonEventHandler(ShellRoot_MouseLeftButtonUp);
    //handle the control button events
    btnClose.Click += new RoutedEventHandler(btnClose_Click);
    btnMaximize.Click += new RoutedEventHandler(btnMaximize_Click);
    btnMinimize.Click += new RoutedEventHandler(btnMinimize_Click);
  }

  private static void btnMinimize_Click(object sender,
    System.Windows.RoutedEventArgs e)
  {
    Application.Current.MainWindow.WindowState = WindowState.Minimized;
  }

  private static void btnMaximize_Click(object sender,
    System.Windows.RoutedEventArgs e)
  {
    Application.Current.MainWindow.WindowState =
      Application.Current.MainWindow.WindowState == WindowState.Maximized ?
      WindowState.Normal : WindowState.Maximized;
  }

  private static void btnClose_Click(object sender,
    System.Windows.RoutedEventArgs e)
  {
    Application.Current.MainWindow.Close();
  }
```

```
private static void ShellRoot_MouseEnter(object sender, MouseEventArgs e)
{
  SetMouseCursor(e);
}
static void ShellRoot_MouseLeftButtonDown(object sender,
  MouseButtonEventArgs e)
{
  CurrentAction = (GetCurrentResizeEdge(e) != default(WindowResizeEdge)) ?
    Action.Resizing : (IsMouseOnMoveZone(e) ? Action.Moving : Action.None);

}
static void ShellRoot_MouseLeftButtonUp(object sender,
  MouseButtonEventArgs e)
{
  CurrentAction = Action.None;
}

static void ShellRoot_MouseMove(object sender, MouseEventArgs e)
{
  if (CurrentAction == Action.Resizing)
  {
    Application.Current.MainWindow.DragResize(GetCurrentResizeEdge(e));
  }
  else if (CurrentAction == Action.Moving)
  {
    Application.Current.MainWindow.DragMove();
  }
  else
    SetMouseCursor(e);
}

static void ShellRoot_MouseLeave(object sender, MouseEventArgs e)
{
  if (CurrentAction != Action.None)
  {
    CurrentAction = Action.None;
    SetMouseCursor(e);
  }
}

private static void SetMouseCursor(MouseEventArgs e)
{
  WindowResizeEdge ResizeZone = GetCurrentResizeEdge(e);
```

```
    if (ResizeZone != default(WindowResizeEdge) && OldCursor == default(Cursor))
      OldCursor = ShellRoot.Cursor;

    switch (ResizeZone)
    {
      case WindowResizeEdge.Top:
      case WindowResizeEdge.Bottom:
        ShellRoot.Cursor = Cursors.SizeNS;
        break;
      case WindowResizeEdge.Left:
      case WindowResizeEdge.Right:
        ShellRoot.Cursor = Cursors.SizeWE;
        break;
      case WindowResizeEdge.TopLeft:
      case WindowResizeEdge.BottomRight:
        ShellRoot.Cursor = Cursors.SizeNWSE;
        break;
      case WindowResizeEdge.TopRight:
      case WindowResizeEdge.BottomLeft:
        ShellRoot.Cursor = Cursors.SizeNESW;
        break;
      default:
        ShellRoot.Cursor = OldCursor;
        OldCursor = default(Cursor);
        break;
    }
  }

  private static bool IsMouseOnMoveZone(MouseEventArgs e)
  {
    return Application.Current.MainWindow.WindowState ==
      WindowState.Maximized ? false :
      MoveHandleRect.Contains(e.GetPosition(ShellRoot));
  }

  private static WindowResizeEdge GetCurrentResizeEdge(MouseEventArgs e)
  {
    WindowResizeEdge RetVal = default(WindowResizeEdge);
    if (Application.Current.MainWindow.WindowState == WindowState.Maximized)
      return RetVal;

    Point CurPos = e.GetPosition(ShellRoot);
    if (CurPos.X < ResizeHandleWidth)
    {
      if (CurPos.Y < ResizeHandleWidth)
```

```
        RetVal = WindowResizeEdge.TopLeft;
      else if (CurPos.Y > ShellRoot.ActualHeight - ResizeHandleWidth)
        RetVal = WindowResizeEdge.BottomLeft;
      else
        RetVal = WindowResizeEdge.Left;
    }
    else if (CurPos.X > ShellRoot.ActualWidth - ResizeHandleWidth)
    {
      if (CurPos.Y < ResizeHandleWidth)
        RetVal = WindowResizeEdge.TopRight;
      else if (CurPos.Y > ShellRoot.ActualHeight - ResizeHandleWidth)
        RetVal = WindowResizeEdge.BottomRight;
      else
        RetVal = WindowResizeEdge.Right;
    }
    else
    {
      if (CurPos.Y < ResizeHandleWidth)
        RetVal = WindowResizeEdge.Top;
      else if (CurPos.Y > ShellRoot.ActualHeight - ResizeHandleWidth)
        RetVal = WindowResizeEdge.Bottom;
      else
        RetVal = default(WindowResizeEdge);
    }
    return RetVal;
  }
}
```

The `WindowManager` class exposes a static method named `RegisterShell()` which takes in all the parameters required for the `WindowManager` to enable window resize and moving. The `shellRoot` parameter is the `FrameworkElement` instance whose mouse events the `WindowManager` attaches to implement the resize and move logic. This would typically be a high level container in your visual tree that covers the entire window area, such as the top level grid in your window design. The `resizeHandleWidth` parameter determines the number of pixels from each edge of the window within which a mouse drag is considered a cause for resize. The `moveHandleRect` defines the dimensions of a rectangular area measured in terms of the coordinates of the `shellRoot` element, within which a mouse drag is considered a cause for a window move. Lastly, the three button parameters refer to the three control buttons on the window. The code for `RegisterShell` simply attaches handlers to the appropriate events on the `shellRoot` and the buttons.

In the `shellRoot_MouseEnter ()` handler, you set the mouse cursor appropriately by calling `SetMouseCursor()` and in `shellRoot_MouseLeave()`, you reset the `CurrentAction` variable to `Action.None` to indicate that neither a resize nor a move is happening any more, and call `SetMouseCursor()` again.

`SetMouseCursor()` accepts a `MouseEventArgs` parameter passed in from the mouse event handlers, and first calls `GetCurrentResizeEdge()` to get the resize edge the mouse might be on. If a valid `WindowResizeEdge` is returned from `GetCurrentResizeEdge()`, you proceed to set the mouse cursor to the appropriate value depending on the resize edge the mouse is currently on.

`GetCurrentResizeEdge()` also accepts a `MouseEventArgs` and works out the `WindowResizeEdge` by comparing the current mouse position to the calculated resize edges based on the `ResizeHandleWidth` value and the `ShellRoot` dimensions.

On `ShellRoot_MouseLeftButtonDown()` you set the `CurrentAction` to `Action.Resizing` if `GetCurrentResizeEdge()` reports the mouse to be on a valid edge, or else to `CurrentAction.Moving` if `IsMouseOnMoveZone()` reports true. `IsMouseOnMoveZone()` also accepts the MouseEventArgs and uses the current mouse coordinates to check if the mouse position falls within the rectangle designated by `MoveHandleRect`. On `ShellRoot_MouseLeftButtonUp()` you reset the `CurrentAction` variable. And finally on `ShellRoot_MouseMove()` handler, you either call `Window.DragMove()` or `Window.DragResize()` depending on the value of the `CurrentAction` variable.

To handle processing the control button clicks, in `btnMinimize_Click()` you set the `WindowState` of the `MainWindow` to `WindowState.Minimized`. In `btnMaximizedClick()` you set the `WindowState` to `Normal` if the window is already maximized or you maximize it if it is not. And in `btnClose_Click()` you close the `MainWindow`, causing the application to exit. Figure 8-11shows the application window being resized by dragging the right edge.

Figure 8-11. *Borderless window being resized*

8-3. Using COM Interoperability and File System Access

Problem

You need to interoperate with COM based APIs and access the file system from an out of browser Silverlight application.

Solution

Use the built-in support for COM interoperability and file system access from an out of browser Silverlight application running with elevated trust.

How It Works

COM Interoperability

A large number of system services and platform features on Microsoft Windows are exposed through an integration technology called COM. Additionally, many applications, both from Microsoft (such as Microsoft Office), as well as a multitude of 3rd party applications for Windows also enable extensibility and programmability by exposing COM based APIs.

Silverlight 4 introduces the ability to interoperate with some of these system services and application API's through a COM Interoperability layer built into the Silverlight runtime. Before we progress in describing how it all works, there are three very important points to be noted here:

- COM is a technology available on Microsoft Windows only. So if you build a Silverlight application with features that take advantage of COM Interop, those features of your application will only work when it runs on Windows.
- COM Interop through Silverlight 4 is only available when the application is running out of browser with elevated trust.
- Not all COM components can be access through the Silverlight COM Interop feature. Only COM objects that support COM Automation are accessible through Silverlight. COM Automation capable COM objects implement a COM interface named Idispatch (or IDispatchEx) and are scriptable through scripting languages such as JavaScript.

■ **Note** A detailed treatment of COM is out of scope for this book. For more details on COM, you can refer to `msdn.microsoft.com/en-us/library/ms680573(VS.85).aspx`. For more details on COM Automation, you can refer to `msdn.microsoft.com/en-us/library/ms221375.aspx` .

Instantiating a COM object

Silverlight 4 exposes the COM Interoperability mechanism through the `AutomationFactory` class in the `System.Runtime.InteropServices.Automation` namespace. The static `CreateObject()` method defined on `AutomationFactory` accepts the ProgID of the COM object you are trying to instantiate and returns the newly instantiated COM objected as a dynamic type instance on success.

The dynamic type is newly introduced in .Net 4 and Silverlight 4 runtime offers it as well. A variable of type `dynamic` bypasses static (compile time) type checking. This makes the `dynamic` type especially suited for representing COM types, as due to the implementation differences between native APIs like COM and the common language runtime, the exact signature of a COM type is not known while compiling the managed code, but only at runtime. Keep in mind that while authoring code using a `dynamic` type, you can call any method or access any property on the variable of type `dynamic` without the compiler checking whether the member actually exists on the underlying

implementing COM object. If the call is erroneous, your application fails at runtime. Also keep in mind that, because of this lack of type description information during authoring, Visual Studio offers no IntelliSense on `dynamic` typed variables. Consequently, having the API documentation available for any COM API that you may want to access is very important for authoring correct Silverlight-based COM Interop code.

Once you acquire the returned object from the `AutomationFactory.CreateObject()`, you can call methods and access properties on it just like you would on any managed object, as long as the members are implemented by the underlying COM object. Remember that these properties and methods will also use `dynamic` types as return values, so feel free to cast them to appropriate CLR types, and Silverlight will do the conversion for you.

You can also use `AutomationFactory.GetObject()` to acquire a reference to a COM object. While `CreateObject()` will load the COM server containing the COM object you requested and start the containing application if it is an out of process executable, `GetObject()` expects the COM server to be already running. For example, calling `CreateObject()` to acquire a handle to a COM object defined in the Microsoft Excel COM object model would cause Excel to start up, while `GetObject()` can be called if you know Excel to already be running. The snippet below shows an example of creating a COM object, accessing a property and calling a method on it:

```
dynamic devManager = AutomationFactory.CreateObject("WIA.DeviceManager");
dynamic DeviceInfoCollection = devManager.DeviceInfos;
devManager.RegisterEvent("{A28BBADE-64B6-11D2-A231-00C04FA31809}");
```

Note that `AutomationFactory` also exposes a property named `IsAvailable` that indicates if the COM automation feature is available to your application at runtime. Before you attempt to create your first COM object in your application, you should check the value of the property and ensure that COM Interop is available to you in the current environment.

Handling a COM event

There are two ways to handle an event raised from the COM object in your Silverlight code. In the first approach, you can use the static `GetEvent()` method on the `AutomationFactory` object to search for a declared event by its string name. The first parameter to `GetEvent()` accepts the object returned from a `CreateObject()` or a `GetObject()` call, and the second parameter accepts the string name of the event you want to look for. If the event is found, an `AutomationEvent` instance is returned from `GetEvent()`. You can then add a handler to the `AutomationEvent.EventRaised` event to handle the occurrence of the COM event. The `AutomationEventArgs` type parameter passed into your event handler implementation exposes an `Arguments` property that contains any event parameters passed in from COM as a collection of objects. The snippet below shows an example of searching for an event named `OnEvent`, registering a handler, and accessing the event arguments inside the handler:

```
dynamic devManager = AutomationFactory.CreateObject("WIA.DeviceManager");
AutomationEvent evt = AutomationFactory.GetEvent(devManager, "OnEvent");
evt.EventRaised += new EventHandler<AutomationEventArgs>((s, e) =>
{
  string EventID = e.Arguments[0] as string;
  string DeviceID = e.Arguments[1] as string;
  string ItemID = e.Arguments[2] as string;
});
```

The other approach is to attach a handler to the event directly, using the dynamic instance of the COM object. You would, of course, need to declare a delegate that matches the event signature as documented for the COM object in question. The snippet below shows an example:

```
private delegate void OnEventHandler
  (string EventID, string DeviceID, string ItemID);

dynamic devManager = AutomationFactory.CreateObject("WIA.DeviceManager");
devManager.OnEvent += new OnEventHandler((evtID, DevID, ItemID) =>
{
  ...
});
```

File System Access

Although File System Access does not have anything to do with COM Interop, the code sample later in the recipe uses both features, and so we thought it prudent to cover this topic in the same recipe. Note that file system access as well requires that the application be running out of browser and with elevated trust.

Up until Silverlight 3, the `OpenFileDialog` and `SaveFileDialog` types discussed in Chapter 3 have been the only ways for Silverlight applications to access any file information on the local file system, and only through user initiated code such as a button click. With a Silverlight 4 application running with elevated trust, you now have the option of using the classes in `System.IO` for a much deeper access to the file system. You can create new files and directories, enumerate the contents of a directory, get detailed file information, etc. A full discussion of the types in `System.IO` is out of scope for this recipe, but you can refer to `msdn.microsoft.com/en-us/library/ms404278(VS.100).aspx` for more details on the common I/O tasks that you can perform using these types.

Note that your file system access is limited to the MyDocuments, MyMusic, MyVideos, and MyPictures system folders and any sub folders and files within. To standardize the path to these folders, Silverlight defines a `SpecialFolder` enumeration within the `Environment` type where the above mentioned folders correspond to `SpecialFolder.MyDocuments`, `SpecialFolder.MyMusic`, ans so on. To make sure that your code remains cross-platform, you should always use `Environment.GetFolderPath()` and pass in one of these values to get the corresponding path for that platform. The snippet below shows an example of enumerating the sub-folders for the `MyDocuments` folder:

```
string MyDocumentsPath = Environment.GetFolderPath
    (Environment.SpecialFolder.MyDocuments);
IEnumerable<string> SubFolders = System.IO.Directory.
  EnumerateDirectories(MyDocumentsPath);
```

The Code

The code sample in this recipe shows an application for viewing photos from a digital camera that is connected to your computer. The application offers the option of saving the photos to your local file system.

Windows Image Acquisition

Windows Image Acquisition (WIA) is an API built into Windows that provides a standard mechanism for acquiring digital images from devices connected to your computer. These devices could be digital cameras that store captured images, or scanners that can scan digital images of documents. WIA exposes a COM Automation API and consequently is well suited for COM Interop-based access from within Silverlight. To ease its use from within our application and to facilitate property binding, you wrap the necessary parts of the WIA object model to create a strongly typed version. This wrapper code is found in a file named `wiaom.cs` in the sample project for this recipe. We describe parts of it here to illustrate the COM Interop aspects, but encourage you to look through the WIA Automation API at `msdn.microsoft.com/en-us/library/ms630827(VS.85).aspx` as well the code in `wiaom.cs` for more details on the wrapping approach.

The top level object in the WIA API is called the `DeviceManager`, and you wrap it in a CLR type named `WIADeviceManager`. Listing 8-10 shows the `WIADeviceManager` class and a few related classes in our wrapper object model.

Listing 8-10. *WIA wrappers*

```
public class WIAObject : INotifyPropertyChanged
{
  //hold the COM native object
  protected dynamic WIASource { get; private set; }
  //
  public WIAObject(dynamic Source)
  {
      WIASource = Source;
      Validate();
  }
  //validate the COM object
  protected virtual void Validate()
  {
      if (WIASource == null)
        throw new ArgumentNullException("Null source");
  }

  #region INotifyPropertyChanged Members

  protected void RaisePropertyChanged(string PropName)
  {
      if (PropertyChanged != null)
          PropertyChanged(this, new PropertyChangedEventArgs(PropName));
  }
  public event PropertyChangedEventHandler PropertyChanged;

  #endregion
}
```

```
public class WIADeviceManager : WIAObject
{
  //raise a CLR event on handling a WIA Event
  public event EventHandler<WIAOnEventArgs> OnEvent;
  //delegate for handling DeviceManager.OnEvent
  private delegate void OnEventHandler
    (string EventID, string DeviceID, string ItemID);
  //get all the devices
  public IEnumerable<WIADeviceInfo> DeviceInfos
  {
    get
    {
      return (COMHelpers.COMIndexedPropertyToList(WIASource.DeviceInfos)
        as List<dynamic>).Select(
        (DeviceInfo) => new WIADeviceInfo(DeviceInfo));
    }
  }
  //construct
  private WIADeviceManager(dynamic Source)
    : base((object)Source)
  {
    //attach handler to onEvent event
    Source.OnEvent += new OnEventHandler((eID, dID, iID) =>
    {
      //raise our own OnEvent wrapper
      if (OnEvent != null)
        OnEvent(this, new WIAOnEventArgs()
        { EventID = eID, DeviceID = dID, ItemID = iID });
    });
  }
  //static factory method
  public static WIADeviceManager Create()
  {
    if (!AutomationFactory.IsAvailable)
      throw new InvalidOperationException
        ("COM Automation is not available");
    return new
      WIADeviceManager(AutomationFactory.CreateObject("WIA.DeviceManager"));
  }
  //register for a WIA event
  public void RegisterEvents(string DeviceID, IEnumerable<string> Events)
  {
    Events.Any((ev) => { WIASource.RegisterEvent(ev, DeviceID); return false; });
  }
  //unregister events
```

```
  public void UnregisterEvents(string DeviceID, IEnumerable<string> Events)
  {
    Events.Any((ev) => { WIASource.UnregisterEvent(ev, DeviceID);
                         return false; });
  }
}
public class COMHelpers
{
  public static List<dynamic> COMIndexedPropertyToList(
          dynamic IndexedPropertyCollection)
  {
    List<dynamic> RetVal = null;
    if (RetVal == null)
      RetVal = new List<dynamic>(IndexedPropertyCollection.Count);
    else
      RetVal.Clear();
    for (int i = 1; i <= IndexedPropertyCollection.Count; i++)
      RetVal.Add(IndexedPropertyCollection[i]);
    return RetVal;
  }
}
public class WIADeviceInfo : WIAObject
{
  public WIADeviceInfo(dynamic Source)
    : base((object)Source)
  {
  }

  public WIADevice Connect()
  {
    WIADevice retval = new WIADevice(WIASource.Connect());
    return retval;
  }

  public WIADeviceType DeviceType
  {
    get
    {
      return (WIADeviceType)WIASource.Type;
    }
  }

  public string DeviceID
  {
    get { return (string)WIASource.DeviceID; }
```

```
  }

  public IEnumerable<WIAProperty> Properties
  {
    get { return (COMHelpers.COMIndexedPropertyToList(WIASource.Properties)
      as List<dynamic>).Select((Prop) => new WIAProperty(Prop)); }
  }
}
```

The `WIADeviceManager.Create()` is a wrapper factory method that creates an instance of the `DeviceManager` COM automation type and returns an instance of a `WIADeviceManager`. The `WIAObject` base class is used to hold the dynamic-typed COM automation object instance, implement property change notification, and validate it to make sure it is not null on creation. You check `AutomationFactory.IsAvailable` to make sure COM Automation is available in the environment you are running before you attempt to create the COM object.

The `DeviceManager` COM object exposes a COM indexed property named `DeviceInfos` that represents a collection of `DeviceInfo` COM objects, each entry representing a device connected to the machine and recognizable by WIA. You wrap this property using `WIADeviceManager.DeviceInfos`. In the property implementation, you use the `COMIndexedPropertyToList()` static method on the `COMHelpers` class. In `COMIndexedPropertyToList()` you enumerate a COM indexed property and return an CLR List instance populated with the same items.

The `DeviceManager` COM object also implements a `RegisterEvent` and an `UnregisterEvent` method that allows for callers to register and unregister for specific events defined in the WIA automation API as GUIDs. You define a `RegisterEvents()` wrapper method on `WIADeviceManager` that accepts a collection of event GUID's and registers each of them. Similarly, `WIADeviceManager.UnregisterEvents()` unregisters an already registered set of events. The first parameter to the `RegisterEvent()` and `UnregisterEvent()` methods are `DeviceID's` for the device in whose events you may be interested. You can pass the string "*" if you are interested in a specific event for all connected devices at the moment. The `DeviceManager` object also raises a COM event named `OnEvent`. You attach a handler to `OnEvent` in the `WIADeviceManager` constructor, and raise your own `OnEvent` implementation, passing in a new instance of `WIAEventArgs` type populated with the individual parameters obtained from the COM `OnEvent` handler.

There are several more WIA automation types that you have wrapped around in your wrapper object model, but we do not list all of them here for brevity. The purpose of this section was to show you a sample of COM Interop code, and the rest of the wrapper object model follows the exact same principles and techniques shown so far. For the rest of the recipe, whenever you encounter a type with a name starting with the string "WIA", know that it is one of your wrapper types defined in `wiaom.cs` wrapping around a corresponding automation type.

The Application Code

Figure 8-12 shows the application user interface.

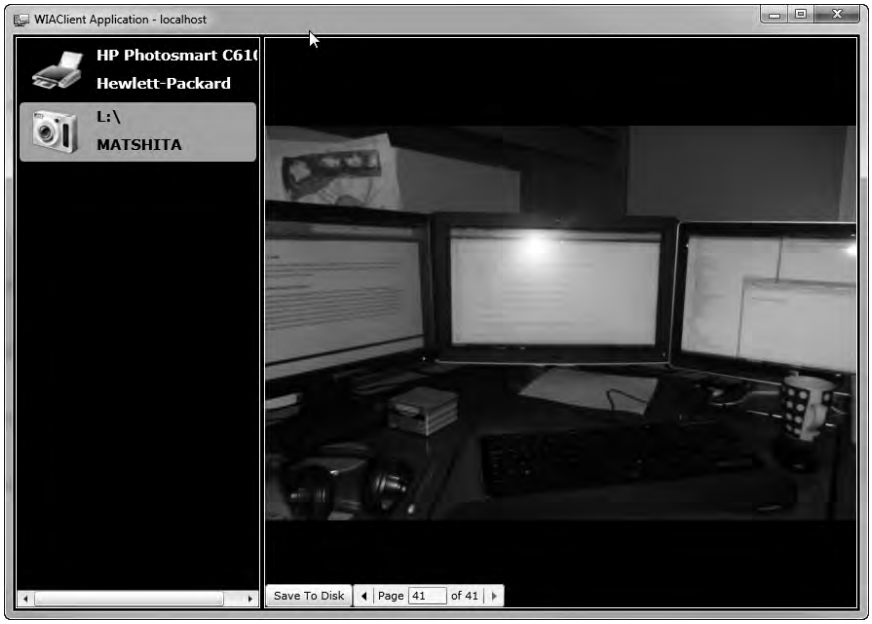


Figure 8-12. *The client application user interface*

On the left is a list of devices connected to the computer that WIA recognizes. The right side shows the photo viewer with a pager control at the bottom to navigate through the photos on a connected camera, plus as a button that allows the user to save a specific photo to the disk. To test the application's functionality, you will need a digital camera with some images already stored in it. Run the application with the camera connected, or connect it to your PC with the application running. Then select the camera device; the right hand pane should let you navigate through the images on the camera as well as save them to your computer's local file system

Note that Figure 8-12 shows both a scanner and a camera connected to the computer. Recall from the earlier section that WIA recognizes scanners as source devices for digital images as well. In this sample, however, you will only deal with digital camera-specific features. Listing 8-11 shows relevant portions of the code for the `MainPage.xaml` from the application.

Listing 8-11. *Portions of MainPage.xaml*

```
<Grid x:Name="LayoutRoot" Background="Black">
    <Grid.ColumnDefinitions>
        <ColumnDefinition Width="0.294*"/>
        <ColumnDefinition Width="0.706*"/>
    </Grid.ColumnDefinitions>
    <Border BorderBrush="White" BorderThickness="1" Margin="2">
        <ListBox Margin="0"  x:Name="lbxDevices"
               ItemContainerStyle="{StaticResource styleImagingDeviceListBoxItem}"
               SelectionChanged="lbxDevices_SelectionChanged" Background="Black"/>
    </Border>
    <Border BorderBrush="White" BorderThickness="1" Margin="2" Grid.Column="1">
```

```
        <ContentControl x:Name="cntctlDataPane" HorizontalAlignment="Stretch"
                        VerticalAlignment="Stretch"
                        HorizontalContentAlignment="Stretch"
                        VerticalContentAlignment="Stretch" Margin="0" />
    </Border>
</Grid>
```

The ListBox named lbxDevices implements the device list shown in Figure 8-12 The ContentControl cntctldataPane is used to display the photos; we will discuss the mechanics of that later in the recipe. Listing 8-12 shows the codebehind for MainPage.xaml.

Listing 8-12. *Codebehind for MainPage.xaml*

```
public partial class MainPage : UserControl
{
  //event handler delegate to handle the WIADeviceManager.OnEvent event
    public delegate void WIADeviceManageOnEventHandler(string EventID,
      string DeviceID, string ItemID);
  //WIADeviceManager singleton
    WIADeviceManager wiaDeviceManager = null;
  //the collection of all connected devices
    ObservableCollection<WIADevice> WIADevicesColl =
      new ObservableCollection<WIADevice>();

    public MainPage()
    {
        InitializeComponent();
      //create the DeviceManager
        wiaDeviceManager = WIADeviceManager.Create();
      //register for connection and disconnection events for all devices
      //that WIA might recognize
        wiaDeviceManager.RegisterEvents("*",
          new string[]{WIAEventID.DeviceConnected,WIAEventID.DeviceDisconnected});
      //attach event handler for OnEvent
        wiaDeviceManager.OnEvent +=
          new EventHandler<WIAOnEventArgs>(wiaDeviceManager_OnEvent);
      //get and connect all the devices
        WIADevicesColl = new ObservableCollection<WIADevice>(
          wiaDeviceManager.DeviceInfos.Select((di) => di.Connect()));
       //set the device list
        lbxDevices.ItemsSource = WIADevicesColl;
    }

    void wiaDeviceManager_OnEvent(object sender, WIAOnEventArgs e)
    {
      //if a device just connected
```

```
    if (e.EventID == WIAEventID.DeviceConnected )
    {
      //connect it
        WIADevice wiaDevice = wiaDeviceManager.DeviceInfos.
          Where((di) => di.DeviceID == e.DeviceID).
          Select((di) => di.Connect()).First();
      //add to the bound collection
        WIADevicesColl.Add(wiaDevice);
      //if minimized - show notification
        if (Application.Current.MainWindow.WindowState ==
          WindowState.Minimized)
        {
            DeviceConnectDisconnectNotification notfcontent =
              new DeviceConnectDisconnectNotification()
              { DataContext = wiaDevice, Connected = true};
            NotificationWindow notfWindow = new NotificationWindow()
            { Height = 60, Width = 400, Content = notfcontent };
            notfcontent.NotificationParent = notfWindow;
            notfWindow.Show(30000);
        }
    }
      //if device disconnected
    else if (e.EventID == WIAEventID.DeviceDisconnected &&
      WIADevicesColl.Where((wiaDeviceInfo)=>wiaDeviceInfo.DeviceID
        == e.DeviceID).Count() > 0)
    {
      //remove it
        WIADevice wiaDevice = WIADevicesColl.
          Where((de) => de.DeviceID == e.DeviceID).First();
        WIADevicesColl.Remove(wiaDevice);
    }
}

private void lbxDevices_SelectionChanged(object sender, SelectionChangedEventArgs e)
{
  //get the selected device
  WIADevice Device = lbxDevices.SelectedValue as WIADevice;
  //display the content on the right pane
  DisplayCameraItems(Device);
}

private void DisplayCameraItems( WIADevice CameraDevice)
{
  //create a new instance of the PhotoItems user control
  //and bind appropriate data
```

```
        cntctlDataPane.Content = new PhotoItems()
        { Device = CameraDevice,
          HorizontalAlignment = HorizontalAlignment.Stretch,
          VerticalAlignment = VerticalAlignment.Stretch };
    }
}
```

In the constructor of the `MainPage` class, you create an instance of the `WIADeviceManager`, which, as discussed in the previous section, instantiates the `DeviceManager` COM object using COM Interop. You also register to receive the `OnEvent` event for all devices whenever they connect to or disconnect from the machine, and then attach a handler to the `OnEvent` handler. As discussed before, WIA events are defined as GUIDs, and the `WIAEventID` type declares the WIA event's GUIDs as named variables. Lastly, you get back and bind the list of connected devices by calling the `Connect()` wrapper method on each `WIADeviceInfo` exposed through the `WIADeviceManager.DeviceInfos` collection property.

In the `OnEvent` event handler, you either remove a device from your bound device collection if you get a `DeviceDisconnected` event, or you add a new device if you get a `DeviceConnected` event. You also show a notification window on device connection; we will discuss this later in the recipe.

In the `SelectionChanged` event handler for the device `ListBox`, you acquire the selected `WIADevice` instance, and call `DisplayCameraItems()`, which in turn creates and displays a new instance of the `PhotoItems` user control, passing in the selected `WIADevice` instance. Listing 8-13 shows portions of the `PhotoItems` user control XAML.

Listing 8-13. *PhotoItems user control XAML*

```
<Grid x:Name="LayoutRoot" HorizontalAlignment="Stretch"
      VerticalAlignment="Stretch">
    <Grid.RowDefinitions>
        <RowDefinition Height="*"/>
        <RowDefinition Height="Auto"/>
    </Grid.RowDefinitions>
    <Image Source=
           "{Binding Converter={StaticResource REF_WIAImageFileToBitmapConverter}}"
           Stretch="Uniform" x:Name="Photo" Grid.RowSpan="2"/>
    <StackPanel Orientation="Horizontal" Grid.Row="2"
                HorizontalAlignment="Stretch"
                VerticalAlignment="Stretch">
        <Button x:Name="btnSave" Content="Save To Disk"
                Click="btnSave_Click" Width="90"/>
        <datacontrols:DataPager x:Name="PhotoPager" PageSize="1"
              DisplayMode="PreviousNext" IsTotalItemCountFixed="True"
              HorizontalAlignment="Stretch" VerticalAlignment="Stretch"/>
    </StackPanel>
</Grid>
```

A `DataPager` control named `PhotoPager` is used to navigate through the images. An `Image` control named `Photo` is used to display the image, and the `Button` named `btnSave` allows the user to save an image to the disk when clicked. Listing 8-14 shows the relevant portions from the codebehind for PhotoItems.

Listing 8-14. *PhotoItems user control codebehind*

```
void PhotoItems_Loaded(object sender, RoutedEventArgs args)
{

    PhotoPager.Source = new PagedCollectionView(
      Device.Items.Where((itm) => itm.Formats.Contains(WIAFormatID.JPEG)))
      { PageSize = 1 };

    ShowPhoto();
    PhotoPager.PageIndexChanged += new EventHandler<EventArgs>((s, e) =>
    {
        ShowPhoto();
    });
    return;
}

private void ShowPhoto()
{
    try
    {
        WIAImageFile img = ((PhotoPager.Source as PagedCollectionView).
          CurrentItem as WIAItem).Transfer(WIAFormatID.JPEG);
        if (img == null) Photo.DataContext = null;
        else
            Photo.DataContext = img.FileData;
    }
    catch (Exception Ex)
    {
        Photo.DataContext = null;
    }
}
```

Each `WIADevice` instance exposes a property named Items, which is collection of `WIAItem` objects that wraps around the Items indexed property on the Device COM object. The items on the device (in this case, the device is a camera) can be images or other types of device specific data. In the Loaded event handler of the `PhotoItem` control, you query the Items property on the selected `WIADevice`, acquire only the JPEG images, wrap the filtered collection into a `PagedCollectionView`, and set it as the `PhotoPager` source. You also set the `PageSize` on the `PhotoPager` to one, ensuring that the user pages forward or backward for each image. You then call `ShowPhoto()`. In `ShowPhoto()`, you invoke the `Transfer()` COM method on the current `WIAItem` on the bound `PagedCollectionView`, which transfers the physical image as a `WIAImageFile` instance to the computer from the device. You then bind the `WIAImageFile.FileData` property to the `Photo` Image control shown in Listing 8-13. You call `ShowPhoto()` once every time a user pages through the `DataPager` to transfer and display other images. As you can also see in the XAML in Listing 8-13, a value converter named `WIAImageFileToBitmapConverter` is used in the image binding to convert the raw image data to a Silverlight bitmap. We do not list that code here, but you can find the converter in the `PhotoItems.xaml.cs` file in the sample project for this recipe.

Saving Images to the disk

Listing 8-15 shows the code to save an image to the disk.

Listing 8-15. *Saving an image to the disk*

```
private void btnSave_Click(object sender, RoutedEventArgs e)
{
  //get the current WIAItem
  WIAItem itm = ((PhotoPager.Source as PagedCollectionView).
    CurrentItem as WIAItem);
  //get the raw data
  byte[] FileData = Photo.DataContext as byte[];
  //get the filename from the Item Properties collection
  string filename = itm.Properties.ToList().Where((wiaprop) =>
    wiaprop.Name == "Item Name").Select((wiaprop) =>
      (string)wiaprop.Value).FirstOrDefault();
  //create a file
  FileStream fs = File.Create(
    System.IO.Path.Combine(
    Environment.GetFolderPath(Environment.SpecialFolder.MyPictures),
    filename + ".jpeg"));
  //write
  fs.Write(FileData, 0, FileData.Length);
  //close file
  fs.Close();
}
```

As you can see in the code shown in bold, you first obtain a target path for the file by combining the path to the `MyPicture` special folder with the file name obtained from the Item Name WIA property on the current `WIAItem`. You then use the well-known `FileStream` API to write the data to the file on the file system, just as you would in a regular desktop .Net application.

Taskbar Notification

If you refer back to the code in Listing 8-13, you will note that when you handle a device connection event, you optionally display a notification window if the main application window is minimized. Figure 8-13 shows this notification window in action.

Figure 8-13. *Notification window showing a device connected event*

Silverlight 4 introduces the `NotificationWindow` type that enables this scenario. The `NotificationWindow` type exposes a `Content` property that you can set to any content in your application, and it exposes a `Show()` method that can be invoked with a timeout parameter in milliseconds so that the notification remains displayed for the specified timeout. As you can see in Listing 8-13, you create your `NotificationWindow` instance, set it to some content that displays the device connection notification, and then show it for 30 seconds.

CHAPTER 9

Building LOB Applications

Many of the public Silverlight sites are media-focused as a result of Silverlight's strong client-side media capabilities, such as HD video coupled with a Windows Media Services or a smooth streaming back end. Many other sites also publish interactive content beyond video; but for corporate development support of traditional Create, Read, Update, and Delete (CRUD) applications as well as data-driven rich Internet applications, you need a strong control set with rich data support.

Silverlight LOB Enhancements

Silverlight 3 introduced additional controls for line-of-business (LOB) application development. In addition, Silverlight 3 introduced the new Silverlight Navigation Application project template, which provides a great starter application for a LOB application. We covered the Silverlight Navigation Application basics in Chapter 6 because it also provides great integration with the browser history and support for direct page links.

Silverlight 4 builds on these capabilities with improved data-oriented controls as well as new controls such as the RichTextBox control to display, enter, and edit rich text and the WebBrowser control for hosting HTML within an out-of-browser (OOB) application. Speaking of which, Silverlight 4 greatly improves OOB functionality to enhance LOB development. We cover the details of OOB development in Chapter 8 but here are some highlights related to LOB development:

- HTML hosting in the WebBrowser control
- Pop-up alerts with the NotificationWindow class
- Support for elevated trust to the underlying platform

Other LOB-related enhancements in Silverlight 4 are drag-and-drop, clipboard access, right-click mouse events, and printing. A major step forward is much better support for Commanding, which allows developers to more easily implement Model-View-ViewModel applications when building data-driven applications.

Data Access Enhancements

Silverlight 4 includes strong network service capabilities (refer to Chapter 7). In this chapter, we highlight additional networking support for accessing data in a structured way via both WCF Data Services and WCF RIA Services. The next two sections provide a high-level overview of these two technologies. For a deeper discussion on these technologies and how they relate to other SOAP and REST-based development models, please go to:

blogs.msdn.com/endpoint/archive/2010/01/04/wcf-data-services-ria-services-alignment-questions-and-answers.aspx.

WCF Data Services

Silverlight 4 includes rich support for accessing web data either on the Internet or intranet via WCF Data Services. Formerly known as ADO.NET Data Services in Silverlight 3, WCF Data Services provides support for REST-based data access as well as support for the new Open Data Protocol (OData) format. You can learn more about OData at

www.odata.org/

Silverlight 4 introduces several improvements for WCF Data Services including a new `DataServiceCollection` class that provides better data binding support with automatic updates to bound controls and greatly simplifying REST development in Silverlight. WCF Data Services also supports both out-of-browser and cross-domain execution in Silverlight 4.

WCF RIA Services

When you think LOB applications, you automatically think *n*-tier development. Introduced at Mix 09 in beta as Microsoft .NET Rich Internet Applications (RIA) Services, the name has changed to WCF RIA Services but the goal is the same, which is to simplify the development of n-tier solutions for Silverlight RIA applications. WCF RIA Services is automatically installed when you download and install the Silverlight 4 Tools for Visual Studio 2010.

The challenge with *n*-tier applications is flowing data across application tiers with support for edits, validation, and so on. WCF RIA Services builds on the capabilities covered in Chapter 7 to provide a framework that enables you to rapidly build Silverlight LOB *n*-tier applications.

WCF RIA Services provides a bridge between Silverlight 4's rich presentation-tier capabilities and ASP.NET's powerful middle-tier capabilities on the server, including support for ASP.NET authentication and user settings management.

To get started with WCF RIA Services, you create classes in the middle-tier web application that inherit from the `System.Web.DomainServices.DomainService` base class to define a set of operations on resources such as an ADO.NET Entity Model or other resources such as a user registration service. You can have classes on the middle tier be available on the client-side in Silverlight by adding the `EnableClientAccess` attribute to the middle-tier classes. WCF RIA Services will automatically generate the corresponding client-side code into the presentation tier (the Silverlight application). At this point, you can code against the generated client-side code without worrying about tracking and packaging up changes and so forth to pass back to the middle tier. WCF RIA Services manages this for you.

9-1. Accessing RESTful Data using OData

Problem

You need to access web data in your Silverlight application.

Solution

Take advantage of existing REST and OData end-points either on the intranet or Internet.

How It Works

Silverlight 4 includes a client development model that enables accessing REST and OData end-points by simply using the Add Service Reference feature in Visual Studio 2010 to create the necessary client-side representations of the server-side data.

To find your Web Data, navigate over to the odata.org site and click Producers to see what sample data is available. You will connect to the OData Test read-only dataset available at

```
services.odata.org/OData/OData.svc/
```

The Code

To get started, right-click on Recipe 9-1 in Visual Studio and select Add Service Reference and enter the URL for the sample OData service as shown in Figure 9-1.

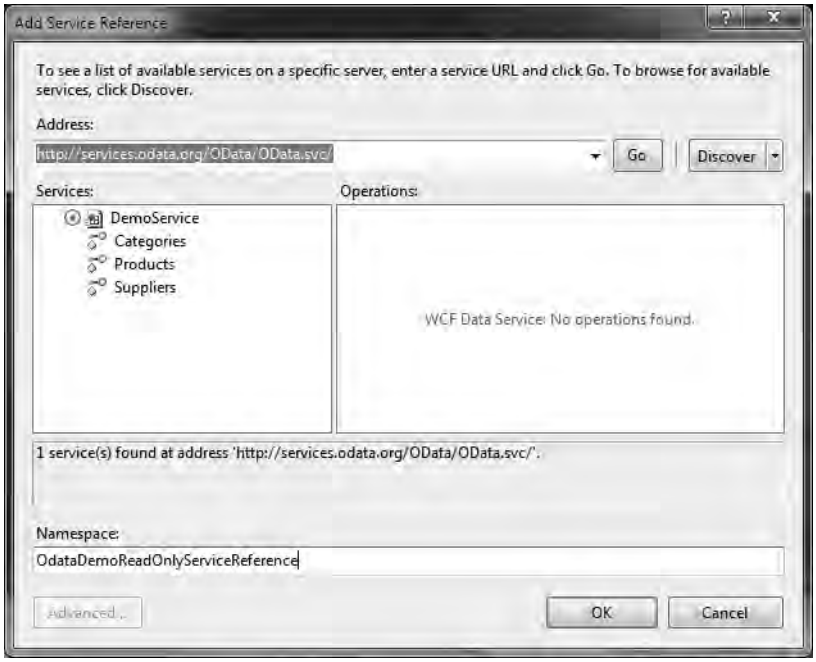


Figure 9-1. *Recipe 9-1 Adding an OData service reference*

Clicking OK generates the necessary client-side code files to enable access to the service. Next, add a `using` reference to bring in the client-side code:

```
using Ch09_LOBApplications.Recipe9_1.OdataDemoReadOnlyServiceReference
using System.Data.Services.Client
```

Then, add a `MainPage_Loaded` event handler on the main page where you do three things:

- Initialize the data service context to connect to the service
- Create a collection to store the data
- Define a handler for the LoadCompleted event for the collection when loaded

Here is the MainPage_Loaded event handler containing these steps:

```
private void MainPage_Loaded(object sender, RoutedEventArgs e)
{
  context = new DemoService(
    new Uri("http://services.odata.org/OData/OData.svc/",
      UriKind.Absolute));
  Products = new DataServiceCollection<Product>(context);
  Products.LoadCompleted +=
    new EventHandler<LoadCompletedEventArgs>(Products_LoadCompleted);
}
```

As you can see, you configure the context variable to point to the OData test service. Next, you instantiate a new DataServiceCollection with the Product type and assign a LoadCompleted event handler. Then you add a Button to kick off loading the data and a DataGrid to display the data in the UI. The LoadCompleted event fires when the GetProductsBtn is clicked.

In the GetProductsBtn Button event, you create a LINQ query to retrieve all of the products and then pass the query in to the LoadAsync method on the Products variable of type DataServiceCollection<Product>. The LoadAsync method uses the context variable to know where to retrieve the data from. Here is the GetProductsBtn_Click event handler:

```
private void GetProductsBtn_Click(object sender, RoutedEventArgs e)
{
  ProductsGrid.DataContext = null;

  var ProductsQuery = from products in context.Products
                      select products;

  Products.LoadAsync(ProductsQuery);
}
```

When LoadAsync completes, the DataServiceCollection.LoadCompleted event is fired on the Products variable, which checks for an error; if no errors are present, it assigns the data to the ProductsGrid.ItemSource property as shown in Listing 9-1.

Listing 9-1. *The Recipe 9-1 Products_LoadCompleted Method*

```
void Products_LoadCompleted(object sender, LoadCompletedEventArgs e)
{
  if (e.Error == null)
  {
    // Load all pages of Orders before binding.
    if (Products.Continuation != null)
```

```
    {
      Products.LoadNextPartialSetAsync();
    }
    else
    {
      // Bind the root StackPanel element to the collection;
      // related object binding paths are defined in the XAML.
      ProductsGrid.ItemsSource = Products;
      ProductsGrid.UpdateLayout();

      // Re-enable the button since the loading is complete.
      GetProductsBtn.IsEnabled = true;

      // Set the focus to the first order, which loads the related items.
      ProductsGrid.SelectedIndex = 0;
    }
  }
  else
  {
    MessageBox.Show(string.Format("An error has occured: {0}", e.Error.Message));
    GetProductsBtn.IsEnabled = true;
  }
}
```

The result of this code is shown in Figure 9-2.

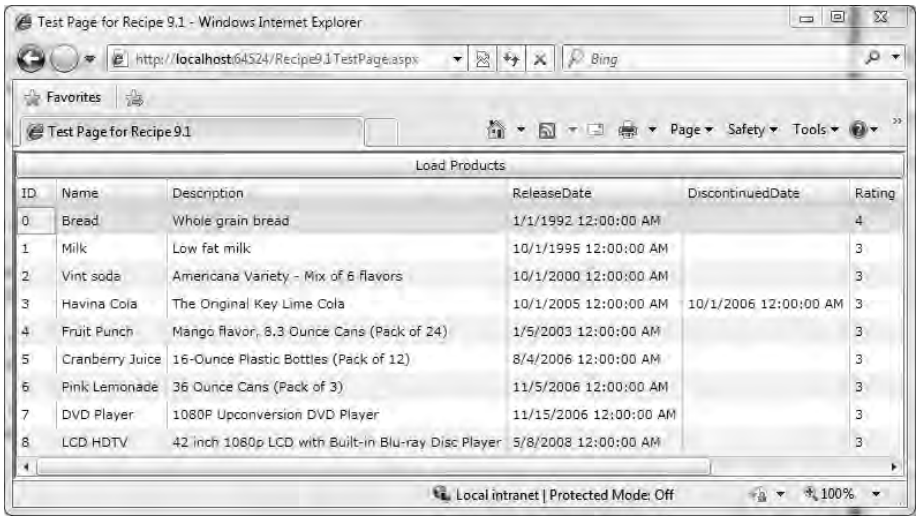


Figure 9-2. *Recipe 9-1 UI after loading data*

9-2. Using Visual Studio 2010 WCF Data Services Tooling

Problem

You have a database that you want to make available via REST and OData programming models.

Solution

Take advantage of Visual Studio 2010 tooling to publish a database via WCF Data Services and the OData protocol and then access the database from Silverlight 4.

How It Works

You already saw the tooling on how to add a Service Reference to an OData service using Visual Studio 2010 in Recipe 9-1. In this recipe, you learn how to make a database available as a service using the tooling in Visual Studio 2010 and then access that service from Silverlight.

The Code

Start by creating an ADO.NET Entity Framework Data Model named `Northwind.edmx` that contains all of the tables in Northwind in a folder named `DataModel` in the ASP.NET `TestWeb` project. Next, create a folder named `DataService` in the ASP.NET `TestWeb` project and then add a WCF Data Service item named `NorthwindDataService.svc` to the `DataService` folder. Here is the generated data service code:

```
public class NorthwindDataService :
               DataService</* TODO: put your data source class name here */ >
{
    // This method is called only once to initialize service-wide policies.
    public static void InitializeService(DataServiceConfiguration config)
    {
      // TODO: set rules to indicate which entity sets and
      // service operations are visible, updatable, etc.
      // Examples:
      // config.SetEntitySetAccessRule("MyEntityset",EntitySetRights.AllRead);
      // config.SetServiceOperationAccessRule(
      //               "MyServiceOperation", ServiceOperationRights.All);
      config.DataServiceBehavior.MaxProtocolVersion = DataServiceProtocolVersion.V2;
      }
}
```

You perform the first TODO mentioned in the code by replacing the comment in the constructor with the type `TestWeb.DataModel.NorthwindEntities` to make the entities available via the `DataService`. Next, you edit the `InitializeService` method to configure access rules for your entities by granting all rights to all entities in this line of code:

```
config.SetEntitySetAccessRule("*", EntitySetRights.All);
```

When you run the service to display it in code, it looks like Figure 9-3.

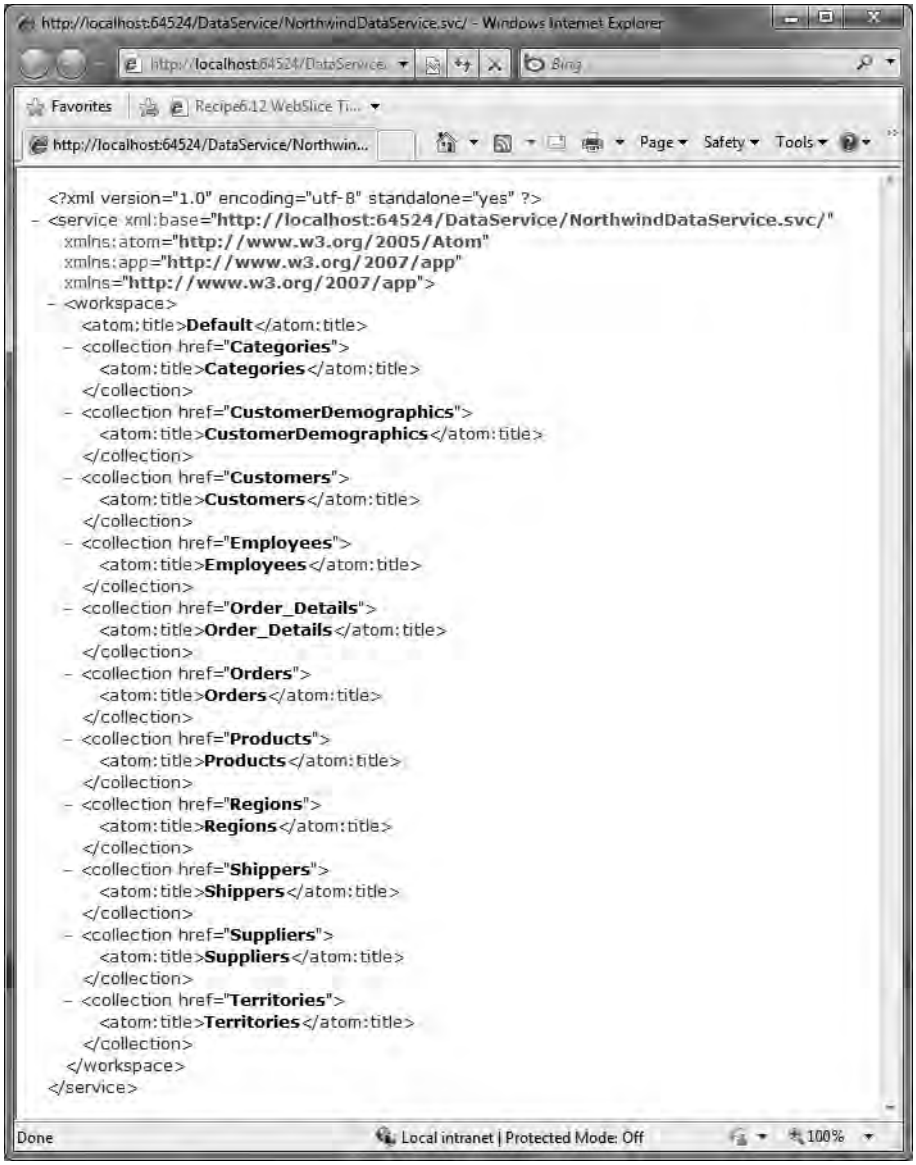


Figure 9-3. *Recipe 9-2 Northwind Data Service*

To view just the Orders data, you can alter the URL by appending Orders to the end like this:

```
http://localhost:64524/DataService/NorthwindDataService.svc/Orders
```

Figure 9-4 shows the results as a feed.

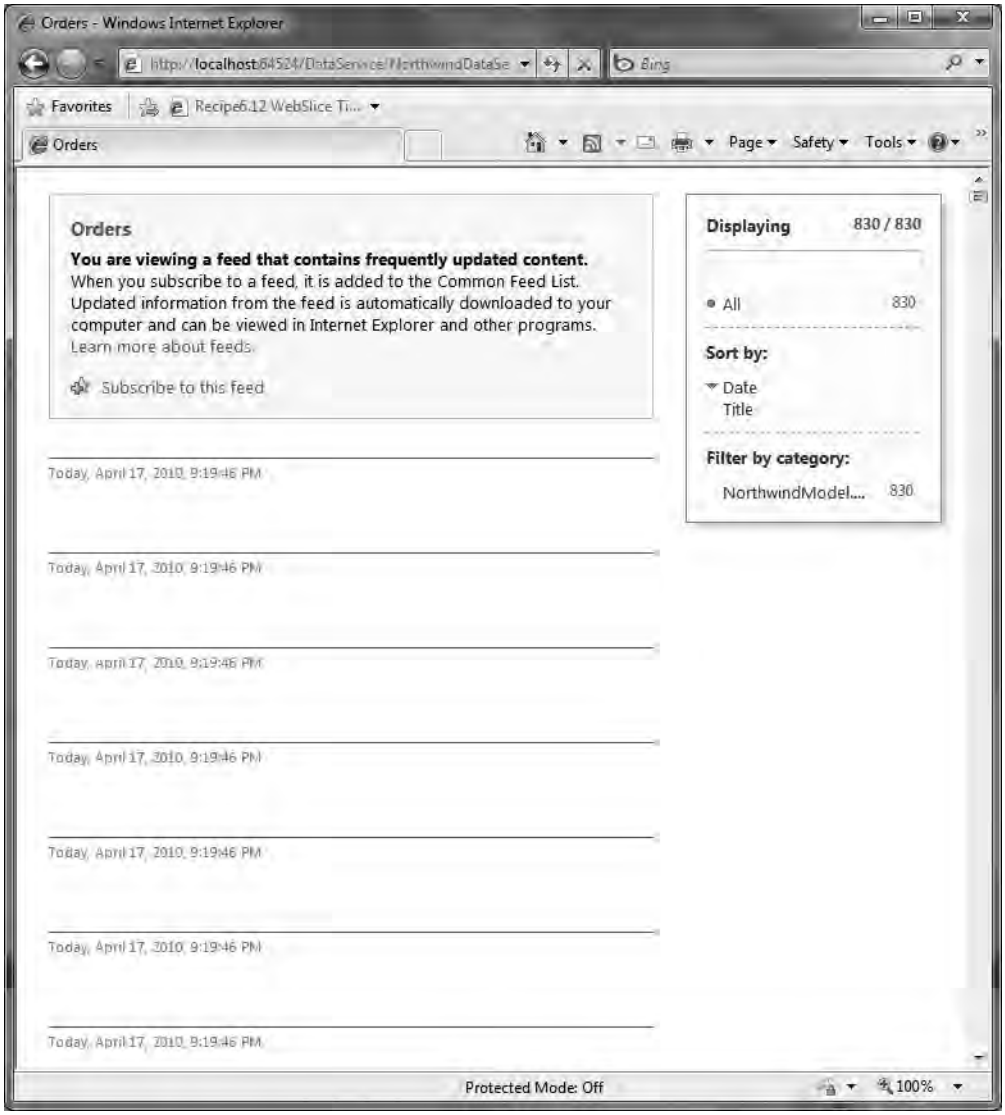


Figure 9-4. *Recipe 9-2 Northwind Data Service Orders feed*

To view the feed as XML, go to Internet Explorer Tools | Internet Options | Content | Feed and Web Slice Settings | and uncheck Turn on feed reading view. Figure 9-5 shows the feed as XML.

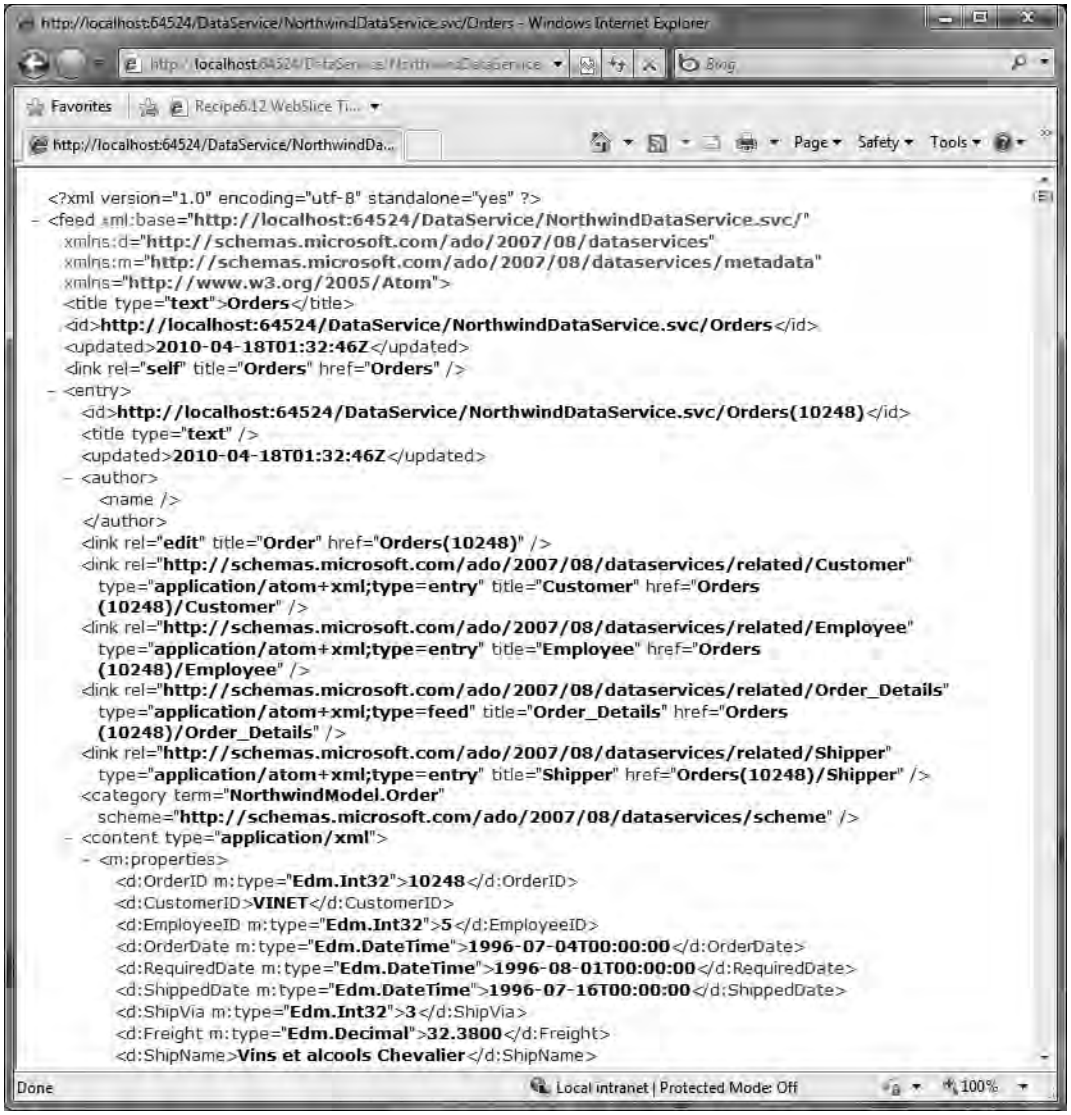


Figure 9-5. *Recipe 9-2 Northwind Data Service Orders feed as XML*

Next, select Recipe 9-2 and right-click to bring up the Add Service Reference menu and click Discover to automatically find the `NorthwindDataService` in the `TestWeb` project. Give the service a namespace of `NorthwindDataServiceReference` and click OK to add the client side code to access the data service.

Add a `using` clause to MainPage.xaml.cs to bring in the service namespace. The code is similar to that in Recipe 9.1 and is shown in Listing 9-2.

Listing 9-2. *The Recipe 9-2 MainPage.Xaml.cs Codebehind File*

```
using System;
using System.Linq;
using System.Windows;
using System.Windows.Controls;
using Ch09_LOBApplications.Recipe9_2.NorthwindDataServiceReference;
using System.Data.Services.Client;

namespace Ch09_LOBApplications.Recipe9_2
{
  public partial class MainPage : UserControl
  {
    NorthwindEntities NorthwindContext;
    DataServiceCollection<Customer> Customers;

    public MainPage()
    {
      InitializeComponent();
    }
    private void UserControl_Loaded(object sender, RoutedEventArgs e)
    {
      NorthwindContext = new NorthwindEntities(
        new Uri("DataService/NorthwindDataService.svc", UriKind.Relative));
      Customers = new DataServiceCollection<Customer>(NorthwindContext);
      Customers.LoadCompleted +=
        new EventHandler<LoadCompletedEventArgs>(Customers_LoadCompleted);
    }

    void Customers_LoadCompleted(object sender, LoadCompletedEventArgs e)
    {
      if (e.Error == null)
      {
        // Load all pages of Orders before binding.
        if (Customers.Continuation != null)
        {
          Customers.LoadNextPartialSetAsync();
        }
        else
        {
          // Bind the root StackPanel element to the collection;
          // related object binding paths are defined in the XAML.
          NorthwindDataGrid.ItemsSource = Customers;
          NorthwindDataGrid.UpdateLayout();
```

```
            // Re-enable the button since the loading is complete.
            GetCustomersBtn.IsEnabled = true;

            // Set the focus to the first order, which loads the related items.
            NorthwindDataGrid.SelectedIndex = 0;
          }
        }
        else
        {
          MessageBox.Show(
             string.Format("An error has occured: {0}", e.Error.Message));
          GetCustomersBtn.IsEnabled = true;
        }
      }

      private void GetCustomersBtn_Click(object sender, RoutedEventArgs e)
      {
        NorthwindDataGrid.DataContext = null;

        var CustomersQuery = from customers in NorthwindContext.Customers
                             select customers;

        Customers.LoadAsync(CustomersQuery);
      }
    }
}
```

Figure 9-6 shows the data displayed in the final user interface.

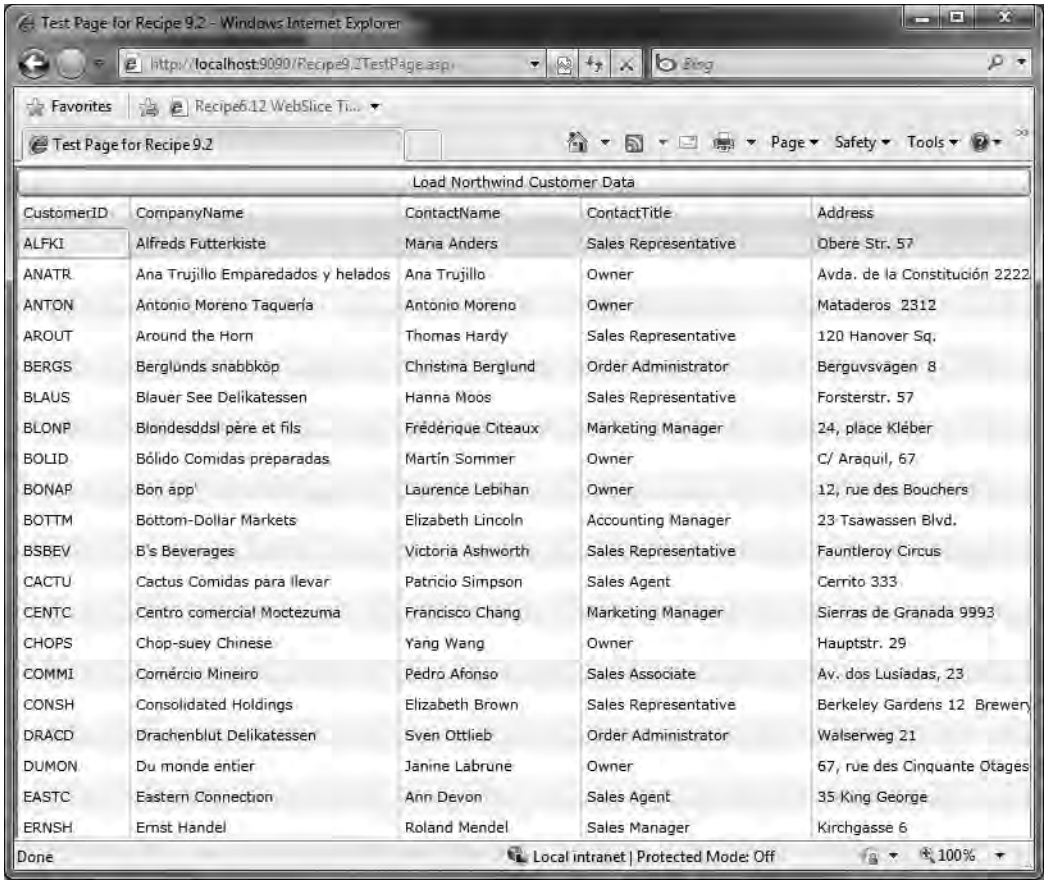


Figure 9-6. *Final UI for Recipe 9-2*

9-3. Implementing CRUD Operations in WCF Data Services

Problem

You need to have read-write access to data published via OData.

Solution

Take advantage of WCF Data Services enhancements such as DataServiceCollection available in Silverlight 4 to implement CRUD operations.

How It Works

WCF Data Services support entity tracking on the client so that you can submit a query to the service in order to populate a `DataServiceCollection` that is databound to a UI control such as a `DataGrid`. You used this technique in Recipe 9-1 and Recipe 9-2 to load read-only data. In this recipe, you do the same but there's a twist: now you can insert, update, and delete edits.

The code is covered in detail in the next subsection but here are the key points on how the code works. In this recipe, you edit order details for the Northwind database, first loading all of the Customers, the related Orders, and finally the related Order Detail line items. The code allows the user to do the following:

- Delete the selected Order Details line item
- Update the Quantity for an existing Order Details line item
- Add an Order Details line item to an existing Order

You created a Service Reference to the Northwind Data Service in Recipe 9-2. The client-side proxy provides the `NorthwindEntities` type that inherits from `System.Data.Services.Client.DataServiceContext`. You create an instance of that class called `NorhwindContext`, running all queries and operations through the `DataServiceContext` instance. This is required in order to keep things synchronized across entities as you make edits.

Once you have the data context established, you go through the process of querying data and enabling edits. The code is very simple once you see the pattern. Essentially, you identify the object to be deleted, updated, or created and call methods on `NorthwindContext` to make it happen. The operation occurs locally in the `DataServiceCollection` instance of interest (i.e. the Order_Details entity) and then the changes are applied on the server via `NorthwindContext`.

The Code

Take advantage of the Northwind Data Service you created in Recipe 9-2 and add a service reference to make it available in Recipe 9-3's Silverlight application. In `UserControl_Loaded` you create a `DataServiceContext` instance named `NorthwindContext` as before. You add one directive to have `NorthwindContext` apply changes as a batch by updating `SaveChangesDefaultOptions` since the insert operation affects multiple tables, as shown here:

```
private void UserControl_Loaded(object sender, RoutedEventArgs e)
{
  NorthwindContext = new NorthwindEntities(
    new Uri("DataService/NorthwindDataService.svc", UriKind.Relative));
  NorthwindContext.SaveChangesDefaultOptions = SaveChangesOptions.Batch;
}
```

Next, you have a series of similar operations as in Recipe 9-1 and 9-2 where you load up three `DataGrid` instances with Customer data, Customer Order data, and finally the corresponding Customer Order Details data where you implement simple CRUD operations. (We don't go through the data loading code so as to not be redundant.) Essentially, when the user clicks the Load Northwind Customer Data button, it populates the `Customers` `DataServiceCollection<Customer>` instance that is databound to the top left `DataGrid`. The Load Customer Orders button loads the Orders that correspond to the selected `Customer` into the `DataGrid` on the upper right. The same process is implemented to load up the corresponding `Order_Details` in the `DataGrid` on the lower right. At this point, you have the data that

you want to perform edits on in the `Order_Details` data. Next, add a UI for making edits with buttons that correspond to deleting, updating, and creating an `Order_Details` entity, as shown in figure 9-7.

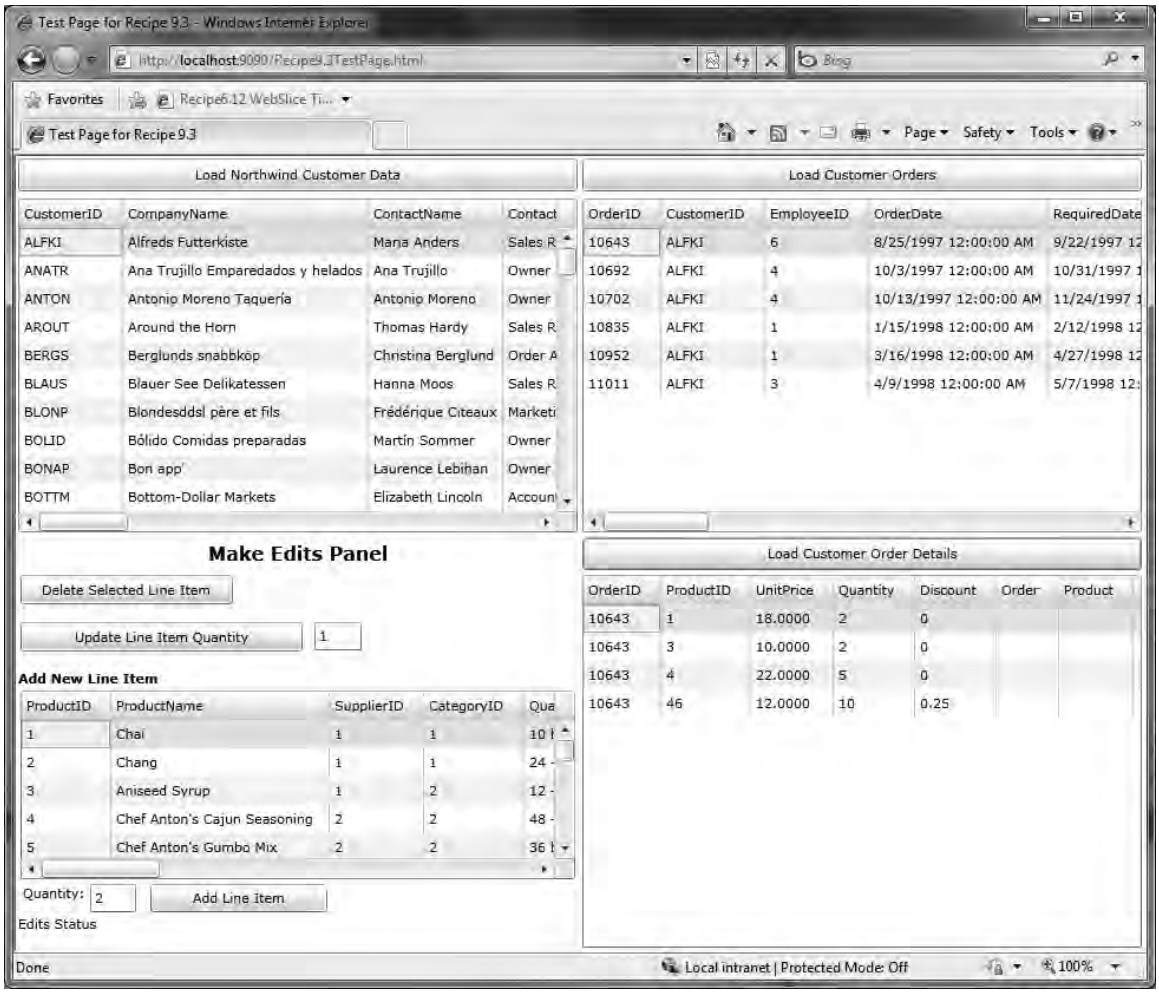


Figure 9-7. *The UI for Recipe 9-3*

To load the data, simply clicked the Load Northwind Customer Data button, followed-by the Load Customer Orders button, and finally the Load Customer Order Details button. You can select a particular record before clicking the next step if desired to test it out but you must click the buttons in that order for the simple UI to function.

The Delete Selected Line Item button does what it suggests: it deletes the selected `Order_Details` record in the Customer Order Details `DataGrid`. Here is the event handler for the button:

```
private void DeleteDetailsItemBtn_Click(object sender, RoutedEventArgs e)
{
```

```
  if (CustomerOrderDetailsDataGrid.SelectedItem != null)
  {
    NorthwindContext.DeleteObject(
      (Order_Detail)CustomerOrderDetailsDataGrid.SelectedItem);
    NorthwindContext.BeginSaveChanges(
      SaveChangesOptions.Batch, ChangesSaved, NorthwindContext);
  }
}
```

Since you have the `Order_Details` object to be deleted already on the client as part of the `CustomerOrderDetails DataServiceCollection<Order_Detail>` collection, you can simply pass in the `DataGrid SelectedItem` to `DeleteObject` and all of the change tracking magic on the client takes care of the rest. However, to push the changes to the server, call `BeginSaveChanges` on the `NorthwindContext` object which knows where the WCF Data Service lives and how to apply the changes.

The code to perform the update operation is a little bit more complicated but not much more. Here is the code:

```
private void UpdateDetailsItemBtn_Click(object sender, RoutedEventArgs e)
{
  ((Order_Detail)CustomerOrderDetailsDataGrid.SelectedItem).Quantity =
       Convert.ToInt16(EditQuantity.Text);
  NorthwindContext.UpdateObject(
    (Order_Detail)CustomerOrderDetailsDataGrid.SelectedItem);

  NorthwindContext.BeginSaveChanges(
   SaveChangesOptions.Batch, ChangesSaved, NorthwindContext);
}
```

The code is similar except you call the `NorthwindContext.UpdateObject` method and pass in the modified object to complete the changes on the client and to mark the edited `Order_Details` entity as modified. You edit the selected `Order_Details` entity by updating the Quantity value to match what is entered in the `EditQuantity` TextBox.

The code to insert a new `Order_Details` entity as a child to the selected Customer Order is shown here:

```
private void InsertlineItemBtn_Click(object sender, RoutedEventArgs e)
{
  Order_Detail od = new Order_Detail();
  Order SelectedOrder = (Order)CustomerOrdersDataGrid.SelectedItem ;
  Product SelectedProduct = (Product)ProductsDataGrid.SelectedItem ;
  od.Order = SelectedOrder;
  od.OrderID = SelectedOrder.OrderID;
  od.Product = SelectedProduct;
  od.ProductID = SelectedProduct.ProductID;
  od.Quantity = Convert.ToInt16(InsertProdQuantity.Text);
  od.UnitPrice = (Decimal)SelectedProduct.UnitPrice;
```

```
  NorthwindContext.AddToOrder_Details(od);
  NorthwindContext.BeginSaveChanges(ChangesSaved, NorthwindContext);
}
```

You have a small `DataGrid` on the left that lists all of the possible `Products` that you can add as a new line item to the selected `Order`. Otherwise, the code to create the new `Order_Details` entity is very straightforward. When the Service Reference client proxy is created, it automatically generates a method called `AddToOrder_Details` on the `NorthwindContext` variable where you pass in the new `Order_Details` entity to add the line item to the Order. As before, client-side changes are persisted to the service via the `BeginSaveChanges` method, which is very different when compared to the ADO.NET Entity Framework

The last item to mention is the `ChangesSaved` method that is called after changes are persisted by `NorthwindContext` shown here:

```
private void ChangesSaved(Object state)
{
  EditsMessage.Text = "Selected Line Item Modified + " + DateTime.Now.ToString();
}
```

You simply update a string with a time stamp, but instead of passing in the `NorthwindContext` variable as the third parameter in the call below that is required to persist CRUD operations to the server, you could pass in a custom structure that has properties to identify more detail such as the type of operation, the name of the entity modified, etc., in order to provide a more robust status:

```
  NorthwindContext.BeginSaveChanges(ChangesSaved, NorthwindContext);
```

9-4. Using Visual Studio 2010 WCF RIA Data Services Tooling

Problem

You need to create a Silverlight application that displays data from a database.

Solution

Take advantage of Microsoft WCF RIA Services and the Silverlight Business Application template to build the foundation of a LOB application.

How It Works

In previous versions of Silverlight, you had to write a lot of custom code to access data in a Silverlight application. With Silverlight 4 and WCF RIA Services, you can easily make data available to Silverlight in a robust way with full support for XAML databinding, validation, and custom extensions to generated code.

When you install the Silverlight 4 tools, it also installs WCF RIA Services, which includes all of the functionality to make data easily accessible in Silverlight. WCF RIA Services includes support to generate needed middle-tier classes that run on the web service. These classes access data from the database and provide end points that the generated classes can access from a Silverlight application.

The first step is to create a data model that lives in the middle tier. You create data models using the ADO.NET Entity Framework classes that can be consumed by WCF RIA Services.

Once you have an ADO.NET Entity Framework data model available on the middle tier, you create highly extensible Domain Services that provide end-points for Silverlight. The Domain Service class provides services that make the Entities from the model available via a WCF end-point. This approach provides a robust programming model in order to perform CRUD operations on the underlying database tables. You can program against domain entities using LINQ to Objects. You can also add additional methods to the Domain Services that implement business logic without breaking the model or the code generation.

Connecting the endpoints to make the Entity classes available in Silverlight is very simple because the WCF RIA Services framework automatically generates Silverlight client-side code to access the Domain Service end-points for "linked" Silverlight applications. When you install WCF RIA Services, it modifies the New Silverlight Application Wizard and the Silverlight project properties to include an Enable WCF RIA Services checkbox. Enabling WCF RIA Services connects a Silverlight application to the middle tier hosting the related Domain Services.

Once on the client, you can write code to instantiate a `DomainContext`, which keeps track of changes as you access and updates Entities in Silverlight.

The Code

First, create a Silverlight application and check the Enable WCF RIA Services checkbox to establish the WCF RIA Link. You can verify this by looking at the Silverlight tab in the project properties for Recipe 9-4 as shown in Figure 9-8.

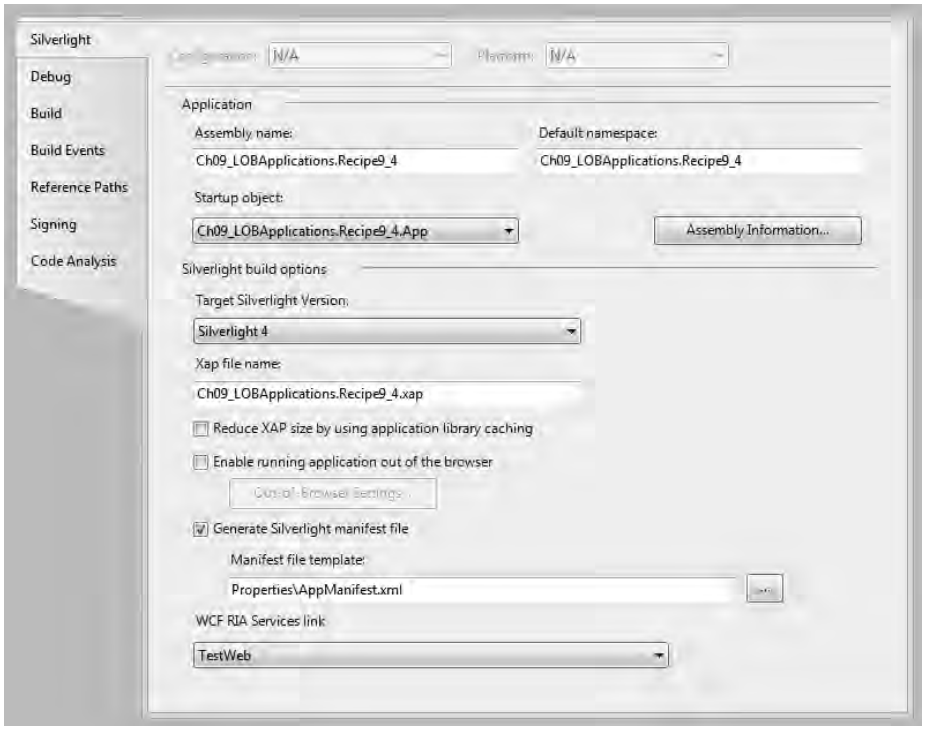


Figure 9-8. *Silverlight application properties with the WCF RIA Services link property highlighted*

When the WCF RIA Services link is established, any domain services created in the TestWeb web application are made available within the Silverlight project via the code-generation functionality built into the WCF RIA Services framework. Figure 9-9 shows the Solution Explorer tool window for Recipe 9-4 with hidden files and folders displayed and all folders expanded.

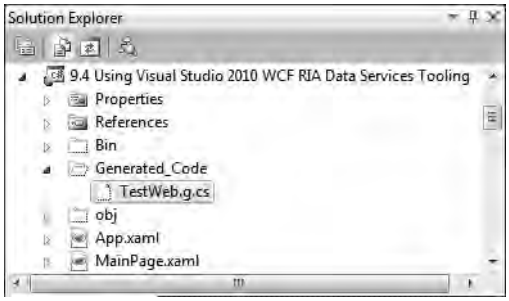


Figure 9-9. *Recipe 9-4 project contents*

With hidden folders displayed, you see a folder named `Generated_Code` with a generated code file named `TestWeb.g.cs`. This code file is brought in via WCF RIA Services code generation and is linked to the `TestWeb` web project, which is also where the file gets its default name of `TestWeb.g.cs`. The contents are auto-generated, not doing much more than establishing the WebContext, which makes web application services such as authentication, authorization, etc. available in a Silverlight application

Now, shift gears to the middle tier and leave your Silverlight application ready to receive the automatically generated client-side code. You will create an Entity Framework data model that contains all of the available entities and then create a Domain Service to access it. First, create two folders named `DataModel` and `DomainService` to hold the Entity Framework model and Domain Services, respectively.

Right-click on the data model folder and select Add New Item to bring up the project items dialog. Click Data on the left to filter the project items available and select ADO.NET Entity Data Model. Name it `Northwind.edmx` and click Add to bring up the Entity Data Model Wizard. Select Generate from database and click Next. Click New Connection… to create a new database connect to the Northwind database or select an existing connection if present. Note that the connection string is saved to the `Web.config` file so you can edit this file as the project is moved between a development, test, and production environment.

In the Choose your Database Objects page of the wizard, select all tables, and click Finish, accepting the defaults. This results in the model shown in Figure 9-10.

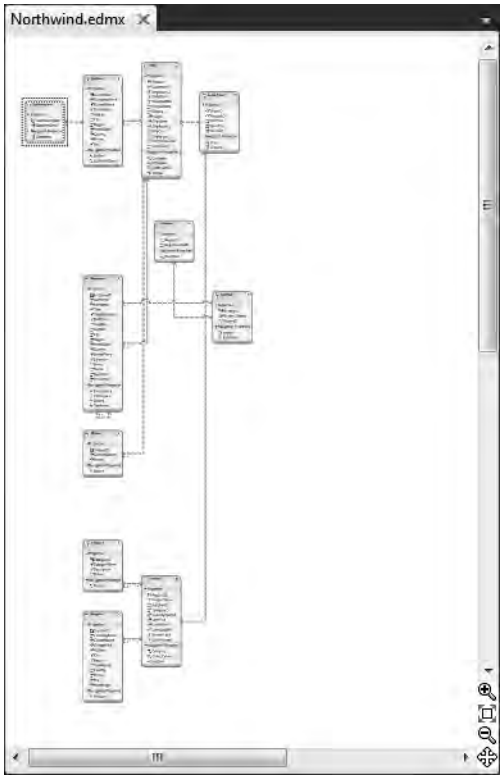


Figure 9-10. *Recipe 9-4 data model*

■ **Note** The ADO.NET Entity Framework is a very powerful object to relational modeling tool. For more information on the ADO.NET Entity Framework, please go to msdn.microsoft.com/data/.

You are not going to customize the data model any further. Instead, create the Domain Service by first compiling the project. Compiling the project makes the newly created data model available so that the Add New Domain Service Class wizard can detect that it is available and thus create the service. The newly created service makes the Person Entity available to the Silverlight application. Right-click on the Domain Service folder, select Add | New Item…, and click on Web to filter the project templates so that the Domain Service Class item template is visible. Give it a name of `NorthwindSimpleDomainService` and click Add. This brings up the Add New Domain Service Class wizard as shown in Figure 9-11.

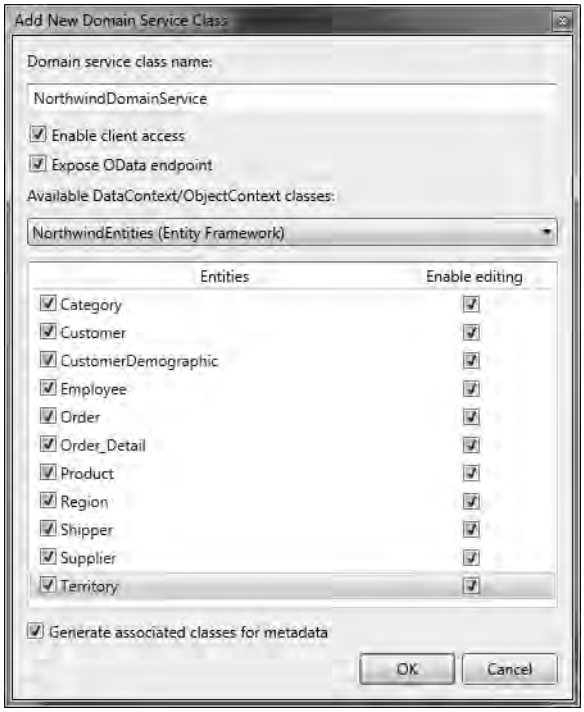


Figure 9-11. *Recipe 9-4 new domain service*

Check all of the options available to generate a read-only OData endpoint, enable editing on all of the available entities in WCF RIA Services, and generate associated classes for metadata. This results in two additional class files and an updated `Web.config` file in the TestWeb project. The two new class files are `NorthwindDomainService.cs` and `NorthwindDomainService.metadata.cs` in the `DomainService` folder.

The `NorthwindDomainService.cs` file is the new domain service. It contains the methods shown in Figure 9-12.

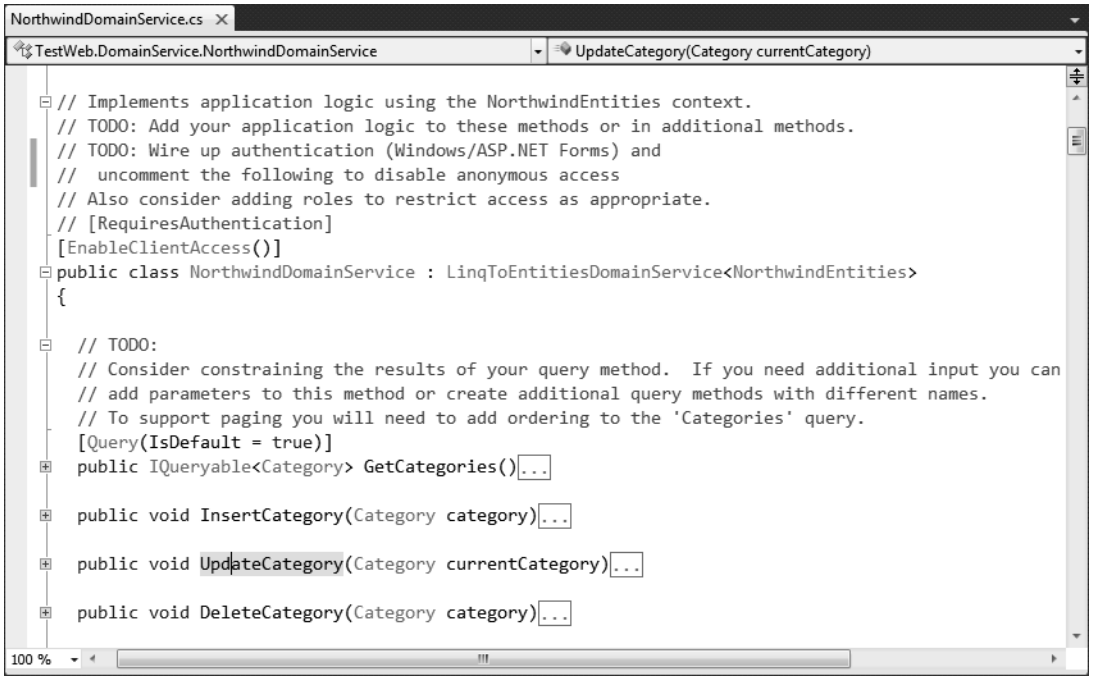


Figure 9-12. *NorthwindDomainService with collapsed methods*

The generated code provides methods to get a list of the various entities as well as methods to perform CRUD actions on entities. As the comments note in Figure 9-12, you can customize the methods, add methods, etc., as needed to build your domain service. So, add a method called `GetCustomersByCity` to return a list of Customers whose `City` starts with the passed in string:

```
public IQueryable<Customer> GetCustomersByCity(string value)
{
  var customerlist = from c in this.ObjectContext.Customers
                     where c.City.StartsWith(value)
                     select c;

  return customerlist;
}
```

The other generated class, `NorthwindDomainService.metadata.cs`, contains the metadata class for the `Person` entity. Figure 9-13 shows the top portion of the class declaration.

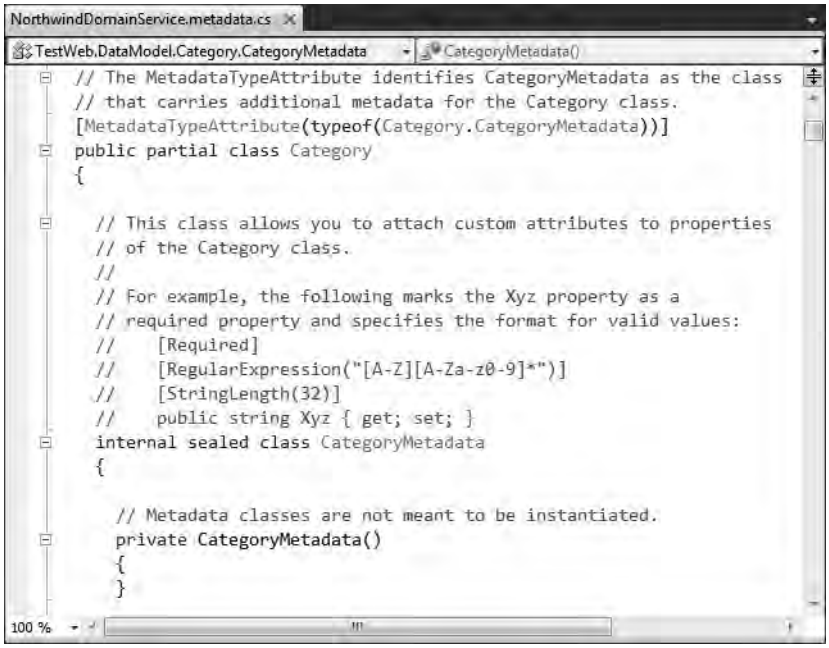


Figure 9-13. *NorthwindDomainService with collapsed methods*

For more detail on how to modify these files, such as how to add custom query methods to the Domain Service and to add validation to the metadata class, see the previous recipe. For this recipe, you now switch your focus to the client-side generated code in `TestWeb.g.cs`, located in the hidden folder of the `Generated_Code` folder of the Silverlight project.

After establishing the WCF RIA Link between Recipe 9-4 and `TestWeb`, and then creating the Adventure Works Domain Service, you build the project. The `TestWeb.g.cs` file in the Recipe 9-4 Silverlight project now has client-side code to allow access to your Northwind Data Model containing the imported entities available in the Northwind Data Model.

You create a simple UI of a `DataGrid` and write some code to databind it to the client-side generated code manually. You drag a `DataGrid` on to `MainPage.xaml` and name it `CustomersDataGrid`. In the codebehind, add two `using` clauses to bring in the client-side generated code:

```
using TestWeb.DomainService;
using TestWeb.DataModel;
```

Next, modify the `MainPage()` constructor to manually call into the WCF RIA Services generated code. Here is the code:

```
public MainPage()
{
  InitializeComponent();

  NorthwindDomainContext context = new NorthwindDomainContext();
```

```
  CustomersDataGrid.ItemsSource = context.Customers;
  context.Load<Customer>(context.GetCustomersQuery());
}
```

Create an instance of the domain context, databind the `CustomersDataGrid` to the Customers entity collection, and then call Load on the `NorthwindDomainContext`, passing in the appropriate query resulting in the customer data loading as shown in Figure 9-14.

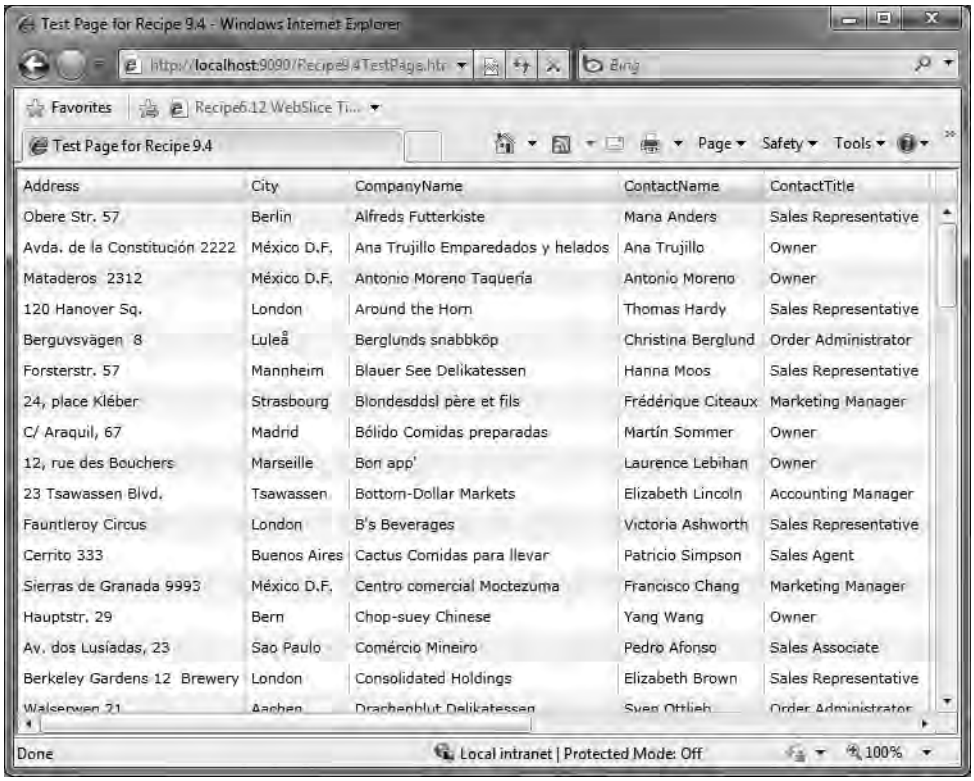


Figure 9-14. *Recipe 9-4 Final UI*

9-5. Taking Advantage of the Business Application Template

Problem

You need a UI framework and development model as a base for building a LOB application.

Solution

Create a project using the Business Application Template and take advantage of WCF RIA Services.

How It Works

Prior to WCF RIA Services, you had to write a lot of custom code to build a robust LOB application in Silverlight. With Silverlight 4 and WCF RIA Services, you can take advantage of powerful built-in functionality to build a LOB application framework.

When you install WCF RIA Services, it adds a new project template called Silverlight Business Application. The Silverlight Business Application template is built on top of the Silverlight 4 Navigation Application template, which includes support for page navigation. The Business Application template with page navigation facilitates creating a UI that implements different data forms or views on the data with a basic menu system.

The Business Application template includes support for WCF RIA Services by default. The application template also includes starter application services for user authentication and user profile services.

The Code

Although you make some additions to the generated code that is highlighted in this recipe, there are no code files other than the default code generated by the Silverlight Business Application project template. We cover the generated code in detail for this recipe as a baseline for the recipes in the rest of this chapter. Also, because the Silverlight Business Application template is based on the Silverlight Navigation Application Project, which is covered in Recipe 6-10, we do not go into detail about the page navigation and other functionality brought in by that application template.

The Silverlight Business Application template defines the WCF RIA Link between the Silverlight application and the web application. When the WCF RIA Link is established, any domain services created in the TestWeb web application are made available within the Silverlight project via the code-generation functionality built into the WCF RIA Services framework. Figure 9-15 shows the Solution Explorer tool window for Recipe 9-5, with the Silverlight application on the left and the Recipe 9.5.Web project on the right.

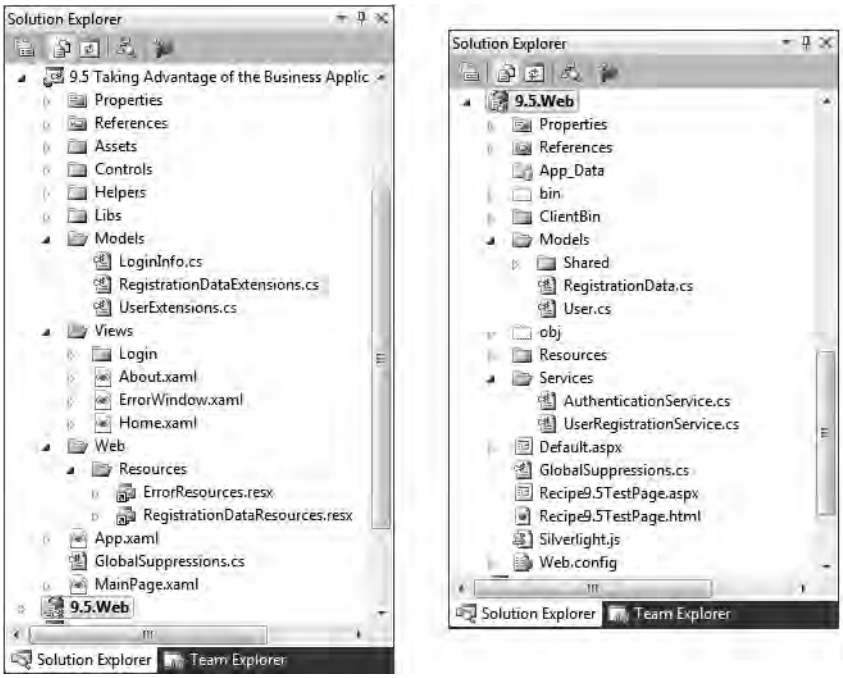


Figure 9-15. *Silverlight Business template and Web site default files and folders*

You see the typical project layout for the Silverlight Navigation template with the `Assets` and `Views` folders along with `App.xaml` and `MainPage.xaml`. You also see the standard contents for a web project, including the output from a linked Silverlight application. The Silverlight Business Application project template adds a new folder named `Services` with two code files: `AuthenticationService.cs` and `UserRegistration.cs`. These two code files contain starter-service functionality typical in a LOB application for authentication, user profile information management, and user registration.

The `AuthenticationService.cs` file represents a simple domain service for authentication in an RIA Services application. This item template includes two class instances based on classes provided by the WCF RIA framework in the `System.ServiceModel.DomainServices.Server.ApplicationService` namespace: `AuthenticationBase` implements a basic contract for authentication via a domain service.

As you can see, the Silverlight Business project includes quite a bit of code. We don't go through it all here because it is automatically generated code but we provide some highlights on extensibility.

Since the Business Application template leverages the ASP.NET services for authentication, profile, and role management, you can customize that functionality to work just like you can in ASP.NET. For example, you can customize authentication to use either Forms authentication or Windows authentication.

In the Recipe 9-5 hidden folder `Generated_Code`, there is a file named `Ch09_LOBApplications.Recipe9_5.Web.g.cs`, which represents the code generated by WCF RIA Services for code in the web project marked with the attribute `[EnableClientAccess]`. When you open the `Ch09_LOBApplications.Recipe9_5.Web.g.cs` to review its contents, you see the WebContext singleton. If you take a look at this variable in IntelliSense, you see the list in Figure 9-16.

Figure 9-16. *WebContext methods and properties*

Looking at the Authentication property, you can see that this is how you can access authentication-related information on the current user as shown in Figure 9-17.

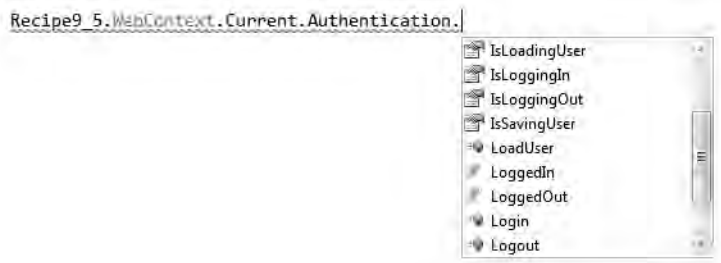


Figure 9-17. *Authentication property methods and properties*

The code `Recipe9_5.WebContext.Current.User` has methods and properties such as `IsAuthenticated`, a `Roles` collection, and an `IsInRole` method to implement role-based authorization. Again, if you are familiar with how this functionality works and is managed in ASP.NET, you are well prepared for implementing it in Silverlight. If this functionality is new to you, we highly recommend checking out the ASP.NET documentation.

The rest of the template is focused on implementing basic building block UI based on the Silverlight Navigation Application template, which is discuss in Recipe 9-10.

9-6. Databinding in XAML

Problem

You prefer to databind controls without writing a large amount of code.

Solution

Take advantage of the Silverlight controls that enable codeless databinding in XAML such as the `DomainDataSource` control.

How It Works

Although the application services (such as authentication, registration, and profile support) that the default Business Application template provides are very useful, WCF RIA Services are all about easily providing data to a Silverlight application.

WCF RIA Services includes the `DomainService` class for the middle tier as covered in Recipe 9-2 and 9-3 so we will not repeat it. However, as quick background, we have an ADO.NET Entity Framework model for the Northwind database as well as a Northwind Data Service.

In previous recipes, you performed all databinding in code. In this recipe, you leverage the `DomainDataSource` XAML control for the presentation tier to manage data flow in the application.

The Code

The first thing you do is open the Recipe 9-6 properties dialog and enable the WCF RIA Services link for the TestWeb project, save the project settings, and then recompile.

Drag a `DomainDataSource` control and a `DataGrid` on to the MainPage canvas. You want to display customers from the `Northwind` database so you name them `CustomersDomainDataSource` and `CustomersDataGrid`, respectively.

To connect the `DomainDataSource` to the Northwind Domain Service, you need to bring the `NorthwindDomainContext` into `MainPage.xaml`. You do this by adding a namespace:

```
xmlns:NorthwindData="clr-namespace:TestWeb.DomainService"
```

Next, add a resource on to the page to make the `NorthwindDomainContext` available in XAML and then configure your `DomainDataSource` and `DataGrid` as shown in Listing 9-3:

Listing 9-3. *The Recipe 9-6 MainPage.Xaml File*

```
<UserControl x:Class="Ch09_LOBApplications.Recipe9_6.MainPage"
    xmlns:dataControls=
       "clr-namespace:System.Windows.Controls;assembly=
        System.Windows.Controls.Data"
    xmlns:sdk="http://schemas.microsoft.com/winfx/2006/xaml/presentation/sdk"
    xmlns:riaControls=
       "clr-namespace:System.Windows.Controls;assembly=
       System.Windows.Controls.DomainServices"
    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:NorthwindData="clr-namespace:TestWeb.DomainService"
    mc:Ignorable="d"
    d:DesignHeight="300" d:DesignWidth="400">
    <UserControl.Resources>
        <NorthwindData:NorthwindDomainContext
         x:Key="NorthwindDomainContext" />
    </UserControl.Resources>
    <Grid x:Name="LayoutRoot" Background="White">
```

```
        <riaControls:DomainDataSource x:Name="CustomersDomainDataSource"
            DomainContext="{StaticResource NorthwindDomainContext}" AutoLoad="True"
            QueryName="GetCustomersQuery" />
        <sdk:DataGrid x:Name="CustomersDataGrid" ItemsSource=
         "{Binding Data, ElementName=CustomersDomainDataSource, Mode=TwoWay}"  />
    </Grid>
</UserControl>
```

To configure the `DomainDataSource`, you set the `DomainContext` to the `NorthwindDomainContext StaticResource`. Please note that it is easy to make a mistake and configure this to the `DataContext` when configuring databinding. This is incorrect. In order to have the customer data load properly, you browse the `Ch09_LOBApplications.Recipe9_6.Web.g.cs` code generated file to find the method `GetCustomersQuery` and configure that on the `QueryName` property. You also tell the control to `AutoLoad` by setting that property to `True`.

To configure the `DataGrid`, you databind its `ItemSource` property to the `Data` property on the `CustomersDomainDataSource object`. Running the code results in Figure 9-18.

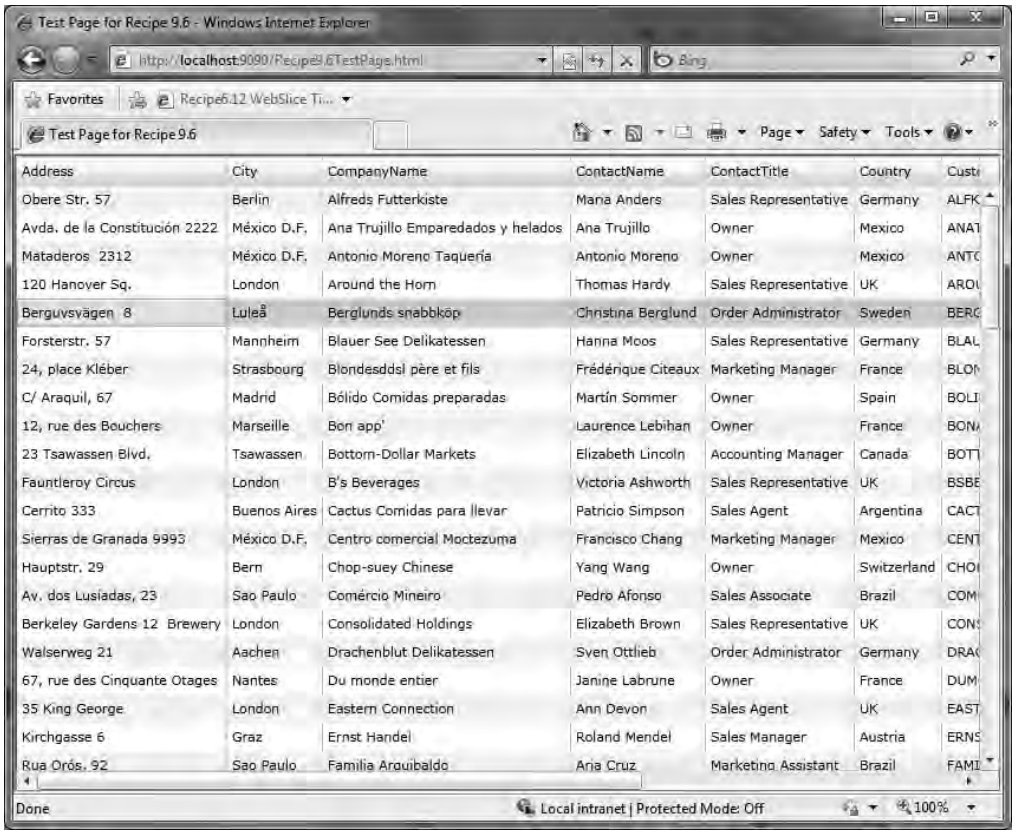


Figure 9-18. *No-code XAML databinding in action*

9-7. Navigating RIA LOB Data

Problem

You have a large amount of data in an application for end users to navigate.

Solution

Take advantage of paging, sorting, and filtering in Silverlight 4 to help end users navigate data.

How It Works

You take advantage of properties like `DomainDataSource.PageSize` as well as add additional controls like the `DataPager` to implement paging. The `DataPager` is databound to the same `DomainDataSource` as the `DataGrid` in order to enable paging.

In order to enable sorting and arranging the columns of data, configure the `CanUserSourtColumns`, `CanUserReorderColumns`, and `CanUserResizeColumns` to `true` for the `DataGrid` object.

To configure Filtering, take advantage of the `FilterDescriptor` object on the `DomainDataSource` control as demonstrated in the next section.

The Code

First, open the Recipe 9-7 properties dialog and enable the WCF RIA Link for the TestWeb project, save the project settings, and then recompile. Then, copy the code from Recipe 9-6 where you databind via XAML as your starting point for this recipe.

The first modification you make is to add `PageSize="5"` to the Customer table `DomainDataSource` control, which results in five records displayed in the Customer `DataGrid`. Next, add a `DataPager` to the UI to allow record navigation. To enable the `DataPager`, you first need to set its Source Property to the same value as what is configured for the DataGrid. You also set the PageSize="5" in order to page through the data five records at a time.

Unless databinding to a collection class that implements `IPagedCollectionView`, you must sort the data. In most cases, you will databind to an `IEnumerable` collection, so configuring a `SortDescriptor` on the `DomainDataSource` is required for the `DataPager` to function. You configure the Customer table data to sort on the CustomerName field.

Configuring user-enabled sorting is very easy to do for the `DataGrid`; you simply set `CanUserSortColumns` to `True`. You also set `CanUserReorderColumns` and `CanUserResizeColumns` to `True` to add more UI flexibility.

The last feature that you want to add in this recipe is record filtering. Add a `TextBlock` to the top of the UI to prompt users to enter a few letters to filter, and add a `TextBox` to enter the filter text. Next, configure the `DomainDataSource` with a `FilterDescriptor`. You configure the `FilterDescriptor` to filter on a `PropertyPath` of `CompanyName` data field with an `Operator` of "`StartsWith`." You databind the Value field on the `FilterDescriptor` to the Text property of the `FilterTextBox` element. If a user enters the letter "c" in the `FilterTextBox` field, the data is automatically filtered down to just the `CompanyNames` that start with c. Listing 9-4 has the XAML for Recipe 9-7.

Listing 9-4. *The Recipe 9-7 MainPage.Xaml File*

```
<UserControl x:Class="Ch09_LOBApplications.Recipe9_7.MainPage"
    xmlns:dataControls=
```

```
       "clr-namespace:System.Windows.Controls;assembly=System.Windows.Controls.Data"
    xmlns:riaControls=
       "clr-
namespace:System.Windows.Controls;assembly=System.Windows.Controls.DomainServices"
    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:NorthwindData="clr-namespace:TestWeb.DomainService"
    mc:Ignorable="d" d:DesignWidth="600"
    xmlns:sdk="http://schemas.microsoft.com/winfx/2006/xaml/presentation/sdk"
xmlns:toolkit="http://schemas.microsoft.com/winfx/2006/xaml/presentation/toolkit"
d:DesignHeight="600”>
  <UserControl.Resources>
    <NorthwindData:NorthwindDomainContext x:Key="NorthwindDomainContext" />
  </UserControl.Resources>
  <Grid x:Name="LayoutRoot" Background="White">
    <Grid.RowDefinitions>
      <RowDefinition Height="34" />
      <RowDefinition Height="36" />
      <RowDefinition Height="*" />
    </Grid.RowDefinitions>
    <riaControls:DomainDataSource x:Name="CustomersDomainDataSource"
            DomainContext="{StaticResource NorthwindDomainContext}"
            AutoLoad="True" QueryName="GetCustomersQuery" Grid.RowSpan="4">
      <riaControls:DomainDataSource.SortDescriptors >
        <riaControls:SortDescriptor PropertyPath="CompanyName"
                                          Direction="Ascending"/>
      </riaControls:DomainDataSource.SortDescriptors>
      <riaControls:DomainDataSource.FilterDescriptors>
        <riaControls:FilterDescriptor PropertyPath="CompanyName"
                                            Operator="StartsWith"
                    Value="{Binding Text, ElementName=FilterTextBox}" />
      </riaControls:DomainDataSource.FilterDescriptors>
    </riaControls:DomainDataSource>
    <sdk:DataPager  PageSize="5" Height="28"
          VerticalAlignment="Top"  Grid.Row="1" Margin="0,3,0,0"
          Source="{Binding Data, ElementName=CustomersDomainDataSource, Mode=TwoWay}" />
    <sdk:DataGrid x:Name="CustomersDataGrid" Grid.Row="2"
          Height="134" VerticalAlignment="Top" CanUserSortColumns="True"
          CanUserReorderColumns="True" CanUserResizeColumns="True"
          ItemsSource="{Binding Data, ElementName=CustomersDomainDataSource, Mode=TwoWay}"
/>
    <TextBlock Height="29" Name="textBlock1" VerticalAlignment="Top"
          LineHeight="13.333" FontSize="13.333" HorizontalAlignment="Left"
```

```
          Width="355" Margin="0,4,0,0"
          Text="Enter The First Few Letters  of the Company Name:"  />
    <TextBox x:Name="FilterTextBox" HorizontalAlignment="Right"
          Margin="0,4,8,1" TextWrapping="Wrap" Width="233"
d:LayoutOverrides="VerticalAlignment"/>
  </Grid>
</UserControl>
```

Figure 9-19 has the UI for Recipe 9-7.

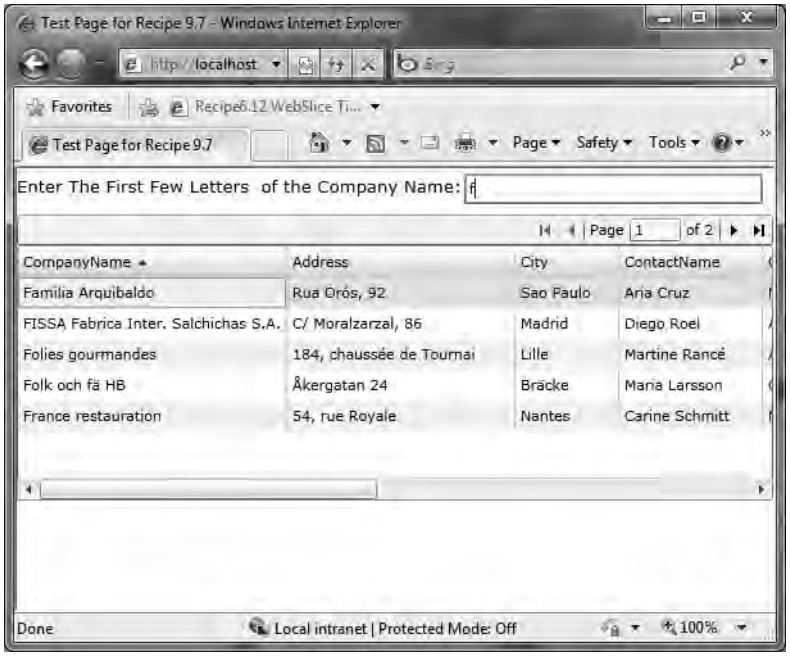


Figure 9-19. *Final UI for Recipe 9-7*

9-8. Implementing CRUD Operations in RIA Services

Problem

You need to implement CRUD operations on LOB data that includes complicated business logic.

Solution

Take advantage of WCF RIA Services features to support CRUD operations in a customizable way.

How It Works

You build on Recipe 9-7's code, updating the layout a bit, adding a button, and adding the star of the recipe: the `DataForm` control. This is a very powerful record details editing control that enables all CRUD operations directly. It can be templated and customized from a UI perspective as well. For this recipe, you introduce the control and focus on how to allow edits to happen on the client but control when edits are sent to the server.

The Code

You start this recipe by opening the Recipe 9-8 properties dialog, enabling the WCF RIA Services link for the TestWeb project, saving the project settings, and then recompiling. Then copy the code from Recipe 9-7 where you databind via XAML and add sorting and paging as your starting point for this recipe.

Adjust the root `Layout Grid` and position on the filtering `TextBox` for space to add a `Button` that commits any edits to the server via WCF RIA Services. Next, add a `DataForm` control. The `DataForm` control can bind to either a collection of records or a single record. In this example, you want the `DataForm` to provide a details view of the selected record in the `DataGrid`.

To enable this, databind the `DataForm.CurrentItem` property to the `DataGrid's SelectedItem` property via Element databinding. Listing 9-5 has the XAML file code listing.

Listing 9-5. *The Recipe 9-8 MainPage.Xaml File*

```
<UserControl  x:Class="Ch09_LOBApplications.Recipe9_8.MainPage"
   xmlns:dataControls=
    "clr-namespace:System.Windows.Controls;assembly=System.Windows.Controls.Data"
    xmlns:riaControls=
    "clr-namespace:System.Windows.Controls;assembly=System.Windows.Controls.DomainServices"
    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:NorthwindData="clr-namespace:TestWeb.DomainService"
    mc:Ignorable="d"
    d:DesignHeight="600" d:DesignWidth="600"
    xmlns:sdk="http://schemas.microsoft.com/winfx/2006/xaml/presentation/sdk"
    xmlns:dataFormToolkit=
     "clr-
namespace:System.Windows.Controls;assembly=System.Windows.Controls.Data.DataForm.Toolkit">
  <UserControl.Resources>
    <NorthwindData:NorthwindDomainContext x:Key="NorthwindDomainContext" />
  </UserControl.Resources>
  <Grid x:Name="LayoutRoot" Background="White" ShowGridLines="False">
    <Grid.RowDefinitions>
      <RowDefinition Height="34" />
      <RowDefinition Height="36" />
      <RowDefinition Height="160" />
      <RowDefinition Height="*" />
```

```
    </Grid.RowDefinitions>
    <riaControls:DomainDataSource x:Name="CustomersDomainDataSource"
            DomainContext="{StaticResource NorthwindDomainContext}"
            AutoLoad="True" QueryName="GetCustomersQuery" Grid.RowSpan="4">
      <riaControls:DomainDataSource.SortDescriptors >
        <riaControls:SortDescriptor PropertyPath="CompanyName"
                                          Direction="Ascending"/>
      </riaControls:DomainDataSource.SortDescriptors>
      <riaControls:DomainDataSource.FilterDescriptors>
        <riaControls:FilterDescriptor PropertyPath="CompanyName"
          Operator="StartsWith"
          Value="{Binding Text, ElementName=FilterTextBox}" />
      </riaControls:DomainDataSource.FilterDescriptors>
    </riaControls:DomainDataSource>
    <sdk:DataPager  PageSize="5" Height="28"
      VerticalAlignment="Top"  Grid.Row="1" Margin="0,3,0,0"
      Source="{Binding Data, ElementName=CustomersDomainDataSource, Mode=TwoWay}" />
    <sdk:DataGrid x:Name="CustomersDataGrid" Grid.Row="2" Margin="2"
      Height="160" VerticalAlignment="Top" CanUserSortColumns="True"
      CanUserReorderColumns="True" CanUserResizeColumns="True"
      ItemsSource="{Binding Data,
       ElementName=CustomersDomainDataSource, Mode=TwoWay}" />
    <StackPanel Margin="0,4,7,0" Orientation="Horizontal" d:LayoutOverrides="Width">
      <TextBlock Height="29" x:Name="textBlock1" VerticalAlignment="Top"
       LineHeight="13.333" FontSize="13.333" HorizontalAlignment="Left"
         Width="355"
                Text="Enter The First Few Letters  of the Company Name:"
TextAlignment="Center"  />
      <TextBox x:Name="FilterTextBox" TextWrapping="Wrap" Width="73"
         Margin="0,2,0,4"/>
      <Button Content="Save To Server" Height="28" HorizontalAlignment="Left"
        Margin="30,0,0,0" x:Name="ButtonCommitToServer"
        VerticalAlignment="Top"
        Width="118" IsEnabled="True" Click="ButtonCommitToServer_Click" />
    </StackPanel>
    <toolkit:DataForm Margin="2" Grid.Row="3" x:Name="CustomerDataForm"
     CurrentItem="{Binding SelectedItem, ElementName=CustomersDataGrid,
                  Mode=TwoWay}"
     AutoCommit="False" AutoEdit="False" Header="Customer Details" />
  </Grid>
</UserControl>
```

Initially, when you drop the `DataForm` control onto the `Grid` and databind it to the `DataGrid`, `AutoEdit` defaults to `True` as does the `AutoCommit` property. Configure both `AutoEdit` and `AutoCommit` to false to

gain more control over how edits are processed. This also enables the additional button editing UI on the `DataForm` control as shown in Figure 9-20.

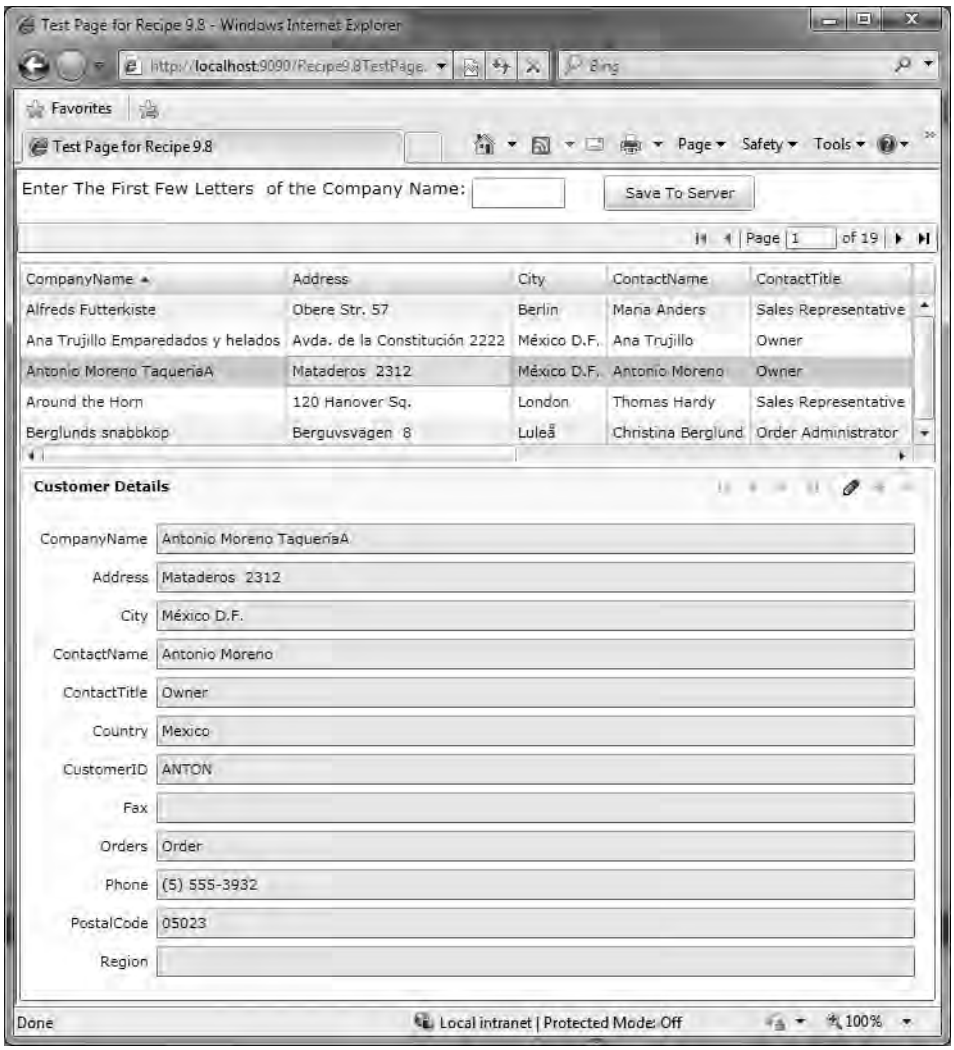


Figure 9-20. *Final UI for Recipe 9-8*

Clicking the Edit button (the pencil) on the Customer Details DataForm control allows the user to perform CRUD operations. You configure the control explicitly to display all of the buttons in the constructor for `MainPage` after Initialization. The only other item to cover is the Save to Server button. When you perform edits using the DataForm, they exist on the client in the form of changes to the object representing each database record. Because you disabled `AutoCommit`, you need to manually send any pending changes, as shown in Listing 9-6.

Listing 9-6. *Recipe 9-8 MainPage.Xaml.cs File*

```
using System.Windows;
using System.Windows.Controls;

namespace Ch09_LOBApplications.Recipe9_8
{
  public partial class MainPage : UserControl
  {
    public MainPage()
    {
      InitializeComponent();
      CustomerDataForm.CommandButtonsVisibility =
        DataFormCommandButtonsVisibility.All;
    }

    private void ButtonCommitToServer_Click(object sender, RoutedEventArgs e)
    {
      if (CustomersDomainDataSource.HasChanges &&
          !CustomersDomainDataSource.IsBusy)
        CustomersDomainDataSource.SubmitChanges();
    }
  }
}
```

9-9. Data Validation through Data Annotation

Problem

You need to implement data validation within your Silverlight LOB application.

Solution

Take advantage of Data Annotations via attributes in Silverlight 4 to implement data validation.

How It Works

When you add a Domain Service to a web project, you have the option of generating a metadata class. The metadata class is a partial class that allows developers to apply validation configuration without having to worry about the classes getting regenerated automatically if the underlying model changes.

The data annotations sit in the `System.ComponentModel.DataAnnotations` namespace. There are three categories of attributes in this namespace that can be applied to entities, validation attributes, display attributes, and data modeling attributes. Table 9-1 has a list of the validation attributes that can be applied to entities via the metadata class.

Table 9-1. *Path Context Menu Suboptions*

Submen Attribute	Description
CustomValidationAttribute	Allows the developer to identify a custom method in code to validate a property. This is an alternative to creating a custom validation attribute.
DataTypeAttribute	Has a related enumeration named DataType that has pre-configured data types on it such as EmailAddress, Phone, etc.
EnumDataTypeAttribute	Validates the value configured on a property to ensure it is part of the identified enumeration type.
RegularExpressionAttribute	Allows the developer to specify a regular expression for validation.
RequiredAttribute	Identifies that the property is required.
StringLengthAttribute	Specifies a minimum and maximum character length.
ValidationAttribute	Abstract base class for validation attributes.

The two available extension points for developers are to create a custom validation attribute that inherits from the `ValidationAttribute` base class or create a custom class method and designate that method using the `CustomValidationAttribute` class.

The Code

For the code, you proceed as before by establishing the WCF RIA Link in the project properties (as in Recipe 9-7 and 9-8). You also copy the UI code from Recipe 9-8 to have a working UI to start out. You generated a metadata class for the Customers Domain Service in Recipe 9-4 so you will edit Customer domain service metadata class.

The file `NorthwindDomainService.metadata.cs` contains the metadata classes for the NorthwindDomain Service. If you search in that file, you will find an `internal sealed` class named `CustomerMetadata`. You apply the `[Required]` attribute to a number of properties. You also apply the `[DataType(DataType.PhoneNumber)]` attribute to the `Fax` and `Phone` fields. Listing 9-7 shows the code.

Listing 9-7. The Recipe 9-9 MainPage.Xaml File

```
internal sealed class CustomerMetadata
{
  // Metadata classes are not meant to be instantiated.
  private CustomerMetadata()
  {
  }
```

```
  [Required]
  public string Address { get; set; }

  [Required]
  public string City { get; set; }

  [Required]
  public string CompanyName { get; set; }

  [Required]
  public string ContactName { get; set; }

  [Required]
  public string ContactTitle { get; set; }

  [Required]
  public string Country { get; set; }

  public EntityCollection<CustomerDemographic> CustomerDemographics { get; set; }

  [Required]
  public string CustomerID { get; set; }

  [Required,DataType(DataType.PhoneNumber)]
  public string Fax { get; set; }

  public EntityCollection<Order> Orders { get; set; }

  [Required, DataType(DataType.PhoneNumber)]
  public string Phone { get; set; }


  public string PostalCode { get; set; }


  public string Region { get; set; }
}
```

Figure 9-21 shows the validation in action with the automatically generated error message at the bottom.

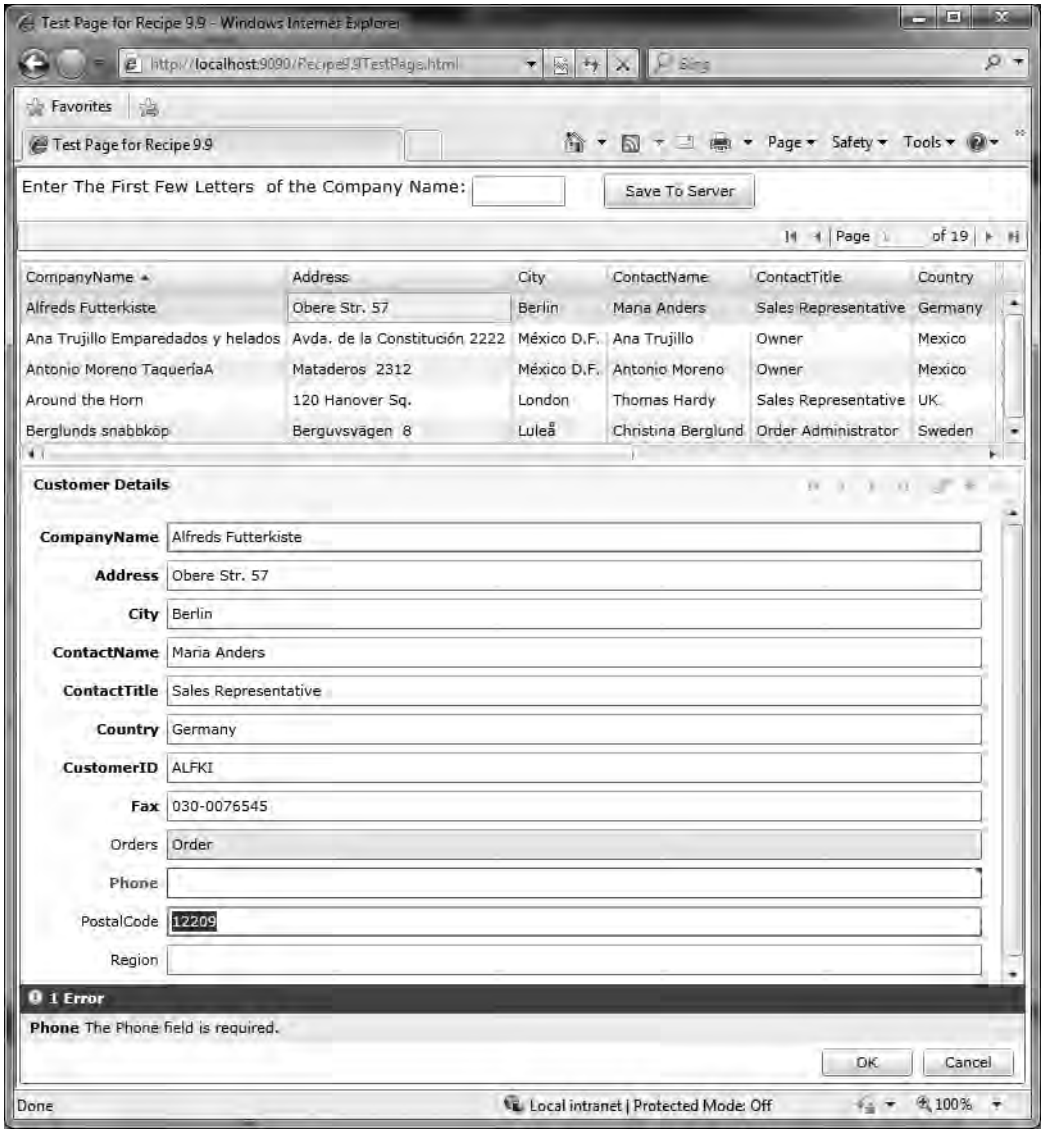


Figure 9-21. *Final UI for Recipe 9-9*

9-10. Printing in a Silverlight LOB Application

Problem

You need to support printing in your Silverlight application.

Solution

Take advantage of the new printing support available in Silverlight 4.

How It Works

Users can leverage the browser printing capabilities to print Silverlight applications in Silverlight 3 but there are many situations where LOB applications need to have customized printing. Silverlight 4 includes the new `PrintDocument` class to provide printing capabilities to Silverlight applications.

After you add a `PrintDocument` object to the application, you can call the `Print()` method in a `Button` event handler. It is required that all dialog boxes in Silverlight must be user-initiated, otherwise a `SecurityException` will occur.

To perform the print operation, you handle the `PrintPage` event for the PrintDocument object. In the `PrintPage` event handler, set the `PrintPageEventArgs.PageVisual` property to the root `UIElement` that you want to print. So, if you want to print a single object like a `DataGrid`, you can set it on the `PageVisual` property. If you want to print a whole set of controls configured on a `Grid`, you set the `PageVisual` property to the Grid and all of its child controls will be printed as well.

To print multiple pages, you can set the `PrintPageEventArgs.HasMorePages` to `true` and the `PrintPage` event will fire again until `HasMorePages` is set to `false`. If you need to print a multi-page document, you can handle the `BeginPrint` event where you can page the data in a multipage document to the next page so that it is ready to be printed when `PrintPage` fires. You can perform post-printing clean up as well as check for errors in the `EndPrint` event.

The Code

To add printing support, you add a `using` clause for the `System.Windows.Printing` namespace. Next, declare an instance of the `PrintDocument` class and a few variables to keep track of current printing (`currentpagePrinting`) page and the page (`savedPageNum`) you should reset to after printing.

You wire up the `PrintPage` event to your `PrintDocument` variable, which is where most of the action happens. In the `PrintPage` event handler, you set the `PageVisual` value to the `CustomersDataGrid`. Next, you have some logic to page through the data in order to print out all of the records. Listing 9-8 has the code.

Listing 9-8. *The Recipe 9-10 MainPage.Xaml.cs File*

```
using System;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Printing;

namespace Ch09_LOBApplications.Recipe9_10
{
```

```
public partial class MainPage : UserControl
{
  PrintDocument pd = new PrintDocument();
  int currentpagePrinting = 1;
  int savedPageNum = 0;

  public MainPage()
  {
    InitializeComponent();
    CustomerDataForm.CommandButtonsVisibility =
        DataFormCommandButtonsVisibility.All;

    pd = new PrintDocument();
    pd.PrintPage +=
      new EventHandler<PrintPageEventArgs>(pd_PrintPage);
  }

  void pd_PrintPage(object sender, PrintPageEventArgs e)
  {
    e.PageVisual = CustomersDataGrid;
    if (currentpagePrinting <= CustomerPager.PageCount)
    {
      e.HasMorePages = true;
      currentpagePrinting++;
      CustomerPager.PageIndex = currentpagePrinting;
    }
    else
    {
      e.HasMorePages = false;
      CustomerPager.PageIndex = savedPageNum;
    }
    CustomersDataGrid.UpdateLayout();
  }

  private void ButtonCommitToServer_Click(object sender,
    RoutedEventArgs e)
  {
    if (CustomersDomainDataSource.HasChanges &&
        !CustomersDomainDataSource.IsBusy)
      CustomersDomainDataSource.SubmitChanges();
  }

  private void PrintButton_Click(object sender, RoutedEventArgs e)
  {
    pd.Print("Customer List");
```

```
      currentpagePrinting = 1;
      savedPageNum = CustomerPager.PageIndex;
      CustomerPager.PageIndex = 1;
      CustomersDataGrid.UpdateLayout();
    }
  }
}
```

For more information on multi-page printing, go to the Multipage printing lab at

```
channel9.msdn.com/learn/courses/Silverlight4/SL4BusinessModule6/SL4LOB_06_Printing_the_Sched
ule/
```

CHAPTER 10

Integrating Rich Media

If you are a developer or a digital content producer of any kind, you probably have already built or are thinking of building applications that integrate video, audio, or other kinds of digital media with the resulting end-user experience. The ability to integrate rich media into web applications is one of the strongest and most publicized features of Silverlight, and it is the focus of the recipes in this chapter.

Silverlight supports playing Windows Media Video (WMV) version 7 through version 9, including the Windows Media implementation of the Society of Motion Picture and Television Engineers (SMPTE) VC-1 high-definition video standard, as well as H.264 encoded media contained in an MP4 container structure, extending video format support to MP4 video as well as other MP4-derived containers such as H.264 encoded QuickTime video.

Silverlight also supports MPEG Layer-3 (or MP3) audio and audio encoded in the Advanced Audio Coding (AAC) format, but it is currently limited to the AAC LC variant for two-channel stereo sound only.

Silverlight supports playing both client-side and server-side playlists. Silverlight supports media acquisition over the HTTP and HTTPS protocols. You can use the Microsoft Media Server (MMS) protocol, Real Time Streaming Protocol (RTSP), or RTSP using TCP (RTSPT) for media access, but Silverlight falls back to using HTTP when it encounters these protocol schemes. Silverlight also supports accessing media through either progressive download or streaming mechanisms.

In this chapter, we discuss recipes that showcase the various media capabilities of Silverlight, especially those of a type named `MediaElement` that is central to Silverlight-based media integration. Along the way, you will build a video player that evolves incrementally over the recipes to highlight specific features. Although we focus on media-related types, APIs, and techniques, we assume that you are already familiar with the fundamentals of the programming model, XAML-based UI design, data binding, control design, and networking. Consequently, in explaining the code in the recipes in this chapter, we focus purely on the media-related aspects and rely on you to understand the aforementioned concepts wherever they are used. If you have not covered these topics in this book or elsewhere, we advise you to read Chapters 2, 3, 4, 5, and 7, which help you prepare for the recipes in this chapter.

10-1. Adding Video to a Page

Problem

You want to play some video on your page.

Solution

Add a `System.Windows.Controls.MediaElement` to the page, and use a `System.Windows.Media.VideoBrush` to render the video.

How It Works

At the heart of enabling rich media in Silverlight applications is an object called `MediaElement` from the `System.Windows.Controls` namespace. `MediaElement` behaves like a datasource for rich media in your application—you place a `MediaElement` in your XAML and connect your code to the media by specifying an URI for the actual media source. The `MediaElement` then starts playing the media on your page. `MediaElement` supports playing both video and audio in the formats mentioned in the chapter's introduction.

Using MediaElement

`MediaElement` implements various properties and events to allow fine-grained control of media playback. Here are some examples:

- You can track and control the progress of play and respond to various stages of download and buffering.
- You can set up various properties to control media playback, such as autoplay, volume, muting, and stretching.
- You can respond to embedded timeline markers in the media to take custom actions.

We look at the `MediaElement` API in more details in the next recipe when we build a complete player. This code snippet shows the `MediaElement` being used in XAML:

```
<MediaElement
  Source="http://localhost/SLBook/Ch10_RichMedia/Media/SuperSpeedway.wmv"
  AutoPlay="True" x:Name="medElem" Opacity="0.0"/>
```

The `Source` property points to the source of the media. In this case, the source is pointing directly to a Windows Media Video file that is progressively downloaded over HTTP. The `AutoPlay` property determines if the media starts playing immediately. When set to `True` for progressive download scenarios, the media starts playing almost immediately. In the case of streamed video, the media starts playing when a specified amount is buffered locally. When set to `False`, the `MediaElement.Start()` method needs to be invoked to start playing the media. You learn more about progressive download and streaming in later recipes.

VideoBrush

`MediaElement` renders video by default in a rectangular shape determined by the `Height` and the `Width` properties of the `MediaElement`. However, you may need to implement more complex designs, such as rendering video bounded by a shape like a `Rectangle` or a control like the `Border`. Silverlight defines a type called `VideoBrush` that can be connected to a `MediaElement` instance and then used to fill a shape or a control in the XAML with video.

This XAML snippet shows an example:

```
<Border CornerRadius="5,5,5,5" HorizontalAlignment="Stretch"
        VerticalAlignment="Stretch" BorderBrush="Black" BorderThickness="3">
  <Border.Background>
    <VideoBrush SourceName="medElem" Stretch="Fill"/>
  </Border.Background>
</Border>
```

This snippet uses a `Border` to bound the video and uses the `VideoBrush` to render the video as the `Border`'s background. The `SourceName` property of the `VideoBrush` points to the name of the `MediaElement` to use, and the `Stretch` property determines how the video is stretched to fill the area being painted with the `VideoBrush`.

Note that because the `MediaElement` renders the video itself, using a `VideoBrush` this way would normally cause the video to be displayed twice on your UI. The traditional approach is to hide the `MediaElement`'s default rendering and choose to use that of the `VideoBrush`. Because the `VideoBrush` can be used any place where any other kind of brush can be used, this approach gives you more control over where and how to display the video in the overall UI. We show how to hide the `MediaElement` later in the recipe's code.

If the `Stretch` property is set to `None`, the video is set to play, maintaining its original resolution and aspect ratio. This means that, depending on the dimensions of the container control in which the `VideoBrush` is rendering, the rendered video may be clipped. Figure 10-1 shows a 720p video clip playing in a `Border` with `Height` set to 400, `Width` also set to 400, and the `Stretch` property value of the `VideoBrush` set to `None`.

Figure 10-1. *720p video playing in 400×400 container with Stretch=None*

As you can see, the video maintains its original resolution of 1280×720 and its original aspect ratio of 16:9 as evident from the cropping.

If the `Stretch` property is set to `Fill`, the `VideoBrush` scales the video to fill the container exactly. The height and width are scaled independently to exactly match the height and the width of the container. This can cause the video to distort because the original aspect ratio is changed to fit the aspect ratio determined by the dimensions of the container. Obviously, if the container dimensions match the video's aspect ratio, you will avoid this. Figure 10-2 shows the result of `Stretch` set to `Fill` for a 16:9 clip playing inside a 400×400 `Border`. Note the obvious distortion in the video resulting from the scaling of 16:9 to 1:1.

Figure 10-2. *16:9 clip playing in a 400×400 container with Stretch=Fill*

When `Stretch` is set to `Uniform`, the video is scaled to fit completely along both of its dimensions within the container, but the aspect ratio is preserved as well. Unless the dimensions of the container result in an aspect ratio matching that of the video, the video does not completely fill the container along one of the dimensions. Figure 10-3 shows an example. If you compare Figure 10-3 to Figure 10-1, you see that in an attempt to maintain the aspect ratio, the video has expanded beyond the available height of the container; the text visible in Figure 10-1 is no longer visible in 10-3.

Figure 10-3. *16:9 clip playing in a 400×400 container with Stretch=Uniform*

The last available setting for `Stretch` is `UniformToFill`. When set, this causes the video to scale and completely fill the container, while maintaining the original aspect ratio. The result is that the video gets clipped along one of its dimensions, unless the container is exactly of the same aspect ratio.

Figure 10-4 shows an example.

Figure 10-4. *16:9 clip playing in a 400×400 container with Stretch=UniformToFill*

The Code

The code sample for this recipe plays a progressively downloaded 720p video clip. Listing 10-1 shows the XAML.

Listing 10-1. *XAML for a Page Playing a Media File*

```
<UserControl x:Class="Recipe10_1.MainPage"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    Width="400" Height="225">
    <Grid x:Name="LayoutRoot" Background="White">
    <MediaElement
    Source="http://localhost/SLBook/Ch08_RichMedia/Media/Amazon_1080.wmv"
      AutoPlay="True" x:Name="medElem" Opacity="0.0"/>
      <Border HorizontalAlignment="Stretch"
              VerticalAlignment="Stretch" BorderBrush="Black" BorderThickness="3">
        <Border.Background>
          <VideoBrush SourceName="medElem" Stretch="Fill"/>
        </Border.Background>
      </Border>
  </Grid>
</UserControl>
```

The page has a `Width` of 400 and a `Height` of 225, providing an aspect ratio of 16:9. The `Border` stretches to fill the entire page, and the `VideoBrush`'s `Stretch` property is set to `Fill`. This setup preserves the original aspect ratio of the clip.

Note that in order to avoid the video being displayed twice, you set `MediaElement.Opacity` to 0, so that you only see the video being rendered through the `VideoBrush` inside the `Border`.

Figure 10-5 shows the output.

Figure 10-5. *Video playing on a page*

10-2. Creating a Complete Video Player

Problem

You want to develop a video player with the following features:

- Standard play controls like play, pause, and stop
- Seek features like forward and rewind
- Volume control
- A video menu
- Multiple playing videos such as picture-in-picture
- Download and play progress notifications

Solution

Build a UI that provides elements to control these features and utilize the `MediaElement` API to implement the necessary code for the UI function.

How It Works

The `MediaElement` type exposes a rich API that makes it easy to implement most of the listed features in a fairly straightforward way. Let's start by taking a look at parts of this API. We continue to cover this API across some of the other recipes later in this chapter as well.

Acquiring Media

`MediaElement` can acquire media through both progressive download and streaming methods. All media players have historically supported the download-and-play mechanism of playing media, where the entire media is first downloaded to the client before play can be started. However, this is cumbersome

and time consuming, especially for large media files, because the user has to wait to start watching until the download has completed.

With the advancement of storage file-format technologies in most of the modern media file formats, including Windows Media, it is now possible for most types of media to be played almost instantaneously. With this feature, called *progressive download*, a player starts playing the media as soon as the first few seconds of the media are downloaded, while the download continues in the background. Progressive download is carried over HTTP, and any modern web server, including Microsoft Internet Information Services (IIS), can be used as a media server.

Streaming is another technique used to deliver media to a player. Streaming does not require downloading the media file locally, and it is well suited for scenarios involving either live or on-demand broadcasts to a large population of viewers.

This recipe uses progressive download as the media-acquisition technique for the code sample shown later. We discuss streaming in Recipe 10-3.

To have a `MediaElement` progressively download and play media, you can point the `Source` property to the HTTP location of the media in XAML, as shown in Recipe 10-1. You can obviously do this in code as well, in scenarios where the URI is possibly only known to you at runtime.

Alternatively, you can use the `MediaElement.SetSource()` method in your code to specify the media to be played. One overload of `SetSource()` accepts a `System.IO.Stream`, which is suited for the scenario where you decide to acquire the media through some other mechanism rather than have the `MediaElement` handle the download. When you acquire the media file, you can create a `Stream` around it (using a more concrete type like `System.IO.FileStream`) and pass it to `SetSource()`.

The second overload of `SetSource()` accepts an instance of the `System.Windows.Media.MediaStreamSource` type. The `MediaStreamSource` type is actually a way to plug a video container file format into Silverlight because the `MediaElement` does not come with a built-in parser. Video container file formats and related specifications are complex topics; consequently, a treatment of `MediaStreamSource` implementations is outside the scope of this book.

When the `Source` is set by either mechanism for progressive download scenarios, the `MediaElement` immediately starts to download the media. The `MediaElement.DownloadProgressChanged` event is raised repeatedly as the download progresses. The `MediaElement.DownloadProgress` property reports the download progress as a percentage value (actually a double between 0 and 1 that you can convert to percentage) that you can use to track and report the download progress in the `DownloadProgressChanged` event handler.

Controlling Media Play

As the media downloads, the `MediaElement` starts to play the media as soon as the first few frames are available, provided the `MediaElement.AutoPlay` property is set to `True`. If not, you have the option of using `MediaElement.Play()` in your code to start play. `MediaElement` also exposes `Pause()` and `Stop()`, which you can use to pause and stop a playing media stream. If a media-control function like `Play()` or `Pause()` is issued before enough media is downloaded to start playing, the command is internally queued by `MediaElement` and executed after playing starts.

MediaElement States

As the `MediaElement` goes through the various states of acquiring and playing media, the `MediaElement.CurrentState` property of type `MediaElementState` reflects the current state of the media. Table 10-1 lists some of the possible values and meanings.

Table 10-1. *Some of the MediaElementState Values and Their Meanings*

Value	Meaning
`Closed`	This is the default state of a `MediaElement` into which no media has been loaded.
`Opening`	This is the first state that occurs when the `MediaElement` tries to load a new media source. For a valid source, the `MediaElement` state moves on to `Buffering` if `MediaElement.AutoPlay` is set to `True` or to `Stopped` if it is not.
`Buffering`	This is the state when the `MediaElement` is buffering content.
`Playing`	This is the state when the `MediaElement` is playing media.
`Paused`	This is the state when currently loaded media has been paused by invoking `MediaElement.Pause()`.
`Stopped`	This state reflects stopped media and can be achieved by calling `MediaElement.Stop()` for playing media. This is also the state at the beginning after the media is opened, when `MediaElement.AutoPlay` is set to `False`, and at again when the media has reached its end and the `MediaElement.Source` has not been changed.

`MediaElement` raises the `CurrentStateChanged` event every time a state change happens between the states in Table 10-1. If you need to respond to any of these state changes, check the value of `MediaElement.CurrentState` in a handler for this event and take appropriate action. `MediaElement` raises a `MediaOpened` event after the media has been loaded successfully and is about to play; it raises `MediaFailed` for a failure to load and play media; and it raises `MediaEnded` when the media has finished playing.

Seeking Within the Media

When the media has been opened and the `MediaOpened` event has been raised, the `MediaElement.NaturalDuration` property of type `System.Windows.Duration` provides the total length of the media in time. The time value is contained in the `Duration.TimeSpan` property. Note that in certain cases like live streams, this value can be `TimeSpan.Zero`, because there is no way to know the duration of a live stream. We cover this scenario in Recipe 10-3.

The `MediaElement.Position` property of type `TimeSpan` determines the position within the media at any given time. Initially, this is set to `TimeSpan.Zero`. As the `MediaElement` plays the media, the `MediaElement.Position` property is updated continuously to reflect the current position. You can set the value of `Position` to any valid `TimeSpan` value between `TimeSpan.Zero` and `MediaElement.NaturalDuration.TimeSpan`. This positions the `MediaElement` at that time point in the media accordingly. To rewind, this value would need to be less than the current position, and vice versa for forwarding the media.

Volume

`MediaElement.Volume` provides the current volume as a double value between 0.0 and 1.0, with the default setting being 0.5. You can set this property to any value in that range to control the volume. The `IsMuted` property when set to `true` mutes the audio completely.

The Code

The code sample for this recipe builds a video player utilizing all the features discussed in the previous section, as well as concepts around programming model fundamentals, controls, and networking explored in earlier chapters in the book and mentioned in the introduction to this chapter. Figure 10-6 shows the full player user interface.

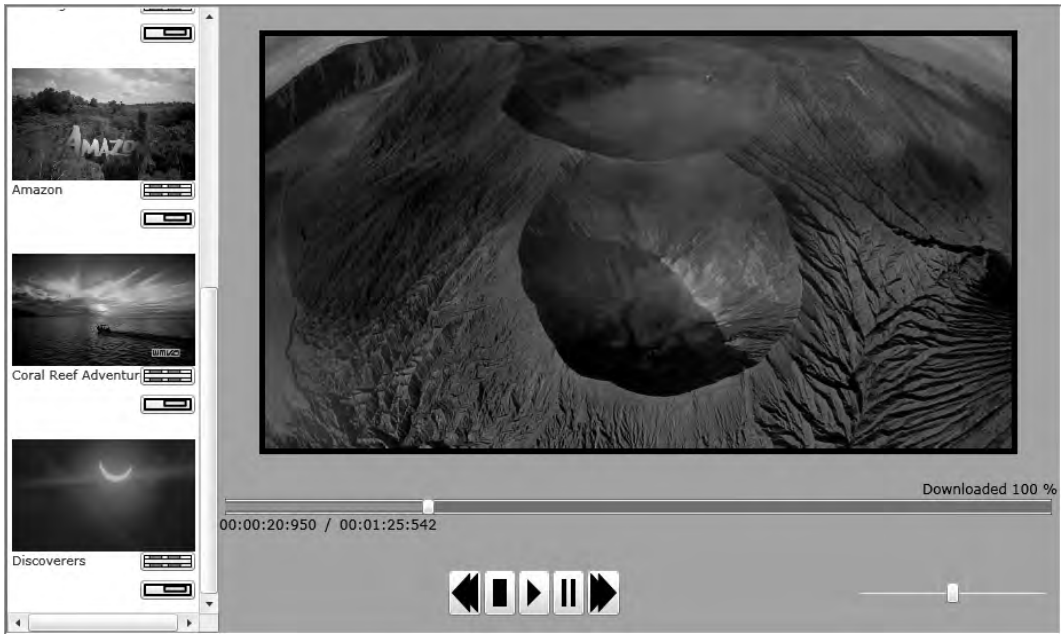


Figure 10-6. *Full video player user interface*

Installing the Sample Code

The sample for this recipe uses progressively downloaded media. To enable this approach, you need to either install or have access to a web server like IIS. The code samples expect all the media to reside under a virtual directory structure `<servername>/SLBook/Media`. We use a locally installed IIS server, and consequently the `<servername>` is `localhost`. After you create the virtual directory structure, you can acquire the media used in the samples as free downloads from `www.microsoft.com/windows/windowsmedia/musicandvideo/hdvideo/contentshowcase.aspx`. Note that we use the 1080p version of the videos whenever available. The following media files are used in the samples:

- Amazon_1080.wmv
- AdrenalineRush.wmv
- Alexander_Trailer_1080p.wmv
- Amazing_Caves_1080.wmv
- Coral_Reef_Adventure_1080.wmv
- Discoverers_1080.wmv

The sample application acquires the list of available media through a Windows Communication Foundation (WCF) service named MediaLocationProvider.svc, which reads this information from a file named Locations.xml stored in its App_Data folder. We do not discuss the implementation of the MediaLocationProvider WCF service in this chapter. MediaLocationProvider is implemented as a WCF service using the WCF web programming model to return XML data, and we discuss this technique, as well as how to consume it using a WebClient, in Chapter 7. We also encourage you to look at the sample code to review MediaLocationProvider's source.

Listing 10-2 shows a sample Locations.xml.

Listing 10-2. *A Sample locations.xml*

```
<?xml version="1.0" encoding="utf-8" ?>
<MediaLocations>
  <MediaLocation>
    <Description>Adrenaline Rush</Description>
    <Uri>http://localhost/SLBook/Ch10_RichMedia/Media/AdrenalineRush.wmv</Uri>
    <ImageUri>
      http://localhost/SLBook/Ch10_RichMedia/Media/AdrenalineRush_Thumb.jpg
    </ImageUri>
  </MediaLocation>
  <MediaLocation>
    <Description>Alexander</Description>
    <Uri>http://localhost/SLBook/Ch10_RichMedia/Media/Alexander_Trailer_1080p.wmv
    </Uri>
    <ImageUri>
    http://localhost/SLBook/Ch10_RichMedia/Media/Alexander_Trailer_1080p_Thumb.jpg
    </ImageUri>
  </MediaLocation>
</MediaLocations>
```

Each <MediaLocation> entry includes three children elements. The <Description> element provides a short description for the media, the <Uri> element points to the actual download location for the media, and the <ImageUri> element points to a JPEG image that represents a thumbnail of the video. You can change the entries in this file to accommodate your own virtual directory structures, server locations, and media files.

The Player Code

Listing 10-3 shows a type named MediaMenuData that maps to an instance of the MediaLocation information shown in Listing 10-2.

Listing 10-3. *MediaMenuData Type Declaration*

```
using System;
using System.ComponentModel;

namespace Recipe10_2
{
  public class MediaMenuData : INotifyPropertyChanged
  {
    public event PropertyChangedEventHandler PropertyChanged;
    private object _Description;
    public object Description
    {
      get { return _Description; }
      set
      {
        _Description = value;
        if (PropertyChanged != null)
          PropertyChanged(this, new PropertyChangedEventArgs("Description"));
      }
    }
    private object _MediaPreview;
    public object MediaPreview
    {
      get { return _MediaPreview; }
      set
      {
        _MediaPreview = value;
        if (PropertyChanged != null)
          PropertyChanged(this, new PropertyChangedEventArgs("MediaPreview"));
      }
    }
    private Uri _MediaLocation;
    public Uri MediaLocation
    {
      get { return _MediaLocation; }
      set
      {
        _MediaLocation = value;

        if (PropertyChanged != null)
        {
          PropertyChanged(this, new PropertyChangedEventArgs("MediaLocation"));
        }
      }
```

```
    }
  }
}
```

Let's look at the player user interface next. Listing 10-4 shows the XAML.

Listing 10-4. *XAML for the Player User Interface*

```
<UserControl x:Class="Recipe10_2.MainPage"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    xmlns:vsm="clr-namespace:System.Windows;assembly=System.Windows"
    xmlns:local="clr-namespace:Recipe10_2"
    Width="920" Height="547"
    xmlns:Ch10_RichMedia_Recipe10_2="clr-namespace:Recipe10_2;assembly=Recipe10_2.PlrCntls">
  <UserControl.Resources>
    <!-- Data Template for displaying a media menu item-->
    <DataTemplate x:Key="dtMediaMenuItem">
      <Grid Height="140" Width="160" Margin="0,8,0,8">
        <Grid.RowDefinitions>
          <RowDefinition Height="0.7*" />
          <RowDefinition Height="0.3*" />
        </Grid.RowDefinitions>
        <Grid.ColumnDefinitions>
          <ColumnDefinition Width="0.7*"/>
          <ColumnDefinition Width="0.3*" />
        </Grid.ColumnDefinitions>
        <Image HorizontalAlignment="Stretch"
               VerticalAlignment="Stretch" Stretch="Fill"
               Source="{Binding MediaPreview}" Grid.Row ="0"
               Grid.ColumnSpan="2"/>
        <TextBlock TextAlignment="Left" HorizontalAlignment="Stretch"
                   VerticalAlignment="Stretch" Grid.Row="1"
                   Text="{Binding Description}" Grid.Column="0"/>

        <Grid Grid.Row="1" Grid.Column="1">
          <Grid.RowDefinitions>
            <RowDefinition Height="0.4*" />
            <RowDefinition Height="0.2*" />
            <RowDefinition Height="0.4*" />
          </Grid.RowDefinitions>
          <Button Grid.Row="0" x:Name="btnPlayFull" Click="PlayFull_Click"
                  Tag="{Binding}" HorizontalAlignment="Center">
            <Button.Content>
              <Path Stretch="Fill" StrokeLineJoin="Round"
```

```
                        Stroke="#FF000000"
                        Data="M 120,9.15527e-005L 149.937,
                          9.15527e-005L 149.937,19.9361L 120,
                          19.9361L 120,9.15527e-005 Z M 120,
                          6.04175L 149.812,6.04175M 120,
                          14.0417L 149.937,14.0417M 123.417,
                          0.991364L 131.167,0.991364L 131.167,
                          4.88376L 123.417,4.88376L 123.417,
                          0.991364 Z M 135.125,1.00012L 142.875,
                          1.00012L 142.875,4.89246L 135.125,
                          4.89246L 135.125,1.00012 Z M 123.542,
                          15.035L 131.292,15.035L 131.292,
                          18.9274L 123.542,18.9274L 123.542,
                          15.035 Z M 135.25,15.0438L 143,
                          15.0438L 143,18.9362L 135.25,18.9362L 135.25,
                          15.0438 Z "/>
        </Button.Content>
      </Button>
      <Button Grid.Row="2" x:Name="btnPlayPIP" Click="PlayPIP_Click"
              Tag="{Binding}" HorizontalAlignment="Center">
        <Button.Content>
          <Path Stretch="Fill" StrokeThickness="2"
                        StrokeLineJoin="Round" Stroke="#FF000000"
                        Data="M 120,39.8333L 149.917,
                        39.8333L 149.917,59.9167L 120,
                        59.9167L 120,39.8333 Z M 132.917,
                        42.8333L 146.667,42.8333L 146.667,
                        52.6667L 132.917,52.6667L 132.917,
                        42.8333 Z "/>
        </Button.Content>
      </Button>
    </Grid>
  </Grid>
</DataTemplate>

<!--Control template for a media menu item -->
<ControlTemplate x:Key="ctMediaMenuListBoxItem" TargetType="ListBoxItem">
  <Grid>
    <vsm:VisualStateManager.VisualStateGroups>
      <vsm:VisualStateGroup x:Name="SelectionStates">
        <vsm:VisualState x:Name="Unselected"/>
        <vsm:VisualState x:Name="SelectedUnfocused">
          <Storyboard/>
        </vsm:VisualState>
        <vsm:VisualState x:Name="Selected">
```

```
            <Storyboard/>
          </vsm:VisualState>
        </vsm:VisualStateGroup>
        <vsm:VisualStateGroup x:Name="FocusStates">
          <vsm:VisualStateGroup.Transitions>
          </vsm:VisualStateGroup.Transitions>
          <vsm:VisualState x:Name="Unfocused"/>
          <vsm:VisualState x:Name="Focused"/>
        </vsm:VisualStateGroup>
        <vsm:VisualStateGroup x:Name="CommonStates">
          <vsm:VisualStateGroup.Transitions>
            <vsm:VisualTransition GeneratedDuration="00:00:00.2000000"
                                  To="MouseOver"/>
            <vsm:VisualTransition From="MouseOver"
                                  GeneratedDuration="00:00:00.2000000"/>
          </vsm:VisualStateGroup.Transitions>
          <vsm:VisualState x:Name="MouseOver">
            <Storyboard>
              <ColorAnimationUsingKeyFrames BeginTime="00:00:00"
                      Duration="00:00:00.0010000"
                      Storyboard.TargetName="brdrMouseOverIndicator"
                      Storyboard.TargetProperty=
                      "(Border.BorderBrush).(SolidColorBrush.Color)">
                <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF126AB3"/>
              </ColorAnimationUsingKeyFrames>
              <ColorAnimationUsingKeyFrames BeginTime="00:00:00"
              Duration="00:00:00.0010000"
              Storyboard.TargetName="brdrMouseOverIndicator"
              Storyboard.TargetProperty=
                    "(Border.Background).(SolidColorBrush.Color)">
                <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF7FDDE6"/>
              </ColorAnimationUsingKeyFrames>
            </Storyboard>
          </vsm:VisualState>

          <vsm:VisualState x:Name="Normal"/>
        </vsm:VisualStateGroup>
      </vsm:VisualStateManager.VisualStateGroups>
      <Border CornerRadius="2,2,2,2" BorderThickness="3,3,3,3"
              x:Name="brdrMouseOverIndicator"
              Background="#007FDDE6" BorderBrush="#00000000">
        <ContentPresenter/>
      </Border>

    </Grid>
```

```
  </ControlTemplate>
  <Style x:Key="STYLE_MediaMenuListBoxItem" TargetType="ListBoxItem">
    <Setter Property="Template"
          Value="{StaticResource ctMediaMenuListBoxItem}"/>
  </Style>
</UserControl.Resources>

 <!--Player UI -->
<Grid x:Name="LayoutRoot"
      Background="#FFA2A2A2" Height="Auto" Width="Auto">
  <Grid.RowDefinitions>
    <RowDefinition Height="0.752*"/>
    <RowDefinition Height="0.248*"/>
  </Grid.RowDefinitions>
  <Grid.ColumnDefinitions>
    <ColumnDefinition Width="0.2*"/>
    <ColumnDefinition Width="0.8*"/>
  </Grid.ColumnDefinitions>
  <Grid Grid.Row="0" Grid.Column="1">
    <Grid.RowDefinitions>
      <RowDefinition Height="0.05*" />
      <RowDefinition Height="0.9*" />
      <RowDefinition Height="0.05*" />
    </Grid.RowDefinitions>
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.05*"/>
      <ColumnDefinition Width="0.9*"/>
      <ColumnDefinition Width="0.05*"/>
    </Grid.ColumnDefinitions>
    <!--Main Display-->
    <Border x:Name="displayMain"
            VerticalAlignment="Stretch" Grid.Column="1" Grid.Row="1"
            HorizontalAlignment="Stretch" BorderThickness="5,5,5,5"
            BorderBrush="#FF000000" >

      <Border.Background>
        <VideoBrush SourceName="mediaelemMain" Stretch="Fill"
                    x:Name="vidbrushMain" />
      </Border.Background>
    </Border>
    <!--Picture in Picture Display-->
    <Grid Grid.Column="1" Grid.Row="1">
      <Grid.RowDefinitions>
        <RowDefinition Height="0.025*" />
        <RowDefinition Height="0.35*" />
```

```
  <RowDefinition Height="0.625*" />
</Grid.RowDefinitions>
<Grid.ColumnDefinitions>
  <ColumnDefinition Width="0.635*"/>
  <ColumnDefinition Width="0.35*"/>
  <ColumnDefinition Width="0.015*"/>
</Grid.ColumnDefinitions>
<Border Grid.Column="1" Grid.Row="1" HorizontalAlignment="Stretch"
        VerticalAlignment="Stretch"
        MouseLeftButtonUp="displayPIP_MouseLeftButtonUp"
        x:Name="displayPIP" BorderThickness="2,2,2,2"
        BorderBrush="#FF000000" Visibility="Collapsed">
  <Border.Background>
    <VideoBrush SourceName="mediaelemPIP"
                Stretch="Fill" x:Name="vidbrushPIP"/>
  </Border.Background>
</Border>
<Grid HorizontalAlignment="Stretch" Margin="8,8,8,8"
      Grid.RowSpan="1" Grid.Column="1" Grid.Row="1"
      x:Name="buttonsPIP" Visibility="Collapsed" >
  <Grid.RowDefinitions>
    <RowDefinition Height="0.1*"/>
    <RowDefinition Height="0.25*"/>
    <RowDefinition Height="0.1*"/>
    <RowDefinition Height="0.25*"/>
    <RowDefinition Height="0.3*"/>
  </Grid.RowDefinitions>
  <Grid.ColumnDefinitions>
    <ColumnDefinition Width="0.749*"/>
    <ColumnDefinition Width="0.176*"/>
    <ColumnDefinition Width="0.075*"/>
  </Grid.ColumnDefinitions>

  <Button Margin="0,0,0,0" Grid.RowSpan="1" Grid.Row="1"
          Grid.ColumnSpan="1" Grid.Column="1"
          x:Name="btnClosePIP" Click="btnClosePIP_Click">
    <Button.Content>
      <Path x:Name="Path" Stretch="Fill" StrokeThickness="2"
            StrokeLineJoin="Round" Stroke="#FF000000" Fill="#FFE91111"
            Data="M 110.5,75.7635L 113.209,
            72.9631L 133.396,92.4865L 130.687,95.2869L 110.5,
            75.7635 Z M 130.801,73.4961L 133.393,76.4048L 112.425,
            95.0872L 109.833,92.1785L 130.801,73.4961 Z "/>
    </Button.Content>
  </Button>
```

```
      <Button Margin="0,0,0,0" Grid.RowSpan="1" Grid.Row="3"
              Grid.ColumnSpan="1" Grid.Column="1"
              x:Name="btnSwitchPIP" Click="btnSwitchPIP_Click">
        <Button.Content>
          <Path Stretch="Fill" StrokeThickness="2" StrokeLineJoin="Round"
                Stroke="#FF000000" Data="M 120,39.8333L 149.917,
                39.8333L 149.917,59.9167L 120,59.9167L 120,
                39.8333 Z M 132.917,42.8333L 146.667,42.8333L 146.667,
                52.6667L 132.917,52.6667L 132.917,42.8333 Z "/>
        </Button.Content>
      </Button>
    </Grid>
  </Grid>
</Grid>
<Grid Margin="2,2,2,2" VerticalAlignment="Stretch" Grid.Column="1"
      Grid.Row="1" HorizontalAlignment="Stretch">
  <Grid.RowDefinitions>
    <RowDefinition Height="0.5*"/>
    <RowDefinition Height="0.5*"/>
  </Grid.RowDefinitions>
  <Grid.ColumnDefinitions>
    <ColumnDefinition Width="0.75*"/>
    <ColumnDefinition Width="0.25*"/>
  </Grid.ColumnDefinitions>
  <!-- Slider to report and control media progress-->
  <Ch08_RichMedia_Recipe10_2:MediaSlider SourceName="mediaelemMain"
               VerticalAlignment="Top"
               IsEnabled="True"
               x:Name="mediaSlider" Grid.ColumnSpan="2"/>

  <!--Buttons to control media-->
  <Ch10_RichMedia_Recipe10_2:MediaButtonsPanel Grid.Row="1" Grid.Column="0"
                   SourceName="mediaelemMain"
                   HorizontalAlignment="Center"
                   VerticalAlignment="Center"
                   Width="150" Height="40"
                   x:Name="mediaControl"/>
  <!--Slider to control volume-->
  <Slider x:Name="sliderVolumeControl"  Margin="5,0,5,0" Maximum="1"
          Minimum="0" SmallChange="0.1"
          LargeChange="0.2"  Value="0.5"
          MinWidth="50" Grid.Row="1"
          Grid.Column="1" ValueChanged="sliderVolumeControl_ValueChanged">
  </Slider>
</Grid>
```

```
    <!--Media element for main display-->
    <MediaElement Height="Auto" Margin="0,0,0,0"
                  VerticalAlignment="Top" x:Name="mediaelemMain"
                  HorizontalAlignment="Left" AutoPlay="True" Opacity="0"/>
    <!--Media element for Picture in Picture display-->
    <MediaElement Height="Auto" Margin="0,0,0,0" VerticalAlignment="Top"
                  x:Name="mediaelemPIP" HorizontalAlignment="Left"
                  AutoPlay="True" Opacity="0" IsMuted="True" />
    <!--Media Menu-->
    <ListBox Margin="0,0,-2,0" VerticalAlignment="Stretch"
             Grid.RowSpan="2" x:Name="lbxMediaMenu"
             ItemTemplate="{StaticResource dtMediaMenuItem}"
             ItemContainerStyle="{StaticResource STYLE_MediaMenuListBoxItem}" >
    </ListBox>
  </Grid>
</UserControl>
```

The `ListBox` named `lbxMediaMenu` lists all the media sources available to the player, using the `dtMediaMenuItem` as the item template. `lbxMediaMenu` is bound to a collection of `MediaMenuData`, as shown shortly in the codebehind for the player. `dtMediaMenuItem` contains an `Image` control bound to the `MediaMenuData.MediaPreview` property, a `TextBlock` bound to the `MediaMenuData.Description` property, and two buttons named `btnPlayFull` and `btnPlayPIP`, each with its `Tag` property bound to the complete `MediaMenuData` instance.

The UI contains two `MediaElement` instances: `mediaelemMain` and `mediaelemPIP`. They play two media streams simultaneously, one of which is in a smaller viewing area overlaid in a standard television picture-in-picture style on the main display area. Both are set to `AutoPlay`, although `mediaelemPIP` is muted by setting `MediaElement.IsMuted` to `True`, in order to avoid having multiple audio streams getting jumbled together.

The primary display is a `Border` named `displayMain`, with its `Background` set to paint with a `VideoBrush` named `vidbrushMain` with `mediaelemMain` as the source. The secondary picture-in-picture (PIP) display is named `displayPIP`, painted with `vidbrushPIP` and sourced from `mediaelemPIP`. You also define two additional buttons, named `btnClosePIP` and `btnSwitchPIP`—the former closes a PIP display, and the latter switches the videos between the PIP display and the main display. You can use `btnPlayFull` to play the corresponding media in the main display, although `btnPlayPIP` plays the media in the PIP window.

The UI also contains two custom controls named `mediaSlider` and `mediaButtons` of types `MediaSlider` and `MediaButtonsPanel`: `MediaSlider` represents the slider control below the main display area and encapsulates all the tracking and progress control functionality while `MediaButtonsPanel` encapsulates the buttons below the media slider that represent play-control functions. We discuss these controls in detail in later sections in this recipe. Lastly, the UI contains a `Slider` control named `sliderVolumeControl` that is used to control the audio volume for the playing media.

Listing 10-5 shows the codebehind for the player.

Listing 10-5. *Codebehind for the Complete Player*

```
using System;
using System.Collections.Generic;
using System.Collections.ObjectModel;
using System.Linq;
using System.Net;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Input;
using System.Xml.Linq;

namespace Recipe10_2
{
  public partial class MainPage : UserControl
  {
    //change this if you install the services at a different location
    private const string MediaLocatorUri =
      "http://localhost:9191/MediaLocationProvider.svc/GetLocationList";

    private ObservableCollection<MediaMenuData> listMedia =
      new ObservableCollection<MediaMenuData>();

    private MediaElement MainVideo
    {
      get
      {
        return (vidbrushMain.SourceName == "mediaelemMain") ?
        mediaelemMain : mediaelemPIP;
      }
    }
    private MediaElement PIPVideo
    {
      get
      {
        return (vidbrushPIP.SourceName == "mediaelemMain") ?
        mediaelemMain : mediaelemPIP;
      }
    }

    public MainPage()
    {
      InitializeComponent();
      lbxMediaMenu.ItemsSource = listMedia;
```

```
  this.Loaded += new RoutedEventHandler(Page_Loaded);
}

void Page_Loaded(object sender, RoutedEventArgs e)
{
  PopulateMediaMenu();
}


private void PopulateMediaMenu()
{
  WebClient wcMediaLocator = new WebClient();
  wcMediaLocator.DownloadStringCompleted +=
    new DownloadStringCompletedEventHandler(
    delegate(object Sender, DownloadStringCompletedEventArgs e)
    {
      this.Dispatcher.BeginInvoke(new Action(delegate
        {
          XDocument xDoc = XDocument.Parse(e.Result);

          List<MediaMenuData> tempList =
            (from medloc in xDoc.Root.Elements()
             select new MediaMenuData
             {
               Description = medloc.Element("Description").Value,
               MediaLocation = new Uri(medloc.Element("Uri").Value),
               MediaPreview = medloc.Element("ImageUri").Value
             }).ToList();
          foreach (MediaMenuData medloc in tempList)
            listMedia.Add(medloc);
        }));
    });
  wcMediaLocator.DownloadStringAsync(new Uri(MediaLocatorUri));
}

private void PlayFull_Click(object sender, RoutedEventArgs e)
{
  MainVideo.Source = ((sender as Button).Tag as MediaMenuData).MediaLocation;
}

private void PlayPIP_Click(object sender, RoutedEventArgs e)
{
  PIPVideo.Source = ((sender as Button).Tag as MediaMenuData).MediaLocation;
  displayPIP.Visibility = Visibility.Visible;
}
```

```
private void btnClosePIP_Click(object sender, RoutedEventArgs e)
{
  PIPVideo.Stop();
  buttonsPIP.Visibility = displayPIP.Visibility = Visibility.Collapsed;
}

private void btnSwitchPIP_Click(object sender, RoutedEventArgs e)
{
  if (vidbrushMain.SourceName == "mediaelemMain")
  {
    vidbrushMain.SourceName = "mediaelemPIP";
    vidbrushPIP.SourceName = "mediaelemMain";
    mediaSlider.SourceName = "mediaelemPIP";
    mediaButtons.SourceName = "mediaelemPIP";
    mediaelemMain.IsMuted = true;
    mediaelemPIP.IsMuted = false;
  }
  else
  {
    vidbrushMain.SourceName = "mediaelemMain";
    vidbrushPIP.SourceName = "mediaelemPIP";
    mediaSlider.SourceName = "mediaelemMain";
    mediaButtons.SourceName = "mediaelemMain";
    mediaelemMain.IsMuted = false;
    mediaelemPIP.IsMuted = true;
  }
  MainVideo.Volume = sliderVolumeControl.Value;
}


private void displayPIP_MouseLeftButtonUp(object sender,
  MouseButtonEventArgs e)
{
  if (displayPIP.Visibility == Visibility.Visible)
  {
    buttonsPIP.Visibility =
      (buttonsPIP.Visibility == Visibility.Visible ?
      Visibility.Collapsed : Visibility.Visible);
  }
}
private void sliderVolumeControl_ValueChanged(object sender,
  RoutedPropertyChangedEventArgs<double> e)
{
  if (vidbrushMain != null)
```

```
      {
        MainVideo.Volume = e.NewValue;
      }
    }
  }
}
```

The `PopulateMediaMenu()` method uses the `WebClient` to invoke the `GetLocationList()` operation on the `MediaLocationProvider` service. The `GetLocationList()` operation returns the contents of the `Locations.xml` file shown in Listing 10-2; and in the `DownloadStringCompleted` handler, you parse the XML into a collection of `MediaMenuData` instances. You then bind the list to `lbxMediaMenu`, which results in the menu interface shown in Figure 10-6.

The strategy of switching a video between the PIP display and the main display is to swap the `MediaElements` between the respective `VideoBrushes`. Because of this, you also create two additional properties named `MainVideo` and `PIPVideo` that wrap the access to the `MediaElements` from code. Within these property getters, you always return the `MediaElement` associated with the `vidbrushMain` as `MainVideo` and the one associated with `vidbrushPIP` as `PIPVideo`. This causes any media source or other property settings on `MainVideo` to always affect the main display and those on `PIPVideo` to always affect the PIP display.

In `PlayFull_Click()`, you set the source for `MainVideo` to the `MediaLocation` property on the `MediaMenuData` bound to `btnPlayFull.Tag`. In `PlayPIP_Click()`, you perform a similar action using `PIPVideo` and `btnPlayPIP.Tag`. Additionally, you make the PIP display visible from its original `Collapsed` state.

While the PIP display is playing media, the mouse left-button-up handler for the PIP display—`displayPIP_MouseLeftButtonUp()`—displays the PIP control buttons. Figure 10-7 shows the PIP display with the PIP control buttons visible; the top button closes the PIP window, and the bottom button switches the media with the main display.

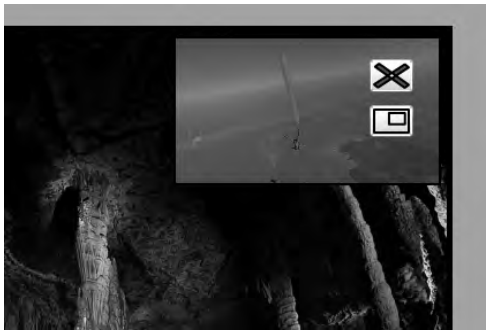


Figure 10-7. *Picture-in-picture display with control buttons visible*

In `btnClosePIP_Click()`, you stop the media by invoking `Stop()` on `PIPVideo` and hide the PIP display and the related buttons. In `btnSwitchPIP_Click()`, you swap the `SourceName` properties of the respective `VideoBrushes` to swap the playing media between the displays. You also swap the muted state to play the audio from the main display (remember, the PIP display remains muted), and you swap the `SourceName` properties on the `MediaSlider` and the `MediaButtonsPanel` control instances (which we discuss in the next sections).

You handle the `ValueChanged` event of `sliderVolumeControl`, where you set the `MainVideo.Volume` property to the current value reflected in `sliderVolumeControl`.

So far, we have not discussed any of the play-control and tracking functionality that is exposed through the `MediaElement` API. A player like this needs to utilize such functionality to be useful, and it would typically contain several visual elements that enable that functionality. It is fairly common to have one or more range-style controls to report various progressive activities like the download or the playing of media, which may also aid in seeking through the media. Buttons to play, pause, stop, and so forth are common as well.

You encapsulate some of this functionality inside the `MediaSlider` and `MediaButtonsPanel` controls (discussed next) to create a clean separation between the player's code shown in Listings 10-4 and 10-5 and these player-control functions. We hope that these controls are reusable enough that you will be able to drop them into your own player projects and not have to make any major modifications. Finally, because they are custom controls, you do not have to settle for our rather pedestrian design skills; you can replace the look and feel of each control with a design that suits your needs while retaining all the functionality.

For more information, you can refer to Chapter 5 where we discuss custom control development and custom control templates in detail. In subsequent sections in this chapter, we assume that you are familiar with those control development concepts.

The MediaSlider Custom Control

The `MediaSlider` custom control encapsulates progress tracking and some of the seeking functionality associated with the player. The `MediaSlider` is implemented by extending the `Slider` control that is packaged with the Silverlight framework libraries. You add visual elements to the default template for the `Slider` control to define the same for `MediaSlider`. You also further extend the `Slider` type with custom functionality.

Let's look at the control template first. Note that because the templates for both this control and the next one are defined in the same `generic.xaml` file, we only list the relevant portions of `generic.xaml` in each section, not the entire file.

Listing 10-6 shows the control template for `MediaSlider`.

Listing 10-6. *MediaSlider Control Template*

```
<ControlTemplate TargetType="local:MediaSlider" x:Key="ctMediaSliderDefault">
  <Grid x:Name="Root">
    <Grid.Resources>
      <ControlTemplate x:Key="ctRepeatButton">
        <Grid x:Name="Root" Opacity="0" Background="Transparent"/>
      </ControlTemplate>
    </Grid.Resources>
    <vsm:VisualStateManager.VisualStateGroups>
      <vsm:VisualStateGroup x:Name="CommonStates">
        <vsm:VisualStateGroup.Transitions>
          <vsm:VisualTransition GeneratedDuration="0"/>
        </vsm:VisualStateGroup.Transitions>
        <vsm:VisualState x:Name="Normal"/>
        <vsm:VisualState x:Name="MouseOver"/>
        <vsm:VisualState x:Name="Disabled">
          <Storyboard>
            <DoubleAnimationUsingKeyFrames Storyboard.TargetName="Root"
            Storyboard.TargetProperty="(UIElement.Opacity)">
```

```
            <SplineDoubleKeyFrame KeyTime="00:00:00" Value="0.5"/>
          </DoubleAnimationUsingKeyFrames>
        </Storyboard>
      </vsm:VisualState>
    </vsm:VisualStateGroup>
  </vsm:VisualStateManager.VisualStateGroups>
  <Grid>
    <Grid.RowDefinitions>
      <RowDefinition Height="0.33*" />
      <RowDefinition Height="0.34*" />
      <RowDefinition Height="0.33*" />
    </Grid.RowDefinitions>
    <Grid Grid.Row="0" VerticalAlignment="Top"
          HorizontalAlignment="Stretch">
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="*" />
        <ColumnDefinition Width="Auto" />
      </Grid.ColumnDefinitions>
      <StackPanel Orientation="Horizontal" Grid.Column="1"
                  HorizontalAlignment="Right">
        <TextBlock Text="Downloaded" FontSize="12"
                   Margin="0,0,4,0"/>
        <TextBlock x:Name="textDownloadPercent" FontSize="12"
                   />
      </StackPanel>
    </Grid>
    <Grid x:Name="HorizontalTemplate" Grid.Row="1" >
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="*" />
      </Grid.ColumnDefinitions>
      <Rectangle Stroke="Black" StrokeThickness="0.5" Fill="#FFE6EFF7"
                 Grid.Column="0" Grid.ColumnSpan="3" Height="14"
                 Margin="5,0,5,0" />
      <Border Height="10" Margin="5,0,5,0" Grid.Column="0"
              Grid.ColumnSpan="3"
              x:Name="elemDownloadProgressIndicator"
              Background="#FF2185D8"
              HorizontalAlignment="Left" Width="0"  />
      <Border Height="6" Margin="5,0,5,0" Grid.Column="0"
              Grid.ColumnSpan="3"
              x:Name="elemPlayProgressIndicator"
              Background="#FF1CE421"
              HorizontalAlignment="Left" Width="0"  />
```

```
        <RepeatButton x:Name="HorizontalTrackLargeChangeDecreaseRepeatButton"
                      Grid.Column="0"
                      Template="{StaticResource ctRepeatButton}"
                      IsTabStop="False"   />
        <Thumb x:Name="HorizontalThumb" Height="14" Width="11" Grid.Column="1"/>
        <RepeatButton x:Name="HorizontalTrackLargeChangeIncreaseRepeatButton"
                      Grid.Column="2"
                      Template="{StaticResource ctRepeatButton}"
                      IsTabStop="False"  />
      </Grid>
      <Grid Grid.Row="2" VerticalAlignment="Bottom"
            HorizontalAlignment="Stretch">
        <StackPanel x:Name="TotalDuration" Orientation="Horizontal">
          <TextBlock x:Name="textPosition" FontSize="12"/>
          <TextBlock Text=" / " FontSize="12" Margin="3,0,3,0"/>
          <TextBlock x:Name="textDuration" FontSize="12" />
        </StackPanel>
      </Grid>
    </Grid>
  </Grid>
</ControlTemplate>

<Style TargetType="local:MediaSlider">
  <Setter Property="Template" Value="{StaticResource ctMediaSliderDefault}" />
</Style>
```

If you look at the default control template of the `Slider` control (one way to do so is to create a copy of the control template in Expression Blend, as we did for the sample in Chapter 5), it is obvious from Listing 10-6 that you use that template as a starting point and make some modifications in creating a control template named `ctMediaSliderDefault`.

The default `Slider` control template contains two visual representations: one for when the `Slider.Orientation` property is set to `Orientation.Horizontal` and another for when it is set to `Orientation.Vertical`. These parts are defined within two `Grids` named `HorizontalTemplate` and `VerticalTemplate`. Because you always use the `MediaSlider` in horizontal orientation, in `ctMediaSliderDefault` you leave out the `VerticalTemplate` portion. You can always add it back if you intend to use this control oriented vertically as well. The definition of `HorizontalTemplate` gives you a good idea of what the vertical counterpart should contain.

Within `HorizontalTemplate` is a `Thumb` control named `Thumb`. As we discuss later, you use the `Thumb` to report progress by moving it along the slider as media plays. The user can also drag the `Thumb` along the slider in either direction to seek within the media. Additionally, the two `RepeatButton` instances, named `HorizontalTrackLargeChangeDecreaseRepeatButton` and `HorizontalTrackLargeChangeIncreaseRepeatButton`, form the clickable areas on the slider on the two sides of the `Thumb`. Clicking causes the `Thumb` to progress on either side. Because these are `RepeatButtons`, holding the mouse left button down causes repeated click events to be raised at an interval defined by the `RepeatButton.Interval` property; this property is set to the number of milliseconds by which you want the click events to be separated. You also add two `Border` controls, named `elemDownloadProgressIndicator` and `elemPlayProgressIndicator`, that progress along the `MediaSlider` background; the former reports

media download progress, and the latter reports play progress and trails the `Thumb` as it moves along the `MediaSlider`.

Finally, you add a `StackPanel` named `TotalDuration` with two `TextBlocks` in it. The `TextBlock` named `textDuration` is set to the total duration of the media after it starts playing, and the one named `textPosition` reports the media's current position as it plays.

To use the control template, you create a style with the target type set to the control's type and the `Template` property set to the control template. The style is shown at the end of Listing 10-6. In the control's code, you can see how the style is used. To learn more about control templating and custom controls, refer to Chapter 5.

Listing 10-7 shows the code for the control.

Listing 10-7. *MediaSlider Control Code*

```
using System;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Controls.Primitives;
using System.Windows.Media;
using System.Windows.Threading;

namespace Recipe10_2
{
 public class MediaSlider : Slider
  {
    private MediaElement MediaSource;
    private FrameworkElement elemDownloadProgressIndicator;
    private FrameworkElement elemPlayProgressIndicator;
    private FrameworkElement Root;
    private TextBlock textPosition;
    private TextBlock textDuration;
    private TextBlock textDownloadPercent;
    private Thumb HorizontalThumb;
    private DispatcherTimer disptimerPlayProgressUpdate;

   //SourceName dependency property - used to attach
   //a Media element to this control
    public static DependencyProperty SourceNameProperty =
      DependencyProperty.Register("SourceName", typeof(string),
      typeof(MediaSlider),
      new PropertyMetadata(new PropertyChangedCallback(OnSourceNameChanged)));
    public string SourceName
    {
      get
      {
        return (string)GetValue(SourceNameProperty);
      }
      set
```

```
    {
      SetValue(SourceNameProperty, value);
    }
  }
 //SourceName change handler
  private static void OnSourceNameChanged(DependencyObject Source,
    DependencyPropertyChangedEventArgs e)
  {
    MediaSlider thisSlider = Source as MediaSlider;
    if (e.NewValue != null && e.NewValue != e.OldValue
      && thisSlider.Root != null)
    {
      thisSlider.MediaSource =
        thisSlider.Root.FindName(e.NewValue as string) as MediaElement;
      //reinitialize
      thisSlider.InitMediaElementConnections();
    }
  }


  public MediaSlider()
    : base()
  {
    this.DefaultStyleKey = typeof(MediaSlider);
    this.Maximum = 100;
    this.Minimum = 0;
    disptimerPlayProgressUpdate = new DispatcherTimer();
    disptimerPlayProgressUpdate.Interval = new TimeSpan(0, 0, 0, 0, 50);
    disptimerPlayProgressUpdate.Tick +=
      new EventHandler(PlayProgressUpdate_Tick);
  }
  public override void OnApplyTemplate()
  {
    base.OnApplyTemplate();

    elemDownloadProgressIndicator =
      GetTemplateChild("elemDownloadProgressIndicator") as FrameworkElement;
    elemPlayProgressIndicator =
     GetTemplateChild("elemPlayProgressIndicator") as FrameworkElement;
    HorizontalThumb = GetTemplateChild("HorizontalThumb") as Thumb;
    if (HorizontalThumb != null)
    {
      HorizontalThumb.DragStarted +=
        new DragStartedEventHandler(HorizontalThumb_DragStarted);
      HorizontalThumb.DragCompleted +=
```

```
            new DragCompletedEventHandler(HorizontalThumb_DragCompleted);
        }
        textPosition = GetTemplateChild("textPosition") as TextBlock;
        textDuration = GetTemplateChild("textDuration") as TextBlock;
        textDownloadPercent = GetTemplateChild("textDownloadPercent") as TextBlock;

        Root = Helper.FindRoot(this);
        MediaSource = Root.FindName(SourceName) as MediaElement;
        InitMediaElementConnections();
      }
      //Initialize by wiring up handlers
      private void InitMediaElementConnections()
      {
        if (MediaSource != null)
        {
          MediaSource.MediaOpened +=
            new RoutedEventHandler(MediaSource_MediaOpened);
          MediaSource.MediaEnded +=
            new RoutedEventHandler(MediaSource_MediaEnded);
          MediaSource.MediaFailed +=
            new EventHandler<ExceptionRoutedEventArgs>(MediaSource_MediaFailed);
          MediaSource.CurrentStateChanged +=
            new RoutedEventHandler(MediaSource_CurrentStateChanged);
          MediaSource.DownloadProgressChanged +=
            new RoutedEventHandler(MediaSource_DownloadProgressChanged);
          MediaSource_CurrentStateChanged(this, new RoutedEventArgs());
        }
      }

    //tick handler for progress timer
      void PlayProgressUpdate_Tick(object sender, EventArgs e)
      {
        this.Value =
          (MediaSource.Position.TotalMilliseconds /
          MediaSource.NaturalDuration.TimeSpan.TotalMilliseconds)
          * (this.Maximum - this.Minimum);

        if (elemPlayProgressIndicator != null)
        {
          elemPlayProgressIndicator.Width =
            (MediaSource.Position.TotalMilliseconds /
            MediaSource.NaturalDuration.TimeSpan.TotalMilliseconds)
            * ActualWidth;
        }
        if (textPosition != null)
```

```
        textPosition.Text = string.Format("{0:00}:{1:00}:{2:00}:{3:000}",
          MediaSource.Position.Hours,
          MediaSource.Position.Minutes,
          MediaSource.Position.Seconds,
          MediaSource.Position.Milliseconds);
    }
   //plug into the thumb to pause play while it is being dragged
    void HorizontalThumb_DragStarted(object sender, DragStartedEventArgs e)
    {
      if (MediaSource != null && MediaSource.CurrentState ==
        MediaElementState.Playing)
        MediaSource.Pause();
    }
    void HorizontalThumb_DragCompleted(object sender, DragCompletedEventArgs e)
    {
      if (MediaSource != null)
      {
        MediaSource.Position = new TimeSpan(0,
          0, 0, 0,
          (int)(this.Value *
          MediaSource.NaturalDuration.TimeSpan.TotalMilliseconds /
(this.Maximum - this.Minimum)));
      }
      MediaSource.Play();
    }


    //media element download progress changed
    private void MediaSource_DownloadProgressChanged(object sender,
      RoutedEventArgs e)
    {
      if (elemDownloadProgressIndicator != null)
      {
        elemDownloadProgressIndicator.Width =
          (MediaSource.DownloadProgress * this.ActualWidth);
        if (textDownloadPercent != null)
          textDownloadPercent.Text = string.Format("{0:##.##} %",
            MediaSource.DownloadProgress * 100);
      }
    }
    //state changes on the MediaElement
    private void MediaSource_CurrentStateChanged(object sender,
      RoutedEventArgs e)
    {
      switch (MediaSource.CurrentState)
```

```
    {
      case MediaElementState.Playing:
        if (textDuration != null)
          textDuration.Text = string.Format("{0:00}:{1:00}:{2:00}:{3:000}",
            MediaSource.NaturalDuration.TimeSpan.Hours,
            MediaSource.NaturalDuration.TimeSpan.Minutes,
            MediaSource.NaturalDuration.TimeSpan.Seconds,
            MediaSource.NaturalDuration.TimeSpan.Milliseconds);
        if (disptimerPlayProgressUpdate.IsEnabled == false)
        disptimerPlayProgressUpdate.Start();
        break;
      case MediaElementState.Paused:
        if (disptimerPlayProgressUpdate.IsEnabled)
        disptimerPlayProgressUpdate.Stop();
        break;
      case MediaElementState.Stopped:
        if (disptimerPlayProgressUpdate.IsEnabled)
        disptimerPlayProgressUpdate.Stop();
        break;
      case MediaElementState.AcquiringLicense:
      case MediaElementState.Individualizing:
      case MediaElementState.Opening:
      case MediaElementState.Buffering:
      case MediaElementState.Closed:
        break;


      default:
        break;
    }
  }

 //media ended
  private void MediaSource_MediaEnded(object sender,
    RoutedEventArgs e)
  {
    if (disptimerPlayProgressUpdate.IsEnabled)
    disptimerPlayProgressUpdate.Stop();
  }

 //media failed
  private void MediaSource_MediaFailed(object sender, RoutedEventArgs e)
  {
    disptimerPlayProgressUpdate.Stop();
  }
```

```
    void MediaSource_MediaOpened(object sender, RoutedEventArgs e)
    {
      //we do nothing here in this sample
    }
  }
}
```

Note in Listing 10-7 that the `MediaSlider` directly extends the `Slider` control type. In the constructor, you set the control's `DefaultStyleKey` property to the control type. This has the effect of associating the control to the style defined at the end of Listing 10-6 and, consequently, applying the control template referenced through that style to the control. You then initialize the `Maximum` and `Minimum` properties to reflect a range from 0 to 100. You can change these defaults by setting a different range where you use the `MediaSlider` in XAML. You also create and initialize a `DispatcherTimer`, whose purpose we discuss later in this section.

The `MediaSlider` defines a dependency property named `SourceName`, very similar in purpose to the `VideoBrush`. This property is set to the `x:Name` of the `MediaElement`; its intent is to look through the entire XAML, starting at the root of the `Page` within which the `MediaSlider` is contained, to locate the `MediaElement`.

The `Helper.FindRoot()` method shown in Listing 10-8 locates the XAML root. It recursively travels upward in the XAML tree, starting at the `MediaSlider`, until no more parents are defined.

Listing 10-8. *Code to Locate the Root of a XAML Document*

```
using System.Windows;

namespace Recipe10_2
{
  public static class Helper
  {
    public static FrameworkElement FindRoot(FrameworkElement CurrentLevel)
    {
      FrameworkElement NextParent = null;
      if (CurrentLevel.Parent is FrameworkElement)
        NextParent = FindRoot(CurrentLevel.Parent as FrameworkElement);
      else
        NextParent = CurrentLevel;
      return NextParent;
    }
  }
}
```

In `OnApplyTemplate()` in Listing 10-7, you first acquire all the named template parts that you are interested in. You then use `FindRoot()` to locate the page root and store it in `MediaSlider.Root`. Finally, you use `FindName()` on the root to locate and store the `MediaElement` in `MediaSlider.MediaSource`. After the `MediaElement` has been located, you invoke `InitMediaElementConnections()`, in which you add handlers to relevant `MediaElement` events that you need to handle in the `MediaSlider`. In the `OnSourceNameChanged()`

property-change handler, you repeat this process for when the MediaSlider is pointed to some other MediaElement during the course of use of the player.

If you refer back to Listing 10-4, note that the SourceName property of the MediaSlider is set to mediaelemMain in the player's XAML. However, if you also refer back to Listing 10-5 and look at the btnSwitchPIP_Click() event handler, notice that when the user switches media from the PIP display to the main display, you switch the MediaSlider.SourceName. This causes the MediaSlider to always reflect the state for the MediaElement currently associated with the main display.

Note that the MediaElement_CurrentStateChanged() handler includes a case label for each permissible state defined in the MediaElementState enumeration. Although you do not need to respond to each of these state transitions to implement this sample, we include them in the code for informational purposes. You can get rid of the fall-through case labels, should you choose to use this code directly.

The first step that a MediaElement performs when trying to load media is to validate and open the media URI. This is signaled by raising the CurrentStateChanged event and by the MediaElement.CurrentState transitioning to MediaElementState.Opening. After the media is successfully opened, the MediaOpened event is raised. In the MediaOpened event handler, you have access to the media's duration through the MediaElement.NaturalDuration property. At this point, the MediaElement begins acquiring the media and CurrentState moves to Buffering. In the case of progressively downloaded media, as the media downloads, the MediaElement.DownloadProgressChanged event is raised continually as the amount of media downloaded grows, and the resulting download percentage value increases. In the handler named MediaSource_DownloadProgressChanged(), you set the Width of the Border element elemDownloadProgressIndicator by the appropriate percentage of the ActualWidth to reflect download progress. You also report the download percentage through textDownloadPercent. When enough media has been downloaded for play to start, the MediaElement state transitions to Playing. This results in raising the CurrentStateChanged event again. Figure 10-8 shows media still downloading while play has just started.

Figure 10-8. *MediaSlider visual state when media is playing while download continues*

One of the challenges of the MediaElement state transitions is that the state change to Playing is raised only once: right when the media is starting to play. Playing then continues without raising any further notifications until a control event like Stop or Pause causes the MediaElement state to change again. This is for several good reasons, not least of which is performance, because the MediaElement may not perform optimally if it tries to keep raising granular events continuously while it is playing.

However, in order to report progress while the media is playing, you need a mechanism to notify the code at regular intervals. This is where the DispatcherTimer named disptimerPlayProgressUpdate (which is initialized in the constructor) plays its role. In handling the Playing state change in MediaSource_CurrentStateChanged(), you start disptimerPlayProgressUpdate, which raises a tick event every 50 milliseconds. We chose this value fairly randomly; you can either change it to a value that suits your needs or make it a property on the control to allow you to set it. Note that in the same case block, you format and set the value of textDuration to that in MediaSource.NaturalDuration to display the total duration of the clip.

In the Tick handler for disptimerPlayProgressUpdate named PlayProgressUpdate_Tick(), you move the Thumb by setting its Value to a proportion of the MediaSlider range, matching the ratio of the current Position to the MediaSource.NaturalDuration. You also increase the Width of elemPlayProgressIndicator by the same proportion to trail the Thumb to indicate play progress, and you set textPosition at the lower-left corner of the slider to reflect the current Position value, as shown in Figure 10-8.

If the MediaElement fails to load and play the media, if the media is stopped or paused, and after the play ends, you can check disptimerPlayProgressUpdate to see if it is currently ticking (in other words, whether the IsEnabled property is set to True), and stop it if it is.

You also need to enable seeking through the media using the Thumb. To do this, you attach handlers to the Thumb.DragStarted and Thumb.DragCompleted events in OnApplyTemplate(). In the HorizontalThumb_DragStarted() handler, you make sure the media is playing; and if it is, you pause it. This prevents your code in the DispatcherTimer.Tick handler from trying to move the Thumb while the user is dragging it. In HorizontalThumb_DragCompleted(), you set MediaSource.Position by transforming the MediaSlider.Value property back to its corresponding time point in the media's timeline. This causes the media to seek to the newly set position. You then start playing the media again.

One last thing to note is that in InitMediaElementConnections(), you deliberately invoke the MediaElement_CurrentStateChanged() handler. This is for cases where the SourceName changes but the new MediaElement being attached is already playing—that is, someone switched the PIP video with the main video. The MediaElement state change is not going to fire again, so calling the state-change handler once deliberately causes the textDuration to be updated to reflect the change in video sources.

The MediaButtonsPanel Custom Control

The MediaButtonsPanel custom control encapsulates the following play-control functions: play, pause, stop, forward, and rewind. Each function is tied to a Button in the control template. Listing 10-9 shows the control template for MediaButtonsPanel.

Listing 10-9. *Control Template for MediaButtonsPanel Custom Control*

```
<ControlTemplate TargetType="local:MediaButtonsPanel"
                 x:Key="ctMediaButtonsPanelDefault">
  <Grid>
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.2*" />
      <ColumnDefinition Width="0.2*" />
      <ColumnDefinition Width="0.2*" />
      <ColumnDefinition Width="0.2*" />
      <ColumnDefinition Width="0.2*" />
    </Grid.ColumnDefinitions>
    <RepeatButton Grid.Column="0" x:Name="btnRewind" Margin="0,0,1,0">
      <RepeatButton.Content>
        <Path x:Name="Rewind" Stretch="Fill" StrokeThickness="1"
              StrokeLineJoin="Round" Stroke="#FF000000" Fill="#FF000000"
              Data="M 69.8333,70.0833L 60.5833,
              63.2862L 60.5833,70.0833L 40,
              54.9583L 60.5833,39.8333L 60.5833,
              46.6304L 69.8333,39.8333L 69.8333,
              70.0833 Z "/>
      </RepeatButton.Content>
    </RepeatButton>
    <Button Grid.Column="1" x:Name="btnStop" Margin="1,0,1,0">
      <Button.Content>
        <Path x:Name="Stop" Fill="#FF000000" Stretch="Fill"
```

```
            StrokeThickness="0" Margin="5,5,5,5"
            Data="M0,0 L3,0 L3,30.249996 L0,30.249996 z"/>
      </Button.Content>
    </Button>
    <Button Grid.Column="2" x:Name="btnPlay" Margin="1,0,1,0">
      <Button.Content>
        <Path x:Name="Play" Stretch="Fill" StrokeThickness="0"
            Fill="#FF000000" Margin="5,5,5,5"
            Data="M 109.833,14.8944L 79.8333,
            -0.0445251L 79.8333,29.8333L 109.833,
            14.8944 Z "/>
      </Button.Content>
    </Button>
    <Button Grid.Column="3" x:Name="btnPause" Margin="1,0,1,0">
      <Button.Content>
        <Path x:Name="Pause" Stretch="Fill" StrokeThickness="0"
            Fill="#FF000000" Margin="5,5,5,5"
            Data="M 39.8333,0L 50.0833,0L 50.0833,29.8333L 39.8333,
            29.8333L 39.8333,0 Z M 59.8333,0L 69.8333,0L 69.8333,
            29.8333L 59.8333,29.8333L 59.8333,0 Z "/>
      </Button.Content>
    </Button>
    <RepeatButton Grid.Column="4" x:Name="btnForward" Margin="1,0,0,0">
      <RepeatButton.Content>
        <Path x:Name="Forward" Stretch="Fill" StrokeThickness="1"
            StrokeLineJoin="Round" Stroke="#FF000000"
            Fill="#FF000000"
            Data="M 1.27157e-006,39.8334L 9.25,
            46.6305L 9.25,39.8333L 29.8333,
            54.9583L 9.25,70.0833L 9.25,
            63.2863L 1.27157e-006,
            70.0833L 1.27157e-006,39.8334 Z "/>
      </RepeatButton.Content>
    </RepeatButton>
  </Grid>
</ControlTemplate>

<Style TargetType="local:MediaButtonsPanel">
  <Setter Property="Template"
          Value="{StaticResource ctMediaButtonsPanelDefault}"/>
</Style>
```

Note that although `btnStop`, `btnPause`, and `btnPlay` are `Buttons`, `btnRewind` and `btnForward` are `RepeatButtons`, with their `Delay` property set to 75 and `Interval` property set to 125. This means that when the user presses and holds down either `btnRewind` or `btnForward`, `Click` events are raised repeatedly at an

interval of 125 milliseconds, with a delay of 75 milliseconds before repeating starts. This gives the effect of being able to continuously seek through the media either way by holding down these buttons.

Listing 10-10 shows the code for `MediaButtonsPanel`.

Listing 10-10. *MediaButtonsPanel Control Code*

```
using System;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Controls.Primitives;
using System.Windows.Media;

namespace Recipe10_2
{
  public class MediaButtonsPanel : Control
  {
    private MediaElement MediaSource;
    private FrameworkElement Root;
    private ButtonBase btnPlay, btnPause,
      btnStop, btnForward, btnRewind;

    public static DependencyProperty SourceNameProperty =
      DependencyProperty.Register("SourceName", typeof(string),
      typeof(MediaButtonsPanel),
      new PropertyMetadata(new PropertyChangedCallback(OnSourceNameChanged)));
    public string SourceName
    {
      get
      {
        return (string)GetValue(SourceNameProperty);
      }
      set
      {
        SetValue(SourceNameProperty, value);
      }
    }
    private static void OnSourceNameChanged(DependencyObject Source,
      DependencyPropertyChangedEventArgs e)
    {
      MediaButtonsPanel thisPanel = Source as MediaButtonsPanel;

      if (e.NewValue != e.OldValue && thisPanel.Root != null)
        thisPanel.MediaSource =
          thisPanel.Root.FindName(e.NewValue as string) as MediaElement;
    }
```

```
public MediaButtonsPanel()
{
  this.DefaultStyleKey = typeof(MediaButtonsPanel);
}

public override void OnApplyTemplate()
{

  btnPlay = GetTemplateChild("btnPlay") as ButtonBase;
  btnPause = GetTemplateChild("btnPause") as ButtonBase;
  btnStop = GetTemplateChild("btnStop") as ButtonBase;
  btnForward = GetTemplateChild("btnForward") as ButtonBase;
  btnRewind = GetTemplateChild("btnRewind") as ButtonBase;
  Root = Helper.FindRoot(this);
  MediaSource = Root.FindName(SourceName) as MediaElement;
  WireButtonEvents();
}

private void WireButtonEvents()
{
  if (btnPlay != null)
    btnPlay.Click += new RoutedEventHandler(btnPlay_Click);
  if (btnPause != null)
    btnPause.Click += new RoutedEventHandler(btnPause_Click);
  if (btnStop != null)
    btnStop.Click += new RoutedEventHandler(btnStop_Click);

  if (btnForward != null)
    btnForward.Click += new RoutedEventHandler(btnForward_Click);
  if (btnRewind != null)
    btnRewind.Click += new RoutedEventHandler(btnRewind_Click);
}

void btnRewind_Click(object sender, RoutedEventArgs e)
{
  if (MediaSource != null && MediaSource.Position > TimeSpan.Zero)
  {
    MediaSource.Pause();
    //5th of a second
    MediaSource.Position -= new TimeSpan(0, 0, 0, 0,200);
    MediaSource.Play();
  }
}
void btnForward_Click(object sender, RoutedEventArgs e)
{
```

```
      if (MediaSource != null &&
        MediaSource.Position <= MediaSource.NaturalDuration.TimeSpan)
      {
        MediaSource.Pause();
        MediaSource.Position += new TimeSpan(0, 0, 0, 0, 200);
        MediaSource.Play();
      }
    }
    void btnStop_Click(object sender, RoutedEventArgs e)
    {
      if (MediaSource != null)
        MediaSource.Stop();
    }
    void btnPause_Click(object sender, RoutedEventArgs e)
    {
      if (MediaSource != null &&
        MediaSource.CurrentState == MediaElementState.Playing)
        MediaSource.Pause();
    }
    void btnPlay_Click(object sender, RoutedEventArgs e)
    {
      if (MediaSource != null &&
        MediaSource.CurrentState != MediaElementState.Playing)
        MediaSource.Play();
    }
  }
}
```

The `MediaButtonsPanel` acquires the `MediaElement` to work on the same way the `MediaSlider` does—by looking for the `MediaElement` with a name specified through the `SourceName` dependency property.

In `OnApplyTemplate()`, you attach handlers to the `Click` events of the buttons in the template. In `btnStop_Click()`, `btnPause_Click()`, and `btnPlay_Click()`, you invoke the appropriate `MediaElement` methods. In `btnRewind_Click()` and `btnForward_Click()`, you check for some boundary conditions to ensure that the resulting position would be a valid time point within the media's timeline, and then shift the `MediaElement.Position` in the appropriate direction by 200 milliseconds for every click. The sample hard-codes the value of 200, but you can easily make this a dependency property, giving you the ability to control the amount of shift.

10-3. Adding Streaming Media Support

Problem

You need to play streaming video in a Silverlight-based player.

Solution

Set up a media streaming infrastructure, set the `MediaElement` source to use appropriate URIs, and adapt various UI elements on the player to reflect streaming media states.

How It Works

As noted in Recipe 10-2, `MediaElement` can play both progressively downloaded as well as streamed media. You need a streaming media server, such as Windows Server with the Windows Media Services add-on, to stream media. Streaming media servers deliver media actively to the player throughout the duration of the media playing session, without requiring a download of the media file. A player playing streamed media usually plays the bits as they are received, and no copying to the disk is performed.

You can use streaming to broadcast live events over the Internet. In this scenario, the live content is passed from the recording source, such as a camera, directly to an encoder to convert it to the correct digital format. The resulting stream is then received by the streaming media server and broadcast out.

Network Considerations

A streaming media player typically buffers a small amount of content, which allows it to stay slightly ahead of the media stream. When a player starts playing a stream, an initial buffering is conducted before the media can begin playing. In the case of congested networks, where the available network bandwidth may vary over time during the playing session, a network stream may fall behind in continuously supplying content to the player to maintain this read-ahead state. In this case, the player may need to buffer again during the play-out in order to gather content to play.

Considering this, you should take the bit rate of the media into consideration when streaming media. For example, if a piece of media is encoded at a rate of 30 frames per second for jitter-free playing, and each frame of video is approximately 34 KB in size, then the player needs to receive the media at about one MB per second. When the network between the user and the streaming endpoint frequently falls below the required speed limit, you may see jitter in play-out when the required frame rate is not being met; or the player may buffer more frequently than expected, resulting in a subpar viewing experience.

Such potential issues with available network bandwidth require that you pay special attention to the settings applied to the video when it is being encoded for streaming, so that the resulting bit-rate requirement of the encoded video is close to the actual network conditions in which it plays. It is common to have multiple encodings done of the same video file at different resulting bit rates, and then have different URIs point to these videos so that players can choose a bit rate suitable to the prevailing network condition.

Silverlight also supports multiple bit rate (MBR) video files. MBR video files are essentially multiple copies of the same video, each fully encoded at a constant bit rate packaged in a single file. When it encounters MBR video, `MediaElement` chooses the appropriate bit rate suitable for the available bandwidth. MBR files can also work with Silverlight in progressive download scenarios, and Silverlight chooses the highest possible bit rate to play the downloaded video. Do not confuse MBR video with variable bit rate (VBR) video. In VBR video, different parts of the same video stream are encoded at different bit rates to achieve optimal compression of the video. VBR video is not suitable for streaming because it is difficult to determine the network requirements of the video in a predictable fashion throughout the playing session.

A detailed discussion of concepts involved in video encoding and network infrastructure for video streaming is beyond the scope of this book. Here are some excellent resources for a better understanding of topics like video encoding and delivering video over IP networks:

- Compression for Great Digital Video: Power Tips, Techniques, and Common Sense, by Ben Waggoner (CMP Books, 2002)
- Video Over IP: A Practical Guide to Technology and Applications, by Wes Simpson (Focal Press, 2005)

Windows Media Services

Windows Media Services (WMS) is a streaming media server for Windows Media and is available freely from Microsoft as an add-on to the Windows Server operating system. The samples in this chapter relating to streaming use WMS to set up the streaming backend. We use WMS 2008, available on Windows Server 2008, which offers the latest features in Windows Media streaming; but WMS is also available on earlier versions of Windows Server.

Setting Up WMS 2008

After you have Windows Server 2008 installed on your server, you can download WMS 2008 at `www.microsoft.com/downloads/details.aspx?FamilyID=9ccf6312-723b-4577-be58-7caab2e1c5b7&displaylang=en`. You can find full instructions for installing WMS 2008 at `support.microsoft.com/kb/934518`.

When you install WMS on a server that has a web server running and listening on port 80, WMS does not enable the HTTP server control protocol during installation. After you have installed WMS 2008, you need to enable this to let Silverlight work with WMS. To do so, open the Windows Media Services console from Administrative Tools on your Start menu. Navigate to the HTTP server control protocol plug-in, as shown in Figure 10-9.

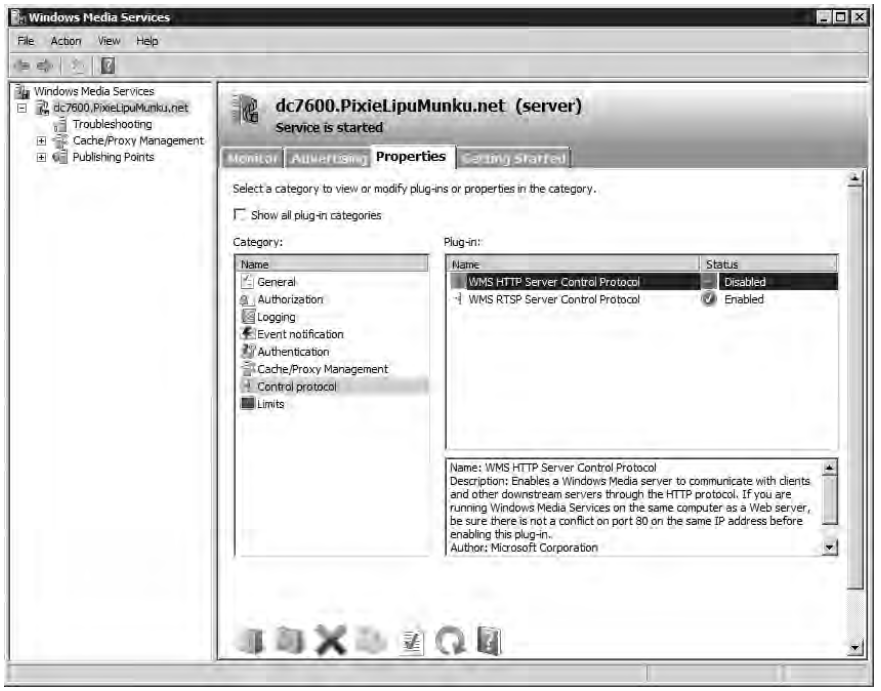


Figure 10-9. *WMS HTTP server control protocol plug-in*

Double-click the protocol entry to bring up the properties sheet. Select Allow all IP addresses to use this protocol, and then specify a custom port other than 80. Allowing all IP addresses lets the server stream media on all available network interfaces, in case the machine has more than one installed network interface. In Figure 10-10, we have selected port 43000.

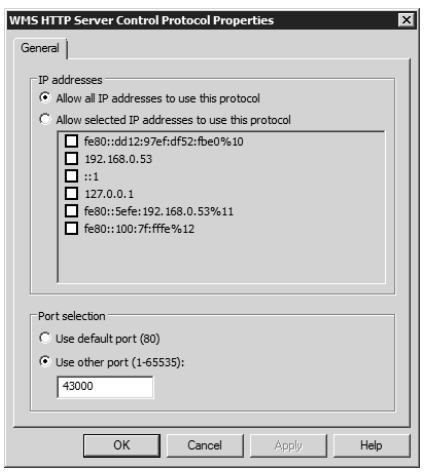


Figure 10-10. *WMS HTTP server control protocol properties*

Right-click the HTTP server control protocol item to bring up its context menu and enable the protocol.

Setting Up Publishing Points

Publishing points define the endpoints of a WMS 2008 installation to which a client connects to in order to receive media. A publishing point can be defined to serve a media file stored on disk, a playlist that defines an ordered collection of media files to be played in sequence, or media that is being acquired real time from a capture device, such as encoder software connected to a camera. The publishing point abstracts the actual source of the media and provides the client with a URL to which the client can connect to start receiving media.

■ **Note** We discuss playlists in more detail in Recipe 10-4. We do not discuss live streaming using a capture device in this book. Typically, doing so requires more setup and some knowledge of encoding. To get good-quality live streaming, you need to have high-grade network equipment and broadcast-quality cameras, and we do not assume that you have access to those readily while you are reading the book. If you want to experiment with live streaming from a camera, you can refer to Jit Ghosh's blog entry at `blogs.msdn.com/jitghosh/archive/2007/11/30/demo-live-streams-in-silverlight.aspx` where he discusses a basic setup using a commodity webcam and uses Microsoft Expression Encoder and WMS 2008 to create a basic live streaming scenario with Silverlight as the client front end.

Two kinds of publishing points are possible in WMS: broadcast and on-demand. Either kind can serve media from any of the sources mentioned earlier. Also, multiple publishing points of each type can be defined on a single installation of WMS.

An on-demand publishing point is most often used when you want the user to control the playback and have the ability to pause, rewind, or forward content. Consequently, on-demand publishing points are mostly used with prerecorded video content stored on disk or with playlists.

Broadcast publishing points create an experience similar to television programs in that the player cannot control playback, and you cannot pause, rewind, or forward content. Also, while streaming from a broadcast publishing point, the `MediaElement` does not have any information about the duration of the media. These conditions are true even if the broadcast publishing point is being used to stream prerecorded media stored on disk. Broadcast publishing points are mostly used to serve live streams coming directly from encoders or other live sources, like remote servers.

The code sample later in this recipe uses one publishing point of each type, but both use disk files as the source of media. Let's look at creating these publishing points.

Right-click the Publishing Points note in the left pane of the WMS management console, and select the Add Publishing Point (Advanced) menu option, as shown in Figure 10-11.

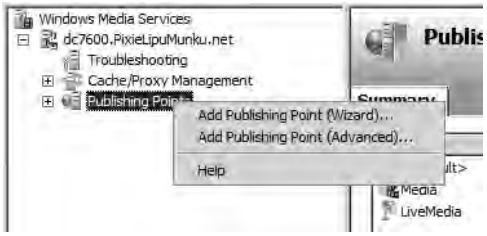


Figure 10-11. *Add Publishing Point context menu*

Choosing that command opens the Add Publishing Point dialog shown in Figure 10-12. Select an on-demand publishing point, provide a name, and select the folder containing the video files. You can also select an individual file for a publishing point or create a playlist. We discuss playlists in greater detail in the next recipe.

Create another publishing point, repeating the same steps, but this time choose a broadcast publishing point, and assign it a different name from the on-demand publishing point. Figure 10-12 shows the choices for the on-demand and broadcast publishing points for this recipe.

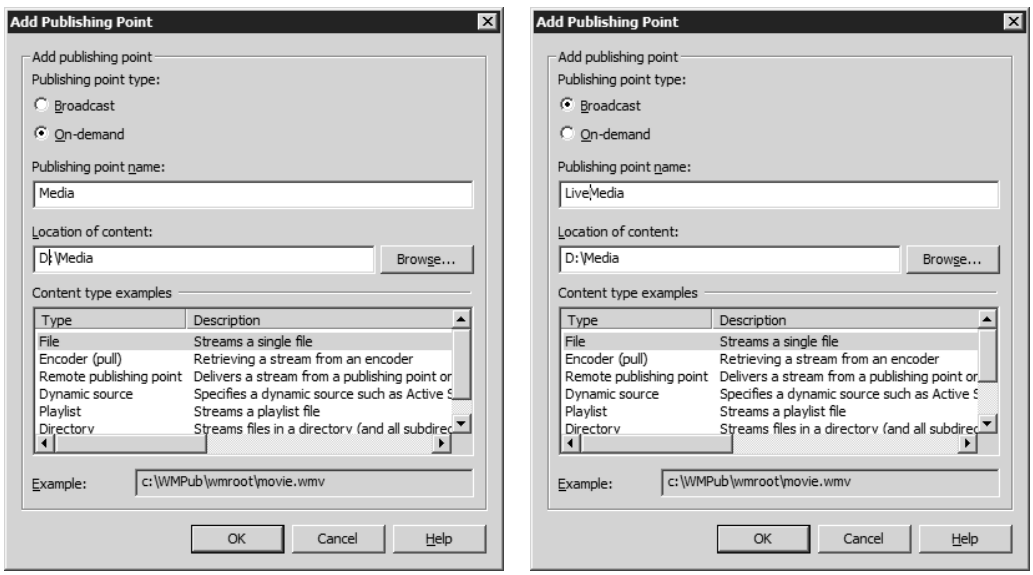


Figure 10-12. *Creating publishing points*

After both publishing points are created, navigate to the Source tab for the broadcast publishing point, and turn on looping by clicking the Loop Directory button, as shown in Figure 10-13. This causes WMS to continuously play all content in the folder in a loop.

Figure 10-13. *Turn on looping for the broadcast publishing point.*

Then, right-click the broadcast publishing point, and start the publishing point from the context menu.

A detailed discussion of all aspects of WMS setup and operation is beyond the scope of this book. You can refer to the WMS documentation online at `technet.microsoft.com/en-us/library/cc753790.aspx` for a thorough exploration of streaming Windows Media and WMS.

The Code

This sample extends the player you built in Recipe 10-2 to support streaming media features.

The first step is to extend the `MediaLocationProvider` WCF service to add two more operations, `GetOnDemandStreamsList()` and `GetBroadcastStreamsList()`, each of which performs exactly like `GetDownloadsList()`, which was defined earlier, but returns different XML. `GetOnDemandStreamsList()` returns the contents of a file named `OnDemandStreams.xml`. Listing 10-11 shows a portion of this file.

Listing 10-11. *OnDemandStreams.xml*

```
<?xml version="1.0" encoding="utf-8" ?>
<MediaLocations>
  <MediaLocation>
    <Description>Adrenaline Rush</Description>
    <Uri>mms://dc7600:43000/Media/AdrenalineRush.wmv</Uri>
    <ImageUri>
      http://localhost/SLBook/Ch10_RichMedia/Media/AdrenalineRush_Thumb.jpg
    </ImageUri>
  </MediaLocation>
  <MediaLocation>
    <Description>Alexander</Description>
    <Uri>mms://dc7600:43000/Media/Alexander_Trailer_1080p.wmv</Uri>
    <ImageUri>
```

```
      http://localhost/SLBook/Ch08_RichMedia/Media/Alexander_Trailer_1080p_Thumb.jpg
    </ImageUri>
  </MediaLocation>
  <!-- more streams here -->
</MediaLocations>
```

As you can see, the <Uri> element for each stream entry points to the media file at the on-demand publishing point on the media server (which, in this sample, is running on a machine named dc7600 at port 43000). Note that the server name and the port number need to be changed to match your environment for the samples to work.

Also note the use of the mms (Microsoft Media Server) protocol identifier in the first <MediaLocation> entry in Listing 10-11. mms is not an actual protocol but rather a rollover scheme. In Silverlight, the MediaElement only operates over the HTTP protocol. So, whenever an mms protocol identifier is used, the MediaElement automatically rolls over to using HTTP. An additional significance of the protocol identifier is that whenever the MediaElement encounters the mms protocol identifier, it tries to stream the content first. If that is not successful, it then tries a progressive download. If it encounters the HTTP protocol identifier, it tries a progressive download first, followed by an attempt to stream. In both scenarios, you are safe using either protocol identifier. You can find more information about MMS at msdn.microsoft.com/en-us/library/cc239490(PROT.10).aspx.

Listing 10-12 shows the BroadcastStreams.xml that is returned by invoking the GetBroadcastStreamsList() operation.

Listing 10-12. *BroadcastStreams.xml*

```
<?xml version="1.0" encoding="utf-8" ?>
<MediaLocations>
  <MediaLocation>
    <Description>Random Loop</Description>
    <Uri>http://dc7600:43000/LiveMedia</Uri>
    <ImageUri>
      http://localhost/SLBook/Ch10_RichMedia/Media/AdrenalineRush_Thumb.jpg
    </ImageUri>
  </MediaLocation>
</MediaLocations>
```

Note that the <Uri> element in this case points to the broadcast publishing point that you created without specifying a media file. Recall that because this is a broadcast publishing point, the user has no control over where to begin playing a specific stream and therefore cannot point to a specific file. Because you marked the content to loop, the publishing point, once started, keeps looping the content continuously, and the client joins the stream at the point where it currently is.

Again, we do not list the code for the service operations; we encourage you to refer to Chapter 7 for a better understanding of how Silverlight interacts with WCF services. Check out the sample code for this recipe for the operation implementations.

Changes to the Player

You add a couple more media menus to the player to display the choices for the on-demand and broadcast streams that are returned through the service operations. Listing 10-13 shows the XAML for the player.

Listing 10-13. *XAML for the Streaming Player*

```
<UserControl x:Class="Recipe10_3.MainPage"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    xmlns:vsm="clr-namespace:System.Windows;assembly=System.Windows"
    xmlns:local="clr-namespace:Recipe10_3"
    Width="920" Height="547"
    xmlns:Ch10_RichMedia_Recipe10_3="clr-namespace:Recipe10_3;assembly=↵
Recipe10_3.PlrCntls" >
  <UserControl.Resources>
    <DataTemplate x:Key="dtMediaMenuItem">
      <Grid Height="140" Width="160" Margin="0,8,0,8">
        <Grid.RowDefinitions>
          <RowDefinition Height="0.7*" />
          <RowDefinition Height="0.3*" />
        </Grid.RowDefinitions>

        <Grid.ColumnDefinitions>
          <ColumnDefinition Width="0.7*"/>
          <ColumnDefinition Width="0.3*" />
        </Grid.ColumnDefinitions>
        <Image HorizontalAlignment="Stretch"
               VerticalAlignment="Stretch" Stretch="Fill"
               Source="{Binding MediaPreview}" Grid.Row ="0"
               Grid.ColumnSpan="2"/>
        <TextBlock TextAlignment="Left" HorizontalAlignment="Stretch"
                   VerticalAlignment="Stretch" Grid.Row="1"
                   Text="{Binding Description}" Grid.Column="0"/>
        <Grid Grid.Row="1" Grid.Column="1">
          <Grid.RowDefinitions>
            <RowDefinition Height="0.4*" />
            <RowDefinition Height="0.2*" />
            <RowDefinition Height="0.4*" />
          </Grid.RowDefinitions>
          <Button Grid.Row="0" x:Name="PlayFull" Click="PlayFull_Click"
                  Tag="{Binding}" HorizontalAlignment="Center">
            <Button.Content>
              <Path Stretch="Fill" StrokeLineJoin="Round"
                            Stroke="#FF000000"
                            Data="M 120,9.15527e-005L 149.937,
                              9.15527e-005L 149.937,19.9361L 120,
                              19.9361L 120,9.15527e-005 Z M 120,
                              6.04175L 149.812,6.04175M 120,
                              14.0417L 149.937,14.0417M 123.417,
```

```
                        0.991364L 131.167,0.991364L 131.167,
                        4.88376L 123.417,4.88376L 123.417,
                        0.991364 Z M 135.125,1.00012L 142.875,
                        1.00012L 142.875,4.89246L 135.125,
                        4.89246L 135.125,1.00012 Z M 123.542,
                        15.035L 131.292,15.035L 131.292,
                        18.9274L 123.542,18.9274L 123.542,
                        15.035 Z M 135.25,15.0438L 143,
                        15.0438L 143,18.9362L 135.25,18.9362L 135.25,
                        15.0438 Z "/>
          </Button.Content>
        </Button>

        <Button Grid.Row="2" x:Name="PlayPIP" Click="PlayPIP_Click"
                Tag="{Binding}" HorizontalAlignment="Center">
          <Button.Content>
            <Path Stretch="Fill" StrokeThickness="2"
                        StrokeLineJoin="Round" Stroke="#FF000000"
                        Data="M 120,39.8333L 149.917,
                        39.8333L 149.917,59.9167L 120,
                        59.9167L 120,39.8333 Z M 132.917,
                        42.8333L 146.667,42.8333L 146.667,
                        52.6667L 132.917,52.6667L 132.917,
                        42.8333 Z "/>
          </Button.Content>
        </Button>
      </Grid>
    </Grid>
  </DataTemplate>
  <ControlTemplate x:Key="ctMediaMenuListBoxItem" TargetType="ListBoxItem">
    <Grid>
      <vsm:VisualStateManager.VisualStateGroups>
        <vsm:VisualStateGroup x:Name="SelectionStates">
          <vsm:VisualState x:Name="Unselected"/>
          <vsm:VisualState x:Name="SelectedUnfocused">
            <Storyboard/>
          </vsm:VisualState>
          <vsm:VisualState x:Name="Selected">
            <Storyboard/>
          </vsm:VisualState>
        </vsm:VisualStateGroup>
        <vsm:VisualStateGroup x:Name="FocusStates">
          <vsm:VisualStateGroup.Transitions>
          </vsm:VisualStateGroup.Transitions>
          <vsm:VisualState x:Name="Unfocused"/>
```

```
            <vsm:VisualState x:Name="Focused"/>
          </vsm:VisualStateGroup>
          <vsm:VisualStateGroup x:Name="CommonStates">
            <vsm:VisualStateGroup.Transitions>
              <vsm:VisualTransition
                GeneratedDuration="00:00:00.2000000" To="MouseOver"/>
              <vsm:VisualTransition From="MouseOver"
                                    GeneratedDuration="00:00:00.2000000"/>
            </vsm:VisualStateGroup.Transitions>

            <vsm:VisualState x:Name="MouseOver">
              <Storyboard>
                <ColorAnimationUsingKeyFrames BeginTime="00:00:00"
                        Duration="00:00:00.0010000"
                        Storyboard.TargetName="brdrMouseOverIndicator"
                        Storyboard.TargetProperty="(Border.BorderBrush)↵
.(SolidColorBrush.Color)">
                  <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF126AB3"/>
                </ColorAnimationUsingKeyFrames>
                <ColorAnimationUsingKeyFrames BeginTime="00:00:00"
                Duration="00:00:00.0010000"
                Storyboard.TargetName="brdrMouseOverIndicator"
                Storyboard.TargetProperty="(Border.Background).(SolidColorBrush.Color)">
                  <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF7FDDE6"/>
                </ColorAnimationUsingKeyFrames>
              </Storyboard>
            </vsm:VisualState>
            <vsm:VisualState x:Name="Normal"/>
          </vsm:VisualStateGroup>
        </vsm:VisualStateManager.VisualStateGroups>
        <Border CornerRadius="2,2,2,2" BorderThickness="3,3,3,3"
                x:Name="brdrMouseOverIndicator"
                Background="#007FDDE6" BorderBrush="#00000000">
          <ContentPresenter/>
        </Border>
      </Grid>
    </ControlTemplate>
    <Style x:Key="STYLE_MediaMenuListBoxItem" TargetType="ListBoxItem">
      <Setter Property="Template"
              Value="{StaticResource ctMediaMenuListBoxItem}"/>
    </Style>

    <ControlTemplate x:Key="ctMenuSwitchButton" TargetType="RadioButton">
      <Grid>
```

```
      <vsm:VisualStateManager.VisualStateGroups>
        <vsm:VisualStateGroup x:Name="CheckStates">
          <vsm:VisualState x:Name="Unchecked"/>

          <vsm:VisualState x:Name="Checked">
            <Storyboard>
              <ColorAnimationUsingKeyFrames BeginTime="00:00:00"
      Duration="00:00:00.0010000"
      Storyboard.TargetName="border"
      Storyboard.TargetProperty="(Border.BorderBrush).(SolidColorBrush.Color)">
                <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF000000"/>
              </ColorAnimationUsingKeyFrames>
              <ColorAnimationUsingKeyFrames BeginTime="00:00:00"
                  Duration="00:00:00.0010000"
                  Storyboard.TargetName="border"
                  Storyboard.TargetProperty="(Border.Background).(SolidColorBrush.Color)">
                <SplineColorKeyFrame KeyTime="00:00:00" Value="#FF3CB1E8"/>
              </ColorAnimationUsingKeyFrames>
            </Storyboard>
          </vsm:VisualState>
          <vsm:VisualState x:Name="Indeterminate"/>
        </vsm:VisualStateGroup>
        <vsm:VisualStateGroup x:Name="CommonStates">
          <vsm:VisualState x:Name="Disabled"/>
          <vsm:VisualState x:Name="Normal"/>
          <vsm:VisualState x:Name="MouseOver"/>
          <vsm:VisualState x:Name="Pressed"/>
        </vsm:VisualStateGroup>
        <vsm:VisualStateGroup x:Name="FocusStates">
          <vsm:VisualState x:Name="Focused"/>
          <vsm:VisualState x:Name="Unfocused"/>
        </vsm:VisualStateGroup>
      </vsm:VisualStateManager.VisualStateGroups>
      <Border HorizontalAlignment="Stretch" VerticalAlignment="Stretch"
              CornerRadius="3,3,0,0" Margin="0,0,0,0"
              BorderThickness="2,2,2,0" BorderBrush="#FF000000"
              x:Name="border" Background="#003CB1E8">
        <TextBlock Text="{TemplateBinding Content}"
                   TextWrapping="Wrap" TextAlignment="Center"
                   FontSize="10" FontWeight="Normal"
                   FontFamily="Portable User Interface"
                   VerticalAlignment="Center"/>
      </Border>
    </Grid>
  </ControlTemplate>
```

```
</UserControl.Resources>


<Grid x:Name="LayoutRoot"
      Background="#FFA2A2A2" Height="Auto" Width="Auto">
  <Grid.RowDefinitions>
    <RowDefinition Height="0.062*"/>
    <RowDefinition Height="0.689*"/>
    <RowDefinition Height="0.249*"/>
  </Grid.RowDefinitions>
  <Grid.ColumnDefinitions>
    <ColumnDefinition Width="0.2*"/>
    <ColumnDefinition Width="0.8*"/>
  </Grid.ColumnDefinitions>
  <MediaElement Height="Auto" Margin="0,0,0,0"
                VerticalAlignment="Top" x:Name="mediaelemMain"
                BufferingTime="0:0:3"
                HorizontalAlignment="Left" AutoPlay="True" Opacity="0"/>
  <MediaElement Height="Auto" Margin="0,0,0,0" VerticalAlignment="Top"
                x:Name="mediaelemPIP" HorizontalAlignment="Left"
                AutoPlay="True" Opacity="0" IsMuted="True"
                BufferingTime="0:0:3"/>

  <Grid Grid.Row="0" Grid.Column="1" Grid.RowSpan="2">
    <Grid.RowDefinitions>
      <RowDefinition Height="0.05*" />
      <RowDefinition Height="0.9*" />
      <RowDefinition Height="0.05*" />
    </Grid.RowDefinitions>
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.05*"/>
      <ColumnDefinition Width="0.9*"/>
      <ColumnDefinition Width="0.05*"/>
    </Grid.ColumnDefinitions>
    <Border x:Name="displayMain"
            VerticalAlignment="Stretch" Grid.Column="1" Grid.Row="1"
            HorizontalAlignment="Stretch" BorderThickness="5,5,5,5"
            BorderBrush="#FF000000" >
      <Border.Background>
        <VideoBrush SourceName="mediaelemMain" Stretch="Fill"
                    x:Name="vidbrushMain" />
      </Border.Background>
    </Border>

    <Grid Grid.Column="1" Grid.Row="1">
```

```
<Grid.RowDefinitions>
  <RowDefinition Height="0.025*" />
  <RowDefinition Height="0.35*" />
  <RowDefinition Height="0.625*" />
</Grid.RowDefinitions>
<Grid.ColumnDefinitions>
  <ColumnDefinition Width="0.635*"/>
  <ColumnDefinition Width="0.35*"/>
  <ColumnDefinition Width="0.015*"/>
</Grid.ColumnDefinitions>
<Border Grid.Column="1" Grid.Row="1" HorizontalAlignment="Stretch"
        VerticalAlignment="Stretch"
        MouseLeftButtonUp="displayPIP_MouseLeftButtonUp"
        x:Name="displayPIP" BorderThickness="2,2,2,2"
        BorderBrush="#FF000000" Visibility="Collapsed">
  <Border.Background>
    <VideoBrush SourceName="mediaelemPIP"
                Stretch="Fill" x:Name="vidbrushPIP"/>
  </Border.Background>
</Border>
<Grid HorizontalAlignment="Stretch" Margin="8,8,8,8"
      Grid.RowSpan="1" Grid.Column="1" Grid.Row="1"
      x:Name="buttonsPIP" Visibility="Collapsed" >
  <Grid.RowDefinitions>
    <RowDefinition Height="0.1*"/>
    <RowDefinition Height="0.25*"/>
    <RowDefinition Height="0.1*"/>
    <RowDefinition Height="0.25*"/>
    <RowDefinition Height="0.3*"/>
  </Grid.RowDefinitions>
  <Grid.ColumnDefinitions>
    <ColumnDefinition Width="0.749*"/>
    <ColumnDefinition Width="0.176*"/>
    <ColumnDefinition Width="0.075*"/>
  </Grid.ColumnDefinitions>
  <Button Margin="0,0,0,0" Grid.RowSpan="1" Grid.Row="1"
          Grid.ColumnSpan="1" Grid.Column="1"
          x:Name="btnClosePIP" Click="btnClosePIP_Click">

    <Button.Content>
```

```
<Path x:Name="Path" Stretch="Fill" StrokeThickness="2"
                    StrokeLineJoin="Round" Stroke="#FF000000" Fill="#FFE91111"
                    Data="M 110.5,75.7635L 113.209,
                    72.9631L 133.396,92.4865L 130.687,95.2869L 110.5,
                    75.7635 Z M 130.801,73.4961L 133.393,76.4048L 112.425,
                    95.0872L 109.833,92.1785L 130.801,73.4961 Z "/>
            </Button.Content>
          </Button>
          <Button Margin="0,0,0,0" Grid.RowSpan="1" Grid.Row="3"
                  Grid.ColumnSpan="1" Grid.Column="1"
                  x:Name="btnSwitchPIP" Click="btnSwitchPIP_Click">
            <Button.Content>
              <Path Stretch="Fill" StrokeThickness="2" StrokeLineJoin="Round"
                    Stroke="#FF000000" Data="M 120,39.8333L 149.917,
                    39.8333L 149.917,59.9167L 120,59.9167L 120,
                    39.8333 Z M 132.917,42.8333L 146.667,42.8333L 146.667,
                    52.6667L 132.917,52.6667L 132.917,42.8333 Z "/>
            </Button.Content>
          </Button>
        </Grid>
      </Grid>
    </Grid>
    <Grid Margin="2,2,2,2" VerticalAlignment="Stretch" Grid.Column="1"
          Grid.Row="2" HorizontalAlignment="Stretch">
      <Grid.RowDefinitions>
        <RowDefinition Height="0.5*"/>
        <RowDefinition Height="0.5*"/>
      </Grid.RowDefinitions>
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="0.75*"/>
        <ColumnDefinition Width="0.25*"/>
      </Grid.ColumnDefinitions>
      <Ch08_RichMedia_Recipe8_3:MediaSlider SourceName="mediaelemMain"
                              VerticalAlignment="Top"
                              IsEnabled="True"
                              x:Name="mediaSlider" Grid.ColumnSpan="2"/>
      <Ch08_RichMedia_Recipe8_3:MediaButtonsPanel Grid.Row="1" Grid.Column="0"
                              SourceName="mediaelemMain"
                              HorizontalAlignment="Center"
                              VerticalAlignment="Center"
                              Width="150" Height="40"
                              x:Name="mediaControl"/>
```

```
<Slider x:Name="sliderVolumeControl"  Margin="5,0,5,0" Maximum="1"
              Minimum="0" SmallChange="0.1"
              LargeChange="0.2"  Value="0.5"
              MinWidth="50" Grid.Row="1"
              Grid.Column="1" ValueChanged="sliderVolumeControl_ValueChanged">
      </Slider>
    </Grid>
    <Grid Grid.RowSpan="3">
      <Grid.RowDefinitions>
        <RowDefinition Height="Auto" MinHeight="41" />
        <RowDefinition Height="*" />
      </Grid.RowDefinitions>
      <Grid Height="Auto" VerticalAlignment="Stretch">
        <Grid.ColumnDefinitions>
          <ColumnDefinition Width="0.33*"/>
          <ColumnDefinition Width="0.34*"/>
          <ColumnDefinition Width="0.33*"/>
        </Grid.ColumnDefinitions>
        <RadioButton HorizontalAlignment="Stretch" VerticalAlignment="Stretch"
                     Content="Download"
                     Template="{StaticResource ctMenuSwitchButton}"
                     HorizontalContentAlignment="Stretch"
                     VerticalContentAlignment="Stretch"
                     GroupName="MediaMenuChoices"
                     IsChecked="False" x:Name="rbtnDownloadsMenu"
                     Checked="rbtnDownloadsMenu_Checked"/>
        <RadioButton HorizontalAlignment="Stretch" VerticalAlignment="Stretch"
                     Content="On Demand" Grid.Column="1"
                     Template="{StaticResource ctMenuSwitchButton}"
                     HorizontalContentAlignment="Stretch"
                     VerticalContentAlignment="Stretch"
                     GroupName="MediaMenuChoices"
                     IsChecked="True" x:Name="rbtnOnDemandMenu"
                     Checked="rbtnOnDemandMenu_Checked"/>
        <RadioButton HorizontalAlignment="Stretch" VerticalAlignment="Stretch"
                     Content="Broadcast" Grid.Column="2"
                     Template="{StaticResource ctMenuSwitchButton}"
                     HorizontalContentAlignment="Stretch"
```

```
                    VerticalContentAlignment="Stretch"
                    GroupName="MediaMenuChoices" x:Name="rbtnBroadcastMenu"
                    Checked="rbtnBroadcastMenu_Checked"/>
      </Grid>

      <ListBox Margin="0,0,0,0" VerticalAlignment="Stretch"
               x:Name="lbxMediaMenuDownloads"
               ItemTemplate="{StaticResource dtMediaMenuItem}"
               ItemContainerStyle="{StaticResource STYLE_MediaMenuListBoxItem}"
               Grid.RowSpan="1" Grid.Row="1" Background="#FF3CB1E8"
               Visibility="Collapsed"/>
      <ListBox Margin="0,0,0,0" VerticalAlignment="Stretch"
                x:Name="lbxMediaMenuOnDemandStreams"
                ItemTemplate="{StaticResource dtMediaMenuItem}"
                ItemContainerStyle="{StaticResource STYLE_MediaMenuListBoxItem}"
                Grid.RowSpan="1" Grid.Row="1" Background="#FF3CB1E8"/>
      <ListBox Margin="0,0,0,0" VerticalAlignment="Stretch"
                x:Name="lbxMediaMenuBroadcastStreams"
                ItemTemplate="{StaticResource dtMediaMenuItem}"
                ItemContainerStyle="{StaticResource STYLE_MediaMenuListBoxItem}"
               Visibility="Collapsed"
                Background="#FF3CB1E8" Grid.RowSpan="1" Grid.Row="1"/>
    </Grid>
  </Grid>
</UserControl>
```

You implement the two additional menus for on-demand and broadcast content by adding two `ListBoxes` named `lbxMediaMenuOnDemandStreams` and `lbxMediaMenuBroadcastStreams`, as shown in Listing 10-13. You set `lbxDownloadsMenu.Visibility` and `lbxBroadcastMenu.Visibility` to `Collapsed` so that the on-demand list shows up by default. You also add three `RadioButton` controls—`rbtnDownloadsMenu`, `rbtnOnDemandMenu`, and `rbtnBroadcastMenu`—which switch between the `ListBoxes`. A custom template named `ctMenuSwitchButton` is defined and applied to the `RadioButtons` to make them look more like tabs. Also note the use of the `BufferingTime` property on the `MediaElement`. It specifies the minimum content length (in time) that the `MediaElement` buffers at the start and every time it runs out of content to play.

Figure 10-14 shows the look of the new menu arrangement at startup.

The `RadioButtons` are also made to belong to the same group by setting a common value for the `GroupName` property. This means that selecting one will deselect the others automatically. You see the menu-switching in the player code shown in Listing 10-14.

Figure 10-14. *Streaming player menu at startup*

Listing 10-14. *Streaming Player Codebehind*

```
using System;
using System.Collections.Generic;
using System.Collections.ObjectModel;
using System.Linq;
using System.Net;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Input;
using System.Xml.Linq;

namespace Recipe10_3
{
  public partial class MainPage : UserControl
  {
    private const string DownloadsListUri =
      "http://localhost:9292/MediaLocationProvider.svc/GetDownloadsList";
    private const string OnDemandStreamsListUri =
      "http://localhost:9292/MediaLocationProvider.svc/GetOnDemandStreamsList";
```

```
private const string BroadcastStreamsListUri =
  "http://localhost:9292/MediaLocationProvider.svc/GetBroadcastStreamsList";
private ObservableCollection<MediaMenuData> listDownloads =
  new ObservableCollection<MediaMenuData>();
private ObservableCollection<MediaMenuData> listOnDemandStreams =
 new ObservableCollection<MediaMenuData>();
private ObservableCollection<MediaMenuData> listBroadcastStreams =
 new ObservableCollection<MediaMenuData>();

public MainPage()
{
  InitializeComponent();
  lbxMediaMenuDownloads.ItemsSource = listDownloads;
  lbxMediaMenuOnDemandStreams.ItemsSource = listOnDemandStreams;
  lbxMediaMenuBroadcastStreams.ItemsSource = listBroadcastStreams;
  this.Loaded += new RoutedEventHandler(MainLoaded);
}

void Page_Loaded(object sender, RoutedEventArgs e)
{
  PopulateMediaMenu();
}
private MediaElement MainVideo
{
  get
  {
    return (vidbrushMain.SourceName == "mediaelemMain") ?
    mediaelemMain : mediaelemPIP;
  }
}
private MediaElement PIPVideo
{
  get
  {
    return (vidbrushPIP.SourceName == "mediaelemMain") ?
    mediaelemMain : mediaelemPIP;
  }
}

private void PopulateMediaMenu()
{
  WebClient wcDownloads = new WebClient();
  wcDownloads.DownloadStringCompleted +=
    new DownloadStringCompletedEventHandler(ListDownloadCompleted);
  WebClient wcOnDemand = new WebClient();
```

```
      wcOnDemand.DownloadStringCompleted+=
        new DownloadStringCompletedEventHandler(ListDownloadCompleted);
      WebClient wcBroadcast = new WebClient();
      wcBroadcast.DownloadStringCompleted +=
        new DownloadStringCompletedEventHandler(ListDownloadCompleted);

      wcDownloads.DownloadStringAsync(new Uri(DownloadsListUri), listDownloads);
      wcOnDemand.DownloadStringAsync(
new Uri(OnDemandStreamsListUri), listOnDemandStreams);
      wcBroadcast.DownloadStringAsync(
new Uri(BroadcastStreamsListUri), listBroadcastStreams);
    }
    void ListDownloadCompleted(object sender, DownloadStringCompletedEventArgs e)
    {
      this.Dispatcher.BeginInvoke(new Action(delegate
      {
        XDocument xDoc = XDocument.Parse(e.Result);

        List<MediaMenuData> tempList =
          (from medloc in xDoc.Root.Elements()
           select new MediaMenuData
           {
             Description = medloc.Element("Description").Value,
             MediaLocation = new Uri(medloc.Element("Uri").Value),
             MediaPreview = medloc.Element("ImageUri").Value
           }).ToList();

        ObservableCollection<MediaMenuData> target =
(e.UserState as ObservableCollection<MediaMenuData>);
        foreach (MediaMenuData medloc in tempList)
          target.Add(medloc);
      }));
    }

    private void PlayFull_Click(object sender, RoutedEventArgs e)
    {
      MainVideo.Source = ((sender as Button).Tag as MediaMenuData).MediaLocation;
    }

    private void PlayPIP_Click(object sender, RoutedEventArgs e)
    {
      PIPVideo.Source = ((sender as Button).Tag as MediaMenuData).MediaLocation;
      displayPIP.Visibility = Visibility.Visible;
    }
```

```
private void btnClosePIP_Click(object sender, RoutedEventArgs e)
{
  PIPVideo.Stop();
  buttonsPIP.Visibility = displayPIP.Visibility = Visibility.Collapsed;
}

private void btnSwitchPIP_Click(object sender, RoutedEventArgs e)
{
  if (vidbrushMain.SourceName == "mediaelemMain")
  {
    vidbrushMain.SourceName = "mediaelemPIP";
    vidbrushPIP.SourceName = "mediaelemMain";
    mediaSlider.SourceName = "mediaelemPIP";
    mediaControl.SourceName = "mediaelemPIP";
    mediaelemMain.IsMuted = true;
    mediaelemPIP.IsMuted = false;
  }
  else
  {
    vidbrushMain.SourceName = "mediaelemMain";
    vidbrushPIP.SourceName = "mediaelemPIP";
    mediaSlider.SourceName = "mediaelemMain";
    mediaControl.SourceName = "mediaelemMain";
    mediaelemMain.IsMuted = false;
    mediaelemPIP.IsMuted = true;
  }
  MainVideo.Volume = sliderVolumeControl.Value;
}

private void displayPIP_MouseLeftButtonUp(object sender,
  MouseButtonEventArgs e)
{
  if (displayPIP.Visibility == Visibility.Visible)
  {
    buttonsPIP.Visibility =
      (buttonsPIP.Visibility == Visibility.Visible ?
      Visibility.Collapsed : Visibility.Visible);
  }
}
private void sliderVolumeControl_ValueChanged(object sender,
  RoutedPropertyChangedEventArgs<double> e)
{

  if (vidbrushMain != null)
```

```
      {
        MainVideo.Volume = e.NewValue;
      }
    }
    private void rbtnDownloadsMenu_Checked(object sender, RoutedEventArgs e)
    {
      if (lbxMediaMenuBroadcastStreams != null &&
        lbxMediaMenuDownloads != null &&
        lbxMediaMenuOnDemandStreams != null)
      {
        lbxMediaMenuBroadcastStreams.Visibility = Visibility.Collapsed;
        lbxMediaMenuOnDemandStreams.Visibility = Visibility.Collapsed;
        lbxMediaMenuDownloads.Visibility = Visibility.Visible;
      }
    }

    private void rbtnOnDemandMenu_Checked(object sender, RoutedEventArgs e)
    {
      if (lbxMediaMenuBroadcastStreams != null &&
        lbxMediaMenuDownloads != null &&
        lbxMediaMenuOnDemandStreams != null)
      {
        lbxMediaMenuBroadcastStreams.Visibility = Visibility.Collapsed;
        lbxMediaMenuOnDemandStreams.Visibility = Visibility.Visible;
        lbxMediaMenuDownloads.Visibility = Visibility.Collapsed;
      }
    }

    private void rbtnBroadcastMenu_Checked(object sender, RoutedEventArgs e)
    {
      if (lbxMediaMenuBroadcastStreams != null &&
        lbxMediaMenuDownloads != null &&
        lbxMediaMenuOnDemandStreams != null)
      {
        lbxMediaMenuBroadcastStreams.Visibility = Visibility.Visible;
        lbxMediaMenuOnDemandStreams.Visibility = Visibility.Collapsed;
        lbxMediaMenuDownloads.Visibility = Visibility.Collapsed;
      }
    }
  }
}
```

You change the `PopulateMediaMenu()` method to add calls to the `GetOnDemandStreamsList()` and `GetBroadcastStreamsList()` service operations, and you bind the results to `lbxMediaMenuOnDemandStreams`

and lbxMediaMenuBroadcastStreams, respectively. Note that because the underlying schema for the XML returned by all three operations is identical, you use the same handler for handling the WebClient.DownloadStringAsyncCompleted event, and the same LINQ to XML–based parsing logic in it. You pass in the appropriate collection bound to the ListBox that the returned XML would populate to get the desired results.

You add Checked event handlers for the RadioButtons where we show only the corresponding ListBox and hide the others, as shown in bold in Listing 10-14.

You also make some changes to the MediaSlider control. Most of the changes made to this control are to accommodate the various constraints that playback of streaming media may impose in broadcast streams, such as the inability to seek through the media. Listing 10-15 shows the modified XAML for the MediaSlider control template.

Listing 10-15. *XAML for the MediaSlider control*

```
<ControlTemplate TargetType="local:MediaSlider" x:Key="ctMediaSliderDefault">
  <Grid x:Name="Root">
    <Grid.Resources>
      <ControlTemplate x:Key="ctRepeatButton">
        <Grid x:Name="Root" Opacity="0" Background="Transparent"/>
      </ControlTemplate>
    </Grid.Resources>
    <vsm:VisualStateManager.VisualStateGroups>
      <vsm:VisualStateGroup x:Name="CommonStates">
        <vsm:VisualStateGroup.Transitions>
          <vsm:VisualTransition GeneratedDuration="0"/>
        </vsm:VisualStateGroup.Transitions>
        <vsm:VisualState x:Name="Normal"/>
        <vsm:VisualState x:Name="MouseOver"/>
        <vsm:VisualState x:Name="Disabled">
          <Storyboard>
            <DoubleAnimationUsingKeyFrames Storyboard.TargetName="Root"
            Storyboard.TargetProperty="(UIElement.Opacity)">
              <SplineDoubleKeyFrame KeyTime="00:00:00" Value="0.5"/>
            </DoubleAnimationUsingKeyFrames>
          </Storyboard>
        </vsm:VisualState>
      </vsm:VisualStateGroup>
      <vsm:VisualStateGroup x:Name="SeekStates">
        <vsm:VisualState x:Name="CannotSeek">
          <Storyboard>
            <ObjectAnimationUsingKeyFrames
              Storyboard.TargetName="HorizontalThumb"
              Storyboard.TargetProperty="Visibility">

              <DiscreteObjectKeyFrame KeyTime="0">
                <DiscreteObjectKeyFrame.Value>
```

```
            <Visibility>Collapsed</Visibility>
          </DiscreteObjectKeyFrame.Value>
        </DiscreteObjectKeyFrame>
      </ObjectAnimationUsingKeyFrames>
    </Storyboard>
  </vsm:VisualState>
  <vsm:VisualState x:Name="CanSeek">
    <Storyboard>
      <ObjectAnimationUsingKeyFrames
        Storyboard.TargetName="HorizontalThumb"
        Storyboard.TargetProperty="Visibility">
        <DiscreteObjectKeyFrame KeyTime="0">
          <DiscreteObjectKeyFrame.Value>
            <Visibility>Visible</Visibility>
          </DiscreteObjectKeyFrame.Value>
        </DiscreteObjectKeyFrame>
      </ObjectAnimationUsingKeyFrames>
    </Storyboard>
  </vsm:VisualState>
</vsm:VisualStateGroup>
  <vsm:VisualStateGroup x:Name="ContentStates">
  <vsm:VisualState x:Name="Buffering">
    <Storyboard>
      <DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
     Duration="00:00:00.0010000"
     Storyboard.TargetName="BufferingProgress"
     Storyboard.TargetProperty="(UIElement.Opacity)">
        <SplineDoubleKeyFrame KeyTime="00:00:00" Value="100"/>
      </DoubleAnimationUsingKeyFrames>
    </Storyboard>
  </vsm:VisualState>
  <vsm:VisualState x:Name="Playing">
    <Storyboard>
      <DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
           Duration="00:00:00.0010000"
           Storyboard.TargetName="BufferingProgress"
           Storyboard.TargetProperty="(UIElement.Opacity)">
        <SplineDoubleKeyFrame KeyTime="00:00:00" Value="0"/>
      </DoubleAnimationUsingKeyFrames>
    </Storyboard>
  </vsm:VisualState>
</vsm:VisualStateGroup>
```

```
<vsm:VisualStateGroup x:Name="DurationStates">
  <vsm:VisualState x:Name="UnknownDuration">
    <Storyboard>
      <ObjectAnimationUsingKeyFrames Storyboard.TargetName="TotalDuration"
                Storyboard.TargetProperty="Visibility">
        <DiscreteObjectKeyFrame KeyTime="0">
          <DiscreteObjectKeyFrame.Value>
            <Visibility>Collapsed</Visibility>
          </DiscreteObjectKeyFrame.Value>
        </DiscreteObjectKeyFrame>
      </ObjectAnimationUsingKeyFrames>
      <ObjectAnimationUsingKeyFrames
        Storyboard.TargetName="elemPlayProgressIndicator"
        Storyboard.TargetProperty="Visibility">
        <DiscreteObjectKeyFrame KeyTime="0">
          <DiscreteObjectKeyFrame.Value>
            <Visibility>Collapsed</Visibility>
          </DiscreteObjectKeyFrame.Value>
        </DiscreteObjectKeyFrame>
      </ObjectAnimationUsingKeyFrames>
    </Storyboard>
  </vsm:VisualState>
  <vsm:VisualState x:Name="KnownDuration">
    <Storyboard>
      <ObjectAnimationUsingKeyFrames Storyboard.TargetName="TotalDuration"
                Storyboard.TargetProperty="Visibility">
        <DiscreteObjectKeyFrame KeyTime="0">
          <DiscreteObjectKeyFrame.Value>
            <Visibility>Visible</Visibility>
          </DiscreteObjectKeyFrame.Value>
        </DiscreteObjectKeyFrame>
      </ObjectAnimationUsingKeyFrames>
      <ObjectAnimationUsingKeyFrames
        Storyboard.TargetName="elemPlayProgressIndicator"
        Storyboard.TargetProperty="Visibility">
        <DiscreteObjectKeyFrame KeyTime="0">
          <DiscreteObjectKeyFrame.Value>
            <Visibility>Visible</Visibility>
          </DiscreteObjectKeyFrame.Value>
        </DiscreteObjectKeyFrame>
      </ObjectAnimationUsingKeyFrames>
    </Storyboard>
```

```
      </vsm:VisualState>
    </vsm:VisualStateGroup>
  </vsm:VisualStateManager.VisualStateGroups>
  <Grid>
    <Grid.RowDefinitions>
      <RowDefinition Height="0.33*" />
      <RowDefinition Height="0.34*" />
      <RowDefinition Height="0.33*" />
    </Grid.RowDefinitions>
    <Grid Grid.Row="0" VerticalAlignment="Top" HorizontalAlignment="Stretch">
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="*" />
        <ColumnDefinition Width="Auto" />
      </Grid.ColumnDefinitions>
      <StackPanel Orientation="Horizontal" Grid.Column="0"
                  HorizontalAlignment="Left"
                  x:Name="BufferingProgress" Opacity="0">
        <TextBlock Text="Buffering" FontSize="12"
                  Margin="0,0,4,0"/>
        <TextBlock x:Name="textBufferingPercent" FontSize="12"/>
      </StackPanel>
      <StackPanel Orientation="Horizontal" Grid.Column="2"
                  HorizontalAlignment="Right"
                  x:Name="DownloadProgress">
        <TextBlock Text="Downloaded" FontSize="12"
                  Margin="0,0,4,0"/>
        <TextBlock x:Name="textDownloadPercent" FontSize="12"
                  />
      </StackPanel>
    </Grid>
    <Grid x:Name="HorizontalTemplate" Grid.Row="1" >
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="*" />
      </Grid.ColumnDefinitions>
      <Rectangle Stroke="Black" StrokeThickness="0.5" Fill="#FFE6EFF7"
                 Grid.Column="0" Grid.ColumnSpan="3" Height="14"
                 Margin="5,0,5,0" />
      <Border Height="10" Margin="5,0,5,0" Grid.Column="0" Grid.ColumnSpan="3"
              x:Name="elemDownloadProgressIndicator" Background="#FF2185D8"
              HorizontalAlignment="Left" Width="0"  />
```

```
        <Border Height="6" Margin="5,0,5,0" Grid.Column="0" Grid.ColumnSpan="3"
                x:Name="elemPlayProgressIndicator" Background="#FF1CE421"
                HorizontalAlignment="Left" Width="0"  />

        <RepeatButton x:Name="HorizontalTrackLargeChangeDecreaseRepeatButton"
                      Grid.Column="0"
                      Template="{StaticResource ctRepeatButton}"
                      IsTabStop="False"   />
        <Thumb x:Name="HorizontalThumb" Height="14" Width="11" Grid.Column="1"/>
        <RepeatButton x:Name="HorizontalTrackLargeChangeIncreaseRepeatButton"
                      Grid.Column="2"
                      Template="{StaticResource ctRepeatButton}"
                      IsTabStop="False"  />
      </Grid>
      <Grid Grid.Row="2" VerticalAlignment="Bottom"
            HorizontalAlignment="Stretch">
        <StackPanel x:Name="TotalDuration" Orientation="Horizontal"
                    Visibility="Collapsed">
          <TextBlock x:Name="textPosition" FontSize="12"/>
          <TextBlock Text=" / " FontSize="12" Margin="3,0,3,0"/>
          <TextBlock x:Name="textDuration" FontSize="12" />
        </StackPanel>
      </Grid>
    </Grid>
  </Grid>
</ControlTemplate>

<Style TargetType="local:MediaSlider">
  <Setter Property="Template" Value="{StaticResource ctMediaSliderDefault}"/>
</Style>
```

As you can see in Listing 10-15 (indicated in bold), a new `TextBlock` named `textBufferingPercent` contained inside a `StackPanel` named `BufferingProgress` reports progress when streaming media is buffering.

You also add several visual states to handle certain aspects of streaming media. The `SeekStates` state group contains two states: `CannotSeek`, which hides the `Thumb` to indicate that the media cannot be forwarded or rewound, and `CanSeek`, which makes the `Thumb` visible in cases where the media can be forwarded or rewound. The `DurationStates` group contains `KnownDuration`, which makes the `StackPanel` named `TotalDuration` and its children visible if the total duration of the media is available, and the `UnknownDuration` state, which hides them when the duration is not known. The `ContentStates` group contains the `Buffering` state, which makes the `StackPanel` named `BufferingProgress` visible, and the `Playing` state, which hides the `StackPanel`. Last is the `DownloadStates` group, where the `NoDownload` state hides the `DownloadProgressIndicator` and the `StackPanel` named `DownloadProgress`, whereas the `NeedsDownload` state does the reverse.

Let's look at the additions to the control code to see how these states are used (see Listing 10-16).

Listing 10-16. *MediaSlider Code with the Changes for Streaming*

```
using System;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Controls.Primitives;
using System.Windows.Media;
using System.Windows.Threading;

namespace Recipe10_3
{
  [TemplateVisualState(GroupName="SeekStates",Name="CanSeek")]
  [TemplateVisualState(GroupName = "SeekStates", Name = "CannotSeek")]
  [TemplateVisualState(GroupName = "ContentStates", Name = "Buffering")]
  [TemplateVisualState(GroupName = "ContentStates", Name = "Playing")]
  [TemplateVisualState(GroupName = "DurationStates", Name = "UnknownDuration")]
  [TemplateVisualState(GroupName = "DurationStates", Name = "KnownDuration")]
 public class MediaSlider : Slider
  {
    private MediaElement MediaSource;
    private FrameworkElement elemDownloadProgressIndicator;
    private FrameworkElement elemBufferingProgressIndicator;
    private FrameworkElement elemPlayProgressIndicator;
    private FrameworkElement Root;
    private TextBlock textPosition;
    private TextBlock textDuration;
    private TextBlock textDownloadPercent;
    private TextBlock textBufferingPercent;
    private Thumb HorizontalThumb;
    private DispatcherTimer disptimerPlayProgressUpdate;

    public static DependencyProperty SourceNameProperty =
      DependencyProperty.Register("SourceName", typeof(string),
      typeof(MediaSlider),
      new PropertyMetadata(new PropertyChangedCallback(OnSourceNameChanged)));
    public string SourceName
    {
      get
      {
        return (string)GetValue(SourceNameProperty);
      }

      set
      {
```

```
    SetValue(SourceNameProperty, value);
  }
}
private static void OnSourceNameChanged(DependencyObject Source,
  DependencyPropertyChangedEventArgs e)
{
  MediaSlider thisSlider = Source as MediaSlider;
  if (e.NewValue != null && e.NewValue != e.OldValue
    && thisSlider.Root != null)
  {
    thisSlider.MediaSource =
      thisSlider.Root.FindName(e.NewValue as string) as MediaElement;
    thisSlider.InitMediaElementConnections();
  }
}

public MediaSlider()
  : base()
{
  this.DefaultStyleKey = typeof(MediaSlider);
  this.Maximum = 100;
  this.Minimum = 0;
  disptimerPlayProgressUpdate = new DispatcherTimer();
  disptimerPlayProgressUpdate.Interval = new TimeSpan(0, 0, 0, 0, 50);
  disptimerPlayProgressUpdate.Tick +=
    new EventHandler(PlayProgressUpdate_Tick);
}
public override void OnApplyTemplate()
{
  base.OnApplyTemplate();

  elemDownloadProgressIndicator =
    GetTemplateChild("elemDownloadProgressIndicator") as FrameworkElement;
  elemBufferingProgressIndicator =
    GetTemplateChild("elemBufferingProgressIndicator") as FrameworkElement;
  elemPlayProgressIndicator =
   GetTemplateChild("elemPlayProgressIndicator") as FrameworkElement;
  HorizontalThumb = GetTemplateChild("HorizontalThumb") as Thumb;

  if (HorizontalThumb != null)
  {
    HorizontalThumb.DragStarted +=
      new DragStartedEventHandler(HorizontalThumb_DragStarted);
    HorizontalThumb.DragCompleted +=
      new DragCompletedEventHandler(HorizontalThumb_DragCompleted);
```

```
    }

    textPosition = GetTemplateChild("textPosition") as TextBlock;
    textDuration = GetTemplateChild("textDuration") as TextBlock;
    textDownloadPercent = GetTemplateChild("textDownloadPercent") as TextBlock;
    textBufferingPercent = GetTemplateChild("textBufferingPercent") as TextBlock;
    Root = Helper.FindRoot(this);
    MediaSource = Root.FindName(SourceName) as MediaElement;
    InitMediaElementConnections();
  }
  private void InitMediaElementConnections()
  {
    if (MediaSource != null)
    {
      MediaSource.MediaOpened += new RoutedEventHandler(MediaSource_MediaOpened);
      MediaSource.MediaEnded +=
        new RoutedEventHandler(MediaSource_MediaEnded);
      MediaSource.MediaFailed +=
        new EventHandler<ExceptionRoutedEventArgs>(MediaSource_MediaFailed);
      MediaSource.CurrentStateChanged +=
        new RoutedEventHandler(MediaSource_CurrentStateChanged);
      MediaSource.DownloadProgressChanged +=
        new RoutedEventHandler(MediaSource_DownloadProgressChanged);
      MediaSource.BufferingProgressChanged +=
        new RoutedEventHandler(MediaSource_BufferingProgressChanged);

      MediaSource_CurrentStateChanged(this, new RoutedEventArgs());
    }
  }

  void PlayProgressUpdate_Tick(object sender, EventArgs e)
  {
    if (MediaSource.NaturalDuration.TimeSpan == TimeSpan.Zero)
      return;

    this.Value =
      (MediaSource.Position.TotalMilliseconds /
      MediaSource.NaturalDuration.TimeSpan.TotalMilliseconds)
      * (this.Maximum - this.Minimum);

    if (elemPlayProgressIndicator != null)
    {
      elemPlayProgressIndicator.Width =
        (MediaSource.Position.TotalMilliseconds /
        MediaSource.NaturalDuration.TimeSpan.TotalMilliseconds)
```

```
      * ActualWidth;
  }
  if (textPosition != null)
    textPosition.Text = string.Format("{0:00}:{1:00}:{2:00}:{3:000}",
      MediaSource.Position.Hours,
      MediaSource.Position.Minutes,
      MediaSource.Position.Seconds,
      MediaSource.Position.Milliseconds);
}
void HorizontalThumb_DragCompleted(object sender, DragCompletedEventArgs e)
{
  if (MediaSource != null && MediaSource.CurrentState ==
    MediaElementState.Playing
    && MediaSource.NaturalDuration.TimeSpan != TimeSpan.Zero)
  {
    MediaSource.Position = new TimeSpan(0,
      0, 0, 0,
      (int)(this.Value *
      MediaSource.NaturalDuration.TimeSpan.TotalMilliseconds / 100));
  }
  MediaSource.Play();
}
void HorizontalThumb_DragStarted(object sender, DragStartedEventArgs e)
{
  if(MediaSource != null &&
    MediaSource.CurrentState == MediaElementState.Playing
    && MediaSource.CanPause)
  MediaSource.Pause();
}

private void MediaSource_DownloadProgressChanged(object sender,
  RoutedEventArgs e)
{
  if (elemDownloadProgressIndicator != null)
  {
    elemDownloadProgressIndicator.Width =
      (MediaSource.DownloadProgress * this.ActualWidth);
    if (textDownloadPercent != null)
      textDownloadPercent.Text = string.Format("{0:##.##} %",
        MediaSource.DownloadProgress * 100);
  }
}
void MediaSource_BufferingProgressChanged(object sender, RoutedEventArgs e)
{
```

```
    if (elemDownloadProgressIndicator != null)
    {

      if (textBufferingPercent != null)
        textBufferingPercent.Text = string.Format("{0:##.##} %",
          MediaSource.BufferingProgress * 100);
    }
  }
  private void MediaSource_CurrentStateChanged(object sender, RoutedEventArgs e)
  {
    switch (MediaSource.CurrentState)
    {
      case MediaElementState.Opening:
        VisualStateManager.GoToState(this, "Normal", true);
        break;
      case MediaElementState.Playing:
        RefreshMediaStates();
        if (disptimerPlayProgressUpdate.IsEnabled == false)
          disptimerPlayProgressUpdate.Start();
        break;
      case MediaElementState.Paused:
        if(disptimerPlayProgressUpdate.IsEnabled)
          disptimerPlayProgressUpdate.Stop();
        break;
      case MediaElementState.Stopped:
        if (disptimerPlayProgressUpdate.IsEnabled)
          disptimerPlayProgressUpdate.Stop();
        break;
      case MediaElementState.Buffering:
        VisualStateManager.GoToState(this,"Buffering",true);
        break;
      default:
        break;
    }
  }
  void MediaSource_MediaOpened(object sender, RoutedEventArgs e)
  {
    RefreshMediaStates();
  }

  private void RefreshMediaStates()
  {
    VisualStateManager.GoToState(this,
```

```
            (MediaSource.CanSeek) ? "CanSeek" : "CannotSeek", true);
        VisualStateManager.GoToState(this,
          (MediaSource.NaturalDuration.TimeSpan != TimeSpan.Zero) ?
          "KnownDuration" : "UnknownDuration", true);
        VisualStateManager.GoToState(this,
          (MediaSource.DownloadProgress == 1.0) ?
          "NoDownload" : "NeedsDownload", true);
        if (textDuration != null &&
             MediaSource.NaturalDuration.TimeSpan != TimeSpan.Zero)
          textDuration.Text = string.Format("{0:00}:{1:00}:{2:00}:{3:000}",
            MediaSource.NaturalDuration.TimeSpan.Hours,
            MediaSource.NaturalDuration.TimeSpan.Minutes,
            MediaSource.NaturalDuration.TimeSpan.Seconds,
            MediaSource.NaturalDuration.TimeSpan.Milliseconds);
      }
      private void MediaSource_MediaEnded(object sender, RoutedEventArgs e)
      {
        if (disptimerPlayProgressUpdate.IsEnabled)
          disptimerPlayProgressUpdate.Stop();
      }
      private void MediaSource_MediaFailed(object sender, RoutedEventArgs e)
      {
        if(disptimerPlayProgressUpdate.IsEnabled)
          disptimerPlayProgressUpdate.Stop();
      }
    }
}
```

Most of the additions to the `MediaSlider` code (shown in bold in Listing 10-16) are to make sure you reflect the correct visual state of the slider depending on the state of the media. After the media is opened in `MediaSource_Opened()`, you invoke the `RefreshMediaStates()` method and check to see if the media is seekable, using the value of the `CanSeek` property, and navigate to the appropriate state in the `SeekStates` group. If the duration of the media is available, you navigate to the appropriate state in the `DurationStates` group. You also check to see if `MediaSource.DownloadProgress` is already at 100 percent (which is the case if the media is being streamed) and navigate to the appropriate state in the `DownloadStates` group. Finally, you update the `textDuration` to reflect the duration of the media just opened.

If you refer to the `MediaSource_CurrentStateChanged()` handler, note that when the media is buffering, you navigate to the `Buffering` visual state. After the `MediaElement` starts playing the media, you repeat a call to `RefreshMediaStates()`. This is to handle cases where the `MediaSlider.SourceName` gets switched to a `MediaElement` (consider the PIP scenario again) that is already playing. Then you navigate to the Playing visual state.

The only other addition here is a `BufferingProgressChanged` handler that updates `textBufferingPercent` with the buffering progress. The next few figures show the effects of the various visual state changes.

Figure 10-15 shows the `MediaSlider` while video is buffering.

Figure 10-15. *Buffering video*

Figure 10-16 shows the `MediaSlider` while an on-demand video is playing. Note that although the duration is displayed along with the play progress, there is no download progress indication because the media is being streamed. Also note the presence of the `Thumb`, indicating that although the media is streamed, seeking within it is enabled because of the combination of an on-demand publishing point and disk-based media.

Figure 10-16. *Playing an on-demand stream*

Figure 10-17 shows the `MediaSlider` while a broadcast video is playing. Note that no play-progress or duration information is displayed. Also note the absence of the `Thumb`, indicating that the broadcast media does not support seeking.

Figure 10-17. *Playing a broadcast stream*

You make similar changes to the `MediaButtonsPanel` to reflect appropriate visual states. Listing 10-17 shows the XAML in bold.

Listing 10-17. *XAML for MediaButtonsPanel Control*

```
<ControlTemplate TargetType="local:MediaButtonsPanel"
                 x:Key="ctMediaButtonsPanelDefault">
  <Grid>
    <vsm:VisualStateManager.VisualStateGroups>
      <vsm:VisualStateGroup x:Name="CommonStates">
        <vsm:VisualStateGroup.Transitions>
          <vsm:VisualTransition GeneratedDuration="0"/>
        </vsm:VisualStateGroup.Transitions>
```

```
    <vsm:VisualState x:Name="Normal"/>
    <vsm:VisualState x:Name="MouseOver"/>
    <vsm:VisualState x:Name="Disabled">
      <Storyboard>
        <DoubleAnimationUsingKeyFrames Storyboard.TargetName="Root"
        Storyboard.TargetProperty="(UIElement.Opacity)">
          <SplineDoubleKeyFrame KeyTime="00:00:00" Value="0.5"/>
        </DoubleAnimationUsingKeyFrames>
      </Storyboard>
    </vsm:VisualState>
  </vsm:VisualStateGroup>
  <vsm:VisualStateGroup x:Name="SeekStates">
    <vsm:VisualState x:Name="CannotSeek">
      <Storyboard>
        <ObjectAnimationUsingKeyFrames
          Storyboard.TargetName="btnRewind"
          Storyboard.TargetProperty="IsEnabled">
          <DiscreteObjectKeyFrame KeyTime="0">
            <DiscreteObjectKeyFrame.Value>
              <system:Boolean>false</system:Boolean>
            </DiscreteObjectKeyFrame.Value>
          </DiscreteObjectKeyFrame>
        </ObjectAnimationUsingKeyFrames>
        <ObjectAnimationUsingKeyFrames
          Storyboard.TargetName="btnForward"
          Storyboard.TargetProperty="IsEnabled">
          <DiscreteObjectKeyFrame KeyTime="0">
            <DiscreteObjectKeyFrame.Value>
              <system:Boolean>false</system:Boolean>
            </DiscreteObjectKeyFrame.Value>
          </DiscreteObjectKeyFrame>
        </ObjectAnimationUsingKeyFrames>
      </Storyboard>
    </vsm:VisualState>
    <vsm:VisualState x:Name="CanSeek">
      <Storyboard>
        <ObjectAnimationUsingKeyFrames
          Storyboard.TargetName="btnRewind"
          Storyboard.TargetProperty="IsEnabled">
          <DiscreteObjectKeyFrame KeyTime="0">
            <DiscreteObjectKeyFrame.Value>
              <system:Boolean>True</system:Boolean>
            </DiscreteObjectKeyFrame.Value>
```

```
          </DiscreteObjectKeyFrame>
        </ObjectAnimationUsingKeyFrames>
        <ObjectAnimationUsingKeyFrames
          Storyboard.TargetName="btnForward"
          Storyboard.TargetProperty="IsEnabled">
          <DiscreteObjectKeyFrame KeyTime="0">
            <DiscreteObjectKeyFrame.Value>
              <Visibility>True</Visibility>
            </DiscreteObjectKeyFrame.Value>
          </DiscreteObjectKeyFrame>
        </ObjectAnimationUsingKeyFrames>
      </Storyboard>
    </vsm:VisualState>
  </vsm:VisualStateGroup>
  <vsm:VisualStateGroup x:Name="PauseStates">
    <vsm:VisualState x:Name="CannotPause">
      <Storyboard>
        <ObjectAnimationUsingKeyFrames
          Storyboard.TargetName="btnPause"
          Storyboard.TargetProperty="IsEnabled">
          <DiscreteObjectKeyFrame KeyTime="0">
            <DiscreteObjectKeyFrame.Value>
              <system:Boolean>false</system:Boolean>
            </DiscreteObjectKeyFrame.Value>
          </DiscreteObjectKeyFrame>
        </ObjectAnimationUsingKeyFrames>
      </Storyboard>
    </vsm:VisualState>
    <vsm:VisualState x:Name="CanPause">
      <Storyboard>
        <ObjectAnimationUsingKeyFrames
          Storyboard.TargetName="btnPause"
          Storyboard.TargetProperty="IsEnabled">

          <DiscreteObjectKeyFrame KeyTime="0">
            <DiscreteObjectKeyFrame.Value>
              <system:Boolean>True</system:Boolean>
            </DiscreteObjectKeyFrame.Value>
          </DiscreteObjectKeyFrame>
        </ObjectAnimationUsingKeyFrames>
      </Storyboard>
    </vsm:VisualState>
```

```
  </vsm:VisualStateGroup>
</vsm:VisualStateManager.VisualStateGroups>

<Grid.ColumnDefinitions>
  <ColumnDefinition Width="0.2*" />
  <ColumnDefinition Width="0.2*" />
  <ColumnDefinition Width="0.2*" />
  <ColumnDefinition Width="0.2*" />
  <ColumnDefinition Width="0.2*" />
</Grid.ColumnDefinitions>
<RepeatButton Grid.Column="0" x:Name="btnRewind" Margin="0,0,1,0">
  <RepeatButton.Content>
    <Path x:Name="Rewind" Stretch="Fill" StrokeThickness="1"
          StrokeLineJoin="Round" Stroke="#FF000000" Fill="#FF000000"
          Data="M 69.8333,70.0833L 60.5833,
          63.2862L 60.5833,70.0833L 40,
          54.9583L 60.5833,39.8333L 60.5833,
          46.6304L 69.8333,39.8333L 69.8333,
          70.0833 Z "/>
  </RepeatButton.Content>
</RepeatButton>
<Button Grid.Column="1" x:Name="btnStop" Margin="1,0,1,0">
  <Button.Content>
    <Path x:Name="Stop" Fill="#FF000000" Stretch="Fill"
          StrokeThickness="0" Margin="5,5,5,5"
          Data="M0,0 L3,0 L3,30.249996 L0,30.249996 z"/>
  </Button.Content>
</Button>
<Button Grid.Column="2" x:Name="btnPlay" Margin="1,0,1,0">
  <Button.Content>
    <Path x:Name="Play" Stretch="Fill" StrokeThickness="0"
          Fill="#FF000000" Margin="5,5,5,5"
          Data="M 109.833,14.8944L 79.8333,
          -0.0445251L 79.8333,29.8333L 109.833,
          14.8944 Z "/>
  </Button.Content>
</Button>

<Button Grid.Column="3" x:Name="btnPause" Margin="1,0,1,0">
  <Button.Content>
    <Path x:Name="Pause" Stretch="Fill" StrokeThickness="0"
          Fill="#FF000000" Margin="5,5,5,5"
          Data="M 39.8333,0L 50.0833,0L 50.0833,29.8333L 39.8333,
          29.8333L 39.8333,0 Z M 59.8333,0L 69.8333,0L 69.8333,
```

```
            29.8333L 59.8333,29.8333L 59.8333,0 Z "/>
      </Button.Content>
    </Button>
    <RepeatButton Grid.Column="4" x:Name="btnForward" Margin="1,0,0,0">
      <RepeatButton.Content>
        <Path x:Name="Forward" Stretch="Fill" StrokeThickness="1"
              StrokeLineJoin="Round" Stroke="#FF000000"
              Fill="#FF000000"
              Data="M 1.27157e-006,39.8334L 9.25,
              46.6305L 9.25,39.8333L 29.8333,
              54.9583L 9.25,70.0833L 9.25,
              63.2863L 1.27157e-006,
              70.0833L 1.27157e-006,39.8334 Z "/>
      </RepeatButton.Content>
    </RepeatButton>
  </Grid>
</ControlTemplate>

<Style TargetType="local:MediaButtonsPanel">
  <Setter Property="Template"
          Value="{StaticResource ctMediaButtonsPanelDefault}"/>
</Style>
```

You add the SeekStates group as before, containing the CanSeek and CannotSeek visual states. For the CannotSeek state, you disable btnRewind and btnForward by setting the IsEnabled property on the buttons to false; for the CanSeek state, you do the reverse. You also add two new visual states—CannotPause and CanPause—in a state group named PauseStates, where you act on btnPause based on the value of the MediaElement.CanPause property. The code to navigate to the states, designed in a similar way to the MediaSlider, is shown in Listing 10-18 in bold.

Listing 10-18. *MediaButtonsPanel Control Code*

```
using System;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Controls.Primitives;
using System.Windows.Media;


namespace Recipe10_3
{
  [TemplateVisualState(GroupName = "SeekStates", Name = "CanSeek")]
  [TemplateVisualState(GroupName = "SeekStates", Name = "CannotSeek")]
  [TemplateVisualState(GroupName = "PauseStates", Name = "CanPause")]
  [TemplateVisualState(GroupName = "PauseStates", Name = "CannotPause")]
  public class MediaButtonsPanel : Control
```

```
{

    private MediaElement MediaSource;
    private FrameworkElement Root;
    private ButtonBase btnPlay, btnPause, btnStop, btnForward, btnRewind;

    public static DependencyProperty SourceNameProperty =
      DependencyProperty.Register("SourceName", typeof(string),
      typeof(MediaButtonsPanel),
      new PropertyMetadata(new PropertyChangedCallback(OnSourceNameChanged)));
    public string SourceName
    {
      get
      {
        return (string)GetValue(SourceNameProperty);
      }
      set
      {
        SetValue(SourceNameProperty, value);
      }
    }
    private static void OnSourceNameChanged(DependencyObject Source,
      DependencyPropertyChangedEventArgs e)
    {
      MediaButtonsPanel thisPanel = Source as MediaButtonsPanel;

      if (e.NewValue != e.OldValue && thisPanel.Root != null)
      {
        thisPanel.MediaSource =
thisPanel.Root.FindName(e.NewValue as string) as MediaElement;
        thisPanel.InitMediaElementConnections();
      }
    }
    public MediaButtonsPanel()
    {
      this.DefaultStyleKey = typeof(MediaButtonsPanel);
    }
    public override void OnApplyTemplate()
    {

      btnPlay = GetTemplateChild("btnPlay") as ButtonBase;
      btnPause = GetTemplateChild("btnPause") as ButtonBase;
      btnStop = GetTemplateChild("btnStop") as ButtonBase;
      btnForward = GetTemplateChild("btnForward") as ButtonBase;
      btnRewind = GetTemplateChild("btnRewind") as ButtonBase;
```

```
    Root = Helper.FindRoot(this);
    MediaSource = Root.FindName(SourceName) as MediaElement;
    InitMediaElementConnections();
    WireButtonEvents();
  }
  private void WireButtonEvents()
  {
    if (btnPlay != null)
      btnPlay.Click += new RoutedEventHandler(btnPlay_Click);
    if (btnPause != null)
      btnPause.Click += new RoutedEventHandler(btnPause_Click);
    if (btnStop != null)
      btnStop.Click += new RoutedEventHandler(btnStop_Click);
    if (btnForward != null)
      btnForward.Click += new RoutedEventHandler(btnForward_Click);
    if (btnRewind != null)
      btnRewind.Click += new RoutedEventHandler(btnRewind_Click);
  }

  void btnRewind_Click(object sender, RoutedEventArgs e)
  {
    if (MediaSource != null && MediaSource.Position > TimeSpan.Zero)
    {
      MediaSource.Pause();
      //5th of a second
      MediaSource.Position -= new TimeSpan(0, 0, 0, 0, 200);
      MediaSource.Play();
    }
  }
  void btnForward_Click(object sender, RoutedEventArgs e)
  {
    if (MediaSource != null && MediaSource.Position
      <= MediaSource.NaturalDuration.TimeSpan)

    {
      MediaSource.Pause();
      MediaSource.Position += new TimeSpan(0, 0, 0, 0, 200);
      MediaSource.Play();
    }
  }
  void btnStop_Click(object sender, RoutedEventArgs e)
  {
    if (MediaSource != null)
      MediaSource.Stop();
  }
```

```
void btnPause_Click(object sender, RoutedEventArgs e)
{
  if (MediaSource != null &&
    MediaSource.CurrentState == MediaElementState.Playing)
    MediaSource.Pause();
}
void btnPlay_Click(object sender, RoutedEventArgs e)
{
  if (MediaSource != null &&
    MediaSource.CurrentState != MediaElementState.Playing)
    MediaSource.Play();
}

private void InitMediaElementConnections()
{
  if (MediaSource != null)
  {
    MediaSource.MediaOpened +=
      new RoutedEventHandler(MediaSource_MediaOpened);
    MediaSource.CurrentStateChanged +=
      new RoutedEventHandler(MediaSource_CurrentStateChanged);

    MediaSource_CurrentStateChanged(this, new RoutedEventArgs());
  }
}
private void MediaSource_CurrentStateChanged(object sender, RoutedEventArgs e)
{
  switch (MediaSource.CurrentState)
  {
    case MediaElementState.Playing:
      VisualStateManager.GoToState(this,
  (MediaSource.CanSeek == false) ? "CannotSeek" : "CanSeek", true);
      VisualStateManager.GoToState(this,
  (MediaSource.CanPause == false) ? "CannotPause" : "CanPause", true);
      break;
    default:
      break;
  }
}

private void MediaSource_MediaOpened(object sender, RoutedEventArgs e)
{
  VisualStateManager.GoToState(this,
  (MediaSource.CanSeek == false) ? "CannotSeek" : "CanSeek", true);
```

```
      VisualStateManager.GoToState(this,
      (MediaSource.CanPause == false) ? "CannotPause" : "CanPause", true);
    }
  }
}
```

Once again, you check for the `MediaElement.CanSeek` and `MediaElement.CanPause` properties to navigate to the appropriate visual states, and you do it both in `MediaOpened` and when the `Playing` state is reached in the `CurrentStateChanged` handler.

Figures 10-16 and 10-17 earlier in this recipe show you the resulting button states. In Figure 10-17, where a broadcast stream is playing, and seeking or pausing is not possible, the corresponding buttons are disabled.

10-4. Using Playlists to Package Media

Problem

You are looking for a way to combine a group of media files to be played as one unit in some ordered fashion.

Solution

Create either a server-side or a client-side playlist, depending on your needs, and have the `MediaElement` play the playlist.

How It Works

Playlists are a convenient way to group media sources to be played as one unit. When the `MediaElement` plays a playlist, the user experience is seamless, and it seems as though a single source of media is playing from start to end. You can use playlists to create a broadcast program–like experience where you play a sequence of media in a certain order, with other media files (such as advertisements) interspersed within specific parts of the program.

Silverlight supports two kinds of playlists: client-side playlists (CSPL) and server-side playlists (SSPL). Both CSPL and SSPL are represented as XML documents with specific schemas, which means they are textual and can easily be created using any text or XML editor.

Server-Side Playlists

An SSPL is not directly served to a player but is associated with a WMS publishing point (refer to Recipe 10-3 for more on WMS). Both broadcast and on-demand publishing points in WMS can specify an SSPL as the source of media. Listing 10-19 shows a sample SSPL.

Listing 10-19. *Sample Server-Side Playlist*

```
 <?wsx  version="1.0" encoding="utf-8"?>
<smil>
  <media src="D:\Media\Amazon_1080.wmv" begin="0s" dur="15s"/>
  <seq>
```

```
    <media src="D:\Media\Coral_Reef_Adventure_1080.wmv" dur="20s"/>
    <media src="D:\Media\Discoverers_1080.wmv" begin="prev.begin+10s" dur="30s"/>
    <switch>
      <media src="D:\Media\AdrenalineRush.wmv" dur="15s"/>
      <media src="D:\Media\Alexander_Trailer_1080p.wmv" dur="15s"/>
    </switch>
  </seq>
  <media src="D:\Media\Discoverers_1080.wmv" begin="70s" dur="45s"/>
</smil>
```

The SSPL syntax is based on the Synchronized Multimedia Integration Language (SMIL) 2.0 specification. You can find more information about SMIL at the World Wide Web Consortium (W3C) web site at `www.w3.org/TR/SMIL2/`. Every SSPL document is defined with a root element, `<smil>`. The `<media>` element specifies a particular media source to be played. The `dur` attribute specifies a duration for the media to play; it can be equal to or less than the total duration of the media. The `begin` attribute specifies the time when the media starts to play relative to its parent time container. So, media specified in the last entry in the previous listing starts playing as soon as 70 seconds have passed from the beginning of the playlist. This happens even if it does not allow enough time for the previous entries to complete playing their full duration. The second entry in the `<seq>` element starts playing 10 seconds after the previous element in the same sequence starts playing, even if the previous one has not finished playing.

The `<seq>` element plays all media items it contains in order. The `<switch>` element provides a series of alternative sources if one fails. In the sample, everything in the `<seq>` element plays in order; if the first media source in the `<switch>` element succeeds in playing, the second one never plays.

The SSPL syntax is extensive and contains many attributes to control the behavior of the media. Coverage of the full SSPL syntax is beyond the scope of this book, but you can refer to `msdn.microsoft.com/en-us/library/ms752512(VS.85).aspx` for a complete reference of all SSPL elements and attributes.

WMS includes an SSPL editor that you can invoke from within the WMS console to create or edit a playlist. To associate an SSPL, select the publishing point, navigate to the Source property tab, and click the View Playlist Editor button, as shown in Figure 10-18.

After the editor is opened, you can create the SSPL by adding the desired children nodes in the tree pane at left and specifying the appropriate attribute values in the grid at right. The context menus for each element type provide options for adding the various possible children elements. When you are done, you can save the SSPL to a desired location. Figure 10-19 shows the Playlist Editor in action. You can learn more about the editor at `technet.microsoft.com/en-us/library/cc725750.aspx`.

Figure 10-18. *Opening the Playlist Editor*

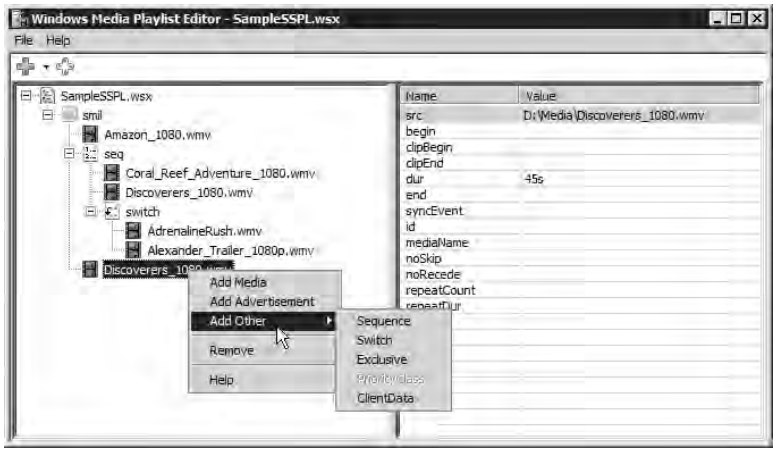


Figure 10-19. *Using the Playlist Editor*

Client-Side Playlists

CSPLs are defined as Windows Media metafiles that Windows Media Player can enumerate and play. A CSPL, in spirit, is essentially just like an SSPL in that it, too, defines grouping of media sources to be played together as one unit. However, the CSPL follows a different syntax from the SSPL. Also, a CSPL is not associated with a streaming media service like WMS; it has no relation to streaming, other than the fact that media sources inside a CSPL can point to streaming media sources. Listing 10-20 shows a sample CSPL.

Listing 10-20. *Sample Client-Side Playlist*

```
<asx version="3.0">
  <Title>SampleCSPL</Title>
  <Entry>
    <Duration value = "00:00:10" />
    <Title>Amazon_1080</Title>
    <Ref href = "mms://dc7600:43000/Media/Amazon_1080.wmv"/>
  </Entry>
  <Entry>
    <Title>AdrenalineRush</Title>
    <Ref href = "mms://dc7600:43000/Media/AdrenalineRush.wmv"/>
  </Entry>
  <Entry>
    <Duration value = "00:00:10" />
    <Title>Alexander_Trailer_1080p</Title>
    <Ref href = "mms://dc7600:43000/Media/Alexander_Trailer_1080p.wmv"/>
  </Entry>
  <Entry>
    <Duration value = "00:00:10" />
    <Title>Amazing_Caves_1080</Title>
    <Ref href = "mms://dc7600:43000/Media/Amazing_Caves_1080.wmv"/>
  </Entry>
</asx>
```

Every CSPL document is defined within an `<asx>` element. Each `<Entry>` element can contain a `<Ref>` element pointing to the source of the media; in Listing 10-20, these elements all point back to the WMS on-demand publishing point as defined in Recipe 10-3. You can also define a `<Duration>` element for each `<Entry>` that specifies what duration the media source plays for before the next media source starts playing, regardless of the total length of the media source. In Listing 10-20, the first entry plays for 10 seconds before making way for the second entry, which plays for its full length, and so on.

Full coverage of CSPL syntax is also beyond the scope of this book, but you can find complete coverage in the Windows Media Metafile reference at `msdn.microsoft.com/en-us/library/dd564670(VS.85).aspx`.

It is important to note that Silverlight does not support some of the SSPL and CSPL elements and attributes. Refer to `msdn.microsoft.com/en-us/library/cc189080(VS.95).aspx` to find out more about the unsupported features.

The Code

This code sample adds an SSPL and a CSPL to the mix of media that you then play through the player developed in Recipes 10-2 and 10-3.

Figure 10-20 shows the new items added to the menus that enable you to test the features.

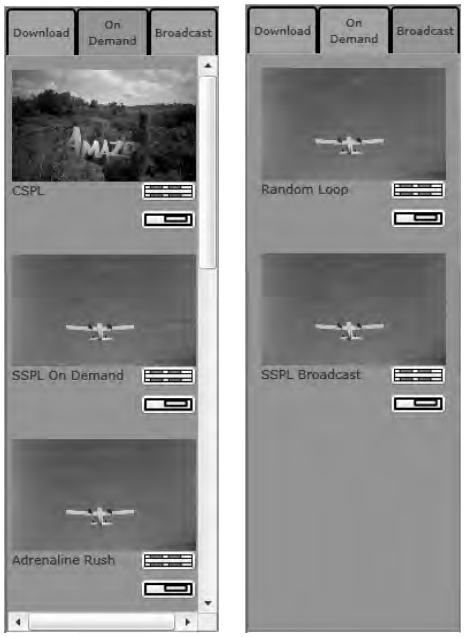


Figure 10-20. *Items added to the On Demand (left) and Broadcast (right) menus*

To play the SSPL, you create two new publishing points named `SSPLBroadcast` of type broadcast and `SSPLOnDemand` of type on-demand in the WMS installation. You then associate the SSPL document shown in Listing 10-19 with each of these publishing points. The SSPL document is named `SampleSSPL.wsx` and is included with the sample code. You create two publishing points in order to observe the behavior of the `MediaElement` while playing an SSPL using the two different publishing point types. You then modify the `OnDemandStreams.xml` file and the `BroadcastStreams.xml` file to include an entry to the two respective publishing points. Recall from the earlier recipes that these files are used by the `MediaLocationProvider` WCF service to provide the content of the menus in the player.

To play the CSPL, you add one more entry to the `OnDemandStreams.xml` that has the `<Uri>` element pointing to the `SampleCSPL.asx` file, as shown in Listing 10-20.

Listing 10-21 shows all the entries in the two files.

Listing 10-21. *New Entries in BroadcastStreams.xml and OnDemandStreams.xml*

```
<!--BroadcastStreams.xml entry-->
<MediaLocation>
  <Description>SSPL Broadcast</Description>
  <Uri>mms://dc7600:43000/SSPLBroadcast</Uri>
  <ImageUri>
    http://localhost/SLBook/Ch10_RichMedia/Media/AdrenalineRush_Thumb.jpg
  </ImageUri>
</MediaLocation>

<!--OnDemandStreams.xml entries-->
```

```
<MediaLocation>
  <Description>SSPL On Demand</Description>
  <Uri>mms://dc7600:43000/SSPLOnDemand</Uri>
  <ImageUri>
    http://localhost/SLBook/Ch08_RichMedia/Media/AdrenalineRush_Thumb.jpg
  </ImageUri>
</MediaLocation>
<MediaLocation>
  <Description>CSPL</Description>
  <Uri>http://localhost:9393/SampleCSPL.ASX</Uri>
  <ImageUri>
    http://localhost/SLBook/Ch08_RichMedia/Media/Amazon_1080_Thumb.jpg
  </ImageUri>
</MediaLocation>
```

These entries cause three new menu items to appear in the player menus: two in the On Demand menu (SSPL On Demand and CSPL) and one in the Broadcast menu (SSPL Broadcast). This is shown in Figure 10-20.

If you play SSPL On Demand, the seek `Buttons` are disabled and the `Thumb` is missing. This is because the `MediaElement` does not allow seeking (`MediaElement.CanSeek` is `false`) even when the SSPL is being served through an on-demand publishing point. This, as you may recall, is different from your experience in Recipe 10-3 when you played individual media files through an on-demand publishing point. However, the `Pause` button is enabled, because a playing SSPL can be paused as long as it is being served through an on-demand publishing point (`MediaElement.CanPause` is set to `true`).

You can also observe the timing behavior specified through the `dur` and `begin` attributes in Listing 10-19 by following the progress and duration counters displayed along with the slider. Note that although the timing behavior forces certain media sources to stop and make way for the next element before they play their entire duration, the `MediaElement.NaturalDuration` always reports the total duration of each media source as it is loaded in the course of playing the SSPL.

Also note that as the SSPL is played by the `MediaElement`, state transitions are reported for certain states for each media source. The `MediaElement.Opened` event is raised every time the SSPL moves to a new source. The `MediaElement.CurrentStateChanged` event is also raised when the source is buffering or starts playing. This allows the player code from Recipe 10-3 to update various media information such as duration, as well as track play progress and buffering progress for every source change within the SSPL. The `MediaElement.Ended` event, however, is raised only once: when the entire SSPL is finished playing.

When you play the SSPL Broadcast menu item, you see the same broadcast publishing point experience as in Recipe 10-3—that is, seeking and pausing are disabled, and no duration information is exposed.

Finally, when you play the CSPL item, seeking is available, and the `Thumb` and the seek `Buttons` are usable. Also notice the effect of the `<Duration>` elements. While playing a CSPL entry with a duration set to a time different from the total duration of the referenced media source, the `MediaElement` reports the duration value from the CSPL rather than the actual total duration. So, for the first element in Listing 10-20, the duration reported is 10 seconds, even though the actual duration of the media source is a little over a minute.

10-5. Using Markers to Display Timed Content

Problem

You want to display some timed content, such as a closed caption, subtitles, or a commercial, at certain points while your media is playing.

Solution

Add markers to the video either through pre-encoding or at runtime, and respond to `MediaElement` events to display your content when markers are reached.

How It Works

A *marker* is a piece of metadata associated with a specific time point in a media's timeline. A Windows media file may contain many such markers, and this collection of markers is stored along with the actual media inside the file. While the media is playing, a player like the `MediaElement` can raise notification events every time a marker is reached, and you can respond to these events in your code to perform a timed task corresponding to that marker's time point.

Markers are useful in many scenarios. Captions or advertisements specific to the content's current context may be displayed at specific time points. You might devise a chapter system by introducing a marker at the beginning of the chapters and allowing the user to seek to the time point defined by the marker to simulate chapter navigation. Markers can also be used to overlay near real-time data, such as a game commentary, over live content.

You can introduce markers into the media either by encoding them using an encoder like Expression Encoder or programmatically at the start of play, provided the playing environment supports such a feature. Let's look at these options.

Encoding Markers Using Expression Encoder 3

Full coverage of Expression Encoder 3 is beyond the scope of the book, and we encourage you to download the trial version and try the different features. You can download a trial version from `www.microsoft.com/expression/try-it/default.aspx?filter=encoder3`. After you import a media file into Expression Encoder, you can navigate to the Metadata tab to add markers to the content. To add a marker, move the thumb along the media timeline to the time point where you want to add the marker, and then click the Add button in the Markers pane. Doing so adds a marker with its `Time` property set to the time point you selected using the `Thumb` and its `Value` property set to a blank string. You can provide a meaningful text value to the marker in the `Value` property if you decide to have application logic dependent on it, as shown later in the sample. When you have added all the markers you need, the Markers pane looks something like Figure 10-21.

Figure 10-21. *Expression Encoder Markers pane with markers added*

Note that the Key Frame check box is checked by default for each marker. This causes the generation of a keyframe the time point for each marker, resulting in a much faster seek to that marker if needed. You can uncheck the Key Frame check box for any markers for which you do not want to generate keyframes. Checking the Thumbnail check box causes Expression Encoder to generate a thumbnail of the video frame at the marker, which may come in handy in scenarios like a chaptering system.

If the media is already encoded to a profile of your choice, you can set the Video encoding profile in the Encode tab to Source, as shown in Figure 10-22. This causes Expression Encoder to add the markers to the media when you click the Encode button, without going through a full encode again, and makes the process a lot faster. A *profile* is a set of predetermined values around the various parameters you can control on the media during the encoding process.

Figure 10-22. *Expression Encoder video profile set to match the source profile*

MediaElement and Markers

When you use a Windows Media file containing markers as a source to a `MediaElement`, the `MediaElement` reads all the markers in the file and stores them in the `MediaElement.Markers` collection, which is of type `System.Windows.Media.TimelineMarkerCollection`. You can access this collection after the media has been successfully opened in the `MediaOpened` event handler and afterward.

Each marker is represented by an instance of the `System.Windows.Media.TimelineMarker` class. The `TimelineMarker.Time` property is of type `TimeSpan` and represents the marker's time point. The `TimelineMarker.Text` property contains the marker's optional text value, which can be user defined. In the case of markers encoded in the video, if you recall the Expression Encoder example in the previous

section, this property reflects the values entered in the Value column in the Markers pane. The `TimelineMarker.Type` property can also be any user-defined string and can be used to categorize markers into sets corresponding to a specific usage.

After the media starts playing, as each marker's time point is reached, the `MediaElement` raises the `MarkerReached` event. In the handler for the event, the `Marker` property on `System.Windows.Media.TimelineMarkerRoutedEventArgs` provides access to the `TimelineMarker` instance that causes the `MediaElement` to raise the event.

In addition to markers introduced in the media during encoding, you can add markers to media at runtime. You achieve this by creating and initializing new instances of the `TimelineMarker` type and adding them to the `MediaElement.Markers` collection before the media starts playing. These markers are temporary and are not stored in the media, but are discarded after a new media file is loaded into the `MediaElement`. Apart from that, their behavior is identical to markers contained in the media file, and the `MarkerReached` event is raised for both kinds the same way.

The Code

The code sample for this recipe shows the use of markers encoded into the media file as well as temporary markers added on the client. You enable two scenarios in this sample: a captioning system and overlaid commercials. In the former scenario, animated and context-specific text captions are overlaid on the video at specific time points; for this, you use file-encoded markers. In the latter scenario, a small commercial-like video is overlaid on the main video at regular intervals; for this, you use client-created markers.

You implement all this in the player you have been developing in the previous few recipes.

Figure 10-23 shows both scenarios at work in the player. The caption is the white text near the upper-right corner of the display, and the small Silverlight logo is actually a small video playing near the lower-right corner.

Let's look at the captioning system first. The captions are implemented as independent snippets of XAML defined in an XML file named `Captions.xml`, keyed by a specific marker value.
Listing 10-22 shows an abridged `Captions.xml` file.

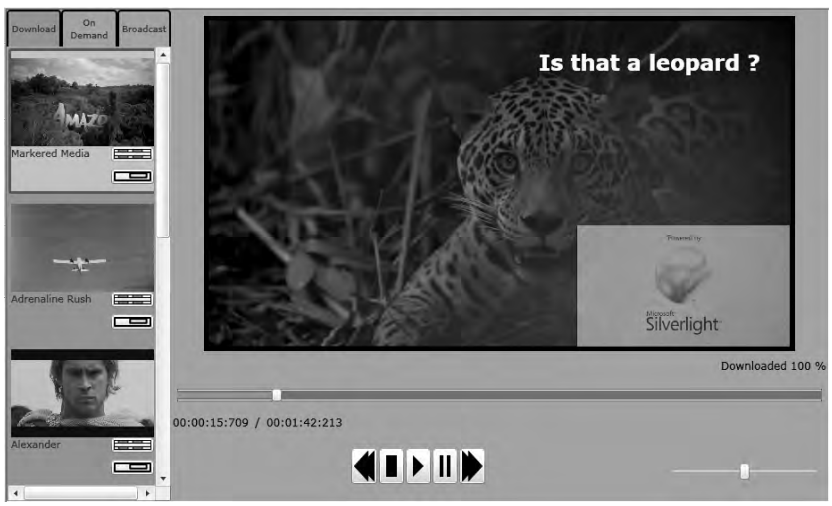


Figure 10-23. *Overlaid caption and Silverlight commercial*

Listing 10-22. *Captions.xml sample*

```
<?xml version="1.0" encoding="utf-8" ?>
<Medias>
  <Media
    Id="http://localhost/SLBook/Ch010RichMedia/Media/Amazon_1080_WithMarkers.wmv">
    <Marker Value="FirstMarker">
      <![CDATA[
      <Canvas  xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml" Height="Auto"
    HorizontalAlignment="Stretch" Margin="0,0,0,0"
    VerticalAlignment="Stretch" Width="Auto"
    Grid.Column="1" Grid.Row="1" x:Name="overlay">

    <Canvas.Resources>
    <Storyboard x:Name="STBD_AnimateCaption">
      <DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
      Storyboard.TargetName="textBlock"
      Storyboard.TargetProperty="(UIElement.Opacity)">
        <LinearDoubleKeyFrame KeyTime="00:00:01" Value="1"/>
        <LinearDoubleKeyFrame KeyTime="00:00:04" Value="1"/>
        <SplineDoubleKeyFrame KeyTime="00:00:05" Value="0"/>
      </DoubleAnimationUsingKeyFrames>
      <DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
      Storyboard.TargetName="textBlock"
      Storyboard.TargetProperty="(Canvas.Left)">
        <SplineDoubleKeyFrame KeyTime="00:00:01" Value="375"/>
        <SplineDoubleKeyFrame KeyTime="00:00:02" Value="375"/>
        <SplineDoubleKeyFrame KeyTime="00:00:03" Value="375"/>
        <SplineDoubleKeyFrame KeyTime="00:00:04" Value="375"/>
        <SplineDoubleKeyFrame KeyTime="00:00:05" Value="0"/>
      </DoubleAnimationUsingKeyFrames>
      <DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
      Storyboard.TargetName="textBlock"
      Storyboard.TargetProperty="(Canvas.Top)">
        <SplineDoubleKeyFrame KeyTime="00:00:01" Value="35"/>
        <SplineDoubleKeyFrame KeyTime="00:00:02" Value="35"/>
        <SplineDoubleKeyFrame KeyTime="00:00:03" Value="35"/>
        <SplineDoubleKeyFrame KeyTime="00:00:04" Value="35"/>
        <SplineDoubleKeyFrame KeyTime="00:00:05" Value="0"/>
      </DoubleAnimationUsingKeyFrames>
    </Storyboard>
  </Canvas.Resources>
  <TextBlock x:Name="textBlock"
  Opacity="0" FontFamily="Portable User Interface" FontSize="24"
```

```
FontWeight="Bold" Foreground="#FFFFFDFD" Text="Beautiful Sunset"
TextAlignment="Right" TextWrapping="Wrap" HorizontalAlignment="Left"
VerticalAlignment="Top"/>
  </Canvas>]]>
  </Marker>
  <Marker Value="SecondMarker">
    <![CDATA[<Canvas Height="Auto"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
  xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
  HorizontalAlignment="Stretch" Margin="0,0,0,0"
  VerticalAlignment="Stretch" Width="Auto"
  Grid.Column="1" Grid.Row="1" x:Name="overlay">

<Canvas.Resources>
  <Storyboard x:Name="STBD_AnimateCaption">
    <DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
    Storyboard.TargetName="textBlock"
    Storyboard.TargetProperty="(UIElement.Opacity)">
      <LinearDoubleKeyFrame KeyTime="00:00:01" Value="1"/>
      <LinearDoubleKeyFrame KeyTime="00:00:04" Value="1"/>
      <SplineDoubleKeyFrame KeyTime="00:00:05" Value="0"/>
    </DoubleAnimationUsingKeyFrames>
    <DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
    Storyboard.TargetName="textBlock"
    Storyboard.TargetProperty="(Canvas.Left)">
      <SplineDoubleKeyFrame KeyTime="00:00:01" Value="375"/>
      <SplineDoubleKeyFrame KeyTime="00:00:02" Value="375"/>
      <SplineDoubleKeyFrame KeyTime="00:00:03" Value="375"/>
      <SplineDoubleKeyFrame KeyTime="00:00:04" Value="375"/>
      <SplineDoubleKeyFrame KeyTime="00:00:05" Value="0"/>
    </DoubleAnimationUsingKeyFrames>
    <DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
    Storyboard.TargetName="textBlock" S
    Storyboard.TargetProperty="(Canvas.Top)">
      <SplineDoubleKeyFrame KeyTime="00:00:01" Value="35"/>
      <SplineDoubleKeyFrame KeyTime="00:00:02" Value="35"/>
      <SplineDoubleKeyFrame KeyTime="00:00:03" Value="35"/>
      <SplineDoubleKeyFrame KeyTime="00:00:04" Value="35"/>
      <SplineDoubleKeyFrame KeyTime="00:00:05" Value="0"/>
    </DoubleAnimationUsingKeyFrames>
  </Storyboard>
</Canvas.Resources>
<TextBlock x:Name="textBlock" Opacity="0"
FontFamily="Portable User Interface" FontSize="24"
FontWeight="Bold" Foreground="#FFFFFDFD" Text="Is that a leopard ?"
```

```
  TextAlignment="Right" TextWrapping="Wrap" HorizontalAlignment="Left"
  VerticalAlignment="Top"/>
</Canvas>]]>
    </Marker>
  </Media>
</Medias>
```

The root element `<Medias>` is expected to have multiple `<Media>` elements, each uniquely identified by its `Id` attribute set to the media URI. Each `<Media>` element in turn can have many `<Marker>` elements with a `Value` attribute set to the marker value, and a CDATA section containing the XAML snippet to be used for that marker. Note that you stipulate that each XAML snippet has at least one `Storyboard` defined, named `STBD_AnimateCaption`; you use it later in the code. Also note that the `TextBlock` at the end of the XAML snippet has the caption text set on the `Text` property.

■ **Note** Several industry standards are defined for including captions and subtitles in digital media for both television and broadband delivery mechanisms. You can look at the Synchronized Multimedia Integration Language (SMIL) specification at `www.w3.org/TR/SMIL2/`or the Synchronized Accessible Media Interchange (SAMI) specification at `msdn.microsoft.com/en-us/library/dd562301(VS.85).aspx`. The schema outlined here is not aligned with an industry standard by any means. If this mechanism works for you as is, we are happy that you have benefited. However, if your goal is to create a production-ready captioning system, we also encourage you to look at some of the industry standards and possibly combine them with the knowledge gained here to achieve your goals with Silverlight.

You also encode the media file (in the sample `Amazon_1080.wmv` file) with markers placed at appropriate time points, with their `Value` properties set to match the `Value` attributes of the `<Marker>` elements in the `Captions.xml` file (we discussed the Expression Encoder–based encoding process briefly in the previous section). To have this file available to the player to play, you place the encoded file for progressive download in the same location as the other progressively downloaded media files from Recipe 10-2 and add a new entry to the `Downloads.xml` file. To see how this works, refer back to Recipe 10-2.

You define a new operation named `GetCaptionsForMedia()` on the `MediaLocationProvider` WCF service that you have been using since Recipe 10-2. `GetCaptionsForMedia()` accepts the Media URI and returns the complete XML for the corresponding `<Media>` element. You also use a `UriTemplate` in the operation contract to map the operation to the format `<`*`service address`*`>/Captions?MediaId={`*`MediaUri`*`}`, where *`MediaUri`* is the URI of the media you are trying to download and play.

We do not list `GetCaptionsForMedia()`, and you are encouraged to look at Chapter 7 for more about WCF services and the sample code for the implementation.

The player XAML from the previous recipes undergoes a few minor changes. We list the player XAML in Listing 10-23, but we left out the Resources section for brevity and because there are no changes to it.

Listing 10-23. *Modified XAML for the Marker-Enabled Player*

```
<UserControl x:Class="Recipe10_5.Page"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    xmlns:vsm="clr-namespace:System.Windows;assembly=System.Windows"
    xmlns:local="clr-namespace:Recipe10_5"
    Width="920" Height="547"
    xmlns:Ch10_RichMedia_Recipe10_4=
"clr-namespace:Recipe10_5;assembly=Recipe10_5.PlrCntls"
 >
  <!-- Resources section deliberately left out -->

  <Grid x:Name="LayoutRoot"
        Background="#FFA2A2A2" Height="Auto" Width="Auto">
    <Grid.RowDefinitions>
      <RowDefinition Height="0.062*"/>
      <RowDefinition Height="0.649*"/>
      <RowDefinition Height="0*"/>
      <RowDefinition Height="0.289*"/>
    </Grid.RowDefinitions>
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="0.2*"/>
      <ColumnDefinition Width="0.8*"/>
    </Grid.ColumnDefinitions>
    <MediaElement Height="Auto" Margin="0,0,0,0"
                  VerticalAlignment="Top" x:Name="mediaelemMain"
                  BufferingTime="0:0:3"
                  HorizontalAlignment="Left" AutoPlay="True" Opacity="0"/>
    <MediaElement Height="Auto" Margin="0,0,0,0" VerticalAlignment="Top"
                  x:Name="mediaelemPIP" HorizontalAlignment="Left"
                  AutoPlay="True" Opacity="0" IsMuted="True"
                  BufferingTime="0:0:3"/>
    <Grid Grid.Row="0" Grid.Column="1" Grid.RowSpan="2" Margin="0,0,0,1">
      <Grid.RowDefinitions>
        <RowDefinition Height="0.018*" />
        <RowDefinition Height="0.961*" />
        <RowDefinition Height="0.021*" />
      </Grid.RowDefinitions>
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="0.05*"/>
        <ColumnDefinition Width="0.9*"/>
        <ColumnDefinition Width="0.05*"/>
      </Grid.ColumnDefinitions>
```

```
<Border x:Name="displayMain"
        VerticalAlignment="Stretch" Grid.Column="1" Grid.Row="1"
        HorizontalAlignment="Stretch" BorderThickness="5,5,5,5"
        BorderBrush="#FF000000" Margin="0,0,0,0" >
  <Border.Background>
    <VideoBrush SourceName="mediaelemMain" Stretch="Fill"
                x:Name="vidbrushMain" />
  </Border.Background>
  <Grid HorizontalAlignment="Right" MaxHeight="135" MaxWidth="240"
        Grid.Column="1" Grid.Row="1" Opacity="0.5"
        x:Name="adContainer" VerticalAlignment="Bottom">
  </Grid>
</Border>
<Grid VerticalAlignment="Stretch" Grid.Column="1" Grid.Row="1"
        HorizontalAlignment="Stretch" x:Name="CaptionContainer"
      Margin="0,0,0,0" />
<Grid Grid.Column="1" Grid.Row="1" Margin="0,0,0,0">
  <Grid.RowDefinitions>
    <RowDefinition Height="0.025*" />
    <RowDefinition Height="0.35*" />
    <RowDefinition Height="0.625*" />
  </Grid.RowDefinitions>
  <Grid.ColumnDefinitions>
    <ColumnDefinition Width="0.635*"/>
    <ColumnDefinition Width="0.35*"/>
    <ColumnDefinition Width="0.015*"/>
  </Grid.ColumnDefinitions>
  <Border Grid.Column="1" Grid.Row="1" HorizontalAlignment="Stretch"
          VerticalAlignment="Stretch"
          MouseLeftButtonUp="displayPIP_MouseLeftButtonUp"
          x:Name="displayPIP" BorderThickness="2,2,2,2"
          BorderBrush="#FF000000" Visibility="Collapsed">
    <Border.Background>
      <VideoBrush SourceName="mediaelemPIP"
                  Stretch="Fill" x:Name="vidbrushPIP"/>
    </Border.Background>
  </Border>
  <Grid HorizontalAlignment="Stretch" Margin="8,8,8,8"
        Grid.RowSpan="1" Grid.Column="1" Grid.Row="1"
        x:Name="buttonsPIP" Visibility="Collapsed" >
    <Grid.RowDefinitions>
      <RowDefinition Height="0.1*"/>
      <RowDefinition Height="0.25*"/>
      <RowDefinition Height="0.1*"/>
```

```
            <RowDefinition Height="0.25*"/>
            <RowDefinition Height="0.3*"/>
          </Grid.RowDefinitions>
          <Grid.ColumnDefinitions>
            <ColumnDefinition Width="0.749*"/>
            <ColumnDefinition Width="0.176*"/>
            <ColumnDefinition Width="0.075*"/>
          </Grid.ColumnDefinitions>
          <Button Margin="0,0,0,0" Grid.RowSpan="1" Grid.Row="1"
                  Grid.ColumnSpan="1" Grid.Column="1"
                  x:Name="btnClosePIP" Click="btnClosePIP_Click">
            <Path x:Name="Path" Stretch="Fill" StrokeThickness="2"
StrokeLineJoin="Round" Stroke="#FF000000" Fill="#FFE91111"
Data="M 110.5,75.7635L 113.209,
                  72.9631L 133.396,92.4865L 130.687,95.2869L 110.5,
                  75.7635 Z M 130.801,73.4961L 133.393,76.4048L 112.425,
                  95.0872L 109.833,92.1785L 130.801,73.4961 Z "/>
          </Button>
          <Button Margin="0,0,0,0" Grid.RowSpan="1" Grid.Row="3"
                  Grid.ColumnSpan="1" Grid.Column="1"
                  x:Name="btnSwitchPIP" Click="btnSwitchPIP_Click">
            <Path Stretch="Fill" StrokeThickness="2" StrokeLineJoin="Round"
Stroke="#FF000000" Data="M 120,39.8333L 149.917,
                  39.8333L 149.917,59.9167L 120,59.9167L 120,
                  39.8333 Z M 132.917,42.8333L 146.667,42.8333L 146.667,
                  52.6667L 132.917,52.6667L 132.917,42.8333 Z "/>
          </Button>
        </Grid>
      </Grid>
    </Grid>
    <Grid Margin="2,-1,2,0" VerticalAlignment="Stretch" Grid.Column="1"
          Grid.Row="2" HorizontalAlignment="Stretch" Grid.RowSpan="2">
      <Grid.RowDefinitions>
        <RowDefinition Height="0.341*"/>
        <RowDefinition Height="0.341*"/>
      </Grid.RowDefinitions>
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="0.75*"/>
        <ColumnDefinition Width="0.25*"/>
      </Grid.ColumnDefinitions>
      <Ch08_RichMedia_Recipe8_4:MediaSlider SourceName="mediaelemMain"
                              VerticalAlignment="Stretch"
                              IsEnabled="True"
                              x:Name="mediaSlider" Grid.ColumnSpan="2"
                              Margin="0,0,0,0" Grid.Row="0" />
```

```
      <Ch08_RichMedia_Recipe8_4:MediaButtonsPanel Grid.Row="2" Grid.Column="0"
                                SourceName="mediaelemMain"
                                HorizontalAlignment="Center"
                                VerticalAlignment="Center"
                                Width="150" Height="40"
                                x:Name="mediaControl"/>
      <Slider x:Name="sliderVolumeControl"  Margin="5,12,5,0" Maximum="1"
              Minimum="0" SmallChange="0.1"
              LargeChange="0.2"  Value="0.5"
              MinWidth="50" Grid.Row="2"
              Grid.Column="1" ValueChanged="sliderVolumeControl_ValueChanged"/>
    </Grid>
    <Grid Grid.RowSpan="4">
      <Grid.RowDefinitions>
        <RowDefinition Height="Auto" MinHeight="41" />
        <RowDefinition Height="*" />
      </Grid.RowDefinitions>

      <Grid Height="Auto" VerticalAlignment="Stretch">
        <Grid.ColumnDefinitions>
          <ColumnDefinition Width="0.33*"/>
          <ColumnDefinition Width="0.34*"/>
          <ColumnDefinition Width="0.33*"/>
        </Grid.ColumnDefinitions>

<RadioButton HorizontalAlignment="Stretch" VerticalAlignment="Stretch"
          Content="Download"
          Template="{StaticResource ctMenuSwitchButton}"
                HorizontalContentAlignment="Stretch"
                VerticalContentAlignment="Stretch"
                GroupName="MediaMenuChoices"
                IsChecked="True" x:Name="rbtnDownloadsMenu"
                Checked="rbtnDownloadsMenu_Checked"/>
  <RadioButton HorizontalAlignment="Stretch" VerticalAlignment="Stretch"
                Content="On Demand" Grid.Column="1"
                Template="{StaticResource ctMenuSwitchButton}"
                HorizontalContentAlignment="Stretch"
                VerticalContentAlignment="Stretch"
                GroupName="MediaMenuChoices"
                IsChecked="False" x:Name="rbtnOnDemandMenu"
                Checked="rbtnOnDemandMenu_Checked"/>
  <RadioButton HorizontalAlignment="Stretch" VerticalAlignment="Stretch"
                Content="Broadcast" Grid.Column="2"
                Template="{StaticResource ctMenuSwitchButton}"
                HorizontalContentAlignment="Stretch"
```

```
                VerticalContentAlignment="Stretch" IsChecked="False"
                GroupName="MediaMenuChoices" x:Name="rbtnBroadcastMenu"
                Checked="rbtnBroadcastMenu_Checked"/>
  </Grid>
  <ListBox Margin="0,0,0,0" VerticalAlignment="Stretch"
                x:Name="lbxMediaMenuDownloads"
                ItemTemplate="{StaticResource dtMediaMenuItem}"
                ItemContainerStyle="{StaticResource STYLE_MediaMenuListBoxItem}"
                Grid.RowSpan="1" Grid.Row="1" Background="#FF3CB1E8"/>
  <ListBox Margin="0,0,0,0" VerticalAlignment="Stretch"
                x:Name="lbxMediaMenuOnDemandStreams"
                ItemTemplate="{StaticResource dtMediaMenuItem}"
                ItemContainerStyle="{StaticResource STYLE_MediaMenuListBoxItem}"
                Grid.RowSpan="1" Grid.Row="1" Background="#FF3CB1E8"↩
 Visibility="Collapsed"/>

      <ListBox Margin="0,0,0,0" VerticalAlignment="Stretch"
                x:Name="lbxMediaMenuBroadcastStreams"
                ItemTemplate="{StaticResource dtMediaMenuItem}"
                ItemContainerStyle="{StaticResource STYLE_MediaMenuListBoxItem}"
               Visibility="Collapsed"
                Background="#FF3CB1E8" Grid.RowSpan="1" Grid.Row="1"/>
    </Grid>
  </Grid>
</UserControl>
```

The only change in the XAML that pertains to the captioning system is the addition of a `Grid` named `CaptionContainer`, overlaid on top of the `Border` that serves as the main display; this change is shown in bold in Listing 10-23.

Listing 10-24 shows the modifications to the player's codebehind. Again, because major portions of the player's code do not change from previous recipes, we have left out some of the unchanged portions. You are encouraged to look at the previous recipe for the full player listing.

Listing 10-24. *Modifications to the Player Code for Marker Support*

```
using System;
using System.Collections.Generic;
using System.Collections.ObjectModel;
using System.Linq;
using System.Net;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Input;
using System.Windows.Markup;
using System.Windows.Media;
using System.Windows.Media.Animation;
```

```
using System.Windows.Threading;
using System.Xml.Linq;

namespace Recipe10_5
{
  public partial class MainPage : UserControl
  {
    private const string DownloadsListUri =
      "http://localhost:9494/MediaLocationProvider.svc/GetDownloadsList";
    private const string OnDemandStreamsListUri =
      "http://localhost:9494/MediaLocationProvider.svc/GetOnDemandStreamsList";
    private const string BroadcastStreamsListUri =
      "http://localhost:9494/MediaLocationProvider.svc/GetBroadcastStreamsList";
    private const string CaptionsListUri =
     "http://localhost:9494/MediaLocationProvider.svc/Captions?MediaId={0}";
    private const string CommercialsListUri =
     "http://localhost:9494/MediaLocationProvider.svc/Commercial?Marker={0}";

    private Dictionary<string, string> dictCaptions = null;

    DispatcherTimer timerAdManager = null;

    void MainPage_Loaded(object sender, RoutedEventArgs e)
    {
      PopulateMediaMenu();

      //handle marker reached for the main display
      MainVideo.MarkerReached +=
        new System.Windows.Media.TimelineMarkerRoutedEventHandler
(MainVideo_MarkerReached);
      //handle both media_opened events
      MainVideo.MediaOpened += new RoutedEventHandler(MainVideo_MediaOpened);
      PIPVideo.MediaOpened += new RoutedEventHandler(PIPVideo_MediaOpened);
      //set up a timer to manage commercials
      timerAdManager = new DispatcherTimer();
      timerAdManager.Interval = new TimeSpan(0, 0, 15);
      timerAdManager.Tick += new EventHandler(delegate(object timer, EventArgs args)
      {
        //clear
        if (adContainer.Children.Count > 0)
          adContainer.Children.Clear();
        //stop timer
        if ((timer as DispatcherTimer).IsEnabled)
          (timer as DispatcherTimer).Stop();
      });
```

```
}

void PIPVideo_MediaOpened(object sender, RoutedEventArgs e)
{
  //we will never display commercials in the PIP,
  //but it might get switched with the main - hence this
  AttachClientMarkers(PIPVideo);
}

void MainVideo_MediaOpened(object sender, RoutedEventArgs e)
{
  //attach the client markers for commercials demo
  AttachClientMarkers(MainVideo);
}

private void AttachClientMarkers(MediaElement medElem)
{
  TimeSpan ts = TimeSpan.Zero;
  if (medElem.NaturalDuration.TimeSpan != TimeSpan.Zero)
  {
    int Ctr = 0;
    while (ts <= medElem.NaturalDuration.TimeSpan)
    {
      //Text = unique name, Time 5,40, 75, ...
      medElem.Markers.Add(new TimelineMarker
      {
        Text = "ClientMarker" + (++Ctr).ToString(),
        Time = ts + new TimeSpan(0, 0, 5),
        Type = "SLMovie"
      });
      ts += new TimeSpan(0, 0, 30);
    }
  }
}

void MainVideo_MarkerReached(object sender,
  System.Windows.Media.TimelineMarkerRoutedEventArgs e)
{
  //Captions markers coming from encoded video
  if (dictCaptions != null && dictCaptions.Count > 0
    && dictCaptions.ContainsKey(e.Marker.Text))
  {
    //clear if we got here before the previous animation completed
    if (CaptionContainer.Children.Count > 0)
      CaptionContainer.Children.Clear();
```

```
    // get the caption XAML
    FrameworkElement fe = XamlReader.Load(dictCaptions[e.Marker.Text])
      as FrameworkElement;
    //add
    CaptionContainer.Children.Add(fe);
    //get the animation
    Storyboard stbd = fe.Resources["STBD_AnimateCaption"] as Storyboard;
    stbd.Completed +=
      new EventHandler(delegate(object anim, EventArgs args)
      {
        //clear on animation completion
        if (CaptionContainer.Children.Count > 0)
          CaptionContainer.Children.Clear();
      });

    //run animation
    stbd.Begin();
  }
  //commercial marker
  else if (e.Marker.Type == "SLMovie")
  {
    WebClient wcCommercial = new WebClient();
    wcCommercial.DownloadStringCompleted +=
      new DownloadStringCompletedEventHandler(
        delegate(object wc, DownloadStringCompletedEventArgs args)
        {
          if (args.Result == null || args.Result == string.Empty) return;
          if (adContainer.Children.Count > 0)
            adContainer.Children.Clear();
          //parse
          XDocument xDoc = XDocument.Parse(args.Result);
          //add
          adContainer.Children.Add(XamlReader.Load((
            (XCData)xDoc.Root.DescendantNodes().ToList()[0]).Value)
            as FrameworkElement);
          //start timer
          timerAdManager.Start();

        });
    //get commercial for this marker type
    wcCommercial.DownloadStringAsync(
      new Uri(string.Format(CommercialsListUri, e.Marker.Type)));
  }
}
private void PlayFull_Click(object sender, RoutedEventArgs e)
```

```
    {
      //get the animations
      Uri mediaUri = ((sender as Button).Tag as MediaMenuData).MediaLocation;
      WebClient wcAnimations = new WebClient();
      wcAnimations.DownloadStringCompleted +=
        new DownloadStringCompletedEventHandler(
          wcAnimations_DownloadStringCompleted);
      //pass in the mediaelement and the source URI
      wcAnimations.DownloadStringAsync(
        new Uri(string.Format(CaptionsListUri, mediaUri.AbsoluteUri)),
        new object[] { MainVideo, mediaUri });

    }


    void wcAnimations_DownloadStringCompleted(object sender,
      DownloadStringCompletedEventArgs e)
    {
      if (e.Result != null && e.Result != string.Empty)
      {
        //parse
        XDocument xDoc = XDocument.Parse(e.Result);
        //get each animation
        var AnimationUnits = from marker in xDoc.Root.Elements()
                             select new
                             {
                               key = marker.Attribute("Value").Value,
                               XamlFragment = ((XCData)marker.DescendantNodes().
                               ToList()[0]).Value
                             };

        dictCaptions = new Dictionary<string, string>();
        //store in dictionary
        foreach (var marker in AnimationUnits)
          dictCaptions.Add(marker.key, marker.XamlFragment);
      }
      //start playing the media
      ((e.UserState as object[])[0] as MediaElement).Source =
        ((e.UserState as object[])[1] as Uri);
    }

    // REST OF THE CODE OMITTED FOR BREVITY -
    //PLEASE LOOK AT RECIPE 10-4 FOR FULL LISTING
  }
}
```

Whenever a user tries to play a media file, you use a `WebClient` to invoke the `GetCaptionsForMedia()` WCF service operation. In the `DownloadStringCompleted` handler, you check to see if any caption definitions were returned. If there is a valid return from the operation, you perform a LINQ query on the returned XML to extract a collection of the marker values and corresponding XAML fragments. You then save each XAML entry representing a caption into a `Dictionary` named `dictCaptions`, keyed with the marker value for later access. After this is done, you start playing the media by setting `MediaElement.Source`.

As the media plays and markers are reached, you handle the `MarkerReached` event, using the `MainVideo_MarkerReached()` event handler. Let's look at the `if` block of the `if-else` statement in the handler. If the `TimelineMarker` being reached has a `Text` property value that corresponds to a key in `dictCaptions`, you first clear the `CaptionContainer`. You then load the XAML fragment using `XamlReader.Load()`. You can find more about `XamlReader` in Chapter 2. When the XAML is loaded, you cast it to a `FrameworkElement` and add it to `CaptionContainer`. Using the `FrameworkElement` base type allows you to use any `FrameworkElement` derivative in the XAML fragment, and not just a `Canvas` as it was defined in the XAML fragment. You then acquire the `Storyboard` named `STBD_AnimateCaption` from the `FrameworkElement.Resources` collection and start it. In the `Storyboard.Completed` handler, you clear the `CaptionContainer` after the animation completes.

■ **Note** The clearing of the `CaptionContainer` at the beginning of the `if` block is for cases where a marker may be reached even before the animation for the previous one has completed.

Also note that the XAML fragments loaded using `XamlReader.Load()` are evaluated by the XAML parser for validity. Because they are not evaluated in the context of a containing XAML document, they need to be valid on their own. Consequently, if you are cutting and pasting from a containing document, be sure to add the necessary namespace declarations to the top-level element in the fragment to make it independently valid and thus avoid loading exceptions.

Now, let's look at the second part of this sample. For the simulated commercials, you create a similarly structured data file named `Commercials.xml`. Listing 10-25 shows a sample.

Listing 10-25. *Commercials.xml Sample*

```
<?xml version="1.0" encoding="utf-8" ?>
<Commercials>
  <Marker Type="SLMovie">
    <![CDATA[<Grid
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml">
            <MediaElement  x:Name="medElem" Opacity="0.0" AutoPlay="true"
            Source="mms://localhost/SLBook/Ch010RichMedia/Media/sl.wmv"
            HorizontalAlignment="Left" VerticalAlignment="Top" />
            <Border>
            <Border.Background>
              <VideoBrush Stretch="Fill" SourceName="medElem"/>
            </Border.Background>
            </Border>
```

```
        </Grid>]]>
  </Marker>
</Commercials>
```

Each commercial is tied to a marker type (derived from the `TimelineMarker.Type` property discussed earlier). Within each `<Marker>` element, you again have an XAML snippet defining the commercial. The previous sample includes another `MediaElement` in the snippet that points to a small Silverlight logo animation captured in a Windows media file. The `sl.wmv` file used here is a part of the Expression Encoder installation and can be found in the `StockContent` folder under the Expression Encoder installation root. But you can replace this with any `.wmv` file or, for that matter, any other XAML snippet.

You also define another WCF service operation named `GetCommercial()` and apply another `UriTemplate` to use the Uri format `<`*serviceaddress*`>/Commercial?Marker={`*MarkerType*`}`. `GetCommercial()` accepts a marker type string and returns the XML for the matching `<`*Marker*`>` element. Again, we encourage you to look at the sample code for the service operation details.

Refer back to Listing 10-23, and notice one more addition to the player XAML: another `Grid` named `adContainer`, this time contained in the `Border` serving as the main display. You set `adContainer` at opacity 0.5 and align it with the lower-right corner of the containing `Border`.

Referring back to the code in Listing 10-24, notice that you attach handlers to the `MediaOpened` event for both the PIP and the main `MediaElements` in the `Page_Loaded()` handler. In both those handlers, you invoke `AttachClientMarkers()` to attach a set of client-side markers to the media right after it opens. Although you always display the commercial in the main display only, you attach the markers to both, because in previous recipes you enabled the user to switch media elements between displays using the PIP feature.

In `AttachClientMarkers()`, you look at the total duration of the media file; create a new `TimelineMarker` at 30-second intervals, starting the first one at 5 seconds into the media; and add each to the `MediaElement.Markers` collection. You set the `TimelineMarker.Type` property to the string "SLMovie", which matches the entry in Listing 10-25. Note that you use a counter to generate a unique `Text` property for each `TimelineMarker`—the `MediaElement` requires that client markers have unique `Text` values. Whenever a piece of media starts playing, the `MarkerReached` event is raised for each client-side `TimelineMarker` as well.

Next, let's look at the `else` block of the `MainVideo_MarkerReached()` method, which is where you handle the client-side markers. After you verify that the `TimelineMarker.Type` property value matches the string "SLMovie", you use another `WebClient` to invoke the `GetCaption()` service operation. You parse the returned XAML into a `FrameworkElement` and add it to the `adContainer Grid`. Using the XAML fragment from the sample in Listing 10-25, this causes the `MediaElement` named `medElem` to download and play the `sl.wmv` file within the bounds of `adContainer`. You also start a `DispatcherTimer` named `timerAdManager` right after you add the XAML fragment. You have already created `timerAdManager` intervals in the `Page_Loaded()` handler and initialized `timerAdManager` to tick at 15-second intervals. In the `Tick` event handler for `timerAdManager`, you clear the `adContainer` and stop the timer, thus causing the commercial to play for its entire duration or 15 seconds, whichever comes first.

10-6. Displaying and Seeking Using SMPTE Timecodes

Problem

You want to display the time elapsed in the SMPTE timecode format when a video is playing. You also want the user to be able to specify a time in the SMPTE timecode format and have the video seek to that time point.

Solution

Use the `TimeCode` class and the `SmpteFrameRate` enumeration available as a part of the Expression Encoder templates to enable timecode handling in your code.

How It Works

Digital video is a collection of *frames*, where each frame is essentially a discrete bitmap. Video players achieve the illusion of a smoothly moving image by displaying these frames sequentially at a certain speed.

Frame Rate

The speed at which frames are displayed is typically measured in the number of frames displayed per second (fps) and is commonly known as the *frame rate* of a video.

Several different frame rates are used for video around the world. Some of the more common ones are as follows:

- 24 fps: Typically used for movie making
- 25 fps: Used in the PAL Television standards in large parts of Europe and Latin America
- 29.97 fps: Used in the NTSC Television standards in North America
- 30 fps: Used in the HDTV standard

Timecodes

A common way to refer to a specific time point in a video is to use a combination of standard time units and frame count. This mechanism has been formalized by the SMPTE and is commonly referred to as an SMPTE timecode or more formally as the SMPTE 12M specification.

An SMPTE timecode is a way to label each frame in a video with time information for that frame. Using the SMPTE timecode standard, each frame is labeled using the *hh*:*mm*:*ss*:*ff* format, where *ff* is the frame number for that frame within the second immediately following the time specified by the *hh*:*mm*:*ss* portion of the timecode.

As an example, consider a video that has been recorded at a frame rate of 25 fps—that is, in the video, a unique frame occurs every 40 milliseconds. The two-thousand-twelfth frame in that video is labeled 00:01:20:12. If you calculate backward, you see that 1 minute and 20 seconds (80 seconds) yields 2,000 frames at 25 fps, and hence 00:01:20:12 denotes the two-thousand-twelfth frame in the video.

Timecodes are typically imprinted into the source video at the time of recording. Consequently, if you are using the source material as is, you may expect the timecodes to be contiguous. However, this is not always the case. Often, video can be edited such that segments of video from different source materials, or disjoint segments from the same source material, are stitched together to form another video. In certain cases, the editor may choose to retain the original SMPTE timecodes from the sources into the resulting video, in which case the resulting video ends up with disjoint ranges of SMPTE timecodes.

We touch on some very basic information about timecoding here. For a somewhat detailed treatment of SMPTE timecodes, you can refer to `en.wikipedia.org/wiki/SMPTE_timecode`. For the detailed 12M timecode specifications, visit the SMPTE at `www.smpte.org`.

Timecodes and Silverlight

The SMPTE timecoding mechanism is very helpful for performing frame-accurate operations on a video, such as seeking to a specific frame within the video or being able to edit the video to the accuracy of specific frames. Consequently, you may need to both display and act on SMPTE timecodes in your Silverlight application.

Calculating the timecode is relatively easy as long as you know the frame rate of the video. If the video clip you are dealing with does not come with any preexisting timecode ranges, you can calculate the timecode at any time point by converting the fractional seconds in the `MediaElement.Position` property into a number of frames based on the frame rate, and then attaching that to the end of a string that contains the whole number of hours, minutes, and seconds at that time point formatted in the timecode format, as discussed in the previous section. In this case, the timecode is extrapolated from the absolute time within the video.

On the other hand, if the video clip is associated with a range of timecodes, you can perform the same extrapolation and then offset the resulting *hh*:*mm*:*ss*:*ff* value with the starting timecode for the range in which that timecode falls.

But you do not have to do this on your own. If you install the Microsoft Expression Encoder tool, it installs a suite of Silverlight player templates that you can use from within Encoder to automatically generate Silverlight players for the video you encode. These templates can typically be found in the *<expression encoder install folder>*`/Templates` folder. Using your favorite search mechanism, search for two files named `Timecode.cs` and `SmpteFrameRate.cs` within the `Templates` folder. Multiple instances of each result from the search, because these classes are included with each template. Copy one instance of each class into your project, and you are ready to deal with SMPTE timecodes on the client.

Before we look at these classes, it is important to note that Silverlight has no built-in mechanism to extract the frame rate of the video your application is handling. Given that the frame rate is required to extrapolate the timecodes, you must devise an alternative mechanism to supply the frame rate of the video to the Silverlight code. Most enterprise content and asset-management systems have a mechanism to extract the frame rate of videos that are stored, and they store that information externally as part of the associated metadata. One option is to build a web service so that the frame rate can be sent to the client for the video concerned.

The `SmpteFrameRate.cs` file contains an enumeration named `SmpteFrameRate` that captures all the well-known frame-rate values as distinct members of the enumeration.

The `TimeCode.cs` file contains a class called `TimeCode` that can handle the lion's share of the work when it comes to translating from absolute time values to SMPTE timecodes and vice versa, as well as parsing timecodes, accessing different parts of the timecode, validating frame rates, and much more. Discussing the entire API exposed by the `TimeCode` type is not our intent, but we encourage you to take a good look at it.

For the purpose of building a sample, we look at four methods on the `TimeCode` class. The `TimeCode.ParseFramerate()` static method accepts a frame rate as a double value and returns one of the `SmpteFrameRate` enumerated values, including `SmpteFrameRate.Unknown`, if the frame rate is not one of the recognizable frame rates listed in the enumeration. You use a `TimeCode` constructor that accepts a formatted timecode string and a `SmpteFrameRate` enumerated value to construct a `TimeCode` instance. You also use the `TimeCode.FromTicks()` static method, which accepts time measured in CPU ticks and a `SmpteFrameRate` enumerated value and returns a `TimeCode` instance. Last, you use the `TimeCode.ValidateSmpte12MTimeCode()` static method, which accepts a string value and validates it to ensure that it is in the correct timecode format.

The Code

The code sample in this chapter extends the player you built in Recipe 10-2 to include SMPTE timecode support. The extended player displays the SMPTE timecode as the video plays and lets the user seek to any portion of the video by typing in a valid timecode.

Figure 10-24. *Video Player with SMPTE timecode support*

Figure 10-24 shows the player interface with the SMPTE timecode displayed in a `TextBox` above the slider in white over a black background. The user can pause the video and then type a valid timecode in the same `TextBox` to seek to that timecode within the video.

Because you extend the code from Recipe 10-2, we only highlight the changes here. Please refer back to Recipe 10-2 for more details about the rest of the player. Listing 10-26 shows the control template for the `Recipe10_6.MediaSlider` control that is used to display the slider on the player.

Listing 10-26. *Control Template for MediaSlider control*

```
<ControlTemplate TargetType="local:MediaSlider"
                 x:Key="ctMediaSliderDefault">
  <Grid x:Name="Root">
    <Grid.Resources>
      <ControlTemplate x:Key="ctRepeatButton">
        <Grid x:Name="Root"
              Opacity="0"
              Background="Transparent" />
      </ControlTemplate>
    </Grid.Resources>

    <vsm:VisualStateManager.VisualStateGroups>
      <vsm:VisualStateGroup x:Name="CommonStates">
        <vsm:VisualStateGroup.Transitions>
          <vsm:VisualTransition GeneratedDuration="0" />
        </vsm:VisualStateGroup.Transitions>
        <vsm:VisualState x:Name="Normal" />
```

```
      <vsm:VisualState x:Name="MouseOver" />
      <vsm:VisualState x:Name="Disabled">
        <Storyboard>
          <DoubleAnimationUsingKeyFrames
            Storyboard.TargetName="Root"
            Storyboard.TargetProperty="(UIElement.Opacity)">
            <SplineDoubleKeyFrame KeyTime="00:00:00"
                                  Value="0.5" />
          </DoubleAnimationUsingKeyFrames>
        </Storyboard>
      </vsm:VisualState>
    </vsm:VisualStateGroup>
  </vsm:VisualStateManager.VisualStateGroups>
  <Grid>
    <Grid.RowDefinitions>
      <RowDefinition Height="0.33*" />
      <RowDefinition Height="0.34*" />
      <RowDefinition Height="0.33*" />
    </Grid.RowDefinitions>
    <Grid Grid.Row="0"
          VerticalAlignment="Top"
          HorizontalAlignment="Stretch">
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="*" />
        <ColumnDefinition Width="Auto" />
      </Grid.ColumnDefinitions>
      <TextBox x:Name="tbxSMPTETimeCode"
               Background="Black"
               Foreground="White"
               Text="{Binding SMPTETimeCode,
        RelativeSource={RelativeSource TemplatedParent},
        Mode=TwoWay, ValidatesOnExceptions=true, NotifyOnValidationError=true}"
               BorderBrush="Blue"
               BorderThickness="2"
               Grid.Column="0"
               HorizontalAlignment="Left"
               Margin="0,0,0,3"
               FontSize="12" />
      <StackPanel Orientation="Horizontal"
                  Grid.Column="1"
                  HorizontalAlignment="Right">
        <TextBlock Text="Downloaded"
                   FontSize="12"
                   Margin="0,0,4,0" />
```

```
    <TextBlock x:Name="textDownloadPercent"
               FontSize="12" />
  </StackPanel>
</Grid>
<Grid x:Name="HorizontalTemplate"
      Grid.Row="1">
  <Grid.ColumnDefinitions>
    <ColumnDefinition Width="Auto" />
    <ColumnDefinition Width="Auto" />
    <ColumnDefinition Width="*" />
  </Grid.ColumnDefinitions>
  <Rectangle Stroke="Black"
             StrokeThickness="0.5"
             Fill="#FFE6EFF7"
             Grid.Column="0"
             Grid.ColumnSpan="3"
             Height="14"
             Margin="5,0,5,0" />
  <Border Height="10"
          Margin="5,0,5,0"
          Grid.Column="0"
          Grid.ColumnSpan="3"
          x:Name="elemDownloadProgressIndicator"
          Background="#FF2185D8"
          HorizontalAlignment="Left"
          Width="0" />
  <Border Height="6"
          Margin="5,0,5,0"
          Grid.Column="0"
          Grid.ColumnSpan="3"
          x:Name="elemPlayProgressIndicator"
          Background="#FF1CE421"
          HorizontalAlignment="Left"
          Width="0" />
  <RepeatButton x:Name="HorizontalTrackLargeChangeDecreaseRepeatButton"
                Grid.Column="0"
                Template="{StaticResource ctRepeatButton}"
                IsTabStop="False" />

  <Thumb x:Name="HorizontalThumb"
         Height="14"
         Width="11"
         Grid.Column="1" />
  <RepeatButton x:Name="HorizontalTrackLargeChangeIncreaseRepeatButton"
                Grid.Column="2"
```

```
                    Template="{StaticResource ctRepeatButton}"
                    IsTabStop="False" />
      </Grid>
      <Grid Grid.Row="2"
            VerticalAlignment="Bottom"
            HorizontalAlignment="Stretch">
        <StackPanel x:Name="TotalDuration"
                    Orientation="Horizontal">
          <TextBlock x:Name="textPosition"
                     FontSize="12" />
          <TextBlock Text=" / "
                     FontSize="12"
                     Margin="3,0,3,0" />
          <TextBlock x:Name="textDuration"
                     FontSize="12" />
        </StackPanel>
      </Grid>
    </Grid>
  </Grid>
</ControlTemplate>
```

The only change in the code in Listing 10-26 is the addition of a `TextBox` named `tbxSMPTETimeCode` that is used to display the timecode as well let the user edit it to navigate to a specific timecode within the video. As you can see, the `Text` property on `tbxSMPTETimeCode` is bound in a `TwoWay` mode to a property named `SMPTETimeCode` on the `MediaSlider` control. Also note that `tbxSMPTETimeCode` is enabled for data-binding validation. For more about binding validation, refer to the recipes in Chapter 4. Listing 10-27 shows the code for the `MediaSlider` control.

Listing 10-27. *Code for the MediaSlider control*

```
using System;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Controls.Primitives;
using System.Windows.Media;
using System.Windows.Threading;
using System.ComponentModel;


namespace Recipe10_6
{
  public class MediaSlider : Slider, INotifyPropertyChanged
  {
    private MediaElement MediaSource;
    private FrameworkElement elemDownloadProgressIndicator;
    private FrameworkElement elemPlayProgressIndicator;
```

```
private FrameworkElement Root;
private TextBlock textPosition;
private TextBlock textDuration;
private TextBlock textDownloadPercent;
private Thumb HorizontalThumb;
private DispatcherTimer disptimerPlayProgressUpdate;

//SourceName dependency property - used to attach
//a Media element to this control
public static DependencyProperty SourceNameProperty =
  DependencyProperty.Register("SourceName", typeof(string),
  typeof(MediaSlider),
  new PropertyMetadata(new PropertyChangedCallback(OnSourceNameChanged)));
public string SourceName
{
  get
  {
    return (string)GetValue(SourceNameProperty);
  }
  set
  {
    SetValue(SourceNameProperty, value);
  }
}
//SourceName change handler
private static void OnSourceNameChanged(DependencyObject Source,
  DependencyPropertyChangedEventArgs e)
{
  MediaSlider thisSlider = Source as MediaSlider;
  if (e.NewValue != null && e.NewValue != e.OldValue
    && thisSlider.Root != null)
  {
    thisSlider.MediaSource =
      thisSlider.Root.FindName(e.NewValue as string) as MediaElement;
    //reinitialize
    thisSlider.InitMediaElementConnections();
  }
}

private double _FrameRate = 24;
public double FrameRate
{
  get
  {
```

```
      return _FrameRate;
    }

    set
    {
      if (TimeCode.ParseFrameRate(value) == SmpteFrameRate.Unknown)
        throw new Exception("Unknown Framerate");
      if (value != _FrameRate)
      {
        _FrameRate = value;
        if (disptimerPlayProgressUpdate.IsEnabled)
        {
          disptimerPlayProgressUpdate.Stop();
          disptimerPlayProgressUpdate.Interval =
            TimeSpan.FromSeconds(1 / FrameRate);
          disptimerPlayProgressUpdate.Start();
        }
        else
          disptimerPlayProgressUpdate.Interval =
            TimeSpan.FromSeconds(1 / FrameRate);

        if (PropertyChanged != null) PropertyChanged(this,
          new PropertyChangedEventArgs("FrameRate"));
      }

    }
  }

  private string _SMPTETimeCode = "00:00:00:00";
  public string SMPTETimeCode
  {
    get
    {
      return _SMPTETimeCode;
    }

    set
    {
      if (TimeCode.ValidateSmpte12MTimeCode(value) == false)
      {
        throw new
          Exception("Invalid time code. Time code format must be hh:mm:ss:ff");
```

```
    }
    if (value != _SMPTETimeCode)
    {
      _SMPTETimeCode = value;
      if (PropertyChanged != null) PropertyChanged(this,
        new PropertyChangedEventArgs("SMPTETimeCode"));
    }

  }
}

public MediaSlider()
  : base()
{
  this.DefaultStyleKey = typeof(MediaSlider);
  this.Maximum = 100;
  this.Minimum = 0;
  disptimerPlayProgressUpdate = new DispatcherTimer();
  disptimerPlayProgressUpdate.Interval = TimeSpan.FromSeconds(1 / FrameRate);
  disptimerPlayProgressUpdate.Tick +=
    new EventHandler(PlayProgressUpdate_Tick);
}
public override void OnApplyTemplate()
{
  base.OnApplyTemplate();

  elemDownloadProgressIndicator =
    GetTemplateChild("elemDownloadProgressIndicator") as FrameworkElement;
  elemPlayProgressIndicator =
   GetTemplateChild("elemPlayProgressIndicator") as FrameworkElement;
  HorizontalThumb = GetTemplateChild("HorizontalThumb") as Thumb;
  if (HorizontalThumb != null)
  {
    HorizontalThumb.DragStarted +=
      new DragStartedEventHandler(HorizontalThumb_DragStarted);
    HorizontalThumb.DragCompleted +=
      new DragCompletedEventHandler(HorizontalThumb_DragCompleted);
  }
  textPosition = GetTemplateChild("textPosition") as TextBlock;
  textDuration = GetTemplateChild("textDuration") as TextBlock;
  textDownloadPercent = GetTemplateChild("textDownloadPercent") as TextBlock;

  this.PropertyChanged +=
    new PropertyChangedEventHandler(MediaSlider_PropertyChanged);
```

```
  Root = Helper.FindRoot(this);
  MediaSource = Root.FindName(SourceName) as MediaElement;
  InitMediaElementConnections();
}

void MediaSlider_PropertyChanged(object sender, PropertyChangedEventArgs e)
{
  if (e.PropertyName == "SMPTETimeCode" &&
     MediaSource.CurrentState == MediaElementState.Paused)
  {
    MediaSource.Position = TimeSpan.FromSeconds(
      new TimeCode(SMPTETimeCode,
        TimeCode.ParseFrameRate(FrameRate)).Duration);
    this.Value =
(MediaSource.Position.TotalMilliseconds /
MediaSource.NaturalDuration.TimeSpan.TotalMilliseconds)
* (this.Maximum - this.Minimum);
  }
}
//Initialize by wiring up handlers
private void InitMediaElementConnections()
{
  if (MediaSource != null)
  {
    MediaSource.MediaOpened +=
      new RoutedEventHandler(MediaSource_MediaOpened);
    MediaSource.MediaEnded +=
      new RoutedEventHandler(MediaSource_MediaEnded);
    MediaSource.MediaFailed +=
      new EventHandler<ExceptionRoutedEventArgs>(MediaSource_MediaFailed);
    MediaSource.CurrentStateChanged +=
      new RoutedEventHandler(MediaSource_CurrentStateChanged);
    MediaSource.DownloadProgressChanged +=
      new RoutedEventHandler(MediaSource_DownloadProgressChanged);


    MediaSource_CurrentStateChanged(this, new RoutedEventArgs());
  }
}

//tick handler for progress timer
void PlayProgressUpdate_Tick(object sender, EventArgs e)
```

```
{
  this.Value =
    (MediaSource.Position.TotalMilliseconds /
    MediaSource.NaturalDuration.TimeSpan.TotalMilliseconds)
    * (this.Maximum - this.Minimum);

  if (elemPlayProgressIndicator != null)
  {
    elemPlayProgressIndicator.Width =
      (MediaSource.Position.TotalMilliseconds /
      MediaSource.NaturalDuration.TimeSpan.TotalMilliseconds)
      * ActualWidth;
  }
  if (textPosition != null)
    textPosition.Text = string.Format("{0:00}:{1:00}:{2:00}:{3:000}",
      MediaSource.Position.Hours,
      MediaSource.Position.Minutes,
      MediaSource.Position.Seconds,
      MediaSource.Position.Milliseconds);


  SMPTETimeCode = TimeCode.FromTicks(MediaSource.Position.Ticks,
    TimeCode.ParseFrameRate(FrameRate)).ToString();

}
//plug into the thumb to pause play while it is being dragged
void HorizontalThumb_DragStarted(object sender, DragStartedEventArgs e)
{
  if (MediaSource != null && MediaSource.CurrentState ==
    MediaElementState.Playing)
    MediaSource.Pause();
}
void HorizontalThumb_DragCompleted(object sender, DragCompletedEventArgs e)
{
  if (MediaSource != null)
  {
    MediaSource.Position = new TimeSpan(0,
      0, 0, 0,
      (int)(this.Value *
      MediaSource.NaturalDuration.TimeSpan.TotalMilliseconds /
      (this.Maximum - this.Minimum)));
  }
  MediaSource.Play();
}
```

```
//media element download progress changed
private void MediaSource_DownloadProgressChanged(object sender,
  RoutedEventArgs e)
{
  if (elemDownloadProgressIndicator != null)
  {
    elemDownloadProgressIndicator.Width =
      (MediaSource.DownloadProgress * this.ActualWidth);
    if (textDownloadPercent != null)
      textDownloadPercent.Text = string.Format("{0:##.##} %",
        MediaSource.DownloadProgress * 100);
  }
}
//state changes on the MediaElement
private void MediaSource_CurrentStateChanged(object sender,
  RoutedEventArgs e)
{
  switch (MediaSource.CurrentState)
  {
    case MediaElementState.Playing:
      if (textDuration != null)
        textDuration.Text = string.Format("{0:00}:{1:00}:{2:00}:{3:000}",
          MediaSource.NaturalDuration.TimeSpan.Hours,
          MediaSource.NaturalDuration.TimeSpan.Minutes,
          MediaSource.NaturalDuration.TimeSpan.Seconds,
          MediaSource.NaturalDuration.TimeSpan.Milliseconds);
      if (disptimerPlayProgressUpdate.IsEnabled == false)
        disptimerPlayProgressUpdate.Start();
      break;
    case MediaElementState.Paused:
      if (disptimerPlayProgressUpdate.IsEnabled)
        disptimerPlayProgressUpdate.Stop();
      break;
    case MediaElementState.Stopped:
      if (disptimerPlayProgressUpdate.IsEnabled)
        disptimerPlayProgressUpdate.Stop();
      break;

    case MediaElementState.AcquiringLicense:
    case MediaElementState.Individualizing:
    case MediaElementState.Opening:
    case MediaElementState.Buffering:
    case MediaElementState.Closed:
      break;
```

```
        default:
          break;
      }
    }

    //media ended
    private void MediaSource_MediaEnded(object sender,
      RoutedEventArgs e)
    {
      if (disptimerPlayProgressUpdate.IsEnabled)
        disptimerPlayProgressUpdate.Stop();
    }

    //media failed
    private void MediaSource_MediaFailed(object sender, RoutedEventArgs e)
    {
      disptimerPlayProgressUpdate.Stop();
    }

    void MediaSource_MediaOpened(object sender, RoutedEventArgs e)
    {
      //we do nothing here in this sample
    }

    #region INotifyPropertyChanged Members

    public event PropertyChangedEventHandler PropertyChanged;

    #endregion
  }
}
```

As you can see in Listing 10-27, you add two properties, `FrameRate` and `SMPTETimeCode`, to the `MediaSlider` control. Both properties are enabled for change notification.

The `FrameRate` property defaults to 24. In the property setter for the `FrameRate` property, you use `TimeCode.ParseFrameRate()` to check whether the `FrameRate` is one of the known frame rates and throw an exception if not. As we mentioned earlier in this recipe, Silverlight has no built-in mechanism to extract frame rates. So, in the sample, this always defaults to 24. However, if you devise another mechanism to acquire the frame rate of the video (maybe from a content-management back end that can supply the frame rate through a web service), you can set this property to some other value.

The `SMPTETimeCode` property defaults to a string representing the timecode at the start of the video. It is bound to `tbxSMPTETimeCode` in the XAML to display the timecode. Because that binding is `TwoWay`, it can also accept user edits. In the property setter, you validate any user input to make sure it is in the valid timecode format using the `TimeCode.ValidateSmpte12MTimeCode()` static method. If the format is invalid, you raise an exception, which is then displayed as a validation error using the binding validation mechanism.

Recall from Recipe 10-2 that the sample uses a `DispatcherTimer` named `PlayProgressUpdate` to raise `DispatcherTime.Tick` events at regular intervals while the video is playing. `PlayProgressUpdate_Tick()` handles the `Tick` event and changes `Slider.Value` to cause the slider thumb to move. You now set the `PlayProgressUpdate.Interval` property to the duration of a single frame, so that the `Tick` even fires at each frame interval. You do this once initially in the `MediaSlider` constructor as well as in the property setter of the `FrameRate` property.

In the `PlayProgressUpdate_Tick()` handler method, you update the `SMPTETimeCode` property to the current timecode using the `TimeCode.FromTicks()` static function; this function accepts the current `MediaElement.Position` as CPU ticks and the current frame rate, and returns a `TimeCode` instance. You convert this to a string before you set the property. Because `SMPTETimeCode` is bound to `tbxSMPTETimeCode`, this updates the UI with the timecode as the video plays.

You also handle the `PropertyChanged` event of the `MediaSlider` control. Because the `SMPTETimeCode` property is `TwoWay` bound to `tbxSMPTETimeCode`, the `PropertyChanged` event on the control is fired when the user edits the value in `tbxSMPTETimeCode`, causing a change in value to `MediaSlider.SMPTETimeCode`. In the `MediaSlider_PropertyChanged()` handler, you ensure that you are handling the correct property change. You also make sure the media is currently paused. You then set the position of the media to the user-supplied timecode. To do so, you construct a new `TimeCode` instance, using a constructor that accepts a string-formatted timecode value that you get from `MediaSlider.SMPTETimeCode`, and the current frame rate parsed into a `SmpteFrameRate` enumerated value. When you have the new `TimeCode` instance, you construct a `TimeSpan` from the `TimeCode.Duration` property, which reflects the total number of whole and fractional seconds in that timecode, and use that to set the current position of the media.

10-7. Building a Managed Decoder for Silverlight

Problem

You want to use Silverlight to play a media file whose storage format and/or encoding scheme is not supported by Silverlight directly.

Solution

Use the managed decoder extensibility mechanism in Silverlight to create a custom `MediaStreamSource` that can parse and decode the custom media file format.

How It Works

The internal structure of a digital media file can be broadly broken up into two parts: metadata and essence.

Metadata is information about the media contained in the file. For example, for a video file, metadata may include information like the aspect ratio of the video, the frame rate, the bit rate, the duration, the author, copyright information, and so on. For an audio file, it may include the bit rate, the artist, album information, and such.

The *essence* is the actual media content, which is also stored inside the container file. Because in most cases an unchanged digital representation of video and audio content is very large, a compression process is used to reduce the size of the essence before it is stored it in the container.

The process of compressing the media to reduce its size and packaging it into a container file along with the correct metadata is generally referred to as *encoding*. The process of parsing the container file to extract the metadata elements and then decompressing the essence to enable play out is called

decoding. Typically, the ability to encode/decode a specific metadata structure and compression format is packaged together in a single piece of software commonly known as a *codec*.

Silverlight, Containers, and Codecs

Silverlight supports the Microsoft Advanced Systems Format (ASF) and the MP4 File Format (also known as the MPEG-4 File Format version 2) file container structures. Windows Media Video (`.wmv`) and Windows Media Audio (`.wma`) files follow the ASF file container structures and can be consumed by Silverlight, and so can MP4 and QuickTime (`.mov`) files that are common variants of the MP4 container structure.

Silverlight supports decoding essence that is encoded using the Windows Media VC-1 or H.264 (or its equivalents in MPEG-4 part 10 and the MPEG-4 Advanced Video Codec) compression standards. Silverlight also supports decompressing Windows Media Audio as well as the AAC encoded audio streams for up to two-channel stereo.

With this support out of the box, Silverlight can play a wide gamut of media file types. However, occasionally you may come across a scenario where Silverlight does not support the file-container structure or the compression standard used (or both). This recipe deals with an extensibility mechanism built into Silverlight that allows you to implement the file-parsing and/or decompression mechanism yourself for formats that are not supported by Silverlight out of the box.

The default behavior of the Silverlight `MediaElement` type is such that you point `MediaElement.Source` to the URL of a media stream or file; that is all you need to do to prepare the `MediaElement` to begin consuming the media. As long as the container structure (Windows Media ASF or MP4) and the codec (VC-1 or H.264) are supported natively, `MediaElement` parses the container file and decodes the media automatically. `MediaElement` also exposes two overloads of a method named `SetSource()`, one of which accepts a `Stream`. If you have direct access to the media stream, you can use this overload of `SetSource()` to achieve the same effect as setting `MediaElement.Source` property .

This recipe uses the second overload of the `MediaElement.SetSource()` method, which accepts an instance of type `System.Windows.Media.MediaStreamSource`. The `MediaStreamSource` type is the extensibility mechanism that lets you build your own managed decoder and plug it into the Silverlight media pipeline. We look at the `MediaStreamSource` API in more details in the next section.

It is important to note that authoring parsers for media file containers or decompression logic for various compression schemes is a specialized task; a lot of care and very skillful engineering are required to produce something that meets the bar for performance and quality. Not doing it properly can result in low-performing and, in some cases, faulty processing of media. Our goal in this recipe is not to make you an expert in doing either task, but rather to familiarize you with the API for the related extensibility mechanism in Silverlight. If you take advantage of this facility to integrate a natively unsupported media format into your Silverlight code, we advise you to research the compression and container structure specifications for that format rigorously and apply best-of-breed engineering resources to building the parsing and the decompression logic.

MediaStreamSource

`System.Windows.Media.MediaStreamSource` is an abstract class that expresses the interaction between the `MediaElement` and a managed decoder in an abstract API. It lets you create your own concrete type by inheriting from `MediaStreamSource` and providing implementations for the abstract API to inject custom media decoding logic into the Silverlight media pipeline. When you call `MediaElement.SetSource()` and pass in an instance of your concrete `MediaStreamSource` implementation, `MediaElement` interacts with your code to consume the media.

The `MediaStreamSource` API is designed to be asynchronous so as to not block the UI thread on calls coming in through the `MediaElement`. As a result, every abstract method that you implement in your inherited class has a `Report<`*`methodname`*`>Completed()` method defined in the `MediaStreamSource` base class.

The goal is to return from the implementation of your method as quickly as possible to stop holding up the UI, and then, when you are ready with the results of the requested operation, to call the `Report<methodname>Completed()` method to signal the completion of the operation to the `MediaElement`. This allows you to spin up asynchronous operations on separate threads from within your `MediaStreamSource`-derived class and process long-running operations in a nonblocking fashion.

As an example, consider the `MediaStreamSource.OpenMediaAsync()` method. The following snippet shows a possible skeletal implementation:

```
protected override void OpenMediaAsync()
{
  //spin up a thread to process
  Thread thdOpen = new Thread(new ThreadStart(() =>
    {
      //process the request - may take some time
      //when done
      ReportOpenMediaCompleted(..,..);
    }));
  thdOpen.Start();
  //return to MediaElement right away - no blocking
  return;

}
```

You create a thread and start it, and then return from the call right away. But in the thread's processing logic, after you are ready with the results of the operation, you call `ReportOpenMediaCompleted()` to signal back to the `MediaElement` that you are finished.

This is an important point to keep in mind. No hard-and-fast rule dictates what has to be done asynchronously and what does not. In the previous snippet, you might have done all the processing in the call in a blocking fashion and then signaled completion before you returned, broken up the processing between the blocking call and the separate thread in some fashion, or done it entirely in an asynchronous fashion as the snippet shows in this case. You make that decision based on the scenario for which you are implementing the `MediaStreamSource`. For instance, if your implementation of an operation involves a network download of content, it is best done in an asynchronous fashion; if it involves reading information locally from the disk, an asynchronous operation may be overkill. The API is designed to let you do everything asynchronously—use your best judgment to decide the course to take on a case-by-case basis.

The `MediaStreamSource` API covers the following basic interactions driven by the `MediaElement`: opening and initializing media, acquiring media samples to play, seeking within the media, switching media streams when there are multiple streams (such as video and audio), diagnostics, and cleanup. Let's look at some of these interactions and the related API.

Initializing the Media Stream

When you pass in an instance of your `MediaStreamSource`-derived class into `MediaElement.SetSource()` method, the `MediaElement` invokes your implementation of the `MediaStreamSource.OpenMediaAsync()` function. The `OpenMediaAsync()` function implementation is your opportunity to initialize your media and make it ready for consumption, as well as to pass metadata information about your media to the `MediaElement` so that it can prepare itself for consuming the media. The logic you implement varies from

implementation to implementation, depending on how your media is accessed, how the container format is parsed, and how you extract or otherwise obtain metadata information about the media.

However you choose to implement that functionality, note that logically the media initialization is complete only after your code calls `MediaStreamSource.ReportOpenMediaCompleted()`. As we noted while discussing the asynchronous nature of the `MediaStreamSource` API, you can return from `OpenMediaAsync()` and then call `ReportOpenMediaCompleted()` asynchronously from elsewhere in your `MediaStreamSource` implementation, or you can call it synchronously from your `OpenMediaAsync()` implementation.

It is worth looking at the information that is expected to be passed in as parameters to `ReportOpenMediaCompleted()`. These parameters are the mechanism through which you need to pass metadata about the media from your `MediaStreamSource` implementation to the `MediaElement`. The method signature for `ReportOpenMediaCompleted()` is as follows:

```
void ReportOpenMediaCompleted(
  IDictionary<MediaSourceAttributesKeys, string> mediaSourceAttributes,
  IEnumerable<MediaStreamDescription> availableMediaStreams);
```

The first parameter is a dictionary of attributes for the overall media source that you are exposing to the `MediaElement` and appropriate values for each of these attributes. If you look at the `System.Windows.Media.MediaSourceAttributesKeys` enumeration, you find the following enumerated values:

- `MediaSourceAttributesKeys.CanSeek`: Use this as a key in the `mediaSourceAttributes` parameter to pass in either the string "true" or the string "false" depending on whether you allow seeking through the media in your `MediaStreamSource` implementation.
- `MediaSourceAttributesKeys.Duration`: Use this to pass in the total duration of the media. Note that the duration is specified as ticks formatted as a string, where one tick is a unit of time measured as 100 nanoseconds.
- `MediaSourceAttributesKeys.DRMHeader`: This consists of digital rights management (DRM) header information for right-protected content.

The second parameter, `availableMediaStreams`, is a collection of `System.Windows.Media.MediaStreamDescription` instances. Note that your media source may contain more than one media stream. For example, a media file that represents a video clip may include one video stream along with one or more audio streams, with each audio stream representing an audio track for the video in a different language. For each of these streams that you want the `MediaElement` to play, you must describe the stream using an instance of the `MediaStreamDescription` added to the `availableMediaStreams` parameter to `ReportOpenMediaCompleted()`. The `MediaStreamDescription` type is shown here:

```
public class MediaStreamDescription
{

  // Methods
  public MediaStreamDescription(MediaStreamType type,
    IDictionary<MediaStreamAttributeKeys, string> mediaStreamAttributes);

  // Properties
  public IDictionary<MediaStreamAttributeKeys, string> MediaAttributes { get; }
  public int StreamId { get; }
```

```
  public MediaStreamType Type { get; }
}
```

As you can see, the first parameter to the `MediaStreamDescription` constructor describes the type of stream you are describing and is of type `System.Windows.Media.MediaStreamType`, which has the following values: `Video`, `Audio`, and `Script`. The second parameter is a dictionary of attributes applicable to the stream you are describing and the corresponding values formatted as strings. The `MediaStreamAttributeKeys` enumeration has the following values:

- `MediaStreamAttributeKeys.CodecPrivateData`: What you pass in here depends on the codec you expect Silverlight to use to decode your samples. For the `CodecPrivateData` values for the various codecs that come out of box with Silverlight (such as VC-1 and AAC), refer to the Silverlight documentation. On the other hand, if you are handling the decoding of the samples yourself in your `MediaStreamSource` code, or if the samples are not compressed, you can safely ignore this attribute.
- `MediaStreamAttributeKeys.VideoFourCC`: This is the four-character code for video stream types that Silverlight expects, should you choose to use one of the Silverlight-supplied codecs to decode the video, or if you are passing uncompressed samples to Silverlight. Some common examples of `FourCC` codes acceptable to Silverlight are RGBA for uncompressed video that is color coded using the 32-bit four-channel (Red, Green, Blue, Alpha) scheme, YV12 for uncompressed YCrCb-coded video, WVC1 for VC-1–encoded video, and H264 for H.264-encoded video. For a full list of the supported `VideoFourCC` codes, refer to the Silverlight documentation.
- `MediaStreamAttributeKeys.Width`: This is the original `Width` of a frame of the video.
- `MediaStreamAttributeKeys.Height`: This is the original `Height` of a frame of the video.

Note that the last three of these attributes are applicable only when you are describing a video stream. Also note that the `MediaStreamDescription.StreamId` property exposes a zero-based identifier for your stream. The `MediaElement` expects the video stream (if you are exposing video and not just audio) to be at index 0 and the audio streams to be arranged starting at index 1 after that. In the `MediaStreamSource` implementation, you must be aware of this convention and add the `MediaStreamDescription` for your video first. You can then add the audio tracks in the order in which you want them to be made available when a developer accesses a specific audio stream using the `MediaElement.AudioStreamIndex` property.

Sampling

In digital media processing, you can think of a sample as a discrete collection of bytes at any specific time point along the timeline over which the media plays. If you think of digital video as a collection of discrete frames, a sample for that video stream at a time point is the bitmap that represents the frame at that time point.

When you are finished passing all the necessary metadata attributes, the `MediaElement` begins playing your media. The process of playing your media involves the `MediaElement` asking for samples of the media from your `MediaStreamSource`-derived class through the `GetSampleAsync()` method. The `MediaElement` passes the stream for which it is requesting samples using a parameter of the `MediaStreamType` enumerated type to the `GetSampleAsync()` method. Consequently, if you receive `MediaStreamType.Video`, the `MediaElement` is expecting the next sample for the video stream; `MediaStreamType.Audio` indicates that you need to return the next sample in the audio stream.

As before, the API supports asynchronous completion. The sample request from the MediaElement can be completed by calling MediaStreamSource.ReportGetSampleCompleted(), either synchronously before returning from GetSampleAsync() or from somewhere else in your MediaStreamSource code in an asynchronous fashion.

MediaStreamSource.ReportGetSampleCompleted() accepts one parameter of type MediaStreamSample. The following snippet shows the constructor for the MediaStreamSample type:

```
public MediaStreamSample(MediaStreamDescription mediaStreamDescription,
  Stream stream, long offset, long count, long timestamp,
  IDictionary<MediaSampleAttributeKeys, string> attributes);
```

As you can see, the first parameter is of type MediaStreamDescription. This parameter must match the MediaStreamDescription you constructed and returned in ReportOpenMediaCompleted() for the stream concerned. It does not have to be the same instance (it could be), but the MediaStreamDescription.Type property and the MediaStreamDescription.MediaAttributes collection property need to return the same values as were reported by you when the media was initialized. The parameter named stream of type Stream points to the actual data stream for the media you are sampling, the offset parameter indicates the byte offset in that stream where the MediaElement should begin reading the sample, the count parameter indicates the byte length of the sample, and the timestamp parameter is an optional timestamp for the sample in ticks.

The last parameter, attributes, is a dictionary of string-formatted attribute values for the specific sample, keyed by the values in the System.Windows.Media.MediaSampleAttributeKeys enumerated type. The MediaSampleAttributeKeys enumerated type has the following values defined:

- MediaSampleAttributeKeys.KeyFrameFlag: If the sample you are returning represents a keyframe, then this can be set to true.
- MediaSampleAttributeKeys.DRMInitializationVector: This is the set of values required to decrypt a DRM-encrypted sample.
- MediaSampleAttributeKeys.FrameWidth: This is the width in pixels of the frame the sample represents. It applies to video samples only.
- MediaSampleAttributeKeys.FrameHeight: This is the height in pixels of the frame the sample represents. This applies to video samples only.

Based on the length of time it takes your code to extract and return the next sample, you may or may not choose to report progress. MediaStreamSource.ReportGetSampleProgress() lets you report the progress of your sample extraction effort to the MediaElement. The only parameter to ReportGetSampleProgress() is a double named bufferingProgress, which represents the percentage of the work done. This is ultimately exposed by the MediaElement.BufferingProgress property that you can display in the UI.

Stream Switching

Note that the MediaElement.AudioStreamIndex property lets you write code that switches the index among multiple audio tracks (if present). The MediaStreamSource.SwitchMediaStreamAsync() method allows you to respond to this in your MediaStreamSource. When a stream is switched in the MediaElement, it calls your implementation of SwitchMediaStreamAsync(), passing in the MediaStreamDescription instance corresponding to the stream to which the switch was made. This gives you an opportunity to perform any kind of initialization/preparation work that may be required before the next sampling request for this stream comes through. As usual, you can use ReportSwitchMediaStreamCompleted() to asynchronously (or

synchronously) notify the MediaElement when you are ready with the switch by passing the MediaStreamDescription of the stream you switched to.

Seeking

If your MediaStreamSource implementation can support seeking within the media source you are handling, you may have indicated this by passing a string value of "true" keyed with MediaSourceAttributesKeys.CanSeek, as discussed earlier. In those cases, the MediaElement calls your implementation of the MediaStreamSource.SeekAsync() method, passing in a single parameter named seekToTime that contains the time point to which the user desires to seek, defined in ticks.

When your MediaStreamSource has positioned the media source at the requested time point, it can report completion by calling MediaStreamSource.ReportSeekCompleted(), passing in the same time value. This causes the MediaElement to resume sampling.

The Code

As we have mentioned, the purpose of this recipe and the sample code is not to make you an expert in authoring codecs but to make you familiar with the related MediaStreamSource extensibility mechanism in Silverlight. Keeping that in mind, the sample we discuss here may seem trivial from a decoder complexity perspective. But if you possess the codec-authoring skill set, we hope this recipe offers you some help in using that knowledge to build Silverlight managed decoders.

Armed with what you have learned so far, let's look at building a relatively simple sample. The sample for this recipe has two parts. In the first part, you build a simple Silverlight component that records screenshots of a Silverlight application at a specific frame rate. The component uses the System.Windows.Media.Imaging.WriteableBitmap class to record the screenshots by capturing the root visual in the application's visual tree, and it saves the bitmaps to a file on disk. For more information about WriteableBitmap, refer to Chapter 3.

In the second part, you build a custom MediaStreamSource that reads this file and plays your recording as a video through a MediaElement. In an effort to keep the sample simple, we do not tackle audio streams in this sample—the result is a silent movie of the recorded screen shots.

The Recorder

The recorder component is implemented as a class named ScreenRecorder in a project named ScreenRecorderLib, as shown in Listing 10-28.

Listing 10-28. *Code for the ScreenRecorder Class*

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.IO;
using System.Linq;
using System.Runtime.Serialization;
using System.Threading;
using System.Windows;
using System.Windows.Media;
using System.Windows.Media.Imaging;
```

```
using System.Windows.Threading;

namespace Recipe10_7
{
  public class ScreenRecorder
  {
    private DispatcherTimer snapshotTimer = new DispatcherTimer();
    List<WriteableBitmap> Buffer1 = new List<WriteableBitmap>();
    List<WriteableBitmap> Buffer2 = new List<WriteableBitmap>();
    List<WriteableBitmap> CurrentBuffer = null;
    List<WriteableBitmap> FlushBuffer = null;
    private long TotalFrameCounter = 0;
    private long FlushCounter = 0;
    private double RenderHeight;
    private double RenderWidth;
    private object WriterLock = new Object();
    private MediaInfo Info = new MediaInfo();
    private Transform BitmapTransform = null;
    private int FrameRate = default(int);

    private Stream _TempFile = null;

    public Stream TempFile
    {
      get { return _TempFile; }
      set { _TempFile = value; }
    }

    private UIElement _RecordingRoot = default(UIElement);
    public UIElement RecordingRoot
    {
      get
      {
        if (_RecordingRoot == null)
          _RecordingRoot = Application.Current.RootVisual;
        return _RecordingRoot;
      }

      set
      {
        _RecordingRoot = value;
      }
    }

    private double _FrameHeight = 180;
```

```
public double FrameHeight
{
  get
  {
    return _FrameHeight;
  }

  set
  {
    _FrameHeight = value;
  }
}

private double _FrameWidth = 320;
public double FrameWidth
{
  get
  {
    return _FrameWidth;
  }

  set
  {
    _FrameWidth = value;
  }
}

public ScreenRecorder(int FrameRate)
{
  this.FrameRate = FrameRate;
  snapshotTimer.Interval = new TimeSpan(1000*10000/FrameRate);
  snapshotTimer.Tick += new EventHandler(snapshotTimer_Tick);
}

public void Start()
{
  CurrentBuffer = Buffer1;
  snapshotTimer.Start();

  if (TempFile != null)
  {
    byte[] MediaInfoSizePlaceHolder = BitConverter.GetBytes(Int32.MaxValue);
    TempFile.Write(MediaInfoSizePlaceHolder, 0,
      MediaInfoSizePlaceHolder.Length);
  }
```

```
}

public void Stop()
{
  if (snapshotTimer != null && snapshotTimer.IsEnabled) snapshotTimer.Stop();
  if (TempFile != null)
  {
    lock (WriterLock)
    {
      TempFile.Flush();

      MediaInfo Info = new MediaInfo { FrameCount = TotalFrameCounter,
        FrameHeight = this.FrameHeight, FrameWidth = this.FrameWidth,
        FrameRate = this.FrameRate };
      DataContractSerializer ser =
        new DataContractSerializer(typeof(MediaInfo));
      MemoryStream ms = new MemoryStream();
      ser.WriteObject(ms, Info);
      ms.Flush();
      Byte[] Buff = ms.GetBuffer();
      TempFile.Write(Buff, 0, Buff.Length);
      TempFile.Seek(0L, SeekOrigin.Begin);
      Byte[] BuffLength = BitConverter.GetBytes(Buff.Length);
      TempFile.Write(BuffLength, 0, BuffLength.Length);
      TempFile.Close();
    }
  }
}

void snapshotTimer_Tick(object sender, EventArgs e)
{

  if (FlushCounter + 1 > FrameRate && Monitor.TryEnter(WriterLock))
  {
    TotalFrameCounter += FlushCounter;
    FlipBackBuffer();
    Monitor.Exit(WriterLock);
  }
  else
    FlushCounter++;

  if (RenderHeight == 0 || RenderWidth == 0)
  {
    RenderWidth = (int)RecordingRoot.RenderSize.Width;
    RenderHeight = (int)RecordingRoot.RenderSize.Height;
```

```
    if (RenderHeight != 0 && RenderWidth != 0)
       BitmapTransform = new ScaleTransform() { CenterX = 0, CenterY = 0,
         ScaleY = FrameHeight / RenderHeight,
         ScaleX = FrameWidth / RenderWidth };
  }

  if (RenderHeight != 0 && RenderWidth != 0)
  {
      WriteableBitmap capture =
        new WriteableBitmap(RecordingRoot, BitmapTransform);
      CurrentBuffer.Add(capture);
  }
}

private void FlipBackBuffer()
{

  CurrentBuffer = (CurrentBuffer == Buffer1) ? Buffer2 : Buffer1;
  FlushBuffer = (FlushBuffer == Buffer1) ? Buffer2 : Buffer1;
  CurrentBuffer.Clear();
  FlushCounter = 0;
  if (TempFile != null)
  {
    BackgroundWorker bwFlusher = new BackgroundWorker();
    bwFlusher.DoWork += new DoWorkEventHandler(bwFlusher_DoWork);
    bwFlusher.RunWorkerAsync(FlushBuffer);
  }
  return;
}

void bwFlusher_DoWork(object sender, DoWorkEventArgs e)
{
  lock (WriterLock)
  {
    List<WriteableBitmap> Buffer = e.Argument as List<WriteableBitmap>;
    byte[] Flattened = null;
    int PixelCount = (int)FrameHeight * (int)FrameWidth;
    for (int i = 0; i < Buffer.Count; i++)
    {
      Flattened = Buffer[i].Pixels.
        SelectMany((p) => BitConverter.GetBytes(p)).ToArray();
      TempFile.Write(Flattened, 0, Flattened.Length);
    }
    TempFile.Flush();
    Buffer.Clear();
```

```
      }
    }
  }


  public class MediaInfo
  {
    public int FrameRate { get; set; }
    public double FrameHeight { get; set; }
    public double FrameWidth { get; set; }
    public long FrameCount { get; set; }
  }

}
```

The `RecordingRoot` property indicates the `UIElement` that is being recorded, and `FrameHeight` and `FrameWidth` indicate the `Height` and `Width` of each frame you want to record; the latter two are set to 180 and 320 by default. You expect the application using the `Recorder` to pass in an open stream through the `TempFile` property, to which the frames and related metadata are recorded; it can also optionally set the desired `FrameHeight` and `FrameWidth` before invoking the `ScreenRecorder.Start()` method.

In the `ScreenRecorder` constructor in Listing 10-28, you pass in a parameter named `FrameRate` that is the time interval in ticks at which individual frames are to be recorded. You then initialize a `DispatcherTimer` instance named `snapshotTimer` to raise its `Tick` event at the interval set by the `FrameRate` parameter.

Also note the class named `MediaInfo` at the end of the listing. This class captures necessary metadata like the frame rate, the width and height of individual frames, and the total number of frames recorded. A serialized instance of this class is stored in the recorded file for later use in the `MediaStreamSource`.

The `ScreenRecorder` class uses two memory buffers to manage the act of capturing screenshots and writing the screenshot data to the application supplied stream. These buffers are represented as two `List<`*`WriteableBitmap`*`>` typed variables named `Buffer1` and `Buffer2`, respectively. The assumption is that writing the buffered bitmaps down to the stream may be a long-running process due to various IO bottlenecks, and you do not want to block the UI thread—thus, the process of recording while saving the screenshots to the disk-based file. As a result, the `ScreenRecorder` implementation attempts to perform the stream IO asynchronously while the application continues to use the recorder to keep recording bitmaps at the specified interval. The two-buffer arrangement helps in this process, because you can use one buffer to keep the recording going while the other buffer is emptied into the stream. You see how this works out as we dig further into the code in Listing 10-28.

The process of recording starts when the application using the `ScreenRecorder` instance calls the `Start()` method. You set the `CurrentBuffer` variable to `Buffer1` and start the timer. You also write a 10-byte array named `MediaInfoSizePlaceHolder` in the code, at the beginning of the stream. The content of the byte array is long enough to hold a 32-bit integer and is set to `System.Int32.MaxValue` initially. But the content is not import, because it is overwritten later—the purpose of this byte array is the important thing to understand.

When the `ScreenRecorder.Start()` is called, you do not yet know all the metadata that is serialized into the file in the form an instance of the `MediaInfo` class, because you can only know the total frame count at the end of the recording process. As a result, that data is written at the tail end of the file, after all the screenshots have been saved and the recording has ended. However, as you see later, you must read and deserialize that information in the `MediaStreamSource` before you can begin processing the file for media consumption. To aid in that process, you need to know the size of that metadata block up front. The

10-byte array you just wrote saves space at the beginning of the file where you write the size of the metadata block when you save it, measured as an integral number of bytes.

To understand this better, look at a diagram of the file layout shown in Figure 10-25.

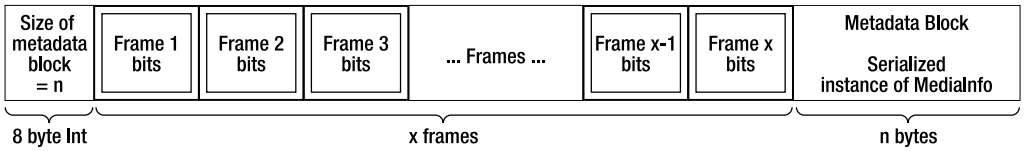


Figure 10-25. *Layout of the file in which the screen recordings are stored*

Now, let's look at what happens when the timer begins raising its `Tick` events at the specified intervals. In the handler method `snapshotTimer_Tick()` in Listing 10-28, you first check the value of a variable named `FlushCounter`, which helps you define an interval at which you save the snapshots in the current buffer to disk. In the current implementation, that point is when you have recorded 1 second of content—that is, when the value of `FlushCounter` equals that of `ScreenRecorder.FrameRate`.

If `FlushCounter` is less than `FrameRate` (you do not have enough data buffered to write to disk yet), you increment `FlushCounter` by 1 and take the next snapshot. To ensure that the snapshot is taken at the specified `FrameHeight` and `FrameWidth`, you must make sure you appropriately shrink or stretch the snapshot to match those dimensions, no matter what the height and width of the `RecordingRoot UIElement` are. You do that by creating a `ScaleTransform`, where the scale is set to match the ratio of the original dimensions of the `RecordingRoot` to the specified dimensions through the `FrameHeight` and `FrameWidth` properties. The `ScaleTransform` is stored in a field named `BitmapTransform` for subsequent use. You then create and store the `WriteableBitmap` snapshot of the `RecordingRoot`, with the `ScaleTransform` applied to it, into the `CurrentBuffer` buffer.

If `FlushCounter` has a value greater than or equal to `FrameRate`, you first attempt to start the process of saving the current buffer to disk. Because you are dependent on a timer to fire this logic at regular intervals, you must be extra careful here and ensure that you never cause two overlapping attempts to write data to the disk at the same time. To prevent that from happening, you try to acquire a lock before you attempt the disk write, and you proceed only if you can acquire the lock. If you cannot acquire the lock, you take the snapshot as usual. If you do acquire the lock, you accumulate the number of frames snapped between the last save and this one in a variable named `TotalFrameCounter` and then invoke the `FlipBackBuffer()` method.

Inside `FlipBackBuffer()`, you switch the buffer values (`Buffer1` and `Buffer2`) between the buffer variables `CurrentBuffer` and `FlushBuffer`, such that the buffer you were using prior to this point to take snapshots is now pointed to by `FlushBuffer`. You also reset `CurrentBuffer` and `FlushCounter`.

Depending on the value of `FrameRate` and how large the snapshots are, the process of writing to disk can take some time. So, you use the `BackgroundWorker` class to delegate the work of writing the buffer to disk to a background thread. After delegation, the `FlipBackBuffer()` method returns immediately to the UI thread, and you take more snapshots as described earlier.

The actual work of saving to disk is done in the `BackgroundWorker.DoWork` event handler, `bwFlusher_DoWork()`. Here, you flatten each `WriteableBitmap` in the `FlushBuffer` to a byte array, join them to make one contiguous but larger byte array, and write the whole thing to the application-supplied stream available through the `TempFile` property. After it is written, this buffer is cleared. Note that because you are on a background thread, to prevent concurrent access, you take the same lock as described earlier before you attempt the write.

The consuming application explicitly stops the recording process by invoking the `ScreenRecorder.Stop()` method. In stopping the recording process, you first stop the timer. You then create a new instance of the `MediaInfo` type and set the `FrameCount`, `FrameWidth`, `FrameHeight`, and `FrameRate` properties accordingly. You finally serialize the `MediaInfo` instance, convert it to a byte array, and write it out to the tail end of the file. You also write the size of the byte array to the placeholder you

saved at the beginning of the file. At this point, the recording session is complete, and you have a file with a custom video format and metadata ready for you to consume.

Before you see how to consume this file, let's take a quick look at how the `ScreenRecorder` component is used from an application. This sample borrows the code for Recipe 4-7 and extends it to use the `ScreenRecorder`. Because most of the code is similar to that in Recipe 4-7, we only highlight the additions to support recording. This code is found in a project named `ScreenRecordingSource` in the associated code sample.

The only change you make to the XAML for the application is to add a `CheckBox` named `cbxRecord`. You handle the `Checked` and `Unchecked` events of `cbxRecord` in the codebehind to start and stop the recording, respectively. After the `CheckBox` is checked and recording starts, you can interact with the UI any way you wish to generate the custom video file. Make sure you spend at least a minute or so between the beginning and end of recording to generate content you can use to test the `MediaStreamSource`. Listing 10-29 shows the `Checked` and `Unchecked` event handlers in the codebehind for the `MainPage` in the application.

Listing 10-29. *Starting and Stopping Recording from an Application Using the ScreenRecorder Class*

```
cbxRecord.Checked += new RoutedEventHandler((s, e) =>
{
  SaveFileDialog sfd = new SaveFileDialog();
  bool? Ret = sfd.ShowDialog();
  if (Ret != null && Ret.Value == true)
  {
    Recorder.TempFile = sfd.OpenFile();
    Recorder.Start();
  }
});

cbxRecord.Unchecked += new RoutedEventHandler((s, e) =>
{
  Recorder.Stop();
});
```

In handling the `Checked` event, you first create and show a `SaveFileDialog` instance to allow the user to pick a file to save the recording to. (`SaveFileDialog` is covered in more detail in Chapter 2.) You then open the file and set the `Recorder.TempFile` property to the file stream, assuming that `Recorder` is an instance of the `ScreenRecorder` type that you created earlier in the `MainPage` codebehind. Finally, you begin recording by invoking the `Recorder.Start()` method. In the `Unchecked` event handler, you invoke `Recorder.Stop()`. Figure 10-26 shows the application UI with the Record check box checked.

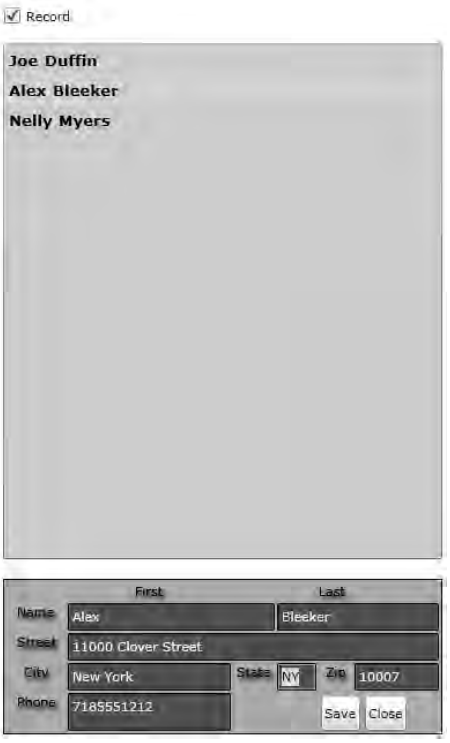


Figure 10-26. *Application user interface with Record turned on*

The Custom MediaStreamSource

Now that you have seen how to create the custom video file, let's look at the `MediaStreamSource` implementation. Listing 10-30 shows the code for the implementation in a class named `BitmapToVideoMediaStreamSource` in a project named `BitmapToVideoMSS`.

Listing 10-30. *Custom MediaStreamSource Implementation*

```
using System;
using System.Collections.Generic;
using System.IO;
using System.Linq;
using System.Runtime.Serialization;
using System.Windows.Media;
using System.Threading;


namespace Recipe10_7
{
```

```
public class BitmapToVideoMediaStreamSource : MediaStreamSource
{
  public Stream MediaStream { get; set; }
  internal MediaInfo mediaInfo { get; set; }

  Dictionary<MediaStreamAttributeKeys, string> mediaStreamAttributes =
    new Dictionary<MediaStreamAttributeKeys, string>();

  Dictionary<MediaSourceAttributesKeys, string> mediaSourceAttributes =
    new Dictionary<MediaSourceAttributesKeys, string>();

  List<MediaStreamDescription> mediaStreamDescriptions = new
    List<MediaStreamDescription>();

  Dictionary<MediaSampleAttributeKeys, string> mediaSampleAttributes =
    new Dictionary<MediaSampleAttributeKeys, string>();

  private long lastFrame = 0;
  private long FrameSize = 0;
  private double FrameDuration = 0;
  private int HdrSizeByteLength = BitConverter.GetBytes(Int32.MaxValue).Length;
  private int HdrByteLength = 0;

  private BitmapToVideoMediaStreamSource()
  {
  }

  public BitmapToVideoMediaStreamSource(Stream media)
  {
    this.MediaStream = media;
    ParseMediaStream(MediaStream);
  }

  private void ParseMediaStream(Stream MediaStream)
  {
    //read the size of the MediaInfo header information
    MediaStream.Seek(0L, SeekOrigin.Begin);

    Byte[] HdrSizeBuff = new Byte[HdrSizeByteLength];
    MediaStream.Read(HdrSizeBuff, 0, HdrSizeByteLength);
    HdrByteLength = BitConverter.ToInt32(HdrSizeBuff, 0);
    Byte[] MediaInfoBuff = new Byte[HdrByteLength];


    MediaStream.Seek(MediaStream.Length - HdrByteLength, SeekOrigin.Begin);
```

```
    MediaStream.Read(MediaInfoBuff, 0, HdrByteLength);
    byte[] TrimmedBuff = MediaInfoBuff.Reverse().SkipWhile((b) =>
      Convert.ToInt32(b) == 0).Reverse().ToArray();
    MemoryStream ms = new MemoryStream(TrimmedBuff);
    DataContractSerializer ser = new DataContractSerializer(typeof(MediaInfo));
    mediaInfo = ser.ReadObject(ms) as MediaInfo;
  }

  protected override void CloseMedia()
  {
    MediaStream.Close();
  }

  protected override void GetDiagnosticAsync(MediaStreamSourceDiagnosticKind
    diagnosticKind)
  {

  }

  protected override void GetSampleAsync(MediaStreamType mediaStreamType)
  {
    if (lastFrame > mediaInfo.FrameCount)
    {
      MediaStreamDescription msd =
        new MediaStreamDescription(MediaStreamType.Video, mediaStreamAttributes);
      MediaStreamSample mediaSample =
        new MediaStreamSample(msd, null, 0, 0, 0, mediaSampleAttributes);
    }
    else
    {
      MediaStreamDescription msd =
        new MediaStreamDescription(MediaStreamType.Video, mediaStreamAttributes);
      MediaStreamSample mediaSample =
        new MediaStreamSample(msd, MediaStream, (lastFrame * FrameSize) +
          HdrSizeByteLength, FrameSize,
          (long)(lastFrame * FrameDuration), mediaSampleAttributes);
      lastFrame++;
      ReportGetSampleCompleted(mediaSample);
    }

  }


  protected override void OpenMediaAsync()
  {
```

```
      lastFrame = 0;
      FrameSize = (long)(mediaInfo.FrameHeight * mediaInfo.FrameWidth * 4);
      FrameDuration = TimeSpan.FromMilliseconds(1000 / mediaInfo.FrameRate).Ticks;

      mediaSourceAttributes.Add(MediaSourceAttributesKeys.CanSeek, true.ToString());
      mediaSourceAttributes.Add(MediaSourceAttributesKeys.Duration,
        ((long)(mediaInfo.FrameCount * FrameDuration)).ToString());
      mediaStreamAttributes.Add(MediaStreamAttributeKeys.Height,
        mediaInfo.FrameHeight.ToString());
      mediaStreamAttributes.Add(MediaStreamAttributeKeys.Width,
        mediaInfo.FrameWidth.ToString());
      mediaStreamAttributes.Add(MediaStreamAttributeKeys.CodecPrivateData, "");
      mediaStreamAttributes.Add(MediaStreamAttributeKeys.VideoFourCC, "RGBA");

      mediaStreamDescriptions.Add(new MediaStreamDescription(MediaStreamType.Video,
        mediaStreamAttributes));

      mediaSampleAttributes.Add(MediaSampleAttributeKeys.FrameHeight,
        mediaInfo.FrameHeight.ToString());
      mediaSampleAttributes.Add(MediaSampleAttributeKeys.FrameWidth,
        mediaInfo.FrameWidth.ToString());

      MediaStream.Seek(HdrSizeByteLength, SeekOrigin.Begin);
      ReportOpenMediaCompleted(mediaSourceAttributes, mediaStreamDescriptions);

    }

    protected override void SeekAsync(long seekToTime)
    {
      //find the corresponding frame
      lastFrame = (long)(mediaInfo.FrameRate *
        TimeSpan.FromTicks(seekToTime).TotalSeconds) + HdrSizeByteLength;
      this.ReportSeekCompleted(seekToTime);
    }

    protected override void SwitchMediaStreamAsync(MediaStreamDescription
      mediaStreamDescription)
    {

    }

  }

}
```

The first thing to note in Listing 10-30 is that you prevent the use of the default constructor for the derived class by marking it private; instead, you create a constructor that accepts a `Stream`. This `Stream` represents an open stream to the video file that this `MediaStreamSource` implementation is supposed to parse and decode, and the expectation is that the consuming application passes that in when constructing the `MediaStreamSource` for the first time. You then save the `Stream` in a member variable for future access and also invoke the `ParseMediaStream()` method to parse the metadata.

Recall from Figure 10-25 that the video file format includes the size of the metadata block at the beginning of the file and the actual metadata block at the end of the file, with the recorded frames in between. In `ParseMediaStream()`, you first read the length of the metadata block. You then seek into the file to position the file pointer at the beginning of the metadata block and read the number of bytes from the tail end of the file as specified by the size information you just retrieved. You trim the byte array for any null byte entries at the tail and then deserialize it into an instance of the `MediaInfo` class at the end of Listing 10-28. You now have the metadata handy.

Next, the `MediaElement` invokes the `OpenMediaAsync()` method, which is where you initialize the media and return the necessary metadata to prime the `MediaElement` for play. You begin by calculating the frame size in bytes. To do so, you multiply the `FrameHeight` and the `FrameWidth` from the `MediaInfo` metadata instance to get the number of pixels; then, you multiply the product further by 4, because each pixel is a 4-byte structure with 1 byte for the Red, Blue, and Green color channels and the last byte for the alpha or transparency channel. You store the frame size in the `FrameSize` variable. You also calculate the duration of a frame in ticks from `MediaInfo.FrameRate` and store the result in the `FrameDuration` variable. The `lastFrame` variable keeps track of the last frame consumed by the `MediaElement` and is initialize to 0. Then, you populate the various metadata structures that you need to return to the `MediaElement`.

You have declared the `mediaSourceAttributes` variable of type `Dictionary<MediaSourceattributesKeys,string>` to be the container for the media source metadata. You populate this by setting `MediaSourceAttributesKeys.CanSeek` to `True` to enable seeking and setting `MediaSourceAttributesKeys.Duration` to the total duration of the clip; you derive that value from the product of `FrameCount` and `FrameDuration`.

You also populate the `mediaStreamAttributes` variable of type `Dictionary<MediaStreamAttributeKeys,string>`. You include `MediaStreamAttributeKeys.Height` and `MediaStreamAttributeKeys.Width` and set them to the `FrameHeight` and `FrameWidth`, respectively. You also set `MediaStreamAttributeKeys.CodecPrivateData` to a blank string and `MediaStreamAttributeKeys.VideoFourCC` to RGBA. The four-character code indicates to the `MediaElement` that the frames are RGBA-style bitmaps and do not need any further decoding—hence the blank string value for `CodecPrivateData`. You then add a new `MediaStreamDescription` instance to the variable `mediaStreamDescriptions`, with the stream type set to `MediaStreamType.Video` and the attributes set to the just-initialized `mediaStreamAttributes`.

Note that you have only one media stream description entry, because you have only one stream: the video. If you had additional streams, such as audio and script streams, you would have to add a description entry and related attributes for each of those streams.

You also initialize the `mediaSampleAttributes` dictionary to set the `FrameHeight` and `FrameWidth` respectively, although you do not need this variable until later. Finally, you complete this method by calling `ReportOpenMediaCompleted()` and passing in the media source attributes and media stream descriptions. Note that you call this method synchronously; but as discussed earlier, if the initialization process lasts longer than this process takes, you can easily return from `OpenMediaAsync` sooner and complete this task on a background thread.

At this point, the `MediaElement` begins calling `GetSampleAsync()` repeatedly to get samples to play. `GetSampleAsync()` receives the `MediaStreamType` for the stream for which samples are being requested as a parameter.

You first check to see if you are at the end of the file by comparing the `lastFrame` variable with `MediaInfo.FrameCount`. If frames remain to be sampled (`lastFrame` is currently not greater than `MediaInfo.FrameCount`), you attempt to create a new instance of the `MediaStreamSample` class to represent the sample. The following snippet shows the `MediaStreamSample` constructor:

```
public MediaStreamSample(MediaStreamDescription mediaStreamDescription,
  Stream stream, long offset, long count, long timestamp,
  IDictionary<MediaSampleAttributeKeys, string> attributes)
```

The `MediaStreamSample` constructor accepts a `MediaStreamDescription` instance as its first parameter. Recall that in the implementation of `OpenMediaAsync()`, you returned instances of `MediaStreamDescription` to the `MediaElement` for each stream you handled. The `MediaStreamDescription` instance that you supply to the `MediaStreamSample` constructor here must match the stream description values used earlier for the same stream. As you can see in Listing 10-30, you use the same `MediaStreamType` and stream attributes dictionary in constructing this `MediaStreamDescription` instance that you used previously in `OpenMediaAsync`.

For the second parameter, `stream`, you pass in the actual media stream. The third parameter, `offset`, is the byte offset into the stream where the `MediaElement` can begin reading this frame. As you can in Listing 10-30, you derive this as the product of `lastFrame` and `FrameSize`: the total byte size of all the frames that have been read so far, further offset by the header size used to store the metadata block size at the beginning of the file.

The fourth parameter, `count`, is the number of bytes to be read to extract the frame—that is, the value of the `FrameSize` variable. The fifth parameter is an optional timestamp that you can associate with the sample; you pass in the starting point of this frame in time ticks calculated as the product of the frames read so far in `lastFrame` and `FrameDuration`. The sixth and last parameter is the `mediaSampleAttributes` dictionary that you prepopulated in the `OpenMediaAsync()` method while initializing the media. You then increment `lastFrame` and call `ReportGetSampleCompleted`, passing in the newly constructed `MediaStreamSample` instance. If you have read all the available frames, you return a `MediaStreamSample` with the `Stream` set to `null`, causing the `MediaElement` to stop sampling and signaling the end of media.

You also support seeking through an implementation of the `MediaStreamSource.SeekAsync()` method. `SeekAsync()` receives the time to which the user wants to seek as a parameter, with the value measured in ticks. In `SeekAsync()`, you set the `lastFrame` variable to the frame at that time point (offset again by the header block size) and let the `MediaElement` resume sampling.

The last part of this sample is a Silverlight player application in a project named `RecordedContentPlayout` that uses the custom `MediaStreamSource` to play recorded content. Listing 10-31 shows the XAML for the application's `MainPage`.

Listing 10-31. *XAML for the Player Application's MainPage*

```
<UserControl x:Class="Recipe10_7.MainPage"
 xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
 xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
 xmlns:mc="http://schemas.openxmlformats.org/markup-compatibility/2006"
 Height="850"
 Width="500">
    <Grid x:Name="LayoutRoot"
          Margin="0,0,0,18">
        <Grid.RowDefinitions>
            <RowDefinition Height="*" />
            <RowDefinition Height="Auto" />
            <RowDefinition Height="Auto" />
        </Grid.RowDefinitions>
```

```
        <Border BorderBrush="Black" Grid.Row="0"
                BorderThickness="2"
                Height="650"
                Width="400">
            <MediaElement x:Name="me"
                          BufferingTime="00:00:00"
                          AutoPlay="False"
                          Stretch="Fill" />
        </Border>
        <StackPanel Orientation="Horizontal"
                    Grid.Row="2">
            <Button x:Name="btnPlay"
                Content="Play"
                Click="btnPlay_Click"
                Height="35"
                Width="50"
                Margin="108,8,0,11"
                HorizontalAlignment="Left" />
        <Button x:Name="btnPause"
                Content="Pause"
                Click="btnPause_Click"
                Height="35"
                Width="50"
                HorizontalAlignment="Right"
                Margin="0,8,125,11" />
            </StackPanel>
        <Slider x:Name="sliderSeek"
                Margin="24,8,21,0"
                Grid.Row="1"
                VerticalAlignment="Top"
                Maximum="100"
                ValueChanged="sliderSeek_ValueChanged" />
    </Grid>
</UserControl>
```

The XAML in Listing 10-31 creates a simple page with one `MediaElement`, a `Slider` control for showing progress and seeking, and two buttons named Play and Pause. Listing 10-32 shows the codebehind for the page.

Listing 10-32. *Codebehind for Player Using Custom MediaStreamSource*

```
using System;
using System.IO;
using System.Linq;
using System.Windows;
using System.Windows.Controls;
```

```
using System.Windows.Controls.Primitives;
using System.Windows.Media;
using System.Windows.Threading;

namespace Recipe10_7
{


  public partial class MainPage : UserControl
  {

    private DispatcherTimer sliderTimer = new DispatcherTimer();
    private Thumb SliderThumb = null;
    public MainPage()
    {
      InitializeComponent();

      me.MediaFailed += new EventHandler<ExceptionRoutedEventArgs>(me_MediaFailed);
      me.MediaOpened += new RoutedEventHandler(me_MediaOpened);
      me.CurrentStateChanged += new RoutedEventHandler(me_CurrentStateChanged);
      sliderTimer.Interval = TimeSpan.FromMilliseconds(100);
      sliderTimer.Tick += new EventHandler(sliderTimer_Tick);

    }


    private void HandleSliderThumbDrag()
    {
      if (SliderThumb == null)
      {
        SliderThumb = VisualTreeHelper.FindElementsInHostCoordinates(
          sliderSeek.TransformToVisual(Application.Current.RootVisual).
          TransformBounds(new Rect(0, 0, sliderSeek.ActualWidth,
            sliderSeek.ActualHeight)),
            sliderSeek).Where((uie) => uie is Thumb).FirstOrDefault() as Thumb;


        SliderThumb.DragStarted += new DragStartedEventHandler((s, args) =>
        {
          if (me.CurrentState == MediaElementState.Playing)
          {
            me.Pause();
          }
        });
      }
```

```
}
void me_CurrentStateChanged(object sender, RoutedEventArgs e)
{
  switch (me.CurrentState)
  {
    case MediaElementState.Playing:
      sliderTimer.Start();
      break;
    default:
      sliderTimer.Stop();
      break;

  }
}


void me_MediaOpened(object sender, RoutedEventArgs e)
{
  HandleSliderThumbDrag();
  me.Play();
}

void sliderTimer_Tick(object sender, EventArgs e)
{
  sliderSeek.Value = me.Position.TotalMilliseconds * 100
    / me.NaturalDuration.TimeSpan.TotalMilliseconds;
}

void me_MediaFailed(object sender, ExceptionRoutedEventArgs e)
{
  System.Diagnostics.Debug.WriteLine("{0} - {1}",e.ErrorException.Message,
    e.ErrorException.StackTrace);
}


private void btnPlay_Click(object sender, RoutedEventArgs e)
{
  if (me.CurrentState == MediaElementState.Paused)
    me.Play();
  else
  {
    OpenFileDialog ofd = new OpenFileDialog() { Multiselect = false };
    if (ofd.ShowDialog() == true)
    {
      FileStream filestream = ofd.File.OpenRead();
```

```
            BitmapToVideoMediaStreamSource mss =
              new BitmapToVideoMediaStreamSource(filestream);
            me.SetSource(mss);
          }
        }

      }
      private void sliderSeek_ValueChanged(object sender,
        RoutedPropertyChangedEventArgs<double> e)
      {
        if (me.CurrentState == MediaElementState.Paused)
        {
          me.Position = TimeSpan.FromTicks((long)e.NewValue *
            me.NaturalDuration.TimeSpan.Ticks  / 100);
        }
      }

      private void btnPause_Click(object sender, RoutedEventArgs e)
      {
        me.Pause();
      }
    }
}
```

The code in Listing 10-32 is very similar to players built in earlier samples in this chapter. The only difference is the way you initialize the `MediaElement`. In the `Click` handler method named `btnPlay_Click()` for the `Button` `btnPlay`, you use the `OpenFileDialog` type to ask the user the name of a disk-based file to be played. Keep in mind that this must be a file that has been recorded using the `Recorder` component discussed previously. After the file is opened, you create a new instance of the `BitmapToVideoMediaStreamSource` type, passing in the stream. Then, you invoke `SetSource()` on the `MediaElement`, passing in the custom `MediaStreamSource` instance. Figure 10-27 shows the player playing a recording using the custom `MediaStreamSource`.

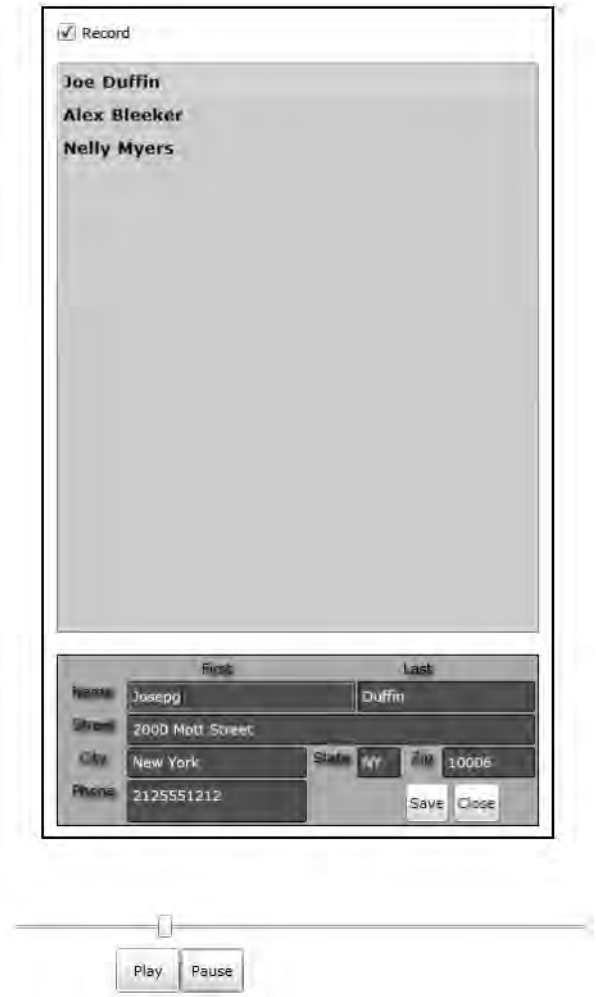


Figure 10-27. *Player using BitmaptoVideoMediaStreamSource*

10-8. Using a WebCam

Problem

You want to use a webcam and microphone in your application to capture audio and video.

Solution

You can use the `VideoCaptureDevice` and `AudioCaptureDevice` types in Silverlight 4 to connect your application to an existing webcam and microphone on your computer and use the `VideoBrush` to display the captured video.

How It Works

Webcam and Microphone as devices

Silverlight 4 adds support for integrating a webcam connected to your machine into your application. Silverlight represents a connected webcam using an instance of the `System.Windows.Media.VideoCaptureDevice` type. It similarly represents a connected microphone using the `AudioCaptureDevice` type in the same namespace. Each of these types inherits the base class `CaptureDevice` meant to represent a generic capture device on your system.

To get a list of the available video and audio capture devices on your system, you can use the `CaptureDeviceConfiguration` class. The `CaptureDeviceConfiguration.GetDefaultVideoDevice()` and `GetDefaultAudioDevice()` static methods return the default video and audio capture devices as designated in your system, while the `GetAvailableVideoCaptureDevices()` and `GetAvailableAudioCaptureDevices()` static methods return collections of all the video and audio capture devices on the system.

Both the `VideoCaptureDevice` and the `AudioCaptureDevice` expose two properties named `FriendlyName` and `IsDefaultDevice` respectively—the former providing a string name for the device and the later returning a `boolean` value indicating if the device is the default device on the system.

Video and Audio Format Choices

Each capture device on the system may support more than one format of capture where formats may differ in properties like resolution, frame rate, sampling rate etc. The `VideoFormat` type exposes several properties that provide information about a specific supported video format. The list below explains the properties:

- `FramesPerSecond` – Frame rate at which the device captures video
- `PixelFormat` – A value of the `PixelFormatType` enumeration indicating the pixel structure. Current allowable values are `PixelFormatType.Unknown` indicating an unknown pixel structure and `PixelFormatType.Format32bppArgb` indicating a 32-bit-sized pixel, with each of the 8 bits storing the alpha, red, green and blue color channel values for the pixel.
- `PixelHeight` – Height of a frame in pixels
- `PixelWidth` – Width of a frame in pixels
- `Stride` – The bitmap stride of the frame bitmap

The `VideoCaptureDevice.DesiredFormat` property exposes the default `VideoFormat` for the device, while the `VideoCaptureDevice.SupportedFormats` collection reports all the video formats supported by the device.

In the same vein, the AudioFormat type represents an audio format and exposes the following properties:

- BitsPerSample – The size of a single audio sample in bits
- Channels – The number of channels in the captured audio
- SamplesPerSecond – The sampling rate
- WaveFormat – A value from the WaveFormatType enumeration type. The currently supported value is limited to WaveFormatType.Pcm for PCM audio.

You can use the AudioCaptureDevice.DefaultFormat and AudioCaptureDevice.SupportedFormats to get the default format and the list of all supported formats for the device respectively.

Starting Device Capture

Before you can start using the capture devices on your system, your application needs to explicitly request access to capture devices on your system using the CaptureDeviceConfiguration.RequestDeviceAccess() method. This method can only be called in a code path originating from user-initiated code (such as a button click) and displays an opt-in dialog seeking permission from the user to allow device access, and it returns true if the user grants device access.

Note that you need to call this method only once in a specific session of your application. You can check the CaptureDeviceConfiguration.AllowDeviceAccess property to see if you have already called this method before in your application and were granted access.

Once your application has been granted access, you can use the CaptureSource type to control your capture. To do this you create a new CaptureSource instance, set the VideoCaptureDevice and AudioCaptureDevice properties on the CaptureSource type to the respective devices you have selected to use, and then call CaptureSource.Start().

The simplest approach to displaying the video being captured is to use a VideoBrush. The VideoBrush.SetSource() method now has an overload that accepts a CaptureSource instance. You can use the VideoBrush associated with the CaptureSource to fill in any shape, such as setting the Background property on a Border element to display the captured video. The VideoBrush, however, does not process the captured audio in any way.

■ **Note** There are other approaches to processing the captured video and audio, and we will examine them in later recipes.

To stop your capture, you can invoke CaptureSource.Stop(), and you can attach a handler to the CaptureSource.CaptureFailed event to handle any capture failures. The CaptureSource.CaptureState allows you to examine the state of the capture process; the possible values are Stopped, Started and Failed defined in the CaptureState enumerated type.

Capturing a still image

Once the capture has been started, you can invoke CaptureSource.CaptureImageAsync() to initiate a still image capture. You will need to handle CaptureSource.CaptueImageCompleted event to get access to the

captured still image. The `CaptureImageCompletedEventArgs.Result` property is of type `WriteableBitmap` and gives you direct access to the captured still image.

The Code

The code sample in this recipe is primarily aimed at illustrating the API discussed in the previous section. Figure 10-28 below shows the application user interface.

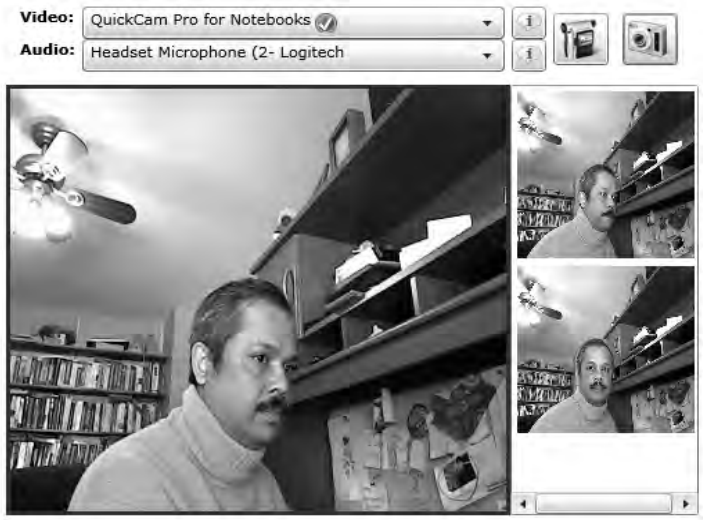


Figure 10-28. *Application user interface*

The dropdowns list the video and audio capture devices on your system. The button marked with a camcorder symbol allows you to toggle between capturing video and stopping an ongoing capture using the selected devices. If no devices are selected, the default devices for the system are used. The rightmost button marked with a camera symbol captures a still image from the capture device on each click, which is displayed right beside the video capture display area in a vertical list as shown in Figure 10-28. Lastly, the information button right beside each dropdown displays the supported formats on the device and their properties.

The XAML for this application is fairly simple, and we do not list it completely here for brevity. Listing 10-33 shows the code for the `Loaded` handler of the page.

Listing 10-33. *Loaded handler for the MainPage*

```
//collection to hold all the still images
ObservableCollection<WriteableBitmap> obscollSnapsTaken =
  new ObservableCollection<WriteableBitmap>();

void MainPage_Loaded(object sender, RoutedEventArgs e)
{
  //populate the video device combobox with all available
```

```
  //video capture devices
  cbxVideoDevices.ItemsSource =
    new ObservableCollection<VideoCaptureDevice>(
      CaptureDeviceConfiguration.GetAvailableVideoCaptureDevices());
  //populate the audio device combobox with all available
  //video capture devices
  cbxAudioDevices.ItemsSource =
    new ObservableCollection<AudioCaptureDevice>(
      CaptureDeviceConfiguration.GetAvailableAudioCaptureDevices());
  //set the itemscontrol for still images to a blank collection
  itmctrlSnappedPics.ItemsSource = obscollSnapsTaken;
}
```

As shown in Listing 10-33, you acquire the available video and audio capture devices using the appropriate static methods on the `CaptureDeviceConfiguration` type and use the returned collections to set the respective comboboxes in the user interface. Listing 10-34 shows the XAML for the data template that are used to bind the data to the comboboxes.

Listing 10-34. *Data Template for the capture device comboboxes*

```
<DataTemplate x:Key="dtDeviceComboItem">
  <Grid>
    <Grid.ColumnDefinitions>
      <ColumnDefinition Width="*"/>
      <ColumnDefinition Width="Auto"/>
    </Grid.ColumnDefinitions>
    <TextBlock Text="{Binding FriendlyName}"/>
    <Image
      Source="{Binding IsDefaultDevice,
          Converter={StaticResource REF_DefaultDeviceIndicatorConverter}}"
      Width="16" Height="16" Margin="3" Grid.Column="1"/>
  </Grid>
</DataTemplate>
```

You display the `FriendlyName` property on the `CaptureDevice` class (base class for all capture devices) and also display an image beside the name if the device is the default device for its category. The converter is used to supply either an image or a null value to the image control depending on the value of the `IsDefaultDevice` property.

Listing 10-35 shows the code behind for the Click event on the button that starts video capture.

Listing 10-35. *Click event handler for btnStartCamera*

```
//currently attached CaptureSource
CaptureSource currentCaptureSource = null;

private void btnStartCamera_Click(object sender, RoutedEventArgs e)
{
```

```
  //if the capture source is not null and there is an ongoing capture
  //lets stop it
  if (currentCaptureSource != null &&
    currentCaptureSource.State == CaptureState.Started)
    currentCaptureSource.Stop();

  //initialize new capture source
  //set VideoCaptureDevice with the user selected one or the default
  //if none selected. Do the same with the AudioCaptureDevice
  currentCaptureSource = new CaptureSource()
  {
    VideoCaptureDevice = cbxVideoDevices.SelectedItem == null ?
      CaptureDeviceConfiguration.GetDefaultVideoCaptureDevice() :
      cbxVideoDevices.SelectedItem as VideoCaptureDevice,
    AudioCaptureDevice = cbxAudioDevices.SelectedItem == null ?
      CaptureDeviceConfiguration.GetDefaultAudioCaptureDevice() :
      cbxAudioDevices.SelectedItem as AudioCaptureDevice
  };

  //if device access has been successfully requested before
  //of if not , and this device access request is unsuccessful as well
  //return
  if (!CaptureDeviceConfiguration.AllowedDeviceAccess &&
    CaptureDeviceConfiguration.RequestDeviceAccess() == false)
    return;

  //access granted - start capture
  currentCaptureSource.Start();
  //create a VideoBrush
  VideoBrush captureBrush = new VideoBrush()
  {
    Stretch = Stretch.Fill
  };
  //set the videobrush to use the CaptureSource
  captureBrush.SetSource(currentCaptureSource);
  //paint a border background with the videobrush
  brdrOutput.Background = captureBrush;
  //handle the CaptureImageCompleted for still images
  currentCaptureSource.CaptureImageCompleted +=
    new EventHandler<CaptureImageCompletedEventArgs>((s, args) =>
  {
    //add the image taken (WriteableBitmap) to the host collection
    obscollSnapsTaken.Add(args.Result);
  });
}
```

You check to see if there is an ongoing capture, and if so, stop it. You then create a new `CaptureSource` instance and initialize the `VideoCaptureSource` and the `AudioCaptureSource` property with the currently selected devices in the user interface or the respective default devices in those categories if no selections are currently made.

You then check to see if access has been granted in this application session already, and if not, request access to use the capture devices. Once the user opts in, you start the capture calling `CaptureSource.Start()`.

To display the captured video, you create a `VideoBrush`, with its source set to the `CaptureSource`, and use the `VideoBrush` as the `Background` property of a `Border` element in the user interface.

Finally, you attach a handler to the `CaptureImageCompleted` event on the `CaptureSource` to handle still image capture and store each `WriteableBitmap` in a collection that was previously bound to an `ItemsControl`. Listing 10-36 shows the code to capture a still image.

Listing 10-36. *Capture a still image*

```
private void btnSnapPic_Click(object sender, RoutedEventArgs e)
{
  //capture a still image
  currentCaptureSource.CaptureImageAsync();
}
```

Listing 10-37 shows the code to display the supported video formats for the selected video capture device.

Listing 10-37. *Listing supported video formats*

```
private void btnVideoDeviceProperties_Click(object sender, RoutedEventArgs e)
{
  //use either the selected video capture device or the default one if none
  //is selected
  VideoCaptureDevice Device = cbxVideoDevices.SelectedItem == null ?
    CaptureDeviceConfiguration.GetDefaultVideoCaptureDevice()
    : cbxVideoDevices.SelectedItem as VideoCaptureDevice;
  //create a child window with a title
  ChildWindow cwDeviceProperties = new ChildWindow()
  {
    Title =
    string.Format("Properties - {0}",
    Device.FriendlyName) , Height=300, Width=400
  };
  //set the child window content to a content control
  //bind the content control to the list of supported formats
  //set the content template to the data template for displaying
  //video formats
  cwDeviceProperties.Content = new ContentControl()
  {
    Content = Device.SupportedFormats,
```

```
    ContentTemplate = this.Resources["dtVideoDeviceProperty"] as DataTemplate
  };
  //show the child window
  cwDeviceProperties.Show();
}
```

You start by picking either the selected video capture device or the default one. You then create a `ChildWindow` instance with its `Title` property set to displaying the `FriendlyName` for the device. You set the content of the `ChildWindow` instance to a `ContentControl` instance, with the `ContentControl.Content` set to the collection of supported video formats by the device. You also set the `ContentControl.ContentTemplate` to a `DataTemplate` used to display the supported formats, and then show the `ChildWindow` instance. Listing 10-38 shows the `DataTemplate` used to display the supported video format collection.

Listing 10-38. *DataTemplate to display the collection of supported video formats*

```
<DataTemplate x:Key="dtVideoDeviceProperty">
  <DataControls:DataGrid AutoGenerateColumns="True"
                         ItemsSource="{Binding}"
                         HorizontalAlignment="Stretch"/>
</DataTemplate>
```

You simply use a `DataGrid` with auto generated columns to bind to the collection of `VideoFormat` objects. Figure 10-29 shows the video formats listed.

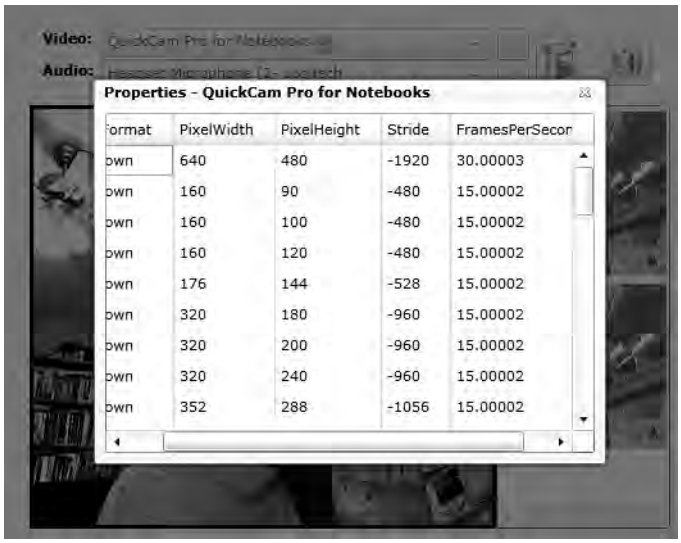


Figure 10-29. *Supported video formats for a specific device*

10-9. Processing Raw WebCam Output

Problem

You want to capture and process the raw video and audio sample from a webcam.

Solution

You can attach and audio and a video sink to the webcam to gain access to the raw samples.

How It Works

There could be a number of reasons why you may want to get access to the raw audio and video samples produced by a webcam. Some application scenarios include:

- Recording – An application that needs to record a webcam session into some sort of media file format that can be replayed later
- Audio/Video Communication – An application such as an instant messaging client that enables remote audio/video communication, where the captured samples from a webcam needs to be transferred over the network to be viewed remotely.

Silverlight 4 allows you to capture raw webcam audio/video samples using two types in the `System.Windows.Media` namespace—namely `VideoSink` and `AudioSink`.

VideoSink and AudioSink

`VideoSink` and `AudioSink` are both abstract classes that expose APIs representing the lifecycle of a capture session. To capture raw samples, you will need to implement concrete types of your own that extend `VideoSink` and `AudioSink` and then use the `CaptureSource` type to connect them to the webcam output. Let's take a look at the `VideoSink` and the `AudioSink` APIs first.

The `VideoSink` type exposes four methods of interest— namely `OnCaptureStarted()`, `OnCaptureStopped()`, `OnFormatChanged()` and `OnSample()`. Each of these is an abstract method, and you will need to provide concrete implementations of these in your `VideoSink` derived class. Once your `VideoSink` derived instance is connected properly, your implementations of these methods get called at various phases of the webcam capture session.

`VideoSink.OnCaptureStarted()` and `VideoSink.OnCaptureStopped()` are called respectively when the video capture session starts and stops. `VideoSink.OnFormatChanged()` is called when the selected video format is applied. You can author your application to allow the user to select from the list of supported video formats for the webcam and apply the selected format to the `VideoCaptureDevice` through its `DesiredFormat` property. For more details on enumerating the supported formats and applying a format selection, please refer to Recipe 10-8. The only parameter passed into the `OnFormatChanged()` method is of type `VideoFormat` and represents the currently applied video format. Finally, `VideoSink.OnSample()` is called once the capture session starts generating samples. The sample timestamp and duration are respectively passed in as the first two parameters to `OnSample();` both are measured in ticks (100 nanosecond unit) and represented as long values. The last parameter is a byte array and represents the actual video sample data.

The `AudioSink` API is identical and exposes similar methods with similar functionality.

Both VideoSink and AudioSink types also expose a single property named CaptureSource of type CaptureSource. Once you create instances of your VideoSink and AudioSink derived types, you can set the CaptureSource property on each of the sink instances to a CaptureSource instance that has been initialized with the appropriate capture device instances. At this point, once you start the capture, the VideoSink and AudioSink lifecycle APIs discussed before are called into by the runtime, giving your code the opportunity to collect and process raw samples.

The Code

The code sample for this recipe demonstrates how to use VideoSink and AudioSink derived classes to capture samples. It also demonstrates how to create a custom MediaStreamSource that can process the captured audio and video samples and play them out through a MediaElement.

The XAML for the application is fairly simple, and for brevity we do not list it here. We encourage you to look at the accompanying sample code for more details. The primary portions application UI are a MediaElement that is driven by the custom MSS to play the captured raw samples and a Border that uses a background VideoBrush connected to the CaptureSource directly to enable a side-by-side view of the captured video stream. It also includes a Button that is used to start and stop the capture.

Figure 10-30 shows a screen shot of the application in action.

Figure 10-30. *Raw Audio/Video Sample Processing*

Let's start by taking a look at the implementation of the sink classes. Listing 10-39 shows the custom sink implementations.

Listing 10-39. *Custom AudioSink and VideoSink implementations*

```
namespace Recipe10_9
{
  public class WebCamVideoSink : VideoSink
  {
    //events to be raised in response to various capture lifecycle phases
    internal event EventHandler CaptureStarted;
```

```
  internal event EventHandler CaptureStopped;
  internal event EventHandler<VideoFormatChangedEventArgs> FormatChanged;
  internal event EventHandler<VideoSampleEventArgs> SampleGenerated;

  protected override void OnCaptureStarted()
  {
    if (CaptureStarted != null) CaptureStarted(this, EventArgs.Empty);
  }

  protected override void OnCaptureStopped()
  {
    if (CaptureStopped != null) CaptureStopped(this, EventArgs.Empty);
  }

  protected override void OnFormatChange(VideoFormat videoFormat)
  {
    if (FormatChanged != null)
      FormatChanged(this,
        new VideoFormatChangedEventArgs() { Format = videoFormat });
  }

  protected override void OnSample(long sampleTimeInHundredNanoseconds,
    long frameDurationInHundredNanoseconds, byte[] sampleData)
  {
    if (SampleGenerated != null)
      SampleGenerated(this,
        new VideoSampleEventArgs()
        {
          Sample = new VideoSample()
          {
            SampleTime = sampleTimeInHundredNanoseconds,
            FrameDuration = frameDurationInHundredNanoseconds,
            SampleData = sampleData
          }
        });
  }
}

public class WebCamAudioSink : AudioSink
{
  internal event EventHandler CaptureStarted;
  internal event EventHandler CaptureStopped;
  internal event EventHandler<AudioFormatChangedEventArgs> FormatChanged;
  internal event EventHandler<AudioSampleEventArgs> SampleGenerated;
```

```
  protected override void OnCaptureStarted()
  {
    if (CaptureStarted != null) CaptureStarted(this, EventArgs.Empty);
  }

  protected override void OnCaptureStopped()
  {
    if (CaptureStopped != null) CaptureStopped(this, EventArgs.Empty);
  }

  protected override void OnFormatChange(AudioFormat audioFormat)
  {
    if (FormatChanged != null)
      FormatChanged(this,
        new AudioFormatChangedEventArgs() { Format = audioFormat });
  }

  protected override void OnSamples(long sampleTimeInHundredNanoseconds,
    long sampleDurationInHundredNanoseconds, byte[] sampleData)
  {
    if (SampleGenerated != null)
      SampleGenerated(this,
        new AudioSampleEventArgs()
        {
          Sample = new AudioSample()
          {
            SampleTime = sampleTimeInHundredNanoseconds,
            SampleDuration = sampleDurationInHundredNanoseconds,
            SampleData = sampleData
          }
        });
  }
}

public class VideoSample
{
  public long SampleTime { get; set; }
  public long FrameDuration { get; set; }
  public byte[] SampleData { get; set; }
}

public class AudioSample
{
  public long SampleTime { get; set; }
  public long SampleDuration { get; set; }
```

```
    public byte[] SampleData { get; set; }
  }

  public class VideoFormatChangedEventArgs : EventArgs
  {
    public VideoFormat Format { get; set; }
  }
  public class AudioFormatChangedEventArgs : EventArgs
  {
    public AudioFormat Format { get; set; }
  }

  public class VideoSampleEventArgs : EventArgs
  {
    public VideoSample Sample { get; set; }
  }

  public class AudioSampleEventArgs : EventArgs
  {
    public AudioSample Sample { get; set; }
  }
}
```

As you can see from the listing above, both the sink implementations are fairly simple. You implement each of the abstract methods from the base `AudioSink` and `VideoSink` classes, and raise appropriate events from those implements to signal to other parts of the application that a specific part of the capture session has occurred. In the `OnFormatChanged()` implementation, you also include the final selected audio or video format in the event argument in raising the `FormatChanged` event. In the `OnSampleGenerated()` implementation, you include the sample information as an instance of the `VideoSample` or the `AudioSample` class in the event argument for the `SampleGenerated` event. The creation of the sinks is handled by the `MainPage`, but let's first look at how the samples are processed. As discussed earlier, we will demonstrate this through a custom `MediaStreamSource` that processes these samples to display the results of the capture side by side with a direct `VideoBrush`-driven display. Listing 10-40 shows the custom MSS implementation.

Listing 10-40. *Custom MediaStreamSource handling raw sample from sinks*

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.IO;
using System.Linq;
using System.Threading;
using System.Windows.Controls;
using System.Windows.Media;

namespace Recipe10_9
```

```
{
  public class WebCamMSS : MediaStreamSource
  {

    WebCamVideoSink vsink = null;
    WebCamAudioSink asink = null;


    private Dictionary<MediaSourceAttributesKeys, string> mediaSourceAttributes =
      new Dictionary<MediaSourceAttributesKeys, string>();
    private List<MediaStreamDescription> availableMediaStreams =
      new List<MediaStreamDescription>();
    private Dictionary<MediaSampleAttributeKeys, string> videoSampleAttributes =
      new Dictionary<MediaSampleAttributeKeys, string>();

    bool VideoFormatSelected = false;
    bool AudioFormatSelected = false;

    Queue<VideoSample> VideoSampleBuffer = new Queue<VideoSample>();
    Queue<AudioSample> AudioSampleBuffer = new Queue<AudioSample>();
    object VideoBufferCritSec = new object();
    object AudioBufferCritSec = new object();
    internal ManualResetEvent AudioSampleRequest = new ManualResetEvent(false);
    internal ManualResetEvent VideoSampleRequest = new ManualResetEvent(false);
    internal AutoResetEvent AudioSampleArrived = new AutoResetEvent(false);
    internal AutoResetEvent VideoSampleArrived = new AutoResetEvent(false);

    private MediaElement meTarget = null;

    private CaptureSource _WebCamSource = default(CaptureSource);
    public CaptureSource WebCamSource
    {
      get
      {
        return _WebCamSource;
      }

      set
      {
        if (value != _WebCamSource)
        {
          _WebCamSource = value;
          //attach the sinks to the capture source
          vsink.CaptureSource = _WebCamSource;
          asink.CaptureSource = _WebCamSource;
```

```
    }
  }
}

public WebCamMSS(MediaElement target, WebCamVideoSink vSink,
 WebCamAudioSink aSink)
{

  meTarget = target;
  vsink = vSink;
  asink = aSink;

  //handle the various sink events
  vsink.FormatChanged +=
      new EventHandler<VideoFormatChangedEventArgs>(VideoSink_FormatChanged);
  vsink.SampleGenerated +=
    new EventHandler<VideoSampleEventArgs>(VideoSink_SampleGenerated);
  asink.FormatChanged +=
    new EventHandler<AudioFormatChangedEventArgs>(AudioSink_FormatChanged);
  asink.SampleGenerated +=
  new EventHandler<AudioSampleEventArgs>(AudioSink_SampleGenerated);

  //cannot seek and duration is infinite
  mediaSourceAttributes.Add(MediaSourceAttributesKeys.CanSeek,
    false.ToString());
  mediaSourceAttributes.Add(MediaSourceAttributesKeys.Duration,
    TimeSpan.MaxValue.Ticks.ToString());

  //create the background workers to handle incoming samples
  BackgroundWorker VideoSampleDispatch = new BackgroundWorker();
  BackgroundWorker AudioSampleDispatch = new BackgroundWorker();

  VideoSampleDispatch.DoWork +=
    new DoWorkEventHandler(VideoSampleDispatch_DoWork);
  AudioSampleDispatch.DoWork +=
    new DoWorkEventHandler(AudioSampleDispatch_DoWork);
  //run the background workers
  VideoSampleDispatch.RunWorkerAsync(this);
  AudioSampleDispatch.RunWorkerAsync(this);
}

void AudioSink_FormatChanged(object sender, AudioFormatChangedEventArgs e)
{
  //switch context to the thread the MSS was created on (UI thread)
```

```
  meTarget.Dispatcher.BeginInvoke(new Action(() =>
      {
        if (_WebCamSource.AudioCaptureDevice != null)
        {
          //set the audio capture device format
          _WebCamSource.AudioCaptureDevice.DesiredFormat = e.Format;
          //create WaveFormatEx instance and populate from format information
          WaveFormatEx wfex = new WaveFormatEx()
          {
            //bits per sample
            BitsPerSample = (ushort)e.Format.BitsPerSample,
            //always PCM
            FormatTag = WaveFormatEx.WAVE_FORMAT_PCM,
            //channel count
            Channels = (ushort)e.Format.Channels,
            //samples per sec
            SamplesPerSecond = (uint)e.Format.SamplesPerSecond
          };
          //add WaveFormatEx as codec private data
          availableMediaStreams.Add(
            new MediaStreamDescription(MediaStreamType.Audio,
              new Dictionary<MediaStreamAttributeKeys, string>()
            {
              {MediaStreamAttributeKeys.CodecPrivateData,
                wfex.ToCodecDataString()}
            }));
          //set flag to indicate audio format processing is done
          AudioFormatSelected = true;
        }

        if (VideoFormatSelected && AudioFormatSelected)
        {
          //if both formats have been processed,
          //attach the MSS to the MediaElement
          meTarget.SetSource(this);
        }
      }
  ));
}

void VideoSink_FormatChanged(object sender, VideoFormatChangedEventArgs e)
{
  //switch context to the thread the MSS was created on (UI thread)
  meTarget.Dispatcher.BeginInvoke(new Action(() =>
  {
```

```
      if (_WebCamSource.VideoCaptureDevice != null)
      {
        //set the video capture device format
        _WebCamSource.VideoCaptureDevice.DesiredFormat = e.Format;
        //add stream attributes
        availableMediaStreams.Add(
          new MediaStreamDescription(MediaStreamType.Video,
              new Dictionary<MediaStreamAttributeKeys, string>()
            {
              //FourCC code - we are processing 32 bit RGBA saqmples
              {MediaStreamAttributeKeys.VideoFourCC,"RGBA"},
              //frame height
              {MediaStreamAttributeKeys.Height,e.Format.PixelHeight.ToString()},
              //frame width
              {MediaStreamAttributeKeys.Width,e.Format.PixelWidth.ToString()},
              //not need for codec private data - RGBA is uncompressed
              {MediaStreamAttributeKeys.CodecPrivateData,String.Empty}
            }
            )
          );
        //add sample attributes - frame height and frame width
        videoSampleAttributes.Add(MediaSampleAttributeKeys.FrameHeight,
          e.Format.PixelHeight.ToString());
        videoSampleAttributes.Add(MediaSampleAttributeKeys.FrameWidth,
          e.Format.PixelWidth.ToString());
        //set format selection flag
        VideoFormatSelected = true;
      }

      //if both formats are set
      if (VideoFormatSelected && AudioFormatSelected)
      {
        //attach MSS to ME
        meTarget.SetSource(this);
      }
    }));
  }

  void VideoSink_SampleGenerated(object sender, VideoSampleEventArgs e)
  {
    lock (VideoBufferCritSec)
    {
      //enque the audio sample
      VideoSampleBuffer.Enqueue(e.Sample);
    }
```

```
  //signal sample arrival
  this.VideoSampleArrived.Set();
}
void AudioSink_SampleGenerated(object sender, AudioSampleEventArgs e)
{
  lock (AudioBufferCritSec)
  {
    //enque the audio sample
    AudioSampleBuffer.Enqueue(e.Sample);
  }
  //signal sample arrival
  this.AudioSampleArrived.Set();
}

protected override void GetSampleAsync(MediaStreamType mediaStreamType)
{
  if (mediaStreamType == MediaStreamType.Audio)
  {
    //signal audio sample request to sample processing loop
    AudioSampleRequest.Set();
  }
  else if (mediaStreamType == MediaStreamType.Video)
  {
    //signal video sample request to sample processing loop
    VideoSampleRequest.Set();
  }
}

void AudioSampleDispatch_DoWork(object sender, DoWorkEventArgs e)
{
  //keep running
  while (true)
  {
    //wait for sample request
    this.AudioSampleRequest.WaitOne();
    //request arrived - is there a sample to dispatch ?
    if (this.AudioSampleBuffer.Count > 0)
    {
      AudioSample audSample = null;
      lock (this.AudioBufferCritSec)
      {
        //dequeue sample
        audSample = this.AudioSampleBuffer.Dequeue();
      }
      //flatten sample and report sample
```

```
      MemoryStream msAud = new MemoryStream(audSample.SampleData);
      ReportGetSampleCompleted(
        new MediaStreamSample(availableMediaStreams.
          Where((msd) => msd.Type == MediaStreamType.Audio).First(),
          msAud, 0, audSample.SampleData.Length,
          audSample.SampleTime, new Dictionary<MediaSampleAttributeKeys,
            string>()));
      //reset wait handle
      this.AudioSampleRequest.Reset();
    }
    else
    {
      //wait for sample arrival
      this.AudioSampleArrived.WaitOne();
    }

  }
}

void VideoSampleDispatch_DoWork(object sender, DoWorkEventArgs e)
{
  //keep running
  while (true)
  {
    this.VideoSampleRequest.WaitOne();
    //request arrived - is there a sample to dispatch ?
    if (this.VideoSampleBuffer.Count > 0)
    {
      VideoSample vidSample = null;
      lock (this.VideoBufferCritSec)
      {
        //dequeue sample
        vidSample = this.VideoSampleBuffer.Dequeue();
      }

      //flatten sample and report sample
      MemoryStream msVid = new MemoryStream(vidSample.SampleData);
      ReportGetSampleCompleted(
        new MediaStreamSample(availableMediaStreams.
          Where((msd) => msd.Type == MediaStreamType.Video).First(),
          msVid, 0, vidSample.SampleData.Length, vidSample.SampleTime,
          vidSample.FrameDuration, videoSampleAttributes));
      //reset wait handle
      this.VideoSampleRequest.Reset();
    }
```

```
        else
        {
          //wait for sample arrival
          this.VideoSampleArrived.WaitOne();
        }

      }
    }
    protected override void CloseMedia()
    {
      return;
    }

    protected override void GetDiagnosticAsync(
      MediaStreamSourceDiagnosticKind diagnosticKind)
    {
      return;
    }

    protected override void OpenMediaAsync()
    {
      ReportOpenMediaCompleted(mediaSourceAttributes, availableMediaStreams);
    }

    protected override void SeekAsync(long seekToTime)
    {
      ReportSeekCompleted(0);
    }

    protected override void SwitchMediaStreamAsync(
      MediaStreamDescription mediaStreamDescription)
    {
      return;
    }
  }
}
```

For the basics on custom `MediaStreamSource` authoring, please refer to recipe 10-7. We will cover only the parts that are pertinent to this recipe.

As you can see in Listing 10-40, you construct the MSS by passing in the `MediaElement` that this MSS will be attached to, as well as instances of the audio and video sinks that you will use to collect samples for the MSS. You attach handlers to the `SampleGenerated` and the `FormatChanged` events raised by the custom sinks. You then set the `MediaSourceAttributesKeys.CanSeek` key to `false` and the `MediaSourceAttributesKeys.Duration` key to a `TimeSpan.MaxValue` to indicate that the video stream cannot support seeking and does not have a finite duration, respectively.

Samples are dispatched to the MSS by the sinks through the SampleGenerated event. Depending on the frame rate of the video, samples can be generated really fast; for example, if video is being captured at 24 frames per second, that would amount to the SampleGenerated event be raised 24 times every second. To keep the main UI thread from getting bogged down in processing the samples, you decide to perform sample processing on background threads. The BackgroundWorker class is a convenient way to leverage the CLR thread pool to automatically offload processing to background threads from the thread pool, without having to do explicit thread management in your code. In the last part of the constructor, you create two instances of the BackgroundWorker classes named AudioSampleDispatch and VideoSampleDispatch for audio sample processing and video sample processing, respectively; attach handlers to the DoWork event of the BackgroundWorker instances; and then run each worker. We will visit the background processing of samples later in the recipe.

You also expose a property named WebCamSource of type CaptureSource from the MSS. This property gets set by the codebehind once the CaptureSource and the MSS instance has been created and initialized; in the property setter, you connect the sinks to the CaptureSource instance.

Before you can start processing samples, you need to respond to the video and audio format selections and initialize some additional aspects of the MSS. If you look at the AudioSink_FormatChanged() handler method in Listing 10-40, you will note that you first set the AudioCaptureDevice.DesiredFormat to the selected audio format. You then create a new instance of the WaveFormatEx class and initialize its various members with information from the audio format data. The WaveFormatEx data structure is used to represent information that is required by the audio codec to successfully process waveform audio (of which PCM audio is one type). To learn more about the WaveFormatEx data structure, you can refer to msdn.microsoft.com/en-us/library/dd757720(VS.85).aspx. We have created a managed version of the type, and you can find it in the accompanying sample code. Once initialized, you use a string representation of the WaveFormatEx data as value to the MediaStreamAttributeKeys.CodecPrivateData key and add as a part of the MediaStreamDescription for the audio stream.

You use the selected video format in a similar fashion to set up the MSS for video processing. In the VideoSink_FormatChanged() event handler, you add the MediaStreamDescription for MediaStreamType.Video, setting the FourCC code to RGBA, the MediaStreamAttributeKeys.Height and MediaStreamAttributeKeys.Width to VideoFormat.PixelHeight and VideoFormat.PixelWidth from the selected video format, and the CodecPrivateData to an empty string since you do not need to initialize a codec to process RGBA frames. You also set height and width keys for each individual sample to the same corresponding values from the selected video format.

Once both the audio and video formats are used to initialize the MSS, you attach the MSS to the MediaElement, using the SetSource() method on the MediaElement.

Since the actual processing of the samples is done in background threads, you need a way to pass on the samples to the background thread as they are generated. In the VideoSink_SampleGenerated() and the AudioSink_SampleGenerated() event handlers in Listing 10-40, you will note two instances of the Queue type, namely VideoSampleBuffer and AudioSampleBuffer, to store the samples as they are generated. You protect the code with a critical section, since the SampleGenerated events are raised on their own threads separate from the UI thread on which the MSS was created. Once you store the samples, you signal the sample processing threads of sample arrival by setting an appropriate AutoResetEvent instance.

You also need to inform the background sample processing threads when a request for a sample arrives from the MediaElement. In the implementation of the GetSampleAsync() method of the MSS, you set a ManualResetevent instance named AudioSampleRequest to signal the request of an audio sample and a different ManualResetEvent instance named VideoSampleRequest to signal the same for video.

So what happens when a sample arrives from the sinks or gets requested by the MediaElement? To understand, let's take a look at the VideoSampleDispatch_DoWork() method that defines the processing for the BackgroundWorker named VideoSampleDispatch discussed earlier. You start with an infinite loop, which keeps running as long as the MSS instance is valid. Inside the loop, you start by blocking on the ManualResetEvent named VideoSampleRequest; recall that this gets signaled when a sample request arrives from the MediaElement. Once you receive a request, you check the VideoSampleBuffer queue to see

if there is an available sample; if so, you extract it and use the `ReportGetSampleCompleted()` method on the MSS to asynchronously report the sample back to the `MediaElement` (for more details on this, please refer back to recipe 10-7). On the other hand, if there are no samples in the sample buffer, you block on the `AutoResetEvent` named `VideoSampleArrived` waiting for a sample to arrive from the video sink. Recall from earlier that this gets signaled when the sink enqueues a sample into the buffer.

If you look at the `AudioSampleDispatch_DoWork()` method you will notice an identical loop for sample processing.

The rest of the MSS method implementations do not serve any meaningful purpose for this sample application, so we do not discuss them here.

So now that you have seen how the sinks and the `MediaStreamSource` are implemented, let's look at how they are tied together. Listing 10-41 shows the code behind for the `MainPage` where it happens.

Listing 10-41. *MainPage code behind*

```
public partial class MainPage : UserControl
{
  VideoBrush vidbrush = new VideoBrush();
  CaptureSource webcamCapture = new CaptureSource();
  WebCamMSS mss = null;
  WebCamVideoSink vSink = new WebCamVideoSink();
  WebCamAudioSink aSink = new WebCamAudioSink();

  public MainPage()
  {
    InitializeComponent();

    this.Loaded += new RoutedEventHandler(MainPage_Loaded);
  }

  void MainPage_Loaded(object sender, RoutedEventArgs e)
  {

    webcamCapture.VideoCaptureDevice =
      CaptureDeviceConfiguration.GetDefaultVideoCaptureDevice();
    webcamCapture.AudioCaptureDevice =
      CaptureDeviceConfiguration.GetDefaultAudioCaptureDevice();
    mss = new WebCamMSS(meWebCamOut,vSink, aSink);
    mss.WebCamSource = webcamCapture;

    vidbrush.SetSource(webcamCapture);
    webcamDirectCapture.Background = vidbrush;

    vSink.FormatChanged +=
      new EventHandler<VideoFormatChangedEventArgs>(vSink_FormatChanged);

  }
  private void BtnCaptureStartStop_Click(object sender, RoutedEventArgs e)
```

```
  {
    if (webcamCapture.State == CaptureState.Stopped)
    {

      if (CaptureDeviceConfiguration.AllowedDeviceAccess ||
        CaptureDeviceConfiguration.RequestDeviceAccess())
        webcamCapture.Start();
    }
    else if (webcamCapture.State == CaptureState.Started)
      webcamCapture.Stop();
  }

  void vSink_FormatChanged(object sender, VideoFormatChangedEventArgs e)
  {
    this.Dispatcher.BeginInvoke(new Action(() =>
    {
      //correct for negative stride
      if (e.Format.Stride < 0)
      {
        brdrMediaElement.Projection = new PlaneProjection()
        {
          CenterOfRotationX = 0.5,
          RotationX = 180
        };
      }
    }));
  }
}
```

On the Loaded event handler of the `MainPage`, you initialize our `CaptureSource` named `webcamCapture` with the default video and audio capture devices on the system, create and initialize the custom `MediaStreamSource`, and also use `webcamCapture` in a `VideoBrush` to paint a Border object named `webcamDirectCapture` that shows the direct video capture results side by side with the MSS processed video.

In `BtnCaptureStartStop_Click()`, you either request access and start the capture or stop the capture based on the current state of the `CaptureSource`.

Lastly, you handle the `FormatChanged` event of the `VideoSink` here as well. If you look at the `vSink_FormatChanged()` event handler method, you will see that you apply a `PlaneProjection` to turn the `MediaElement` by 180 degrees around the X-axis if the `VideoFormat.Stride` value is negative. The stride of a bitmap is dependent on the order in which the pixels in a bitmap are stored. When a bitmap is stored with the pixels going from top to bottom, it has a negative stride and will appear to be vertically flipped. This is what you correct using the `PlaneProjection`. Figure 10-31 shows the result if the above mentioned stride correction was not made on the `MediaElement` on the left.

Figure 10-31. *MediaElement without stride correction applied.*

CHAPTER 11

Integrating Microsoft IIS Smooth Streaming

With HTTP being the most ubiquitous protocol on the Internet, the benefit of being able to deliver video streams over HTTP with a high degree of reliability and quality is very important to the future of glitch-free, high-definition video streaming.

The reality, however, is that network bandwidth fluctuates over time. Also, the processing capacity of a client computing device can vary over time, too, depending on the CPU load due to the various programs running on it. These factors can cause degradation of the quality of the viewing experience if a video stutters or freezes while the player is waiting to buffer enough data to show the next set of video frames or waiting for the CPU cycles needed to decode those frames. An approach called adaptive streaming addresses this problem by adapting the bitrate to prevailing resource constraints.

In the adaptive streaming approach, the same media is encoded in small sized chunks at multiple bitrates and is delivered over a specialized streaming server. The video player on the client computer constantly monitors network conditions, CPU load, and other resource utilization metrics on the client computer, and uses that information to calculate the most appropriate bitrate that it can decode and render efficiently given the current conditions. The player requests chunks of video encoded at that currently appropriate bit rate, and the streaming server responds with content from the video sources encoded at that bit rate. As a result, when resource conditions degrade, the player can continue displaying the video without any significant disruptions—and with only a slight degradation in overall resolution—until an improvement or further degradation in conditions causes a different bit rate to be requested.

This kind of continuous collaboration between the player and the server requires a special implementation of processing logic on both the streaming server and the client runtime in the player. Internet Information Server (IIS) Smooth Streaming is the server-side implementation of adaptive streaming over HTTP from Microsoft. The client-side implementation is provided as an extension to Microsoft Silverlight called the IIS Smooth Streaming Player Development Kit, which lets applications consume content being streamed over IIS Smooth Streaming. It also provides a rich API that offers programmatic access to various aspects of the Smooth Streaming logic.

This chapter will primarily focus on recipes that allow you to build rich Silverlight experiences for IIS Smooth Streaming leveraging the Smooth Streaming PDK. Specifically, we will cover:

- Using the PDK to consume a smooth stream
- The client-side data model of streams and tracks
- Consuming additional data streams such as closed captions and animations
- Merging external data streams with an existing presentation
- Scheduling external clips such as advertisements within a presentation

- Variable Playback rates
- Composite manifests that lend to robust editing scenarios

Since this book focuses on Silverlight, we do not cover the server side architecture and implementation of Smooth Streaming in any great detail here. We show you how to set up a basic Smooth Streaming environment in the first recipe, and then discuss specific aspects in the rest of the recipes. For more details on Smooth Streaming itself, please review the library of articles available at

```
www.iis.net/expand/SmoothStreaming
```

and at

```
www.iis.net/expand/LiveSmoothStreaming
```

Note that this chapter is based on the beta 2 version of the IIS Smooth Streaming Player Development Kit, and APIs discussed here may be subject to change when the PDK finally releases.

■ **Note** Examples in this chapter use media downloaded from `www.microsoft.com/windows/windowsmedia/musicandvideo/hdvideo/contentshowcase.aspx` and then encoded into the Smooth Streaming format.

11-1. Setting up Smooth Streaming

Problem

You need to set up a Smooth Streaming server environment and encode media to be delivered over Smooth Streaming.

Solution

You will need IIS 7, the IIS Media Services package, and Expression Encoder version 3 or 4.

How It Works

IIS Media Services

You will need a machine running IIS7. Windows Server 2008, Windows 7 and Windows Vista all support II7, but for production grade deployment, you want a Windows Server 2008 based environment. You can install IIS Media Services version 3 using the Microsoft Web Platform Installer from

```
www.iis.net/media
```

```
Expression Encoder
```

Both versions 3 and 4 of Expression Encoder support encoding media for Smooth Streaming for on-demand viewing. Support for software-based encoding for live smooth streaming is available in Expression Encoder version 4 only. We use Expression Encoder v4 for the rest of this chapter.

Once you install and run Expression Encoder v4, you will see the screen in Figure 11-1 when the application starts up.

Figure 11-1. *Expression Encoder v4 start screen*

To encode a media file for smooth streaming, select the transcoding option. Once you are in the workspace window, import (Ctrl+I) the source media file that you want to transcode to the Smooth Streaming format. Expand the Encoding for Silverlight option in the Presets window, expand IIS Smooth Streaming, select the encoding profile you want to target, and click the Apply button. Figure 11-2 shows a screenshot with a video file named AdrenalineRush.wmv selected as the source file, and VC-1 IIS Smooth Streaming – 720p CBR selected as the target encoding profile.

Figure 11-2. *Selecting a target profile in Expression Encoder v4*

If you navigate to the Encode tab and expand the pane titled Video, you will also see that a range of bitrates has been selected for encoding, each defined in its own tab. You can remove some of the bitrate settings if you do not need them by selecting the specific bitrate tab and clicking the little garbage can symbol on right-bottom corner of the Video pane. Alternatively, if you need additional bitrates, you can define them by clicking the bitrate tab marked +. Figure 11-3 shows the Encode tab with the bitrates expanded and the 2.1 mbps bitrate selected.

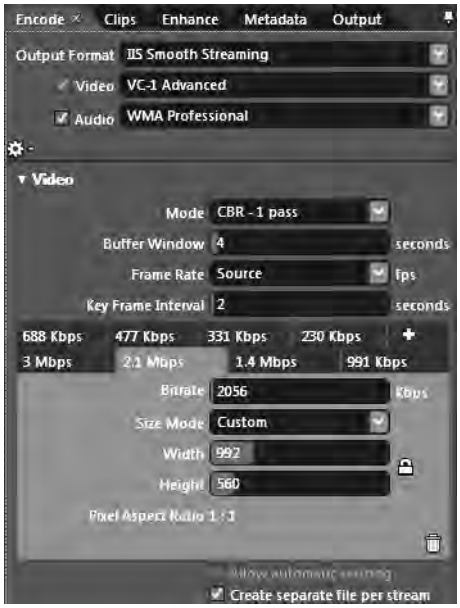


Figure 11-3. *Video bitrate selection for smooth streaming*

If you navigate over to the Output tab, you can specify the folder where you want to put the output files. Once you do that, you can start encoding by clicking the Encode button or Ctrl+E. Figure 11-4 shows the output files for an encoding session done for four bitrates—2.1 mbps, 1.4 mbps, 991 kbps, and 688 kbps respectively.

Name	Type	Size
AdrenalineRush.ism	ISM File	3 KB
AdrenalineRush.ismc	ISMC File	14 KB
AdrenalineRush_688.ismv	Expression Encoder Smooth Streaming File	9,890 KB
AdrenalineRush_991.ismv	Expression Encoder Smooth Streaming File	14,065 KB
AdrenalineRush_1427.ismv	Expression Encoder Smooth Streaming File	20,070 KB
AdrenalineRush_2056.ismv	Expression Encoder Smooth Streaming File	28,824 KB

Figure 11-4. *Output files in four bitrates*

Each of the files with an .ismv extension contains the video encoded at a specific bit rate. For example, the AdrenalineRush_688.ismv contains the video encoded at a bit rate of 688 kbps, while AdrenalineRush_2056.ismv contains the video encoded at 2.1 mbps.

For each bit rate, the video content is broken into fragments of 2 seconds each, and the .ismv files store these fragments in a file format called Protected Interoperable File Format (PIFF). Note that you can have additional audio tracks (or just audio, if the presentation is audio only) encoded in similar files that have an .isma extension.

The AdrenalineRush.ism file is a server manifest, which is structured in the Synchronized Multimedia Integration Language (SMIL) format and contains a mapping of quality levels and bit rates

to the .ismv and .isma files. This mapping in the server manifest is used by the server to access the right disk files to create the next fragment of content encoded at the right bit rate, before responding to a client side request.

The server manifest also contains a mapping to a client manifest file (identified by the extension .ismc). In this case, it is AdrenalineRush.ismc. The client manifest contains all the information that a Silverlight client will need to access the various media and data streams, as well as metadata about those streams, such as quality levels, available bit rates, timing information, codec initialization data, and so on. The client-side logic will use this metadata to sample and decode the fragments and request bit rate switches based on prevailing local conditions.

Setting Up IIS7

To serve smooth streaming content through IIS7, all you need to do is create a virtual directory pointing to the folder that contains your .ism, .ismc and .ismv files. Once you have a virtual directory created, navigate to the Features View of the virtual directory in the IIS Management Console and you will see a Media Services section with a Smooth Streaming Presentations option (see Figure 11-5).

Figure 11-5. *IIS Management Console showing Smooth Streaming Presentation Management*

Selecting this view shows you a list of all the smooth streaming presentations (all the .ism unique files in the folder), and further specific presentation allows you to manage certain aspects, such as

removing bitrates that you do not need, adding titles to streams, etc. Figure 11-6 shows a screenshot of a specific smooth streaming presentation being managed.

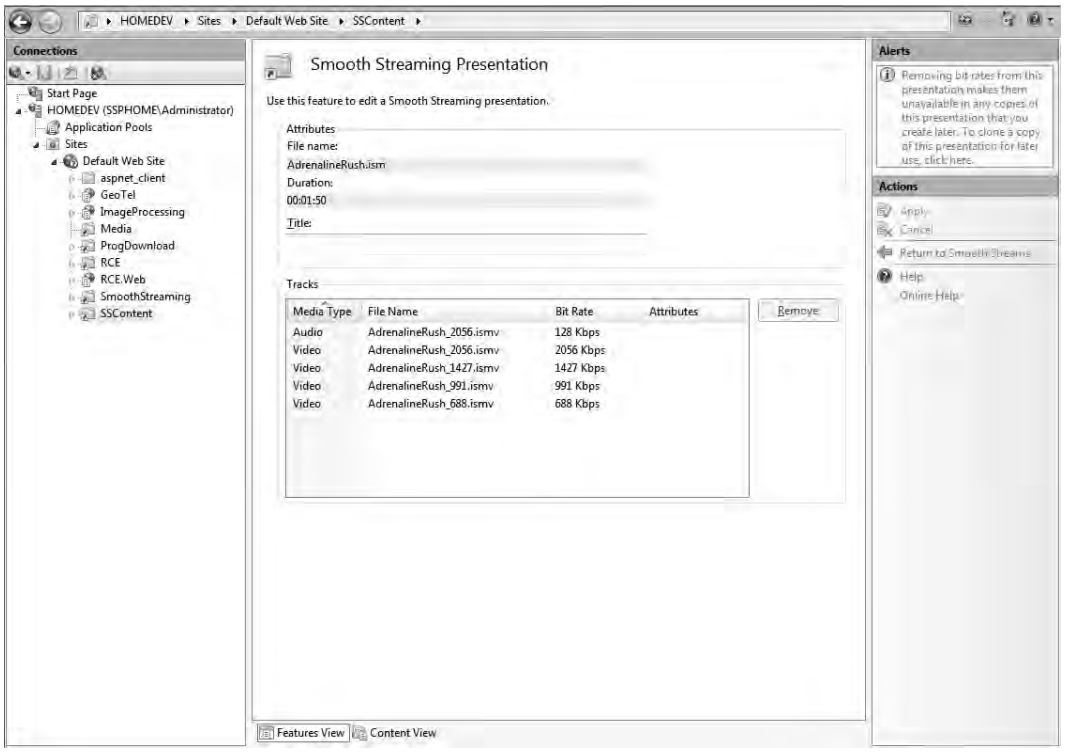


Figure 11-6. *Managing a smooth streaming presentation*

The Silverlight Client/Smooth Streaming Server Data Exchange

At runtime, the presentation begins with the client requesting the client manifest from the server. Once the client receives the manifest, it checks to see what bit rates are available and requests fragments of content starting at the lowest available bit rate. The server responds by preparing and sending the fragments by reading the data from the disk file encoded at that bit rate (utilizing the mapping in the server manifest). The content then gets displayed on the client.

The client gradually requests higher bit rates as allowed by the resource-monitoring logic and eventually reaches the highest allowable bit rate as determined by the prevailing resource conditions. This interchange continues until the client's monitoring logic senses a change in resource conditions resulting in a different lower desired bit rate. Subsequent client requests are for media encoded at the new bit rate and the server again responds accordingly. This goes on until the presentation completes or is stopped. Figure 11-7 shows a sequence diagram outlining the exchange.

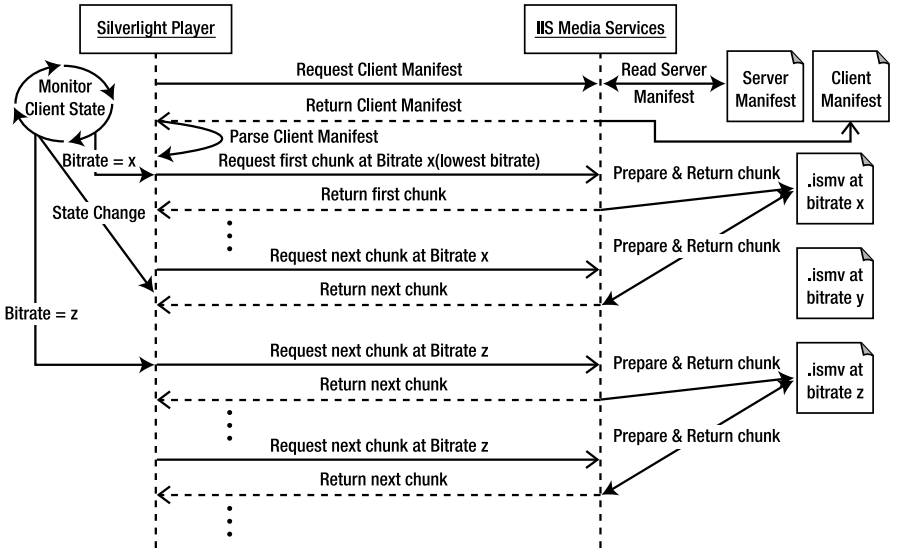


Figure 11-7. *Interchange sequence between Smooth Streaming Client and Server*

Testing the Smooth Streaming Presentation

We will discuss building players using the IIS Smooth Streaming PDK in later recipes in this chapter, but an easy way to quickly get a player to test your smooth stream is to utilize the player generation feature in Expression Encoder.

Before you start encoding your media, navigate to the Template tab in Expression Encoder v4. On the template dropdown, you will see a list of Silverlight player templates that are supplied with Expression Encoder. Select the one you want, and start your encode. If you do not see the Template tab, you can use the Window menu option (ALT+W) to add the Template tab to your view. Figure 11-8 shows the Template tab.

Figure 11-8. *Silverlight player template selection in Expression Encoder 4*

Once the encode is completed, you will find a Default.html file in the same virtual directory as your smooth streaming content along with a few Silverlight XAP files containing the player binaries. Navigating to the Default.html page will start the player with your smooth streaming content being played. The sample smooth streaming player also allows you to monitor the bitrate adaptive behavior by clicking on the Show Graphs button on the player. Figure 11-9 shows the sample player with the bitrate monitor turned on.

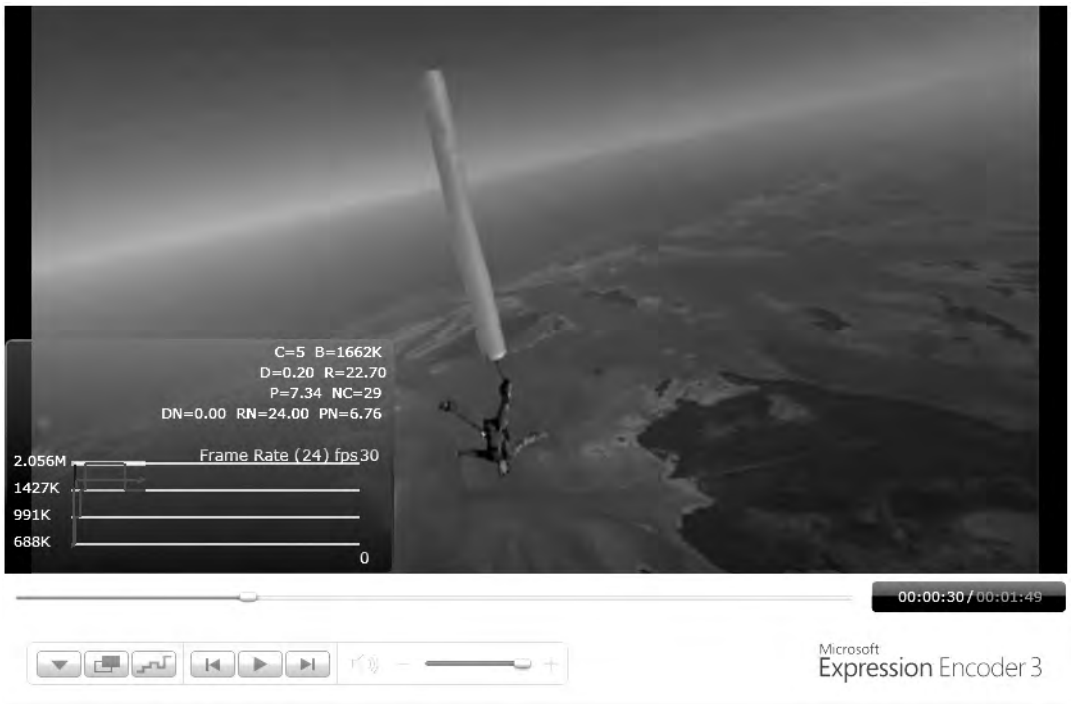


Figure 11-9. *Sample Smooth Streaming Player generated using Expression Encoder with the Show Graphs option turned on*

The Code

There are no code samples for this recipe.

11-2. Using the SmoothStreamingMediaElement

Problem

You want to play a Smooth Streaming presentation in Silverlight.

Solution

Use the `SmoothStreamingMediaElement` in the IIS Smooth Streaming Player Development Kit.

How It Works

You can download the IIS Smooth Streaming Player Development Kit from

```
www.microsoft.com/downloads/details.aspx?FamilyID=2b1ce605-3b99-49ad-8a26↩
-1250f2acbbf6&displaylang=en
```

The IIS Smooth Streaming Player Development Kit

The Smooth Streaming PDK consists of a single assembly named Microsoft.Web.Media.SmoothStreaming.dll. At the heart of the PDK is a type named `SmoothStreamingMediaElement` in the `Microsoft.Web.Media.SmoothStreaming` namespace. (For brevity, we will refer to this type as the SSME in the rest of this chapter.) Note that this assembly needs to be manually referenced in your projects from within Visual Studio by browsing to physical location of the assembly.

The SSME, for the most part, exposes an API that is a superset of the Silverlight `MediaElement` API. Using the SSME in your code is similar to the way you would use a regular `MediaElement`. Listing 11-1 shows some XAML that uses the SSME.

Listing 11-1. *SmoothStreamingMediaElement XAML usage*

```
<smooth:SmoothStreamingMediaElement x:Name="ssme"
          Height="450"
          Width="800"
          SmoothStreamingSource=
          "http://localhost/media/smooth/fighterpilot/fighterpilot.ism/manifest"
          HorizontalAlignment="Stretch"
          VerticalAlignment="Stretch" AutoPlay="False">
```

The `SmoothStreamingSource` property points the SSME to a valid Smooth Streaming presentation. In general, the SSME API is a superset of the `MediaElement` API, with this property being one of the few differences. SSME exposes the `Source` property just like `MediaElement` does, but SSME also exposes the `SmoothStreamingSource` property to attach to smooth streams. If you are authoring players that need the ability to consume both smooth streams as well as the other formats traditionally supported by `MediaElement`, you can safely use SSME, but you will most likely need to author some code to appropriately set the right property to attach to the media source.

Also note the URL to the smooth streaming presentation. Smooth Streaming URLs are of the format `http://<virtual-directory-address>/<server -manifest-file-name>/manifest`.

The Code

The code sample in this recipe forms the beginning of a player that will gradually evolve over the next set of recipes to include other features of smooth streaming. Figure 11-10 shows the player as developed in this recipe.

Figure 11-10. *Smooth Streaming Player using the SSME*

The sample is divided into two assemblies (`SSPlayer` and `SSPlayerControls`). `SSPlayerControls` includes three controls (`PlayerUI`, `Scrubber`, and `ButtonsPanel`). `PlayerUI` encapsulates all the smooth streaming functionality and contains the SSME instance in its XAML. `Scrubber` defines the scrubber bar, and `ButtonsPanel` contains the various buttons used in the player.

The `MainPage` in `SSPlayer` includes an instance of the `PlayerUI` control, as shown in Listing 11-2.

Listing 11-2. *MainPage XAML*

```
<UserControl x:Class="Recipe11_2.MainPage"
    xmlns:SSPlayerControls=
             "clr-namespace:Recipe11_2;assembly=Recipe11_2.SSPlayerControls"
             ...
    >

  <Grid x:Name="LayoutRoot" ”>
   ...
    <StackPanel Orientation="Horizontal" HorizontalAlignment="Center">
      <TextBox x:Name="tbxUrl" Margin="3"
          HorizontalContentAlignment="Stretch" Width="300"/>
      <Button Content="Load" x:Name="btnLoad" Click="btnLoad_Click"
              Margin="5,0,0,0" />
    </StackPanel>
    <SSPlayerControls:PlayerUI Grid.Row="1" x:Name="playerUI"
      VerticalAlignment="Center" HorizontalAlignment="Center"/>
```

```
  </Grid>
</UserControl>
```

The MainPage also contains a TextBox named tbxUrl where the user types in the URL of a valid smooth streaming presentation and a Button named btnLoad which loads the presentation when clicked. Listing 11-3 shows the Click event handler for btnLoad.

Listing 11-3. *Click handler for btnLoad*

```
private void btnLoad_Click(object sender, RoutedEventArgs e)
{
  playerUI.SmoothSource = tbxUrl.Text;
}
```

Note that you set the SmoothSource property of the PlayerUI control to the URL types in tbxUrl when btnLoad is clicked.

As mentioned, the PlayerUI control contains the SSME. Listing 11-4 shows the relevant parts of the XAML in bold for the PlayerUI control template.

Listing 11-4. *PlayerUI Control Template*

```
<Style TargetType="local:PlayerUI">
  <Setter Property="Template">
    <Setter.Value>
      <ControlTemplate TargetType="local:PlayerUI">
        <Grid x:Name="LayoutRoot" ...>
         ...
          <Border...>
            <Grid x:Name="MediaElementContainer" ...>
              <smooth:SmoothStreamingMediaElement x:Name="ssme"
                          Height="450"
                          Width="800"
                          HorizontalAlignment="Stretch"
                          VerticalAlignment="Stretch" AutoPlay="False" >
              </smooth:SmoothStreamingMediaElement>
            </Grid>
          </Border>
          <Border ...>
            <Grid>
              ...
              <local:ButtonsPanel x:Name="buttonsPanel"
                   DataContext="{Binding
                RelativeSource={RelativeSource TemplatedParent},
                Mode=OneWay, Path=DataContext}" />
            </Grid>
          </Border>
```

```
          <local:Scrubber VerticalAlignment="Center"
                          Grid.Row="2" Width="600"
                          HorizontalAlignment="Center"
                          SmallChange="1000"
                          LargeChange="10000"
                          Margin="0,5,0,5"
                           x:Name="scrubber"
                           DataContext="{Binding
            RelativeSource={RelativeSource TemplatedParent},
            Mode=OneWay, Path=DataContext}" />
        </Grid>
      </ControlTemplate>
    </Setter.Value>
  </Setter>
</Style>
```

As you can see, the PlayerUI control contains an instance of the SSME named ssme, an instance of the Scrubber control, and an instance of the ButtonsPanel named buttonsPanel. Listing 11-5 shows the PlayerUI control code with relevant parts in bold.

Listing 11-5. *PlayerUI control code*

```
namespace Recipe11_2
{

  public class PlayerUI : Control, INotifyPropertyChanged
  {
    Scrubber scrubber = null;
    ButtonsPanel buttonsPanel = null;
    Grid MediaElementContainer = null;
    internal SmoothStreamingMediaElement ssme = null;


    public string SmoothSource
    {
      get { return (string)GetValue(SmoothSourceProperty); }
      set { SetValue(SmoothSourceProperty, value); }
    }
    public static readonly DependencyProperty SmoothSourceProperty =
        DependencyProperty.Register("SmoothSource", typeof(string),
        typeof(PlayerUI), new PropertyMetadata(null,
          new PropertyChangedCallback(OnSmoothSourceChanged)));

    //Change handler for dependency property SmoothSourceProperty
```

```
private static void OnSmoothSourceChanged(DependencyObject Src,
  DependencyPropertyChangedEventArgs Args)
{
  PlayerUI thisObj = Src as PlayerUI;
  //act on the change...
  if (thisObj.ssme != null &&
    Uri.IsWellFormedUriString(Args.NewValue as string, UriKind.Absolute))
  {
    thisObj.SetMediaSource(Args.NewValue as string, thisObj.ssme);
  }
}

private void SetMediaSource(string MediaSourceUri,
  SmoothStreamingMediaElement ssme)
{

  if (MediaSourceUri.Contains(".ism") || MediaSourceUri.Contains(".csm"))
    ssme.SmoothStreamingSource = new Uri(MediaSourceUri);
  else
    ssme.Source = new Uri(MediaSourceUri);
}

public PlayerUI()
{
  base.DefaultStyleKey = typeof(PlayerUI);
}

public override void OnApplyTemplate()
{
  base.OnApplyTemplate();
  ssme = GetTemplateChild("ssme") as SmoothStreamingMediaElement;
  scrubber = GetTemplateChild("scrubber") as Scrubber;
  buttonsPanel = GetTemplateChild("buttonsPanel") as ButtonsPanel;
  MediaElementContainer = GetTemplateChild("MediaElementContainer") as Grid;
  if (scrubber != null && ssme != null)
    scrubber.Viewer = ssme;
  if (buttonsPanel != null && ssme != null)
    buttonsPanel.Viewer = ssme;
  if (ssme != null)
    ssme.ConfigPath = "config.xml";
}

#region INotifyPropertyChanged Members
```

```
    public event PropertyChangedEventHandler PropertyChanged;

    #endregion
  }
}
```

In the `PropertyChangedCallback` handler named OnSmoothSourceChanged(), of the dependency property `SmoothSourceProperty`, you check to make sure that an SSME instance has been defined and that the URL is indeed a well formed URI. You then call the `SetMediaSource()` method where you check to see if the Uri contains the strings ".ism" or ".csm" to indicate that it is a URL to a smooth streaming presentation. If so, you set the `SmoothStreamingSource` property on the SSME instance to the URI. Alternatively, you set the `Source` property to the URI. We will discuss the .csm extension in later recipes.

Also note the setting of the `ConfigPath` property on the SSME to a config.xml file in the `OnApplyTemplate()` method. The SSME allows you to configure a variety of settings related to its behavior and the various settings that it applies when monitoring the local resource metrics, network behavior etc. The SSME applies a default configuration, but you can override it by supplying a config file of your own in the above way. You can supply the config file by including it simply as content in your project.

We do not list a full config file here; you are encouraged to look at the config file supplied with the sample code, as well as IIS Smooth Streaming documentation at

```
msdn.microsoft.com/en-us/library/ee230811.aspx
```

for more details. The primary reason to supply a custom config file is to change the seek behavior of the SSME. Since smooth streams are delivered in 2 second chunks of video and audio, the default seek behavior of the SSME is to jump 2 seconds at a time. To get a more granular seek behavior, add an attribute named `ForceAccurateSeeks` set to `true` to the `BufferingEngineSettings` element in the SSME config file. To note the difference in seek behavior, you can try the scrubber in the player with and without that attribute added.

11-3. Adding Metadata Streams

Problem

You want to add additional metadata like captions and animations to your smooth streaming presentation.

Solution

Add the additional data as additional streams to the smooth streaming client manifest and use the SSME API to extract and display them in the player.

How It Works

There are two approaches to adding metadata to a smooth streaming presentation—you can mix the metadata stream as an additional data stream alongside the actual media while encoding, or you can add the metadata streams to the client manifest. The former approach either relies on encoder-specific

utilities or the use of something like the Smooth Streaming Format SDK—both of which are outside the scope of this chapter. You will take the later approach, but to understand how it works, you need to better understand the streams and tracks related to the API exposed by the SSME.

Streams and Tracks

The Smooth Streaming client manifest contains rich metadata about the presentation and it can be useful to have programmatic access to that metadata inside your player application. SSME exposes parts of this metadata through a well-defined API in an arrangement of streams and tracks within each stream. Listing 11-6 shows an excerpt from a client manifest file named FighterPilot.ismc.

Listing 11-6. *Client Manifest excerpt*

```
<SmoothStreamingMedia MajorVersion="2" MinorVersion="0" Duration="1456860000">
  <StreamIndex Type="video" Chunks="73" QualityLevels="4" MaxWidth="992"
       MaxHeight="560" DisplayWidth="992" DisplayHeight="560"
       Url="QualityLevels({bitrate})/Fragments(video={start time})">
    <QualityLevel Index="0" Bitrate="2056000" FourCC="WVC1" MaxWidth="992"
       MaxHeight="560"
       CodecPrivateData=
       "250000010FD37E1EF1178A1EF845E8049081BEBE7D7CC00000010E5A67F840" />

     <!-- ADDITIONAL QUALITY LEVELS REMOVED FOR BREVITY -->

    <QualityLevel Index="3" Bitrate="688000" FourCC="WVC1" MaxWidth="448"
      MaxHeight="252"
      CodecPrivateData=
      "250000010FCB540DF07D8A0DF81F6804908114FED3FBC00000010E5A67F840" />
    <c n="0" d="20020000" />
    <c n="1" d="20020000" />
    <c n="2" d="20020000" />

    <!--ADDITIONAL VIDEO CHUNK METADATA REMOVED FOR BREVITY-->

    <c n="71" d="20020000" />
    <c n="72" d="15010001" />
  </StreamIndex>
  <StreamIndex Type="audio" Index="0" FourCC="WMAP" Chunks="73"
               QualityLevels="1"
               Url="QualityLevels({bitrate})/Fragments(audio={start time})">
    <QualityLevel Bitrate="64000" SamplingRate="44100" Channels="2"
                  BitsPerSample="16" PacketSize="2973" AudioTag="354"
                  CodecPrivateData="1000030000000000000000000000E00042C0" />
    <c n="0" d="21246187" />
    <c n="1" d="19620819" />
    <c n="2" d="22755556" />
```

```
    <!--ADDITIONAL AUDIO CHUNK METADATA REMOVED FOR BREVITY-->

    <c n="71" d="19504762" />
    <c n="72" d="14900906" />
  </StreamIndex>
</SmoothStreamingMedia>
```

A stream represents the overall metadata for tracks of a specific type—video, audio, text, advertisements, and so on. The stream also acts as a container for multiple tracks of the same underlying type. In Listing 11-6, each `StreamIndex` entry represents a stream. There can be multiple streams in the presentation, as depicted by the multiple `StreamIndex` entries. There can also be multiple streams of the same type. In such cases, the stream name can be used to disambiguate between multiple occurrences of the same type.

The `StreamInfo` type represents the stream in your Silverlight code. Once SSME downloads the client manifest, it raises the `SmoothStreamingMediaElement.ManifestReady` event. At this point, the `SmoothStreamingMediaElement.AvailableStreams` collection property contains a `StreamInfo` instance for each `StreamIndex` entry in the client manifest.

For a given video stream in the client manifest, the video track is broken into many fragments of 2-second durations. Each `c` element in the manifest represents metadata for the fragment; the `n` attribute signifies an ordinal for the chunk (i.e. the order in which chunks are played); and the `d` attribute specifies the length of the chunk in ticks. In this case, the fragments in the track are contiguous and define the entire duration of the video track without any breaks in between. In other words, the stream is not sparse.

A track is a timed sequence of fragments of content of a specific type—video, audio, or text. Each track is represented using an instance of a `TrackInfo` type, and all the tracks in a stream are made available through the `StreamInfo.AvailableTracks` collection property.

Each track in a client manifest is uniquely identified via a `QualityLevel`. A `QualityLevel` is identified by the associated bit rate and is exposed through the `TrackInfo.Bitrate` property. For example, a video stream in a client manifest may have several `QualityLevels`, each with a unique bit rate. Each represents a unique track of the same video content, encoded at the bit rate specified by the `QualityLevel`.

Note that for the audio and video streams depicted in Listing 11-6, the actual data (i.e. the encoded video and audio bitstreams) are not contained in the manifest itself but in the .ismv (or .isma) files. The client manifest, however, does allow you to add streams where the data representing each fragment for the tracks in the stream are contained in the manifest itself. To do this, you need to set the `ManifestOutput` attribute to `TRUE` in the `StreamIndex` entry, as shown in Listing 11-7.

Listing 11-7. *Track fragment data contained in the manifest itself*

```
<StreamIndex Type="text" Name="ClosedCaptions" Subtype="CAPT"
  TimeScale="10000000" ParentStreamIndex="video"
  ManifestOutput="TRUE" QualityLevels="1" Chunks="6"
  Url=
"QualityLevels({bitrate},{CustomAttributes})/
Fragments(ClosedCaptions={start time})">
  <QualityLevel Index="0" Bitrate="1000" CodecPrivateData="" FourCC=""/>
  <c n="0" t="100000000">
    <f>PENhcHRpb24gSWQ9IntERTkwRkFDRC1CQzAxLTQzZjItQTRFQy02QTAxQTQ5QkFGQk
    J9IiAKICAgICAgICBBY3Rp</f>
```

```
  </c>
  <c n="1" t="150000000">
    <f>PENhcHRpb24gSWQ9IntERTkwRkFDRC1CQzAxLTQzZjItQTRFQy02QTAxQTQ5QkFGQk
    J9IiAKICAgI</f>
  </c>
</StreamIndex>
```

For the text stream shown in Listing 11-7, the track includes only two fragments, each with individual timing information (the `t` attribute on the `c` element). Further, the `ParentStreamIndex` attribute is set to "video", parenting the closed caption stream with the video stream. This causes the closed caption stream to align with the timing information from the video stream. The closed caption stream starts and ends exactly with its parent video stream; the first caption is displayed 10 seconds into the video stream, while the second is displayed 15 seconds into the video. A stream in which the timeline is based on a parent stream and the fragments are non-contiguous is called a sparse stream.

Note the nested content within the `f` elements—each represents caption item data to be displayed at the time specified by the containing chunk. The client manifest specification requires that the data be represented as a base64 encoded string version of the original data item.

When the above manifest entry is parsed by the SSME, the `TrackInfo.TrackData` collection property contains a list of `TimelineEvent` instances, one for each `f` element corresponding to the track. For each `TimelineEvent` entry, `TimelineEvent.EventTime` represents the time point in the sequence and the `TimelineEvent.EventData` provides the base64 encoded text string. `TrackInfo` also exposes `Bitrate`, `CustomAttributes`, `Index`, `Name`, and `ParentStream` properties. In the code sample, you will see how to combine the above concepts to add textual metadata to your smooth streaming presentation.

The Code

The code sample for this recipe has two parts. The first part shows you an example of injecting textual metadata and content into the client manifest, and the second part shows you how to use that data during playback.

Injecting the Metadata and Content

In a production media workflow, there can be many different ways to inject such content into the manifest during or after encoding, and the data could be coming from several different sources like ad-serving platforms and caption generators. But for this example, you are going to use a simple XML data file as the data source, use some LINQ over XML queries to manufacture the text streams, and insert them into an existing client manifest. The sample code can be found in the 11.3 Manifest Injector project, with the LINQ To XML query in the `InsertContent()` method in the `Programs.cs` file. To use the injector, run `11.3 ManifestInjector.exe` from the command line, and supply the path of the client manifest file as the first command line parameter and the path for the included `Content.xml` file as the second parameter.

The structure of the data source does not need to be complex. We do not list the full data source file here, but you are encouraged to look at the `Content.xml` file in the 11.3 ManifestInjector project for the full data file. The data file begins with a `Tracks` element, which contains two `ContentTrack` elements. Each `ContentTrack` entry will ultimately result in one distinct text stream in the client manifest. The first `ContentTrack` element is for the captions:

```
<ContentTrack Name="ClosedCaptions" Subtype="CAPT">
```

The second is for animations:

```
<ContentTrack Name="Animations" Subtype="DATA">
```

Each ContentTrack contains multiple Event elements, with the time attributes specifying the time points on the video's timeline when these text events need to occur. The Event elements, in turn, contain the actual caption events defined in XML or the XAML for the animation as CDATA sections. The code in Listing 11-8 shows an example.

Listing 11-8. *Defined events in the XML data source*

```
<Event time="00:00:10">
  <![CDATA[<Caption Id="{DE90FACD-BC01-43f2-A4EC-6A01A49BAFBB}"
    Action="ADD">
    Test Caption 1
  </Caption>]]>
</Event>
<Event time="00:00:15">
  <![CDATA[<Caption Id="{DE90FACD-BC01-43f2-A4EC-6A01A49BAFBB}"
    Action="REMOVE"/>]]>
</Event>
```

Note that for each added closed caption event, there is a corresponding event that indicates the time point when the previously added caption needs to be removed. The Caption element contained within the CDATA section for a closed caption event defines an Action attribute with a value of ADD or REMOVE to indicate appropriate action.

At this point, you use a simple LINQ over XML query that transforms the XML data into appropriate entries for a client manifest and inserts them into an existing client manifest file. You can find an example in the code download for this recipe, in a method named InsertContent() in the Programs.cs file. Since the LINQ code is not very pertinent to the Smooth Streaming topic, we skip it.

■ **Note** This mechanism or the data source format described above is not prescriptive and nor is it a part of the Smooth Streaming platform or SDKs by any means. You are encouraged to investigate the best way to do this kind of injection in your environment. You can define whatever structure suits the needs of your application, as long as you transform it to the format required by the client manifest specification, which includes encoding the text content to a base64 format.

Once the transformation is executed, the resulting client manifest file will contain the text streams as shown in Listing 11-9.

Listing 11-9. *Client manifest excerpt with text content streams*

```
<SmoothStreamingMedia MajorVersion="2" MinorVersion="0" Duration="1456860000">
  <StreamIndex Type="video" Chunks="73" QualityLevels="8"
    MaxWidth="1280" MaxHeight="720" DisplayWidth="1280" DisplayHeight="720"
```

```
    Url="QualityLevels({bitrate})/Fragments(video={start time})">
    ...
  </StreamIndex>
  <StreamIndex Type="audio" Index="0" FourCC="WMAP" Chunks="73"
    QualityLevels="1"
    Url="QualityLevels({bitrate})/Fragments(audio={start time})">
    ...
  </StreamIndex>
  <StreamIndex Type="text" Name="ClosedCaptions" Subtype="CAPT"
    TimeScale="10000000" ParentStreamIndex="video"
    ManifestOutput="TRUE" QualityLevels="1" Chunks="6"
    Url="QualityLevels({bitrate},{CustomAttributes})
    /Fragments(ClosedCaptions={start time})">
    <QualityLevel Index="0" Bitrate="1000" CodecPrivateData="" FourCC="" />
    <c n="0" t="100000000">
      <f>
        PENhcHRpb24gSWQ9IntERTkwRkFDRC1CQzAxLTQzZjItQTRFQy02QTAxQTQ5QkFGQkJ9
        IiAKICAgICAgICBBY3Rpb249IkFERCI+CiAgICAgICAgVGVzdCBDYXB0aW9uIDEKICAg
        ICAgPC9DYXB0aW9uPg==
      </f>
    </c>
    <c n="1" t="150000000">
      <f>
        PENhcHRpb24gSWQ9IntERTkwRkFDRC1CQzAxLTQzZjItQTRFQy02QTAxQTQ5QkFGQkJ9I
        iAKICAgICAgICBBY3Rpb249IlJFTU9WRSIvPg==
      </f>
    </c>
    ...
  </StreamIndex>
  <StreamIndex Type="text" Name="Animations" Subtype="DATA"
    TimeScale="10000000" ParentStreamIndex="video"
    ManifestOutput="TRUE" Chunks="2" QualityLevels="1"
    Url="QualityLevels({bitrate})/Fragments(Animations={start time})">
    <QualityLevel Index="0" Bitrate="1000" CodecPrivateData="" FourCC="" />
    <c t="120000000">
      <f>
        +CgkJCQkJPEdyYWRpZW5OU3RvcCBDb2xvcjOiUmVkIiBPZmZzZXQ9IjEiLz4KCQkJCQ
        k8R3JhZGllbnRTdG9wIENvbG9yPSIjRkY4Nzg2ODYiIE9mZnNldD0iMC4OOTIiLz4KC
        QkJCTwvTGluZWFyR3JhZGllbnRCcnVzaD4KCQkJPC9FbGxpcHNlLkZpbGw+CgkJPC9Fb
        GxpcHNlPgoJPC9HcmlkPgogICAgICA8L1NjZW5lQW5pbWFOaW9uPg==
      </f>
    </c>
    ...
  </StreamIndex>
</SmoothStreamingMedia>
```

The video and audio streams already existed in the client manifest shown above, and you added the two text streams following that, named `ClosedCaptions` and `Animations`, respectively. Note that each stream uses the video stream as its parent and sets `ManifestOutput` to `TRUE` as outlined in the previous section. The former is because the text streams are sparse in nature, and parenting them to the video stream ensures correct timing of each text content entry (the `c` elements) along the video stream's timeline. The latter is to ensure that the SSME reads the actual data (the base64 encoded strings within the `f` elements) from the manifest itself.

Using Metadata at Playback

The SSME exposes the additional text streams as `StreamInfo` instances in the `AvailableStreams` property, with each `StreamInfo` containing the track data as a `TrackInfo` instance. The `TrackInfo.TrackData` collection property will contain as many instances of the `TimelineEvent` type as there are text events in each text track. The `TimelineEvent.EventData` property exposes a byte array representing the string content (decoded from its base64 encoded format), and the `TimelineEvent.EventTime` property exposes the time point where this event needs to occur.

When you start playing the presentation, as these events are reached, the SSME raises the `TimelineEventReached` event. Listing 11-10 shows a sample of handling the closed caption and animation tracks that were added to the client manifest, as discussed in the previous section.

Listing 11-10. *Using the TimelineEventReached event to handle text streams*

```
//handle TimelineEventReached
ssme.TimelineEventReached += new EventHandler<TimelineEventArgs>((s, e) =>
{
  //if closed caption event
  if (e.Track.ParentStream.Name.ToLower() == "closedcaptions" &&
    e.Track.ParentStream.Subtype.ToLower() == "capt")
  {
    //base64 decode the content and load the XML fragment
    XElement xElem = XElement.Parse(Encoding.UTF8.GetString(e.Event.EventData,
      0, e.Event.EventData.Length));

    //if we are adding a caption
    if (xElem.Attribute("Action") != null &&
      xElem.Attribute("Action").Value == "ADD")
    {
      //remove the text block if it exists
      UIElement captionTextBlock = MediaElementContainer.Children.
      Where((uie) => uie is FrameworkElement &&
        (uie as FrameworkElement).Name == (xElem.Attribute("Id").Value)).
        FirstOrDefault() as UIElement;
      if (captionTextBlock != null)
        MediaElementContainer.Children.Remove(captionTextBlock);

      //add a TextBlock
```

```
      MediaElementContainer.Children.Add(new TextBlock()
      {
        Name = xElem.Attribute("Id").Value,
        Text = xElem.Value,
        HorizontalAlignment = HorizontalAlignment.Center,
        VerticalAlignment = VerticalAlignment.Bottom,
        Margin = new Thickness(0, 0, 0, 20),
        Foreground = new SolidColorBrush(Colors.White),
        FontSize = 22
      });
    }
    //if we are removing a caption
    else if (xElem.Attribute("Action") != null &&
      xElem.Attribute("Action").Value == "REMOVE")
    {
      //remove the TextBlock
      MediaElementContainer.Children.Remove(MediaElementContainer.Children.
        Where((uie) => uie is FrameworkElement &&
          (uie as FrameworkElement).Name == (xElem.Attribute("Id").Value)).
          FirstOrDefault() as UIElement);
    }
  }
  //if animation event
  else if (e.Track.ParentStream.Name.ToLower() == "animations" &&
    e.Track.ParentStream.Subtype.ToLower() == "data")
  {
    //base64 decode the content and load the XML fragment
    XElement xElem = XElement.Parse(Encoding.UTF8.GetString(e.Event.EventData,
      0, e.Event.EventData.Length));

    //if we are adding the animation
    if (xElem.Attribute("Action") != null &&
      xElem.Attribute("Action").Value == "ADD")
    {
      //remove the Grid if it exists
      Grid AnimationContainer = MediaElementContainer.Children.
          Where((uie) => uie is FrameworkElement && (uie as FrameworkElement).
            Name == (xElem.Attribute("Id").Value)).
            FirstOrDefault() as Grid;
      if (AnimationContainer != null)
        MediaElementContainer.Children.Remove(AnimationContainer);

      //add the animation to a grid overlay
      AnimationContainer = XamlReader.Load(xElem.Element(
       XName.Get("Grid",
```

```
        "http://schemas.microsoft.com/winfx/2006/xaml/presentation")).
        ToString(SaveOptions.DisableFormatting)) as Grid;
      AnimationContainer.Name = xElem.Attribute("Id").Value;
      MediaElementContainer.Children.Add(AnimationContainer);

      //load the animation
      Storyboard anim = AnimationContainer.Resources["SceneAnimation"] as
        Storyboard;

      //handle animation completion
      anim.Completed += new EventHandler((animSender, animargs) =>
      {
        //if animation is completed, remove it
        MediaElementContainer.Children.Remove(MediaElementContainer.Children.
          Where((uie) => uie is FrameworkElement && (uie as FrameworkElement).
            Name == (xElem.Attribute("Id").Value)).
            FirstOrDefault() as UIElement);
      });

      //start the animation
      anim.Begin();
    }

  }
}
);
```

As each `TimelineEvent` is handled, you either insert a `TextBlock` into the UI to display a caption or load the animation XAML string to start the animation. Note that since the text content is base64 encoded, it is decoded to its original state. Also note that the code checks the `Action` attribute on the `Caption` element to decide whether it is adding a caption to the UI or removing an existing caption. For animation events, you can rely on an animation's own completion handler to remove it from the UI.

Figure 11-11 shows a screen shot of a caption being displayed and an ellipse being animated overlaid on a playing video.

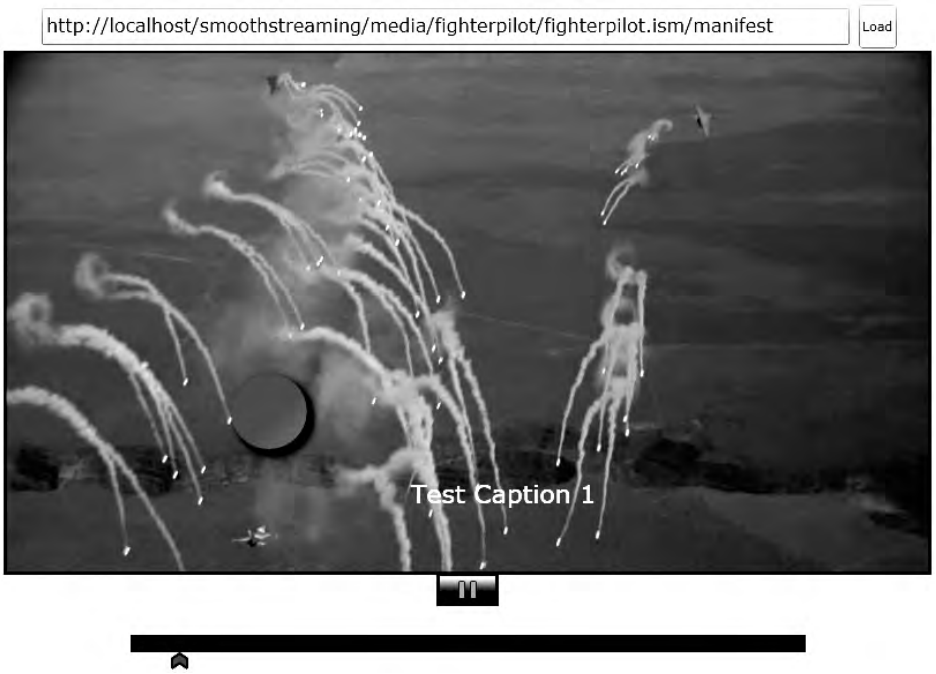


Figure 11-11. *Caption and animation overlay using text content streams*

While this approach works well, there is one consideration you should make before utilizing this technique. The current release of SSME handles `TimlineEvents` at 2-second boundaries. To understand this better, let's say you had a closed caption timed at the 15.5 second time point along the video timeline. SSME would raise the `TimelineEventReached` event for this closed caption at the closest previous time point that is a multiple of 2—in other words, at approximately 14 seconds.

If your scenario demands greater accuracy and you cannot position your content chunks close to 2-second boundaries, then using the `TimelineEventReached` to handle the content tracks may not be the right way. You can, however, use the `TimelineMarker` class (as used in the standard `MediaElement` type) to add markers to your timeline that can raise the `MarkerReached` event at any granularity you need. For more on the `TimelineMarker` type, please refer to Recipe 10-5. Listing 11-11 shows the outline of a method called `AddAndHandleMarkers()` that adds `TimelineMarkers` for each content event and responds to them in the `MarkerReached` event handler.

Listing 11-11. *Handling TimelineEvent using TimelineMarker*

```
private void AddAndHandleMarkers()
{
  //get the Caption stream
  StreamInfo CCStream = ssme.AvailableStreams.Where((si) =>
    si.Name.ToLower() == "closedcaptions" &&
    si.Subtype.ToLower() == "capt").FirstOrDefault();

  //get the animation stream
```

```
  StreamInfo AnimStream = ssme.AvailableStreams.Where((si) =>
    si.Name.ToLower() == "animations" &&
    si.Subtype == "data").FirstOrDefault();

  //enumerate each TimelineEvent and add corresponding markers
  foreach (TimelineEvent te in CCStream.AvailableTracks[0].TrackData)
  {
    TimelineMarker tm = new TimelineMarker()
    { Text = Encoding.UTF8.GetString(te.EventData, 0, te.EventData.Length),
      Time = te.EventTime, Type = "CC" };
    ssme.Markers.Add(tm);
  }
  foreach (TimelineEvent te in AnimStream.AvailableTracks[0].TrackData)
  {
    TimelineMarker tm = new TimelineMarker() {
      Text = Encoding.UTF8.GetString(te.EventData, 0, te.EventData.Length),
      Time = te.EventTime, Type = "ANIM" };
    ssme.Markers.Add(tm);
  }

  //handle the markers when reached
  ssme.MarkerReached += new TimelineMarkerRoutedEventHandler((s, e) =>
  {
    XElement xElem = XElement.Parse(e.Marker.Text);

    //if closed caption event
    if (e.Marker.Type == "CC")
    {
       //REST OF THE CODE SIMILAR TO LISTING 11-10
    }
    //if animation event
    else if (e.Marker.Type == "ANIM")
    {
        //REST OF THE CODE SIMILAR TO LISTING 11-10
      }
    }
  });
}
```

To gain access to the animation and caption streams, query the `AvailableStreams` property on the SSME with the appropriate filter. Then, enumerate through the `TimelineEvent` instances for each stream and add a `TimelineMarker` instance with the actual event text stored in the `TimelineMarker.Text` property for each `TimelineEvent` instance to the SSME. Lastly, attach a handler to the `MarkerReached` event and extract the Text property from the `TimelineMarker`. The rest of the processing is identical to the one shown in Listing 11-10.

11-4. Merging Data from External Manifests

Problem

You want to merge metadata defined in external manifests into one single presentation.

Solution

You can use the manifest merging capabilities of the SSME to achieve this.

How It Works

In the previous recipe, you saw an example of injecting additional metadata (in that case, one of captions and animation overlays) into the client manifest for a smooth streaming presentation. That approach works well when you have access to the client manifest file. In cases when you do not have the necessary permissions to make modifications to the client manifest, you will need an alternative mechanism to achieve the same result. Additionally, there may be scenarios where the additional content or metadata that you want to add to the client manifest are conditionally dependent on other factors such as the user's locale, thus requiring closed captions in different languages. Adding the data for all the possible conditions, especially the temporal ones, would make the client manifest more time-consuming to transfer, load, and parse.

The SSME solves this problem by allowing you to merge additional manifest files at runtime on the client to the original client manifest, thus giving you the ability to bring in additional data streams and act upon them without having to modify the original client manifest on the server.

The SSME API raises an event named `ManifestMerge` during its initialization cycle, which you will use to perform any merging of external manifests into the primary client manifest.

The first step to merging a external manifest is to parse it to ensure validity of format and data, and the `ParseExternalManifest()` method on the SSME does exactly that. It accepts a URI to the external manifest as its first parameter and attempts to download and parse the manifest from the stated URI. It then returns the parsed manifest as an object through the third parameter to the function. The second parameter accepts a timeout value in milliseconds, which can be used to unblock the `ParseExternalManifest()` call in case the manifest download or parsing takes too long.

The SSME also exposes a `MergeExternalManifest()` method, the only parameter which can accept a parsed external manifest returned from the `ParseExternalManifest()` call and merge it with the original client manifest data.

Note that calls to `ParseExternalManifest()` and `MergeExternalManifest()` are only valid when called in the handler for the `ManifestMerge` event. Calls to these methods elsewhere will raise an `InvalidOperationException`. Also note that you can call these methods multiple times to merge multiple external manifests, if you so need.

As far as the structure of an external manifest goes, it needs to be identical to a regular client manifest: a top-level `SmoothStreamingMedia` element with appropriate `StreamIndex` child elements to represent your data.

Keep in mind that external manifests need to have an extension that has an associated MIME type registered with the Web server from which they are available. Using a common extension such as .XML is a good idea, since the content is XML is anyway. If the external manifest files are served from the same Web server that is acting as your Smooth Streaming server, then you should refrain from using the .ismc extension as the IIS Media Services handler prevents .ismc files from being accessed directly and `ParseExternalManifest` will fail to download the external manifest.

The Code

The code sample for this solution extends the sample from Recipe 11-3. In this sample, you have decided to keep your caption content and related metadata in separate external manifests. Additionally, you have decided to create multiple such external manifests, one for each locale you want to support, and merge the appropriate external manifest at runtime depending on the locale that the player is running in.

Creating the External Manifests

You once again use a similar approach as shown in Recipe 11-3, but instead of injecting additional `StreamIndex` entries into the client manifest, your LINQ to XML query actually creates separate external manifest files. The 11.4 ManifestInjector project contains the LINQ query in the `CreateExternalManifests()` method in `Programs.cs` file. To create the external manifests, you can run 11.4 ManifestInjector.exe, passing in the path to the client manifest as the first parameter and the path to the included data file named `MultiManifestContent.xml` as the second parameter.

11-12 shows portions from the data source file.

Listing 11-12. *Portion from the data source file MultiManifestContent.xml*

```
<Manifests>
  <Manifest RelativePath="en-US\CC.xml">
    <ContentTrack Name="ClosedCaptions" Subtype="CAPT" >
      <Event time="00:00:10">
        <![CDATA[<Caption Id="{DE90FACD-BC01-43f2-A4EC-6A01A49BAFBB}"
        Action="ADD">
        Test Caption 1
      </Caption>]]>
      </Event>
      <Event time="00:00:15">
        <![CDATA[<Caption Id="{DE90FACD-BC01-43f2-A4EC-6A01A49BAFBB}"
        Action="REMOVE"/>]]>
      </Event>
     ...
    </ContentTrack>
  </Manifest>
  <Manifest RelativePath="fr-FR\CC.xml">
    <ContentTrack Name="ClosedCaptions" Subtype="CAPT">
      <Event time="00:00:10">
        <![CDATA[<Caption Id="{DE90FACD-BC01-43f2-A4EC-6A01A49BAFBB}"
        Action="ADD">
        Test de légende 1
      </Caption>]]>
      </Event>
      <Event time="00:00:15">
        <![CDATA[<Caption Id="{DE90FACD-BC01-43f2-A4EC-6A01A49BAFBB}"
        Action="REMOVE"/>]]>
```

```
      </Event>
       ...
    </ContentTrack>
  </Manifest>
</Manifests>
```

Each `Manifest` entry defines a single external manifest with the `RelativePath` attribute specifying the path to the external manifest file relative to the folder where the client manifest resides. As you can see, there are multiple `Manifest` entries, one for each locale you intend to support through your external manifests, with each of them containing the caption data in the appropriate language.

Once it is processed, two external manifests are created in two separate subfolders, under the folder containing the client manifest, named "en-US" and "fr-FR" corresponding to the English-United States and French-France locales. Each external manifest file is named `CC.xml` in your case, as specified in the data source file.

Merging the Manifests at Runtime

Listing 11-13 shows the code used to merge the external manifests.

Listing 11-13. *ManifestMerge event handler*

```
ssme.ManifestMerge +=
  new SmoothStreamingMediaElement.ManifestMergeHandler((sender) =>
  {
    object ParsedExternalManifest = null;

    //URI of the right external manifest based on current locale
    //for example expands to
    string UriString = string.Format(
      "http://localhost/SmoothStreaming/Media/FighterPilot/{0}/CC.xml",
      CultureInfo.CurrentCulture.Name);

    //parse the external manifest - time out in 3 secs
    ssme.ParseExternalManifest(new Uri(UriString), 3000, out ParsedExternalManifest);

    //merge the external manifest
    ssme.MergeExternalManifest(ParsedExternalManifest);
  });
```

The code to parse and merge manifests has to execute in the `ManifestMerge` event handler, as shown in the above listing. Since your external manifests are stored in folders named after the locale, you first form the target URI string for the external manifests, using the current culture in use on the client machine. Then, call `ParseExternalManifest()`, using a timeout value of 3 seconds. Once the parsed manifest is returned using the `ParsedExternalManifest()` out parameter, you use that to invoke the `MergeExternalManifest()` method to do the final merge.

The display of the captions using either the `TimelineEvent` instances directly or using markers remains the same as outline in Recipe 11-3. Figure 11-12 shows the results of the caption display with US English and French locale settings on the client.

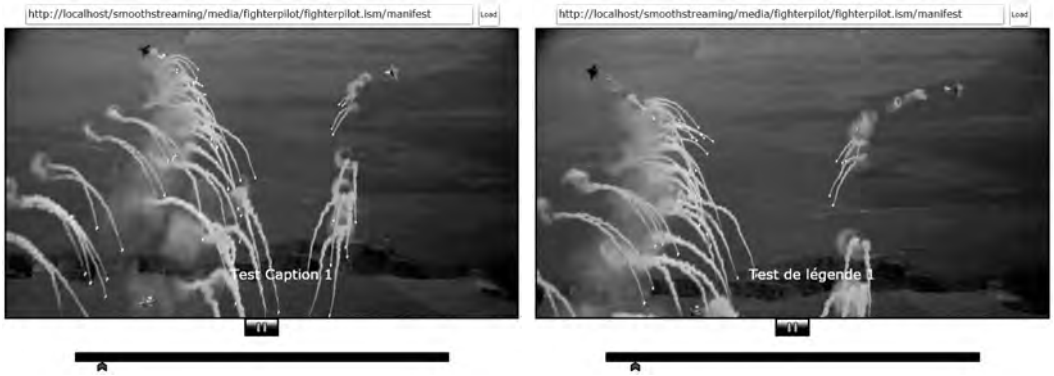


Figure 11-12. *Locale specific captions using merged manifests*

11-5. Scheduling Additional Clips

Problem

You want to schedule playback of additional video clips interspersed with portions of smooth streaming presentation.

Solution

You can use the clip scheduling facility provided by the SSME to achieve this.

How It Works

You may face the need to insert additional video clips into a presentation at specific time points. Advertisement videos, breaking news, or filler clips in a presentation are just a few examples of this scenario. The problem can be viewed in two parts: first, acquiring the necessary content data and determining where in the timeline to insert it; and second, actually scheduling and playing the clips.

The first problem can be tackled in the same way as outlined in the previous recipes in this chapter: by injecting some metadata in a text track in the client manifest describing information such as the clip's URI and the timing information of when to start displaying the clip.

To handle the second part of the problem, the SSME exposes some clip scheduling APIs. The `ClipInformation` type is used to encapsulate information about a clip that you want to schedule; the `ClipInformation.ClipUrl` property can be set to the address of the clip media; the `Duration` property specifies the duration which you want the clip to play for (can be less than the total duration of the clip itself); the `IsSmoothStreamingSource` bool property indicates if the clip itself is a smooth stream; and the `ClickThroughUrl` represents a web address that you want to navigate to in response to the viewer clicking on the clip.

To schedule a clip, you need to create a new instance of `ClipInformation`, populate the property values, and pass the instance to the `ScheduleClip()` method on the SSME as its first parameter. Below is the signature of the `ScheduleClip()` method:

```
public ClipContext ScheduleClip(ClipInformation clipInfo,
      TimeSpan startTime, bool pauseTimeline, object userData)
```

The `startTime` parameter accepts the time when the clip is scheduled to start, and the `pauseTimeline` parameter accepts a `bool` indicating whether the original presentation timeline should be paused during the clip playback (causing the `Position` property on the SSME to freeze while the clip is playing). The last parameter `userData` accepts any additional data as an object, and `ScheduleClip` returns an instance of the `ClipContext` type. You will see the use of the return value and the last parameter in a little bit.

If you have multiple clips to schedule, you can enumerate through all your clip data and use the above approach to schedule them at specific time points within your overall presentation. Sometimes, however, clips need to be scheduled in a sequence where start timing information is only applied to the first clip in a sequence and subsequent clips are chained so that all the scheduled clips play out in one continuous sequence. The `ScheduleClip()` method facilitates this feature as well through an overload whose signature is shown below:

```
public ClipContext ScheduleClip(ClipInformation clipInfo,
      ClipContext clipToAppendTo, bool pauseTimeline, object userData)
```

Recall the `ClipContext` value returned when you call the previously shown overload of `ScheduleClip()`. You can subsequently call the second overload of `ScheduleClip()` for all the other clips to be scheduled, passing in the `ClipContext` instance returned from the previous call as the `clipToAppendto` parameter. This causes the clips to be chained together to play out sequentially. The `ClipContext.Data` property passes in any data passed in through the `userData` property in the previous call, as well as the `ClipInformation` property contains the previously scheduled clip.

Lastly, there is an overload of `ScheduleClip()` that accepts neither a `ClipContext` nor a start time, in which case the clip gets scheduled to play back immediately.

There are also several events of interest raised by the SSME around clip playback. The `ClipError` event is raised if there is an error in playing a clip, while the `ClipStateChanged` reports a change of state for a specific clip. The `ClipContext.CurrentClipState` gives you the clip's current state defined as one of the values in the `MediaElementState` enumeration.

The `ClipClickThrough` event is raised when the viewer clicks on a clip while viewing it. If click-through destination was intended for this clip, `ClipEventArgs.ClipContext.ClipInformation.ClickThroughUrl` exposes it, and you can use a technique of your choice (like interacting with the browser to open a pop-up window) to open up the Web resource targeted by the click-through URL.

The `ClipProgressUpdate` event can be handled to track the progress of the clip. `ClipPlaybackEventArgs.Progress` is of the enumeration type `ClipProgress`, which represents the clip's progress in quartiles. The `ClipProgressUpdate` event is only raised at the start and end of the clip and at time points denoting 25, 50, and 75 percent of the clip's duration. Note that the `ClipContext.HasQuartileEvents` `boolean` property indicates if the quartile events will be raised for a clip. In certain cases, like when the duration of a clip is not known, quartile progress events may not be raised.

The Code

The code sample shows how to use schedule clips both in the chaining fashion as well as with each clip being scheduled independently. To provide the clip metadata to your application, you continue to use the same approach of injecting the clip metadata as a text stream into your client manifest. Listing 11-14 shows a portion of the data source file used to define the clip metadata.

Listing 11-14. *Clip metadata data source*

```
<ContentTrack Name="AdClips" Subtype="DATA">
  <Event time="00:00:04">
    <![CDATA[<Clip Id="{89F92331-8501-41ac-B78A-F83F6DD4CB40}"
  Uri="http://localhost/SmoothStreaming/Media/Robotica/Robotica_1080.ism/manifest"
    ClickThruUri="http://msdn.microsoft.com/en-us/robotics/default.aspx"
    Duration="00:00:20" />]]>
  </Event>
  <Event time="00:00:10">
    <![CDATA[<Clip Id="{3E5169F0-A08A-4c31-BBAD-5ED51C2BAD21}"
    Uri="http://localhost/ProgDownload/Amazon_1080.wmv"
    ClickThruUri="http://en.wikipedia.org/wiki/Amazon_Rainforest"
    Duration="00:00:25"/>]]>
  </Event>
</ContentTrack>
```

For each clip to be scheduled, there is a URI for the content, a URI for a Web page that the user can navigate to as a click through on the clip, and the playback duration for the clip. The time attribute on the Event element specifies where in the timeline the clip is scheduled.

You can transform this data and add the corresponding text stream into the client manifest, using the same approach of a LINQ to XML query as outlined in Recipe 11-3. As before, the text stream is exposed to the code as a `StreamInfo` instance. You can then use the clip scheduling API on the SSME to utilize this information to schedule these clips. Listing 11-15 shows a method that schedules clips based on this information.

Listing 11-15. *Scheduling clips at absolute time points*

```
private void ScheduleClips()
{
  //get the clip data stream
  StreamInfo siAdClips = ssme.AvailableStreams.
    Where(si => si.Name.ToLower() == "adclips").FirstOrDefault();

  //if we have tracks
  if (siAdClips != null && siAdClips.AvailableTracks.Count > 0)
  {
    //for each event in that track
    foreach (TimelineEvent te in siAdClips.AvailableTracks[0].TrackData)
    {
      //parse the inner XML fragment
      XElement xeClipData = XElement.Parse(
        Encoding.UTF8.GetString(te.EventData, 0, te.EventData.Length));

      //schedule the clip
      ssme.ScheduleClip(
          new ClipInformation
```

```
          {
            ClickThroughUrl =
              new Uri(xeClipData.Attribute("ClickThruUri").Value),
            ClipUrl =
              new Uri(xeClipData.Attribute("Uri").Value),
            IsSmoothStreamingSource =
              xeClipData.Attribute("Uri").Value.ToUpper().Contains("ism"),
            Duration =
              TimeSpan.Parse(xeClipData.Attribute("Duration").Value)
          },
          te.EventTime,
          true, //pause the timeline
          null);
    }
  }
}
```

Listing 11-16 shows the same clip metadata being used, but this time to schedule the clips in a chained fashion using the `ClipContent` value to pass information from one schedule addition to the next one.

Listing 11-16. *Chained clip scheduling using ClipContext*

```
private void ScheduleClips()
{
  StreamInfo siAdClips = ssme.AvailableStreams.
    Where(si => si.Name.ToLower() == "adclips").
      FirstOrDefault();

  //if we have tracks
  if (siAdClips != null && siAdClips.AvailableTracks.Count > 0)
  {
    ClipContext clipCtx = null;
    foreach (TimelineEvent te in siAdClips.AvailableTracks[0].TrackData)
    {
      XElement xeClipData = XElement.Parse(
        Encoding.UTF8.GetString(te.EventData, 0,te.EventData.Length));

      //if this is the first clip to be scheduled
      if (clipCtx == null)
      {
        clipCtx = ssme.ScheduleClip(
            new ClipInformation
            {
              ClickThroughUrl =
                new Uri(xeClipData.Attribute("ClickThruUri").Value),
```

```
            ClipUrl =
              new Uri(xeClipData.Attribute("Uri").Value),
            IsSmoothStreamingSource =
              xeClipData.Attribute("Uri").Value.ToUpper().Contains("ISM"),
            Duration =
              TimeSpan.Parse(xeClipData.Attribute("Duration").Value)
          },
          te.EventTime, //pass in the start time for the clip
          true,
          null);
      }
      else //subsequent clips
      {
        clipCtx = ssme.ScheduleClip(
          new ClipInformation
          {
            ClickThroughUrl =
              new Uri(xeClipData.Attribute("ClickThruUri").Value),
            ClipUrl =
              new Uri(xeClipData.Attribute("Uri").Value),
            IsSmoothStreamingSource =
              xeClipData.Attribute("Uri").Value.ToUpper().Contains("ISM"),
            Duration = TimeSpan.Parse(xeClipData.Attribute("Duration").Value)
          },
         //pass in the clip context for the previous scheduled clip to chain
          clipCtx,
          true,
          null);
      }
    }
  }
}
```

You only use an absolute time to schedule the first clip when there is no `ClipContext` (in other words, the `clipCtx` variable is null). Each subsequent call to `ScheduleClip()` accepts the `ClipContext` instance returned from the previous call to `ScheduleClip()` instead of a scheduled start time for a clip, and this schedules the clip to start right after the previously scheduled clip (represented by the passed-in `ClipContext`).

11-6. Varying Playback Speeds

Problem

You want to rewind, fast forward, or play a smooth streaming presentation at different speeds.

Solution

Use the variable playback rate feature on the SSME to control the speed of rewind, fast forward, or playback.

How It Works

Variable playback speed involves playing back the frames at a frame rate which is some multiple of the normal frame rate of the video. If you are displaying a video stream that has a normal frame rate of 24 frames per second, a 2x playback would be playing the video in forward direction at 48 frames per second, while a -2x playback would be playing the video backwards at the same rate. So, effectively the first option is a fast forward, while the latter is a rewind.

The SSME supports playing content at varying speeds and direction. The `SmoothStreamingMediaElement.SupportedPlaybackRates` property returns a list of supported playback speeds as double values, where 1.0 denotes the default playback speed. In the current public beta, this list contains the additional values of 0.5, 4.0, 8.0, -4.0 and -8.0. The positive values enable playback at half, 4x, and 8x speeds, and the negative values enable reverse play (rewind) at 4x and 8x speeds.

The `SmoothStreamingMediaElement.SetPlaybackRate()` method can be called to set the playback speed at any point during playback. `SetPlaybackRate()` accepts the desired playback speed as its only parameter.

Note that controlling playback speed only works for Smooth Streaming content, so if you are using SSME to play content that is being progressively downloaded or streamed using some other technique, `SetPlaybackRate()` will raise an exception.

■ **Note** While a lot of players try to simulate variable playback speeds or actions like rewind and fast forward using the seek feature, that is not the right approach. If you are using seek (the Silverlight equivalent of which would be changing the `Position` property value on the `MediaElement` or the SSME), you are essentially skipping frames of content, as opposed to displaying the frames at a faster rate. Furthermore, there is no way to approximate a slower-than-normal playback rate using a seek-based approximation mechanism.

The Code

Due to the simplicity of this API, involving a single method call to change the playback rate, we do not supply a full code sample.

11-7. Combining Streams Using Composite Manifests

Problem

You want to combine sections from multiple smooth streaming presentations into one single presentation.

Solution

You can use the composite manifest feature of the SSME to achive this.

How It Works

You may encounter the need to combine portions from multiple Smooth Streaming presentations into a single composite presentation. You might have done this by using a rough-cut editor to specify mark-in and mark-out time points in a master source to produce a clips, and then had several such clips from different master sources play in a linear fashion as a single presentation.

The composite manifest feature of SSME allows you accomplish this by creating a separate manifest document that contains clip segments, where each clip segment defines a portion of a complete presentation bounded by begin and end time points of the clip. The biggest benefit of using this approach is the ability to create different edits on existing presentations without the need to transcode the source material.

A composite manifest always ends with the extension .csm. To consume such a manifest, you simply set the `SmoothStreamingSource` property to a valid URL pointing to a composite manifest file:

```
ssme.SmoothStreamingSource = new
Uri("http://localhost/SmoothStreaming/Media/MyCompositeSample.csm");
```

Listing 11-17 shows an excerpt from a composite manifest. (The entire file is included in the sample code download for this recipe.)

Listing 11-17. *Sample composite manifest*

```
<SmoothStreamingMedia MajorVersion="2" MinorVersion="0" Duration="269000000">
  <Clip
    Url=
    "http://localhost/SmoothStreaming/Media/Amazing_Caves_1080.ism/manifest"
    ClipBegin="81000000" ClipEnd="250000000">
    <StreamIndex Type="video" Chunks="9" QualityLevels="3"
      MaxWidth="992" MaxHeight="560"
      DisplayWidth="992" DisplayHeight="560"
      Url="QualityLevels({bitrate})/Fragments(video={start time})">
      <QualityLevel Index="0" Bitrate="2056000" FourCC="WVC1"
        MaxWidth="992" MaxHeight="560"
        CodecPrivateData=
        "250000010FD37E1EF1178A1EF845E8049081BEBE7D7CC00000010E5A67F840"/>
      <QualityLevel Index="1" Bitrate="1427000" FourCC="WVC1"
        MaxWidth="768" MaxHeight="432"
        CodecPrivateData=
        "250000010FCB6C17F0D78A17F835E8049081AB8BD718400000010E5A67F840"/>
      <QualityLevel Index="2" Bitrate="991000" FourCC="WVC1"
        MaxWidth="592" MaxHeight="332"
        CodecPrivateData=
        "250000010FCB5E1270A58A127829680490811E3DF8F8400000010E5A67F840"/>
      <c t="80130000" />
```

```
      <c t="100150000" />
      <c t="120170000" />
      <c t="140190000" />
      <c t="160210000" />
      <c t="180230000" />
      <c t="200250000" />
      <c t="220270000" />
      <c t="240290000" d="20020000" />
    </StreamIndex>
    <StreamIndex Type="audio" Index="0" FourCC="WMAP"
      Chunks="10" QualityLevels="1"
      Url="QualityLevels({bitrate})/Fragments(audio={start time})">
      <QualityLevel Bitrate="64000" SamplingRate="44100"
        Channels="2" BitsPerSample="16" PacketSize="2973"
        AudioTag="354"
        CodecPrivateData="1000030000000000000000000000E00042C0" />
      <c t="63506576" />
      <c t="81734240" />
      <c t="102632199" />
      <c t="121672562" />
      <c t="142106122" />
      <c t="162075283" />
      <c t="181580045" />
      <c t="202478004" />
      <c t="222447165" />
      <c t="241313378" d="20143311" />
    </StreamIndex>
  </Clip>
  <Clip
    Url=
  "http://localhost/SmoothStreaming/Media/Coral_Reef_Adventure_1080.ism/manifest"
    ClipBegin="102000000" ClipEnd="202000000">
    <StreamIndex Type="video" Chunks="6" QualityLevels="3"
      MaxWidth="992" MaxHeight="560"
      DisplayWidth="992" DisplayHeight="560"
      Url="QualityLevels({bitrate})/Fragments(video={start time})">
      ...
    </Clip>
</SmoothStreamingMedia>
```

The composite manifest shown in Listing 11-16 contains two `Clip` elements, each defining a clip (also called an edit) from an existing Smooth Streaming presentation. The `Url` attribute points to an existing Smooth Streaming presentation, and the `ClipBegin` and `ClipEnd` attributes contain the beginning and ending time values that provide the bounds to the clip. The `Duration` attribute on the top level `SmoothStreamingMedia` element needs to be the exact sum of the durations of each clip in the

manifest. You can sum the difference of the `ClipEnd` and `ClipBegin` values of each `Clip` entry to get the total manifest duration.

Each `Clip` element contains the video and the audio `StreamIndex` and their child `QualityLevel` entries, mirroring the client manifest (.ismc) files of the source presentations. The chunk metadata (`c`) entries for each `StreamIndex` entry, however, can be limited to only those chunks that are required to satisfy the `ClipBegin` and `ClipEnd` boundaries. In other words, the `ClipBegin` value needs to be greater than or equal to the start time (`t` attribute) value of the first `c` entry for the stream, and the `ClipEnd` value needs to be less than or equal to the sum of the start time and the duration (`d` attribute) values of the last `c` entry for that stream.

Note that in your client manifest, chunks may be defined in an indexed (`n` attribute) fashion with durations specified. However, for the composite manifest, the chunks need to be defined using their start times (which can be easily calculated by summing the durations of the preceding chunks). Also note that the `Chunks` attribute on each `StreamIndex` entry needs to reflect the number of chunks in the clip, but all the other attributes mirrors the entries in the source client manifest.

■ **Note** Creating composite manifests by hand is an onerous task at best. The best way to build a composite presentation is to use some sort of rough cutting tool (or build one yourself) that allows the user to visually provide the mark-in and mark-out points of each constituent smooth streaming client manifest making up the composite. A full treatment of how to build such a tool is beyond the scope of this book, but with smooth streaming getting the attention that it is now, you can expect to see major rough cut editors supporting this scenario very soon.

The Code

We include a working composite manifest as a part of the sample code download. You just need to provide the constituent smooth streams, and you should be able to test the composite using the player built in Recipe 11-2 by supplying the URL to the composite manifest as opposed to a client manifest in the textbox shown in Figure 11-10.

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