"This book doesn't just focus on singular concepts, it also provides end-to-end perspective on building an app in WinRT. It is one of those essential tools for Windows developers that will help you complete your software goals sooner than without it!"

—**Tim Heuer,** Principal Program Manager Lead, XAML Platform, Microsoft Corporation

Programming the Windows® Runtime by Example

A Comprehensive Guide to WinRT with Examples in C# and XAML

Microsoft Windows Development Series

Jeremy **Likness**
John **Garland**

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Know how.

Praise for
Programming the Windows Runtime by Example

“This is a great from-the-ground-up, very complete book on building Windows Store Apps. You’ll find it on your desk a year from now all dog-eared and marked up from use.”

Dave Campbell, MVP, WindowsDevNews.com

“*Programming with Windows Runtime by Example* is a must-have book for any professional developer building apps for WinRT/Win8.1, especially in the LOB space for modern apps on Windows 8.1. For me it is the reference I provide my team building LOB applications for WinRT. Jeremy and John have done a great job putting together a great reference and educational book on professional development for the WinRT platform.”

David J. Kelley, CTO, Microsoft MVP

“Jeremy and John are both very much IT masters from the old guard of software development. With countless years of bending, shaping, and influencing the world of software development behind them both, they continue to do so as they push forward into new and emerging technologies.

“As with everything they do, this book also reflects their ongoing dedication and passion for their quest to bring the reader not only the information he or she requires, but far more beyond that, they build knowledge step-by–step, then deliver it to the reader with cutting-edge, ninja-like precision to deliver exactly what knowledge is needed, when it’s needed, and where it’s needed.

“If you want to learn the Windows Runtime, then I can think of no finer book, and no finer guides to the WinRT landscape. By the end of this book, you’ll have the knowledge, the power, and a hefty dose of passion to go out into the new millennium and create some of the best WinRT apps available.”

Peter “Shawty” Shaw, LinkedIn .NET User Group manager

“This book is an invaluable resource for budding WinRT developers. It covers the basics to more advanced topics like MVVM. Readers will find the chapter entitled ‘Connecting to the Cloud’ especially useful in getting up to speed with Azure and creating cloud connected apps.”

Daniel Vaughan, President of Outcoder, Microsoft MVP,
Author of *Windows Phone 8 Unleashed*

“There are books that provide reference for a development topic, and others that you will read from cover to end. *Programming the Windows Runtime by Example* by Jeremy Likness and John Garland should be your go-to guide for getting up to speed on WinRT. Jeremy and John wrote this book with the intention of being easy to follow and hard to forget, and they succeeded in both areas. I recommend this book for all developers, whether new to WinRT development, or those like me who just want to fill in the gaps on advanced topics.”

Chris Woodruff, DeepFriedBytes.com, Microsoft MVP

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– CHRIS SELLS, Independent Consultant specializing in Windows, devices, and the cloud

Programming the Windows Runtime by Example

A Comprehensive Guide to WinRT with Examples in C# and XAML

■ Jeremy Likness
■ John Garland

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Library of Congress Control Number: 2013954295

ISBN-13: 978-0-321-92797-2
ISBN-10: 0-321-92797-4

Text printed in the United States on recycled paper at Edwards Brothers Malloy, Lillington, North Carolina

First printing, June 2014

For Doreen and all her arrows, Lizzie and all her travels,
and Gordon and all his paint.
—Jeremy Likness

To Karen, Callie, Winnie, and Dude,
for the new adventure that is soon to begin.
—John Garland

Contents at a Glance

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Foreword

The concept of an app has changed dramatically over time, and more increasingly so in the past eight years. The approachability for the masses to have super computers in their pockets has led to the rapid adoption of mobile apps at the fingertips of every user—not just those in cubicles all day long. You can't sit in public transit, walk down a street, or even enjoy a nice meal without looking around and seeing the glow from a screen of some sort on someone's face. Everyone is a part of the app ecosystem now. Whether it is a mobile phone, music device, e-reader, watch, or even glasses, apps are a part of our lives. People desire them to make their lives and jobs more productive or just to have fun. As a software developer, it is hard to ignore this surge in opportunity and the desire to capitalize on this ecosystem.

Microsoft technologies present a large opportunity to software developers to reach a vast ecosystem of traditional users who have used Windows technologies in their personal, educational, and professional lives. These users seek out new ways to accomplish tasks and have fun on their technology devices. Microsoft has computing devices across the various screens presented in our lives in our hands, on our desks, and in our living rooms. All these represent opportunities for you, the developer, to extend your reach and ideas into the world.

As this evolution of mobility, multiple screens, and wearables has increased, so has technology. Microsoft technologies have evolved as well on the client app areas. Over time Microsoft has delivered various ways to write client applications through standard C++, MFC, Windows Forms, Windows Presentation Foundation (WPF), Silverlight, and HTML. Putting developers on a better path for development, Microsoft introduced the Windows Runtime (WinRT). This technology and principles enable developers to have a single platform to target that extends their potential across the personal, professional, and entertainment endpoints we have in our lives. WinRT enables developers to choose how they can be most productive using their skills in C++, C#, Visual Basic, or JavaScript. Alongside the language of choice, developers have a native UI framework in XAML they can use for the best client app experience on Windows. XAML is everywhere now in Windows, from system shell UI to system apps to key experiences delivered from Microsoft, such as Microsoft Office. When developing an app in C# and XAML, you'll be joining other successful developers in the world and can tap into that ecosystem of knowledge, experience, and examples.

Software is an art. Just like any art project, approaching software development requires thought into the necessary tools, philosophies, and principles you will use to create your app. I still remember one of my earliest "professional" software development jobs, sitting in a meeting listening to the customer describe all these (what was at the time) high-tech requirements of their app, all needing to be done in Internet Explorer 3. I scribbled notes as fast as I could while my dev lead at the time, all too quickly I thought, was busy nodding his head in acceptance of the requirements. As we walked out of the meeting, I expressed my concern about the requirements and available technology at the time. He smiled and shrugged like it was no problem stating, "No worries Tim, we just need the right tools."

One of the key tools is a good guide and mentor. In my early days, for me that was books just like this one you have now. To this day I still prefer books on my shelf when learning new technology concepts. I've had the pleasure of working with Jeremy Likeness over the years in the XAML ecosystem, and I can attest to his expertise in building real-world apps using these technologies. In *Programming the Windows Runtime by Example*, Jeremy and John provide these key tools for any software developer to understand the fundamentals of the Windows Runtime and XAML, and be successful quickly. This book doesn't try to only focus on singular concepts but also provides an end-to-end perspective on building an app in WinRT. Jeremy and John know that your scenarios are connected ones and deal with web services, data, security, and integration. The book will walk you through understanding how the pieces fit together in WinRT while still providing you the knowledge and tools to be productive at the core concepts of working with C# and XAML in the Windows Runtime. John and Jeremy describe philosophies and different approaches to using WinRT, empowering you with knowledge to make the best decisions for your app. This knowledge will enable you to write the best apps for Windows, Windows Phone, Xbox, and whatever future Microsoft has in store for WinRT areas.

Like any artist, tools are essential. This book is one of those essential tools for Windows developers and will help you complete your software goals sooner than without it! To this day, my bookshelf is filled with books just like this one that I refer to often. Even as your experience grows, you'll find yourself referring back to this book for knowledge when developing, just like I did.

—**Tim Heuer**, Principal Program Manager Lead, XAML Platform, Microsoft Corporation

Preface

In 2011 I heard the first rumors about Windows 8 and knew immediately what my next book would be about. Unlike *Designing Silverlight Business Applications* that captured years of experience writing Line of Business (LOB) apps in Silverlight, this book would be an introduction to an entirely new platform. My goal was to take what I knew and loved about Silverlight, find its similarities in the new platform, and then highlight what I felt were some amazing developer experiences. It was important to get to market fast, so through several iterations of the Windows 8 releases (including changes to terminology) that required substantial rewrites of content and a rapid release cycle, I managed to release *Building Windows 8 Apps with C# and XAML* as Windows 8 was revealed to the world.

By necessity, this book introduced developers to the new platform but didn't dig into best practices (there were none yet) or get very deep (there simply wasn't time). I vowed to release another book that would fill in the missing pieces and provide a comprehensive overview of the entire Windows Runtime. Because anyone can read the documentation and reference the API, my intent with this book was to make it example-driven and provide thousands of lines of code for you to integrate and use to kick-start your own Windows Store apps.

I was relieved at the thought of not rewriting most of the book three times, as I had to do with the first one, but Microsoft once again proved too fast for me. What sounded at first like a relatively minor release (Windows

8.1) managed to integrate enough changes to warrant revisiting every one of the ten chapters I had completed to date. With an eye on //BUILD in 2014, I reached out to Windows Store expert and Wintellect colleague John Garland to help me finish the remaining chapters. John and I have worked on several projects together (and incidentally two of them won awards for their groundbreaking use of XAML for touch and mobile), and he helped write pilot code for several of our customers who were early Windows 8 adopters, so I knew he was the right person to bring a fresh set of example projects and content-rich chapters. As a bonus, he is also well-versed in cloud technology and brought this firsthand knowledge to bear in the chapters that deal with connecting to Azure.

In Windows 8.1 and the Windows Runtime, Microsoft has successfully demonstrated their commitment to the development ecosystem by providing us with a rich, vast array of APIs, SDKs, and tools for building incredible apps that run on a variety of devices. I was absolutely amazed when I discovered how easy it was to connect to a web cam, open a web socket, download files in the background, or profile my app to find "hot spots" that I could target to improve performance using WinRT. I was delighted to find that Portable Class Libraries (PCL), something I evangelized heavy as a solution to target multiple platforms in the Silverlight and WPF days, was evolving to embrace Windows Store apps. The first-class support for mature design patterns like MVVM makes it easier than ever to write stable, reusable code that runs on a variety of target devices.

In *Building Windows 8 Apps with C# and XAML,* I shared my intent to guide you through the process of learning the new territory quickly to begin building amazing new applications using skills you already had with C# and XAML. In this book, it is our goal to take you beyond that initial exposure and help you dive deep into all the various APIs WinRT makes available. Our goal was to hit virtually any scenario possible using the Windows Runtime—not just provide code snippets, but full projects you can use to experiment, learn, and use as a starting point for your own apps. The most rewarding feedback I received from my first book was hearing from authors sharing with me their excitement having their first Windows 8 apps approved for the Store. I hope this book not only helps take those apps to the next level, nor simply inspires your imagination, but empowers you to implement solutions you only dreamed possible using this incredible new platform. I know I speak for both John and myself when I say we look forward to hearing back from you about what you were able to achieve with Visual Studio, Windows 8.1, and this reference on your desk.

What This Book Is About

The purpose of this book is to explain how to write applications—mainly Windows Store apps—that are based on the Windows Runtime. The intent is to explore every available API, exposing you to possibilities across all areas and diving deep into major areas that are likely common to most apps that will be built. Instead of a traditional reference guide that shares API details and code snippets, this book includes more than 80 sample projects. These projects provide a "by example" approach to learning the various APIs; and the text either walks through how they were built, or breaks apart the code step-by-step to make it easy to understand and use as a template for your own projects.

This book is not an introduction to Windows 8.1. We assume you have some experience working with C# and XAML and are familiar with Windows Store apps. We also assume that you are at least familiar with the concept of design patterns and the notion of decoupled code. Both of these ideas have been core to the success of the applications we've helped build and will be used as foundations for the concepts presented in this book.

Whether you're a Windows 8.1 developer looking to improve an existing app, or an experienced client technologies developer transitioning to the Windows Runtime for the first time, this book will give you the guidance, proven patterns and practices, and example projects you'll need to build functional apps that run well across the myriad Windows 8.1 devices.

This version of the book specifically addresses Windows 8.1 using Visual Studio 2013. At this writing, the Windows 8.1 Update was announced at //BUILD, but fortunately the changes did not impact development as much as use of the OS and deployment options. During the course of this book, several changes have occurred that may not be reflected throughout: Visual Studio 2013 Update 2 was released, the name SkyDrive was changed to OneDrive, Windows Azure became Microsoft Azure, and Azure Mobile Services are constantly being revised.

Where to Access the Source Code

The source code for this book is open source and will be maintained and updated as needed to match any future revisions that may come out. You can download the code samples from the companion website: winrtexamples.codeplex.com.

How to Use This Book

The aim of this book is to enable you to discover the appropriate APIs to build your Windows Store apps. Each chapter is designed to help you discover what features are available in that area of the framework and how they are applied through example projects. Code examples are provided that demonstrate the features for programming them using C# and XAML. Although different chapters may relate to various parts of a comprehensive project, the individual samples are designed to stand on their own.

Each chapter is similarly structured. The chapters begin with an introduction to a topic and an inventory of the capabilities that topic provides. This is followed by explanations of areas of the framework and runtime and a walkthrough of the target APIs. The code samples are explained in detail, either as a walkthrough "lab" or by analyzing the existing sample, and the topic is summarized to highlight the specific information that is most important for you to consider.

I suggest you start by reading the book from start to finish, regardless of your existing situation. Inexperienced developers will find their understanding grows as they read each chapter and concepts are introduced, reinforced, and tied together. Experienced developers will gain insights into areas they might not have considered or had to deal with in the past, or simply didn't factor into their software lifecycles. Once you've read the book in its entirety, you will then be able to keep it as a reference guide and refer to specific chapters any time you require clarification about a particular topic.

Acknowledgments

Jeremy Likness: Although this is my third book through Pearson and fourth full book I've authored, writing a good book still depends on a solid team. I continue to be grateful for my superhuman Editor, Joan Murray, who has been patient and understanding, encouraging, and continuously provided her support and guidance throughout the process. Once again, Eleanor Bru braved working with me on this very ambitious project and, like Joan, was very patient and understanding while keeping me honest and on target. I can't thank Lori Lyons and the production team (including Krista Hansing and Debbie Williams) enough for taking my rambling and helping turn it into coherent prose.

The content of this book was amazingly enriched by our thorough and passionate technical editors. Thank you, Harry Pierson and Christophe Nasarre, for your incredible attention to detail. If anything was missed, I'll take the blame because Harry and Christophe ran every example, pored over every word, and provided me with volumes of suggestions and feedback that helped shape the book to its present form. It is always a pleasure to work with technical editors who bring strong technical insights to the table and help keep me honest when I want to take a shortcut and leave a thread spinning where it shouldn't.

Many thanks to my boss and friend, Steve Porter, for letting me devote a large chunk of my time to a project that made me disappear for a few hours every day. Thanks to Barbara Keihm for her support and encouragement, to Todd Fine for always recognizing our hard work and being one of the first to pre-order copies whenever they are available, and Bethany Vananda and Sara Faatz for working tirelessly to help spread the word and share what we're doing.

A special note goes to Dave Baskin, Dave Black, Josh Carroll, Aaron Carta, Phil Denoncourt, Dave Frommer, James Katic, Edward Kim, Wes McCammon, and Dan Sloan. This team worked with me on a major project that has lasted longer than the writing of this book and always understood when I had to turn down dinner or other outings so I could get back to my hotel and write. OK, who am I kidding—sometimes I managed to break away.

My wife and daughter have waited patiently through several books now, so they know the routine. Doreen is always quick to remind me when I need to push away from the dinner table and get back to writing, but Lizzie always noticed when I'd been writing too much and was always ready to have a movie date so I could unwind.

Finally, last but certainly not least, thank you! I appreciate my readers—and of course it is for you this was written—so it is my sincere hope you receive tremendous value from these pages.

John Garland: Like Jeremy, I'd very much like to thank Joan Murray, Eleanor Bru, and Lori Lyons, as well as everyone else at Pearson for their unwavering help and guidance throughout this project. Many thanks go to Harry Pierson and Christophe Nasarre for their invaluable help and insight throughout the technical review process—especially for helping to me find the right mix of code and prose, which invariably was along the lines of less prose and more code.

I'd like to very much thank my friends and colleagues at Wintellect. It is truly a privilege for me to count myself in your company and your passion for your craft is absolutely contagious. Many thanks to Steve Porter and Todd Fine for the continued opportunity, and to Bethany Vananda for all the help in putting my work in the best possible light. Much gratitude is owed to Jeff Richter, Jeff Prosise, and John Robbins for their insights into the writing process and for providing the Wintellect stage that I am fortunate to be able to stand on.

Families often have to take a back seat when these projects are in high gear, and mine was no exception. My wife Karen has been more than understanding and forgiving of many late nights, lost weekends, and grumpy mornings. My daughter Callie continues to be a walking smile that forces me to keep things in perspective, despite our having had to skip a few of our priceless Daddy-Callie days. Now that the book is done and the snow has melted, we can get back to bike rides, games of tag, and swing-pushes in the backyard.

I owe many thanks to the folks on and involved with the Zumo (Azure Mobile Services) team, including Kirill Gavrylyuk, Yavor Georgiev, Merwan Hade, and Heinrich Nielsen, among several others. Your insights into the Mobile Services inner workings, and prompt and helpful replies to my inquiries, have been invaluable both for the content included in this book as well as in my professional endeavors.

Finally, I'd like to thank Jeremy for asking me to come along not only on this ride as his co-author, but also as a technical editor on two of his previous books. The experiences, insights, and most importantly, the friendship, have been both personally and professionally invaluable.

About the Authors

Jeremy Likness is a multi-year Microsoft MVP for XAML technologies. A Principal Consultant for Wintellect with 20 years of experience developing enterprise applications, he has worked with software in multiple verticals ranging from insurance, health and wellness, supply chain management, and mobility. His primary focus for the past decade has been building highly scalable web-based solutions using the Microsoft technology stack with client stacks ranging from WPF, Silverlight, and Windows 8.1 to HTML5 and JavaScript. Jeremy has been building enterprise line of business applications with Silverlight since version 2.0, and he started writing Windows 8 apps when the Consumer Preview was released in 2011.

Prior to Wintellect, Jeremy was Director of Information Technology and served as development manager and architect for AirWatch, where he helped the company grow and solidify its position as one of the leading wireless technology solution providers in the United States prior to their acquisition by VMware. A fluent Spanish speaker, Jeremy served as Director of Information Technology for HolaDoctor (formerly Dr. Tango), where he architected a multilingual content management system for the company's Hispanic-focused online diet program. Jeremy accepted his role there after serving as Development Manager for Manhattan Associates, an Atlanta-based software company that provides supply chain management solutions.

John Garland is a Principal Consultant for Wintellect with more than 15 years of experience developing software solutions. Prior to consulting, he spent much of his career working on high-performance video and statistical analysis tools for premier sports teams, with an emphasis on the NFL, the NBA, and Division 1 NCAA football and basketball. His consulting clients range from small businesses to Fortune-500 companies, and his work has been featured at Microsoft conference keynotes and sessions.

John is a Microsoft Client Development MVP, as well as a member of the Windows Azure Insiders and Windows Azure Mobile Services Advisory Board. He lives in New Hampshire with his wife and daughter, where he is an active speaker and participant in the New England software development community. He is a graduate of the University of Florida with a Bachelor's degree in Computer Engineering and holds Microsoft Certifications spanning Windows, Silverlight, Windows Phone, and Windows Azure. John is the author of the ebook *Windows Store Apps Succinctly* (Syncfusion, 2013).

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Networking

Network connectivity is a major feature of most Windows Store apps, as you learned in previous chapters. Although you have learned how to connect to services and keep your content fresh, Windows 8.1 devices are capable of connecting to the Internet and other devices in myriad ways. In this chapter, you learn some of these more advanced methods and how to integrate them into your own apps.

In addition to supporting the HTTP protocols, WinRT provides APIs that make it easy to enumerate resources on your HomeGroup network. You can enumerate network information and obtain the current data plan so that your app can modify its behavior to avoid downloading large amounts of data over a metered connection. The sockets APIs enable low-level communications using traditional UDP and TCP protocols, as well as the newer HTML5 WebSockets protocol. The proximity APIs enable communications between peer devices using Near Field Communications (NFC) and Wi-Fi Direct. Finally, the background transfer API allows your app to effectively manage long-running data transfers even when the app itself is not running.

Web and HTTP

In Chapter 5, “Web Services and Syndication,” you learned how to use the `HttpClient` class to connect to an HTTP server and retrieve content using the REST architecture. The `Windows.Web.Http` namespace contains several classes that you can use to connect with HTTP-based services. The `HttpClient` class represents a simple and easy-to-use interface for sending HTTP-related requests and retrieving responses. Other classes provide more advanced features and fine-grained control over interactions.

To provide more control over HTTP requests, use the `HttpRequestMessage` class. For example, the following requests content from my blog:

```
var client = new HttpClient();
var httpResponse = await client.GetAsync(new Uri(
    "http://csharperimage.jeremylikness.com/", UriKind.Absolute));
```

If you want more control over the type of request and process the request immediately after the headers have been read (instead of having to wait for the entire body), you can issue the request like this instead:

```
var client = new HttpClient();
var request = new HttpRequestMessage(
    HttpMethod.Get, new Uri("http://csharperimage.jeremylikness.
                             com"));
var response = await client.SendRequestAsync(request,
    HttpCompletionOption.ResponseHeadersRead);
```

Using the latter method also gives you more control over the response. You can create a cancellation token and convert the response to a `Task` that uses the token:

```
this.cancellation = new CancellationTokenSource();
var response = await client.SendRequestAsync(
    request, HttpCompletionOption.ResponseHeadersRead)
    .AsTask(cancellation.Token);
```

When the page takes a significant time to load, from either a slow network or a large amount of information, you can cancel the load automatically or through user input by calling the cancel method on the cancellation token. You see an example of this in the `CancelUrl` method of the `ViewModel` class in the **AdvancedHttpExample** project:

```
cts.Cancel();
cts.Dispose();
```

The project enables you to enter a URL and then downloads and displays the content. The initial request ends when the headers are received so that you can stream the content with progress updates. You can cancel longer-running downloads and watch the progress. The content is exposed through the `Content` property of the `HttpResponseMessage` that is returned. The `LoadUrl` method demonstrates creating a progress handler that takes a type `ulong` and asynchronously downloads the content as a string.

```
this.progress = new Progress<ulong>(ProgressHandler);
var stringContent = await response.Content
   .ReadAsStringAsync().AsTask(cancellation.Token, this.progress);
```

The progress handler is passed the number of bytes received and uses the dispatcher to set them as a property on the viewmodel to show the progress to the user.

```
private void ProgressHandler(ulong progressArgs)
```

If you use the default URL of my blog, the content loads immediately and the progress method never gets called. Using a longer URL, such as the URL to a large book such as *Ulysses* in HTML format from the Gutenberg project, results in a longer download and progress updates. The URL, listed in the source of the viewmodel, to make it easy for you to copy, is www.gutenberg.org/files/4300/4300-h/4300-h.htm.

You can also use the request message to post content, including streams, to the server. The `Content` property of the `HttpRequestMessage` can be assigned any instance that implements `IHttpContent`. This includes the following content:

- `HttpBufferContent`—Content that uses an `IBuffer` instance
- `HttpFormUrlEncodedContent`—Content that uses name/value pairs for a form post
- `HttpJsonContent`—Content that is represented using the JSON format
- `HttpMultipartContent`—Content that uses the multipart MIME type for uploading multiple attachments

- `HttpMultipartFormDataContent`—A special format for forms encoded using the `multipart/form-data` MIME type
- `HttpStreamContent`—Content that uses a stream, such as when uploading files to the server
- `HttpStringContent`—Content that uses a string

The HTTP API also provides the `HttpProgress` class for tracking and handling the progress of long-running HTTP uploads. Simply create an instance of the progress handler and pass it to the extension method that converts the call to a `Task`:

```
var progress = new Progress<HttpProgress>(ProgressHandler);
HttpResponseMessage response = await httpClient.PostAsync(
    resourceAddress, streamContent).AsTask(cts.Token, progress);
```

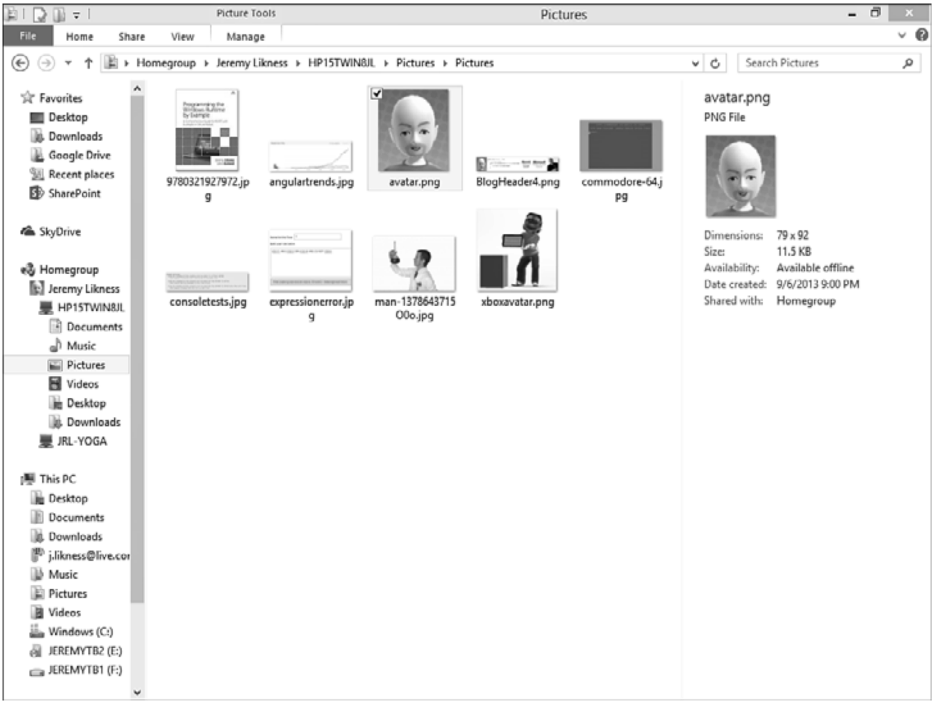
The signature of the handler is a simple method that takes an instance of `HttpProgress` and can query items such as bytes sent versus total bytes sent, number of retries, and the stage of the process (for example, sending or receiving content).

HomeGroup

Microsoft provides a special service named HomeGroup that is designed to make it easier to share folders, files, and devices on home networks. If you are not familiar with HomeGroup, Microsoft provides an online tutorial to help you set one up "from start to finish."[1] The Windows shell handles the special network behind the scenes and exposes it as a file system in **Explorer**.

Figure 10.1 shows an example folder in the HomeGroup. Notice that the initial set of "folders" corresponds to users on the network, followed by the machines they are logged into. These, in turn, expose libraries based on the user's preferences for sharing pictures, documents, music, or other items. You can browse to the folders you have permissions for and access the items as you normally would.

[1] HomeGroup from start to finish, http://bit.ly/1ak28nC



avatar.png
PNG File

Dimensions: 79 x 92
Size: 11.5 KB
Availability: Available offline
Date created: 9/6/2013 9:00 PM
Shared with: Homegroup

FIGURE 10.1 The HomeGroup network

The **HomeGroupExample** project for Chapter 10 demonstrates access to the HomeGroup. The first step is to declare your capabilities in the package manifest. You must have at least one of the available library capabilities (music, pictures, or videos) checked, or you will receive an access denied exception when you attempt to access the HomeGroup. Otherwise, you will have access only to the folder types that you specified capabilities for.

Use the `KnownFolders.HomeGroup` enumeration to access the HomeGroup network. The first set of folders you receive is mapped to the usernames of users currently participating in the HomeGroup. The following code in the `Initialize` method of the `ViewModel` class fetches the user-level folders:

```
var folders = await Windows.Storage.KnownFolders
    .HomeGroup.GetFoldersAsync();
```

The example project defines the `HomeGroupUser` class for user information and maps the `DisplayName` attribute of the folder to the username displayed.

```
foreach (var user in folders.Select(
    folder => new HomeGroupUser
{
        UserName = folder.DisplayName,
        IsHomeGroupUser = true
})) { this.Users.Add(user); }
```

When you have a `StorageFolder` instance for the user, you can use queries to iterate items within the folder. This query sets up a search for pictures with a known set of filename extensions and ultimately retrieves any shared photos that user is sharing across all devices on the HomeGroup.

```
var query = new QueryOptions(CommonFileQuery.OrderBySearchRank,
    new[] { ".jpg", ".png", ".bmp", ".gif" })
        { UserSearchFilter = "kind:picture" };
var files = await targetFolder
    .CreateFileQueryWithOptions(query).GetFilesAsync();
```

The app is designer-friendly and shows a sample image and title in the designer. When you run the app, you see either an error message displayed on a disabled button if the app cannot access a valid HomeGroup, or a list of buttons for each user on the HomeGroup. Tap the button to see the images that user is sharing. You can use similar functionality as covered in Chapter 4, "Data and Content," to access other folders and content types.

Connectivity and Data Plans

Windows Store apps can be connected in a number of ways. Although traditional wired connections (Ethernet LAN) and Wireless Fidelity (Wi-Fi) connections (also known as wireless local area connections, or WLAN) are still popular, many devices offer wireless wide area network (WWAN) connections over cellular technologies such as Global System for Mobile Communications (GSM) and Long Term Evolution (LTE). Many of these data plans have data limits and may charge for bandwidth usage. If users roam outside their regular coverage area, they could incur additional charges.

Windows Store apps should be aware of the type of connection they are using to access information over the Internet so they can implement specific behaviors that are suitable for the type of connection. An app might consider implementing this typical set of behaviors:

- **Offline—**The app cannot connect to the Internet and must rely on local cached data to function.
- **High Cost—**The app is connected to the Internet, but the data plan is either roaming, approaching a fixed data limit, or over the data limit and, therefore, might incur additional charges. The app should limit network activity to only extremely low bandwidth scenarios (such as loading a set of headers but deferring the details).
- **Conservative—**The app is connected to the Internet over a metered connection. Downloading data is fine but should be done only as needed and based on user-configurable preferences (the user must have a way to disable large downloads when the connection is metered). Lower-resolution images and lesser-bandwidth movies should be used when available.
- **Standard—**The app is connected to the Internet, and no charges appear to be associated with data usage; therefore, the application can download or upload data as needed.

The `Windows.Networking.Connectivity` namespace contains the APIs necessary to determine the types of connections that are available and examine data plans and usage. You interact with the `NetworkInformation` class to determine the available connections, the connection your app will use to access the Internet, and what type of connection is being used. The example app that demonstrates this API is called **NetworkInfoExample**; you can find it in the Chapter 10 solution folder.

Each network that your device either is currently connected to or has connected to in the past (as long as you did not ask Windows to forget the connection) has a `ConnectionProfile` instance associated with it. The `UpdateNetworkInformation` method in the `ViewModel` class in the `Data` folder demonstrates how to access this API. A simple call retrieves the full list of available profiles:

```
var profiles = NetworkInformation.GetConnectionProfiles();
```

You can iterate the various profiles and acquire information from each of them, but the most interesting profile is the one used to gain access to the Internet. You can use the `GetInternetConnectionProfile` call to get the profile associated with the active connection, if one exists. If the result is null, the user is not currently connected. In the example app, this call is used to get the identifier for the network adapter that is being used to connect and then select that connection from the list. If your connection is bridged for any reason (for example, you might be running Hyper-V virtual machines that use virtual adapters to connect to your wireless connection), the bridged connection might show up as the active connection instead of the connection you were expecting.

The `ConnectionProfile` has a name that matches what you see in the various network dialogs (either the list of available connections from the **Control Panel** or the list of networks in the **Networks** flyout accessed from the Charms bar). It indicates whether the network is a WLAN (wireless) or a WWAN (wide area network or cellular) connection. If it is neither, it is likely a wired Ethernet or Bluetooth connection.

You can quickly access information about the connected network adapter, as well as the security settings for the connection. For example, the wireless access point I run in my house uses RSNA-PSK authentication with CCMP encryption. You might have security settings available for both wired and wireless networks. The `FromConnectionProfile` method on the `ConnectionInfo` class demonstrates how these values are obtained.

```
if (profile.NetworkSecuritySettings != null)
{
    connectionInfo.AuthenticationType = profile
        .NetworkSecuritySettings.NetworkAuthenticationType.
➥ToString();
    connectionInfo.EncryptionType = profile
        .NetworkSecuritySettings.NetworkEncryptionType.ToString();
}
```

Other information is available through method calls. To get the signal strength from the connection (a value that ranges from 0 for no signal to 5 for maximum signal strength), you call the `GetSignalBars` method. The example app shows only four of five possible bars because it uses the built-in symbol library, and that provides only four bars.

```
connectionInfo.SignalBars = profile.GetSignalBars();
```

The main reason for examining the connection is likely to understand whether costs are associated with it. To find out, call the `GetConnectionCost` method. This returns a class that contains an enumeration and several flags. The enumeration provides you with details about how the connection is metered.

- **Unrestricted—**No costs are associated with data usage.
- **Fixed—**A data limit exists; until that limit is reached, usage is unrestricted.
- **Variable—**Data usage is charged on a per-byte basis.
- **Unknown—**No cost information is available for the connection.

Additional flags provide further insights into the current plan:

- **Roaming—**This flag is set when the user is outside the normal usage area. You can assume that additional charges will apply.
- **ApproachingDataLimit—**The plan has almost reached its limit; additional costs might be incurred.
- **OverDataLimit—**The plan has exceeded the data limit, and the user is likely being charged for any additional usage.

Use this information to strategize how you will access the Internet from your Windows Store app. When the type is fixed or variable, you should follow a conservative behavior. When the flags indicate that the connection is roaming or over the data limit, you should implement the high-cost behavior and allow the user to opt in to any data usage. Other scenarios can follow the standard or offline behavior, depending on the status of the connection.

If you need to find out more details about the plan, you can call the `GetDataPlanStatus` method, as shown in the `FromProfile` method on the `DataPlanInfo` class in the example app. The result gives you more details when available, including the data limit and how much has been used against the limit, the available speeds of the connection, and even when the next billing cycle begins so you know when the usage is reset.

You can also query for historical usage of any connection. The GetNetworkUsageAsync method enables you to specify a time range and a sample frequency (increments in minutes, hours, or days, or a total for the time period). Depending on how you call the method, you can get a list of NetworkUsage instances for each data sample. If you requested hourly samples, each instance represents a sample taken for a given hour. The instance contains the duration it represents, along with the bytes received and sent during that period. The ConnectionInfo class in the example app retrieves a total for the previous day:

```
var usage =
    await profile.GetNetworkUsageAsync(
        DateTimeOffset.Now.AddDays(-1),
        DateTimeOffset.Now,
        DataUsageGranularity.Total,
        new NetworkUsageStates { Roaming = TriStates.DoNotCare,
        Shared = TriStates.DoNotCare });
```

You might not sample data earlier than 60 days before the current date (about 2 months), and minute granularity is available for only the previous 2 hours. You can also specify what network states you want to sample. You can restrict the data to times when the connection was roaming or part of a shared connection, or indicate that you "do not care," as in the example code.

The advantage of many Windows 8.1 devices is that they are highly mobile. For this reason, it's common for the current active connection to change frequently. The user might be using a cellular connection and might come into range of a wireless connection that is lower cost, or the user might travel and switch to different connections. The NetworkInformation class raises an event when the current connection status changes. The ViewModel class in the example app registers for this event:

```
NetworkInformation.NetworkStatusChanged +=
    this.NetworkInformationNetworkStatusChanged;
```

The event itself does not provide other information. The typical practice is to query for the current Internet connection again to determine whether the app behavior should change. You can prompt the user or restrict data usage when you find that the user has roamed or moved from an unrestricted connection to a metered one. By default, Windows 8.1 prefers unrestricted networks over metered networks and automatically connects to the fastest available network in its category when multiple choices are available.

Sockets

Windows Store apps have the capability to communicate over lower-level networking protocols. The Windows Runtime provides built-in support for User Datagram Protocol (UDP),[2] Transmission Control Protocol (TCP),[3] Bluetooth RFCOMM,[4] and the recent HTML5 WebSocket Protocol.[5] Support for socket-based operations is provided through the types of the `Windows.Networking.Sockets` namespace. Sockets in general provide low-level network communications and enable real-time network notifications.

WebSockets

The WebSocket protocol was designed to be implemented in web browsers and web servers, and it is fully supported from Windows Store apps. Although it is part of the HTML5 group of specifications, it is an independent TCP protocol. Its main advantage is that it provides a way for the browser or Windows Store app to maintain a single connection with a server and send data both ways while keeping that connection open. The standard port for WebSockets is 80, the same one HTTP uses, which means it is less likely to be blocked by firewalls.

The **WebSocketsExamples** project for Chapter 10 demonstrates two APIs you can use from WinRT to take advantage of the WebSockets protocol. The example app leverages a server supplied by the WebSocket.org website that provides an “echo service.” This service, when connected to,

[2] User Datagram Protocol, RFC 768, http://bit.ly/16TkVsS

[3] Transmission Control Protocol, RFC 793, http://bit.ly/HLcHtJ

[4] Bluetooth RFCOMM, http://bit.ly/1fu50ni

[5] WebSocket Protocol, RFC 6455

echoes back any data sent to it. WebSockets are accessed using a standard URI, as declared in `MainPage.xaml.cs`:

```
private readonly Uri echoService =
    new Uri("ws://echo.websocket.org", UriKind.Absolute);
```

The `MessageWebSocket` class is an abstraction of the protocol that focuses on sending simple messages. A message is either read or written in a single operation, instead of being streamed continuously. It is also the class you must use to support UTF8 messages; the stream-based API supports only binary (although you can encode and decode the binary to and from UTF8, the `MessageWebSocket` class provides native support for this). To use any socket type within a Windows Store app, you must enable a networking capability such as **Internet (Client)**.

The `ButtonBase_OnClick` method in the `MainPage.xaml.cs` file demonstrates how to use the `MessageWebSocket` class. After creating an instance of the class, set the type of the message (either binary or UTF8):

```
this.socket.Control.MessageType = SocketMessageType.Utf8;
```

You can also register for events that fire whenever a message is received and when the socket is closed. The socket uses underlying unmanaged resources, and you should dispose of it when you are done using it. The easiest way to do this is to call `Dispose` in the `Closed` event handler.

Initiate the connection by calling and waiting for `ConnectAsync` to complete:

```
await this.socket.ConnectAsync(echoService);
```

The example app accepts any message you type and sends it to the echo service. The message must be sent using the `OutputStream` property exposed by the socket. The easiest way to do this is to create an instance of a `DataWriter` to send the message. The `DataWriter` enables you to write various data types that it buffers until you call `StoreAsync`. This flushes the buffer to the underlying stream.

```
var writer = new DataWriter(this.socket.OutputStream);
writer.WriteString(this.Text.Text);
await writer.StoreAsync();
```

Not all error messages for the socket are mapped to .NET Exception class instances. Instead, you must inspect the HResult of the underlying exception to determine what went wrong. Fortunately, the WebSocketError class provides a static method that translates the result to the corresponding WebErrorStatus enumeration. The ToErrorMessage method returns a string with the original message and the enumeration value.

```
private static string ToErrorMessage(Exception ex)
{
    var status = WebSocketError.GetStatus(
        ex.GetBaseException().HResult);
    return string.Format("{0} ({1})", ex.Message, status);
}
```

The MessageReceived event is raised whenever a message is sent from the server to the client through the socket. In the example app, this should happen any time data is sent because the server echoes back the data. The event provides the socket that the information was received from with event arguments: You can inspect the message type (binary or UTF8) and open a reader or stream to access the message. In this example, the reader is set to use UFT8 encoding; then it obtains the message and displays it in the SocketMessageReceived event handler.

```
using (var reader = args.GetDataReader())
{
    reader.UnicodeEncoding = UnicodeEncoding.Utf8;
    var text = reader.ReadString(reader.UnconsumedBufferLength);
    this.Response.Text = text;
}
```

This is the simplest method for dealing with sockets that are designed to share messages. When you are using the socket to stream real-time information and you don't necessarily have simple messages, you might want to use the StreamWebSocket implementation instead. It provides a continuous two-way stream for sending and receiving information. The example app uses the same echo service to stream prime numbers and echo them back to the display when you click the **Start** button.

You create and connect to a StreamWebSocket the same way as with a MessageWebSocket. You can also register for the Closed event. Instead of sending and receiving messages, however, the stream version expects you to interface directly with the input and output streams provided by the socket. The app starts a long-running `Task` encapsulated in the `ComputePrimes` method. It is passed the `OutputStream` of the socket. It iterates through positive integers and writes out any that are computed to be primes; then it delays for 1 second:

```
if (IsPrime(x))
{
    var array = Encoding.UTF8.GetBytes(string.Format(" {0} ", x));
    await outputStream.WriteAsync(array.AsBuffer());
    await Task.Delay(TimeSpan.FromSeconds(1));
}
```

If the integer is not a prime, it delays for a millisecond just to prevent hogging the CPU. Another long-running task receives the echo. It allocates a buffer, waits for data to arrive in the stream, and then reads and decodes the data.

```
var bytesRead = await stream.ReadAsync(buffer, 0, buffer.Length);
if (bytesRead > 0)
{
    var text = Encoding.UTF8.GetString(buffer, 0, bytesRead);
    this.DispatchTextToPrimes(text);
}
```

This example also demonstrates that you can have multiple sockets open to the same server and port at once. You can run the example, click the button to start generating primes, and then use the message-based version to send and receive messages without interrupting the stream of prime numbers. Both methods for communicating with the socket simplify the amount of code you have to write by not worrying about the details of the underlying transport (TCP). When you need to manage a raw TCP connection, you can use the traditional sockets components.

UDP and TCP Sockets

UDP and TCP protocols have been around for decades. Many modern protocols, including HTTP, sit on top of these more low-level protocols (TCP is the transport used by both HTTP and the WebSocket protocol you learned to use in the previous section). Two main differences exist between UDP and TCP: UDP does not require a connection, and UDP does not require any special ordering of packets or chunks of data. As a result, TCP tends to be more reliable and useful for bidirectional communication, and UDP is used when faster transmission rates are required and the application understands how to deal with unordered data.

Examples of protocols that sit on top of UDP include Domain Name Service (DNS) and Simple Network Management Protocol (SNMP). Protocols that sit on top of TCP include HTTP and Simple Mail Transfer Protocol (SMTP). The UDP classes are all prefixed with `Datagram` and operate similarly to the TCP classes prefixed with `StreamSocket`. The API enables you to "connect" to either protocol and send or receive messages. This provides a consistent interface and approach to using each protocol. The main difference is that no specific "listener" service for the UDP implementation exists because a persistent connection is not needed. Instead, you simply create a socket, register for the event when a message is received, and then send data packets or process incoming data as needed.

The **SocketsGame** example provides a more comprehensive example of using a persistent TCP connection. Although the game starts a server to listen for incoming requests, it should be clear that you cannot use these types of connections for communication between Windows Store apps on the same machine. Network isolation prevents the loopback interface from allowing connections across processes. The only reason this works in the example project is that the client and server are hosted in the same process. The example should show how to spin up a server to listen when necessary (for example, the same type of connection can be used to host a service for a Bluetooth service that allows Bluetooth devices to connect), as well as act as a client for a server hosted on the Internet.

The game itself is a text-based adventure game. It creates a 10x10 matrix of rooms for 100 rooms total and randomly connects rooms and places trophies in the various rooms. The object of the game is to explore the rooms and collect trophies until all have been found. A rudimentary parser accepts commands such as "look," "get," "north," and "inventory." Instead of playing as a local game, however, the game is hosted on a socket; the app must connect as a client to issue commands and receive updates.

Two sockets are defined in `MainPage.xaml.cs`: a `StreamSocketListener`, which is the server that listens for and establishes connections to clients, and a `StreamSocket`, which emulates a client connecting to the server. The server provides several options to bind to a generic service and listen to all incoming connections, to bind to a specific address, or even to bind to a specific network adapter. The service name can be a local service name or a port, or it can remain empty to have a port assigned. If you are using the socket for Bluetooth (RFCOMM), use the Bluetooth service ID. In this example, the name is set to 21212 as a unique port for the game. Binding enables your app to use that specific port to listen for incoming requests. If another app has already bound to the specified service, an exception is thrown.

```
this.serverSocket = new StreamSocketListener();
this.serverSocket.ConnectionReceived +=
    this.ServerSocketConnectionReceived;
await this.serverSocket.BindServiceNameAsync(ServiceName);
```

As with Web Sockets, to understand errors thrown by the sockets API, use the `GetStatus` static method of the `SocketError` class, as shown in the `GetErrorText` method.

```
private static string GetErrorText(Exception ex)
{
    return string.Format("{0} ({1})", ex.Message,
        SocketError.GetStatus(ex.GetBaseException().HResult));
}
```

When a connection is received, the server creates a persistent writer and reader for the connection (note that this example uses exactly one client, so only one writer and reader are used—if you are building a server to manage multiple connections, you need to spin up a new reader and writer for each unique connection).

```
if (serverWriter == null)
{
    serverWriter = new DataWriter(args.Socket.OutputStream);
    serverReader = new DataReader(args.Socket.InputStream);
}
```

The listener for the socket goes into an infinite loop waiting for messages. As messages are received, they are passed to the parser to interact with the game world, and the result is written back to the client. To facilitate communication over the socket, the messages are written with a special format. The size of the string in bytes is sent ahead of the string itself so that the reader can allocate the appropriate buffer size to process the incoming message. The `SendString` method encodes the text and sends it over the socket.

```
writer.WriteUInt32(writer.MeasureString(text));
writer.WriteString(text);
await writer.StoreAsync();
```

Listing 10.1 shows the `GetStringFromReader` method that receives the incoming data. It loads enough data to constitute an unsigned integer, processes the integer, and finally loads enough data to create a string based on the size that was passed in.

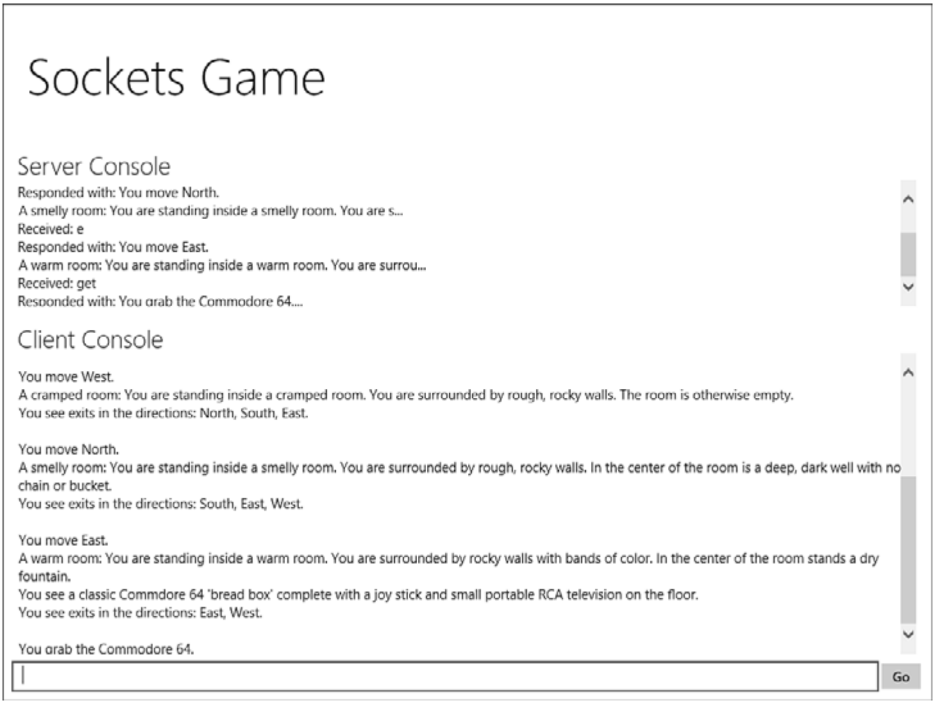
LISTING 10.1 Reading a String from the TCP Socket

```
private static async Task<string> GetStringFromReader(
    IDataReader reader)
{

    var sizeFieldCount = await reader.LoadAsync(sizeof(uint));
    if (sizeFieldCount != sizeof(uint))
    {
        return string.Empty;
    }
    var stringLength = reader.ReadUInt32();
    var actualStringLength = await reader.LoadAsync(stringLength);
    if (stringLength != actualStringLength)
    {
        return string.Empty;
    }
    var data = reader.ReadString(actualStringLength);
    return data;
}
```

Just as the server goes into an infinite loop after a connection is received, waits for instructions, and then returns a response, the client also starts a long-running task. On the UI thread, the `Go_OnClick` method is called whenever the user clicks the button to send the next command. The click handler simply sends the command to the socket and then forgets about it. The long-running `ClientListener` method waits to get the data from the server and then writes it for the end user to see.

Figure 10.2 shows a game in progress. At the top, you can see the server messages that involve receiving the incoming connection, receiving commands, and sending responses. The bottom is the client console for game play; it shows all the responses from the server and provides an input box for the user to type and send commands.



```
Responded with: You move North.
A smelly room: You are standing inside a smelly room. You are s...
Received: e
Responded with: You move East.
A warm room: You are standing inside a warm room. You are surrou...
Received: get
Responded with: You grab the Commodore 64....
```

```
You move West.
A cramped room: You are standing inside a cramped room. You are surrounded by rough, rocky walls. The room is otherwise empty.
You see exits in the directions: North, South, East.

You move North.
A smelly room: You are standing inside a smelly room. You are surrounded by rough, rocky walls. In the center of the room is a deep, dark well with no
chain or bucket.
You see exits in the directions: South, East, West.

You move East.
A warm room: You are standing inside a warm room. You are surrounded by rocky walls with bands of color. In the center of the room stands a dry
fountain.
You see a classic Commdore 64 'bread box' complete with a joy stick and small portable RCA television on the floor.
You see exits in the directions: East, West.

You grab the Commodore 64.
```

FIGURE 10.2 The example game played over a TCP socket

The provided example handles both client and server aspects for TCP connections. The RFCOMM for Bluetooth uses the same classes. Although UDP uses a different set of classes, the implementation is similar—the only difference is that you don't create a persistent listener for managing connections because the protocol is stateless.

Proximity (Near Field Communications)

Near Field Communications (NFC[6]) is a set of standards based on Radio-Frequency Identification (RFID) standards for smartphones, tablets, smart tags, and other devices to establish communications in extremely close situations (less than a few inches difference). Two main NFC scenarios exist. The first is a tap gesture for a short transmission of information, such as contact information, a URL, or a "smart poster." The second is a similar gesture used to create a handshake between two devices so they can establish a peer-to-peer connection over wireless to exchange large amounts of information.

NFC not only operates over extremely short distances, but it also has a fairly slow transfer rate, with theoretical speeds between 50 and 100 bytes per second. For this reason, it is useful for exchanging only a small amount of information, unless you use the NFC tap to establish a more persistent connection over a longer range and using faster technology, including Bluetooth, Wi-Fi, and Wi-Fi Direct. The WinRT API fully supports both of these scenarios.

NFC-Only Scenarios

When you exchange information via NFC, you must either send or receive a message encoded in the NFC Data Exchange Format (NDEF). This is a lightweight, platform-independent binary format for exchanging messages. The message allows one or more specific payloads (referred to as NDEF records) to be sent in a single package. Windows provides built-in support for a set of proprietary NDEF records that Windows 8.1 and Windows Phone devices can exchange. You can also format and exchange other types of records that target other platforms or are platform-independent by either building your own payload or using an open source library such as the NDEF Library for Proximity APIs that is available as a NuGet package.[7]

[6] Near Field Communication Technical Specifications, http://bit.ly/HQSnXA

[7] NuGet package for NDEF Library for Proximity APIs, http://bit.ly/1avcmFo

The **ProximityExample** project provides some examples of using the Proximity APIs defined in the `Windows.Networking.Proximity` namespace. The `ProximityDevice` class provides the simplest API to use and focuses specifically on short-range, short-duration NFC scenarios. To see whether the system has a proximity device available, simply call the `GetDefault` static method, shown in the constructor of the `ViewModel` class. Be sure to declare the **Proximity** capability in the application's manifest.

```
this.proximityDevice = ProximityDevice.GetDefault();
```

The call returns null when a device is not present. If this is the case on your machine, you will not be able to take advantage of NFC exchanges and gestures, but you may still be able to create peer-to-peer connections using Bluetooth, Wi-Fi, or Wi-Fi Direct. You learn more about that in a later section. The proximity device exposes properties for its unique identifier, the maximum number of bytes it can send in a single message, and the bits per second it is capable of transmitting or receiving. You can also register for events that fire when another proximity device comes within range:

```
this.proximityDevice.DeviceArrived +=
    this.ProximityDeviceDeviceArrived;
this.proximityDevice.DeviceDeparted +=
    this.ProximityDeviceDeviceDeparted;
```

The events are purely informational and do not provide any specific information. The `ProximityDevice` parameter of the handler is a reference back to the device that detected the event, which, in most cases, is the default device referenced in the constructor. Other classes exist for enumerating multiple proximity devices, in the rare case that the machine has multiple ones installed. This is a rare scenario because one NFC device is usually sufficient.

An easy way to share information with another NFC device is to use the `PublishMessage` method on the `ProximityDevice` class. This method is useful for sharing simple string data with other Windows or Windows Phone devices. It takes two parameters: the message type and the message itself. The message type is a unique identifier that enables other devices to determine how to handle the message. The message type always starts with a protocol, followed by a dot, followed by whatever custom identifier you prefer. In this case, the protocol must always be Windows. (The simple code for publishing and subscribing in this section is shared here for reference purposes but is not part of a specific example project.)

```
var publishedMessageId =
    proximityDevice.PublishMessage("Windows.WinRTByExampleMessage",
    "This is a simple message.");
```

The publication is not a transient event. The message will be available until you explicitly stop publishing, so multiple NFC devices over time can connect and subscribe for that message to receive it. To stop publishing, you call the `StopPublishingMethod` on the `ProximityDevice`.

```
proximityDevice.StopPublishingMessage(publishedMessageId);
```

If you want to know when the message has been transmitted, you can pass a `MessageTransmittedHandler` as a third parameter when you publish. The handler is called with the proximity device and the identifier for the message. You can use this to log that the message was transmitted, or even unsubscribe in the callback to ensure that the message is sent only once.

```
private void MessagePublished(ProximityDevice sender,
    long messageId)
{
    proximityDevice.StopPublishingMessage(messageId);
}
```

To receive a message, you use the `SubscribeForMessage` method on the `ProximityDevice` class. You do not have to wait for a device to arrive or depart before you subscribe, and the subscription is valid for any device that publishes that particular message type. The subscription includes a handler that is called whenever the message is received, and it is provided a unique identifier that you can use to unsubscribe when you want to stop receiving the message.

```
var subscribedMessageId =
    proximityDevice.SubscribeForMessage("Windows.
➥WinRTByExampleMessage",
    MessageReceived);
```

The method to receive the message is passed the `ProximityDevice` and a `ProximityMessage`. The message includes the data as a buffer, the data as a string, and the subscription ID, in case you want to use that to stop subscribing.

```
private void MessageReceived(ProximityDevice device,
    ProximityMessage message)
{
    var messageText = message.DataAsString;
    device.StopSubscribingForMessage(subscribedMessageId);
}
```

The subscription method enables you to subscribe to any type of message. For messages that use non-Windows protocols, you need to decode the message. For example, the message type `WindowsUri` provides a URI, but you must first decode it from UTF16LE:

```
void messageReceivedHandler(ProximityDevice device,
    ProximityMessage message)
{
    var buffer = message.Data.ToArray();
    var uri = Encoding.Unicode.GetString(buffer, 0, buffer.Length);
}
```

Note that some devices, such as the Windows Phone, handle URIs at the operating system level. In other words, you cannot override the default behavior. The OS itself intercepts the NFC tag and opens the corresponding program. The program depends on the protocol. HTTP launches the Internet Explorer browser and navigates to the encoded web page, and a `mailto` protocol results in the default mail program being launched.

You can use the NFC API to write to smart tags, or special tags that use induction to store and publish information. Smart tags have varying capacities, depending on the manufacturer. Publishing to a smart tag always overwrites the data, and most smart tags have a lifetime of several hundred thousand writes. To get the capacity of a smart tag, you can subscribe to the `WriteableTag` message. This transmits an `Int32` message that contains the capacity of the tag.

```
private void MessageReceived(ProximityDevice device,
    ProximityMessage message)
{
    var capacity = System.BitConvert.ToInt32(
        message.Data.ToArray(), 0);
}
```

Table 10.1 lists the various message types you can subscribe to.

Table 10.1 Common NFC Message Protocols

Protocol	Description
`Windows`	Consists of raw binary data.
`Windows.*`	Provides a custom string type proprietary to Windows, where * represents a custom type.
`WindowsUri`	Consists of a UTF-16LE encoded URI string. Note that the operating system shell intercepts these messages and marshals them to the appropriate protocol handler.
`WindowsMime`	Contains a specific MIME type–like image/jpeg for a bitmap image.
`WriteableTag`	Published by smart tags when they come within range of reading or writing. Contains the capacity of the smart tag in bytes.
`NDEF[:*]`	Consists of formatted NDEF records. Third-party libraries are available to easily encode and decode these record formats.

You also can publish messages for cross-platform compatibility or for the purpose of writing to smart tags. Instead of using the proprietary `PublishMessage` method, use the `PublishBinaryMessage` method. You can use this method to publish messages to other NFC devices, but it is also useful for writing messages to smart tags. The following code snippet encodes the URI to launch Skype and calls the echo service on a Windows or Windows Phone device.

```
var uri = new Uri("skype:echo123?call");
var buffer = Encoding.Unicode.GetBytes(uri.ToString());
var publishId = device.PublishBinaryMessage("WindowsUri:WriteTag",
    buffer.AsBuffer());
```

Table 10.2 lists various protocols you can use when writing messages to tags.

TABLE 10.2 Message Protocols for Writing to Smart Tags

Protocol	Description
`Windows:WriteTag`	Publish binary data to a static smart tag
`WindowsUri:WriteTag`	Write a URI to a static smart tag
`LaunchApp:WriteTag`	Write a tag that launches an app with specific launch parameters
`NDEF:WriteTag`	Write a cross-platform message using the NDEF format

To write a tag that launches an app, use the `LaunchApp:WriteTag` format; then provide a tab-delimited list that starts with the text to pass in as an argument and then includes pairs of platforms and application names. You can find the application name for a Windows 8.1 application in the application manifest. It is in the format of the **Package family name** (from the **Packaging** tab) and an exclamation mark. The following tag passes an argument named `id` with a value of `1` to both the Windows 8.1 **ProximityExample** app and a fictional app on Windows Phone 8 (the application name on Windows Phone is simply the GUID for the application ID).

```
var launchTag =
    "id=1\tWindows\tWinRTByExampleProximityExample_req6rhny9ggkj! " +
    "ProximityExample.App\tWindowsPhone\t{063e933a-fc8e-4f0c" +
    "-8395-ab0e84725f0f}";
```

If the app is present on the target device, it is launched with the arguments passed (the user is always prompted to opt in for the launch whenever this type of tag is encountered). If the app is not present, the device automatically takes the user to the app's entry in the Windows Store. This makes the tag extremely useful: If you pass out smart tags with the encoding, users can easily discover and install your app, as well as subsequently launch it.

In this section, you learned ways to publish small messages that can be sent to other devices or encoded in smart tags. You also learned how to subscribe to and receive these messages. I mentioned earlier a way to share much more information than permitted by the limited bandwidth and speed of the NFC protocol. In this next section, you explore the tap-to-connect scenario that uses NFC to establish a persistent peer-to-peer connection for exchanging information.

Tap-to-Connect Scenarios

The `PeerFinder` class enables you to find and interact with other devices capable of peer-to-peer communications. Although a common use case is through NFC, you can also use Bluetooth and Wi-Fi Direct to locate and communicate with peers. The WinRT API abstracts these decisions from you and enables you to focus on the actual process of locating a peer and establishing a socket so that you can stream data back and forth.

Even if you don't have a proximity device, chances are good that you can take advantage of the **ProximityExample** sample app to create a peer-to-peer connection. That's because the WinRT API supports a browse scenario using Wi-Fi Direct, a technology that enables peer-to-peer wireless connections between devices that exists in most modern radios. Using the browsing scenario, you can install the app on two different devices and use them to discover each other.

The proximity APIs support finding peers running the same application. The application is defined by the package family, a unique identifier for your app that is shared across target platforms. For this reason, your app on a machine running Windows 8.1 can easily connect to the same app on a machine running Windows RT. You can also extend the peer to find instances of your app on other platforms, such as Windows Phone and Android. The `PeerFinder` class contains a dictionary named `AlternateIdentities` that hosts a list of platforms and application identifiers. In the previous section, you learned how to create a tag that launches the application and can contain multiple platforms and identities. You can add the same identifier to recognize that app as a peer like this:

```
PeerFinder.AlternateIdentities.Add("WindowsPhone",
    "{063e933a-fc8e-4f0c-8395-ab0e84725f0f}");
```

You can discover and negotiate the peer connection either through an NFC tap gesture or by browsing Wi-Fi Direct. After the devices recognize each other and initiate the handshake, Windows tries to connect simultaneously using infrastructure (wireless or wired), Wi-Fi Direct, and Bluetooth. It uses whichever connection completes first (most likely, Bluetooth, when available) and passes the connection as an active socket to your app. You can restrict which connection types to allow by setting the static `AllowBluetooth`, `AllowInfrastructure`, and `AllowWiFiDirect` properties on the `PeerFinder` class.

The `PeerSocket` class in the example app provides a convenient way to manage a persistent socket connection. It takes a `StreamSocket` in the constructor and immediately creates a persistent reader and writer to interact with it.

```
public PeerSocket(StreamSocket socket)
{
    this.socket = socket;
    reader = new DataReader(socket.InputStream);
    writer = new DataWriter(socket.OutputStream);
}
```

It exposes a write method that uses the `DataWriter` to send a message to the socket and starts an infinite loop that runs on a background thread to listen for incoming messages. When it receives an incoming message, it raises an event so the app can register for the event, receive the message, and process it (in the case of the sample app, by marshalling it to the UI thread and showing it on the display). It also raises an error event whenever it encounters an error and disposes of both the reader and the writer when its own `Dispose` method is called.

To begin the process of connecting with a peer, you must first set your app to advertise. This broadcasts its identity over Wi-Fi Direct and makes it available for tap gestures if a proximity device is present. The Wi-Fi Direct mode is referred to as a browsed connect, and the NFC mode is referred to as a triggered connect. The `PeerFinder` class is instructed to begin advertising in the `StartPeerFinder` method on the `ViewModel` class.

First, the app registers to two events: the `TriggeredConnectionStateChanged` that is raised when an NFC tap gesture is received, and the `ConnectionRequested` event that is raised when another device browses your device and requests a connection.

```
PeerFinder.TriggeredConnectionStateChanged +=
    this.PeerFinderTriggeredConnectionStateChanged;
PeerFinder.ConnectionRequested +=
    this.PeerFinderConnectionRequested;
```

Next, the role is set. Three possible roles exist. In the `Peer` role (included in the example app), two apps can connect with each other and communicate as peers. In a client/server scenario, one app can serve as the host and must set the `Host` role; then up to four other apps can connect using the `Client` role. Note that only `Peer` roles can browse to each other. The `Host` role can browse only `Client` roles, and vice versa.

```
PeerFinder.Role = PeerRole.Peer;
```

Finally, some discovery text is set. This is additional text you can share, such as an application name, an invitation to connect, information about the host system, or any other data up to 240 bytes in length. This data is broadcast and can be displayed when browsing. After the data is set, the `PeerFinder` starts advertising when you call the `Start` method.

```
PeerFinder.Role = PeerRole.Peer;
PeerFinder.DiscoveryData = Encoding.UTF8.GetBytes(
    DiscoveryText).AsBuffer();
PeerFinder.Start();
```

When both peers have started advertising, one of two scenarios can take place. The first is the NFC tap-to-connect scenario. When the proximity devices are tapped together, the `TriggeredConnectionStateChanged` event is raised. This event fires multiple times as the devices come within range and negotiate a connection.

The event handler for the triggered connection receives a `State` property of the type `TriggeredConnectState` (an enumeration). The handler on the viewmodel is called `PeerFinderTriggeredConnectionStateChanged`. The `Listening` state indicates that the proximity device is waiting for a tap. When the state is `PeerFound` or `Connecting`, the connection is being established and the handler simply updates the status for the user. If the connection fails, a

Failed state is passed. The Completed state indicates success, and the arguments contain a Socket property with the active socket between the two devices:

```
case TriggeredConnectState.Completed:
    this.RouteToUiThread(() =>{this.IsConnecting = false;});
    this.InitializeSocket(args.Socket);
    break;
```

The InitializeSocket method sets up an instance of the PeerSocket to handle further communications. A state of Canceled means the connection was broken for some reason—for example, the devices moved out of range or a user intervention occurred.

The browse scenario starts when you request a list of available peers. The BrowseCommand method on the viewmodel calls the FindAllPeersAsync method and then loads the results to the list of available peers.

```
var peers = await PeerFinder.FindAllPeersAsync();
```

The user can then select a peer and request a connection. The connection is initiated in the ConnectCommand method.

```
var socket = await PeerFinder.ConnectAsync(
    this.SelectedPeer.Information);
this.InitializeSocket(socket);
```

Note that the end result is the same as the triggered connection scenario: A socket is obtained and initialized to establish communications. The mode of the connection is transparent to your app, and there is no way to determine whether the connection was made using Bluetooth, infrastructure, or Wi-Fi Direct (unless you have restricted the allowable connection types to a single mode).

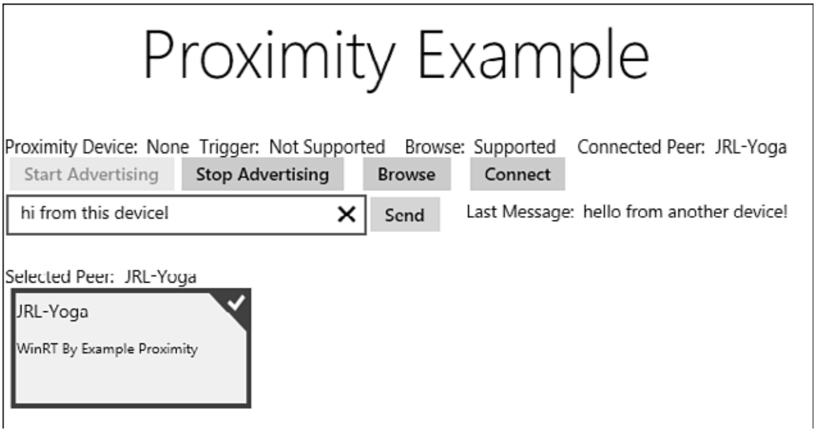
If your device is running a version of the app and the connection is requested from another device, a ConnectionRequested event is raised. The viewmodel handles this in the PeerFinderConnectionRequested method. In this scenario, you typically prompt the user to confirm that he or she wants to accept the request, and then either ignore the request or connect. The sample app automatically initiates the connection. The method to connect is identical for the host, client, or peer; the only difference is that, instead of passing a peer from a list of selections, the peer requesting the connection is passed as arguments to the event.

```
var socket = await PeerFinder.ConnectAsync(args.PeerInformation);
this.InitializeSocket(socket);
```

If the call succeeds for both peers, a connection is established and duplex communication can be initiated. You can transmit anything over the binary socket—from images, to streaming videos, to text or documents. The sample app simplifies the connection by transmitting only text. The text you enter is sent to the peer via the output stream of the socket, and any text received raises an event that is marshalled to the UI.

To use the sample program, install it on two Windows 8.1 devices that support Wi-Fi Direct or have proximity devices. The easiest way is to build and deploy the source, but you can also use the **Store** option on the **Project Properties** menu to create a side load package. Copy the package to a thumb drive and execute the included PowerShell script to install it on the other device.

Run the app on both devices. You must start advertising on both devices to establish a connection. After you've started advertising, either tap the devices or tap **Browse** to use Wi-Fi Direct. If you browse, select another machine and tap **Connect**. When the connection is established, via either NFC tap or browsing, you can begin to send messages between the two peers (see Figure 10.3).



Proximity Example

Proximity Device: None Trigger: Not Supported Browse: Supported Connected Peer: JRL-Yoga

hi from this device!

Last Message: hello from another device!

Selected Peer: JRL-Yoga

JRL-Yoga
WinRT By Example Proximity

FIGURE 10.3 Example of communicating between peers using the Proximity API

Numerous possibilities exist for taking advantage of the peer connection. You can use it to share documents or pictures between devices, archive data, create a chat session, or even share game state in a multiplayer game. The API handles all the necessary low-level handshakes and connectivity so that you can focus on the implementation of your application without worrying about the underlying NFC protocol or even whether the devices connect over Bluetooth or Wi-Fi Direct. The Proximity API is nearly identical on the Windows Phone, making it possible to build apps that span devices and create a truly continuous user experience among Windows PCs, tablets, and phones.

Background Transfers

Many apps must download large amounts of information to present to the user. For example, an app focused on providing instructional videos might need to download new videos from the Internet. These files could be hundreds of megabytes or even gigabytes in size. Although the `HttpClient` class is capable of retrieving files of this size, you must also take into account the application lifecycle.

As you learned in Chapter 2, "Windows Store Apps and WinRT Components," whenever the user moves your app into the background, your app can be suspended or frozen, essentially stopping any downloads dead in their tracks. In some scenarios, the app might even be terminated, forcing you to create a new instance of the class in an attempt to start the download again. Fortunately, WinRT provides a way to handle this specific scenario using a background task.

You learn more about background tasks in Chapter 15. This chapter introduces a specific API for downloading files that exists in the `Windows.Networking.BackgroundTransfer` namespace. The API is defined for several reasons. The most obvious is to enable your app to download files without interruption. These download tasks should continue even if your app is swapped to the background or terminated. You should also be able to discover any existing downloads when your app is launched again, to either continue to download or cancel them as needed. The extra advantage this API provides is a power-friendly and cost-aware means of transferring files. The API is architected to handle the download in a way that maximizes battery life and can pause the transfer when the user switches to a metered network. These features combine to provide the best mobile experience possible for the device user.

The reference project **TapAndGoProximityNetworking** serves two purposes. As a follow-up to the previous section about the Proximity API, it downloads an excellent video presentation by my colleague Jeff Prosise from Microsoft's Channel 9 website. His talk, given at TechEd Europe in 2013, covers the Proximity API and provides working examples of encoding tags, reading tags, and tapping to share data between multiple devices. It is a great way to reinforce the information you learned in the previous section. The project downloads a high-fidelity version of the video that is almost 600MB in size. The second purpose is to demonstrate the background transfer capabilities.

To simplify the example, I placed all the code in the code-behind of the main page to simply download a file and then play it using the file launcher. The associated video player should pick up the file and begin playing the presentation after it is downloaded. The app first checks to see whether the movie already exists, based on a specific name in your video library. The **Video Library** capability must be enabled in the manifest for this to work. If the video exists, you are given the option to delete it to start over or launch it.

To start a background transfer, you need only two pieces of information: the URI of the resource to download and a file to download it to. The example app encodes the URI to the video download and creates a file with the name `TapAndGo_Prosise.mp4` in your video library in the `DownloadOnClick` method.

```
var source = new Uri(DownloadUri, UriKind.Absolute);
var destinationFile =
    await KnownFolders.VideosLibrary.CreateFileAsync(
        LocalName, CreationCollisionOption.ReplaceExisting);
```

An instance of the `BackgroundDownloader` class is created, and the `CreateDownload` method is called with the source and destination.

```
var downloader = new BackgroundDownloader();
download = downloader.CreateDownload(source, destinationFile);
```

You can provide a callback to receive updates as the download progresses. This is done by creating an instance of the `Progress` class of type `DownloadOperation` and passing the callback handler, as shown in the `DownloadProgressAsync` method.

```
var progress = new Progress<DownloadOperation>(UpdateProgress);
```

The download is then kicked off and cast to a `Task` with a cancellation token and the callback for progress.

```
await this.download.StartAsync().AsTask(cts.Token, progress);
```

The download is now kicked off and continues to execute even after your app terminates. If it encounters an error, it updates the error state for your app to query when the app is launched again. While the app is running, it provides progress updates, as shown in the `UpdateFromProgress` method.

```
BytesReceived.Text = download.Progress.BytesReceived.ToString();
TotalBytes.Text = download.Progress.TotalBytesToReceive.ToString();
```

Table 10.3 lists the possible statuses available via the `Progress.Status` enumeration. Use this to determine the state of the download and take appropriate action (in the example app, it is used to enable or disable the Pause and Resume buttons).

TABLE 10.3 `BackgroundTransferStatus` Enumeration

Status	Description
`Idle`	The application is idle (the download is still active).
`Running`	The transfer is in progress.
`PausedByApplication`	The app has paused the download by calling the `Pause` method on the `DownloadOperation`.
`PausedCostedNetwork`	The user transitioned to a metered network, and the download has been paused to avoid additional cost. It will resume when the user returns to a nonmetered network.

Status	Description
PausedNoNetwork	The user has lost network connectivity. The download will resume when Internet connectivity is restored.
Completed	The operation successfully completed.
Canceled	The operation was canceled.
Error	An error was encountered.

While the download is running, you can perform a number of actions. For example, you can call the `Pause` method on the `DownloadOperation` to temporarily pause the download. After it is paused, you can call `Resume` to continue the download. Calling `Pause` twice in a row or calling `Resume` before `Pause` results in an exception, so always keep track of or check the current status. If you passed a cancellation token to the task, you can also call `Cancel` on the token source to abort the download.

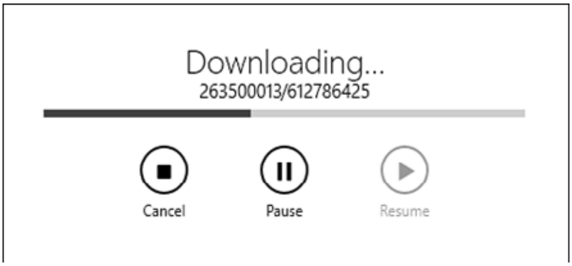
If the download completes while your app is still running, it returns control after `await` of the `StartAsync` call. The example app disposes of the cancellation token and then launches the video. If your app is terminated or exits before the download is finished, it will continue in the background. When the app is launched again, you can check for existing transfers, as the `CheckState` method shows.

```
var downloads = await BackgroundDownloader
    .GetCurrentDownloadsAsync();
```

An entry for the download exists whether it is still downloading or it completed when your app was not running. Either way, you can obtain the reference to the download, query the status, or attach to receive updates. The sample app always reattaches to update the status. If the download has completed, the call to `AttachAsync` returns immediately; otherwise, it continues the same way the call to `StartAsync` worked.

```
await this.download.AttachAsync().AsTask(cts.Token, progress);
```

To test the app, compile, deploy, and run it. Tap the Download button. You then see a status similar to Figure 10.4. You can pause, resume, or cancel the download. After the download has begun, close the app by stopping it if you are running through the debugger or by pressing **Alt+F4**. You can navigate to the video library and refresh the file list to verify that the download is still running. Start the app again; it should return to the progress display and begin showing you the current progress. If you let the download finish, the app automatically launches the video and closes itself.



Downloading...
263500013/612786425

FIGURE 10.4 The download progress

The transfer API enables you to launch multiple downloads and keep track of each download individually. You can also group downloads and perform various tasks on the group. In addition, you can set a priority for the download and even request that the download run unconstrained so that it happens more quickly. This prompts the user and also can affect battery life and quality of the user experience. You learn more about the various background APIs in Chapter 15.

Summary

In this chapter, you learned how to use advanced features of the `HttpClient`. You used the Windows 8.1 seamless integration of HomeGroup technology to enumerate resources on your home network and then queried network information to determine what type of connection was active and see whether it was a metered plan. You leveraged the Sockets APIs to transfer messages and packets of data between a client and a server. You learned how to use NFC to transmit short, fast messages; subscribe to messages; and write data to smart tags. The APIs also enable a scenario to tap and create a persistent connection over your wired or wireless infrastructure, Bluetooth, or Wi-Fi Direct. Finally, the background transfer API enabled an app to download a large video resource even when it wasn't running.

In Chapter 11, "Windows Charms Integration," you learn more about the special icons that appear on the right side of your monitor when you swipe or hold down **Windows+C**. These icons, called charms, provide a special way for your app to integrate with the OS and communicate with other apps. Using charms enables scenarios such as streaming media to a projector, using one app to take notes and then sending those notes to another app to post them online, or accessing the specific settings of various apps in a consistent way.

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13
Devices

In earlier chapters, you saw that although the built-in controls you can use in your Windows 8.1 apps include extensive support for touch-based interactions, input from mouse and keyboard input devices continues to be fully supported. The Windows Runtime also features extensive support for gathering information from other inputs, including sensors. The information these sensors provide includes details about a device's location, as well as knowledge about its position and motion within its immediate environment. Having the capability to incorporate this information into your apps means you can consider giving your users new kinds of interactivity and immersion.

In this chapter, you see how the WinRT APIs provide a common model for working with the various kinds of input pointer devices. This model provides a range of access, allowing you not only to obtain information about raw pointer events, but also to work with higher-level abstract gestures, depending on the needs of your app. You also see how you can access keyboard events from your code and obtain information about the user's key presses.

In addition, you learn about the WinRT APIs for working with location information, including the capability to set up geographic fences that can result in automatic notifications to your app when your device crosses a fence boundary. Furthermore, you learn how to work with the WinRT APIs that provide access to sensors that can give you information about your device’s interactions with the physical world around it, including details about its orientation, its heading, the rate and direction of its motion, and even the amount of light currently shining on it.

Working with Input Devices

In Chapter 2, “Windows Store Apps and WinRT Components,” you saw how the built-in controls that the Windows Runtime provides are designed to support first-class interactions through touch, as well as keyboard and mouse combinations. Although access to touch input is becoming more common in modern computers and devices, it is not yet available everywhere. Attached keyboards, mouse devices, and pens continue to be important tools for application interaction, not only when touch input is unavailable, but also in addition to touch input when certain interactions are simply easier and more natural using these other input mechanisms.

For touch, mouse, and pen inputs, the Windows Runtime API provides several different kinds of methods and events for working with these devices and responding to user interaction with them. In addition to the APIs for working with these devices, a set of methods and events are available for responding to user interactions with their keyboards.

The Example App

The **InputsExample** project illustrates several kinds of input device API integration that you can add to your apps. The app enables the user to add shapes to the application canvas, which are then animated to move around the canvas area. The app also detects what input devices are available and shows information about these connected devices, and it provides options for configuring what device types the app will listen to for input and which of the screen or keyboard events the app will respond to. Shapes can be added through buttons provided on the user interface or by pressing predefined keyboard buttons. The shapes themselves are configured to respond in several ways to interaction with pointer input devices. When a pointer intersects the edge of a shape, the shape is highlighted and stops moving. The shapes can also be manipulated to change position, degree of rotation, and size, with or without inertia. Finally, the shapes respond to gestures by changing color when tapped, changing direction when double-tapped, and resetting to their initial size, color, and rotation when they are held or right-clicked.

Identifying Connected Input Devices

You can determine which touch input devices are connected and what their capabilities are in a couple ways. One approach is to use the information that the `PointerDevice` class provides to obtain detailed information about available touch, mouse, or pen devices. Alternatively, higher-level classes can garner more general information about the current mouse and touch capabilities.

The `PointerDevice` class can obtain detailed information about one or more connected pointer devices. It provides a static `GetPointerDevices` method that returns a list of available devices as `PointerDevice` object instances, as well as a static `GetPointerDevice` method that can retrieve a specific device based on a pointer ID value (the "Pointer Events" section, later in this chapter, explains how to obtain a pointer ID). Properties of particular interest that the `PointerDevice` type exposes include the `PointerDeviceType`, which shows whether the device is a `Mouse`, `Touch`, or `Pen` device, and the `IsIntegrated` flag, to indicate whether the device is considered to be integrated into the current machine or has been connected externally. It also includes a `SupportedUsages` collection that lists Human Interface Device (HID) "usages" as `PointerDeviceUsage` objects. These usages are defined by Usage Page and Usage Id values that are part of the USB HID specification[1] and expose value ranges that the pointer device supports.

Listing 13.1 shows how the example application uses device information to determine whether touch, mouse, or pen devices are available. A list of available devices is obtained depending on whether the list should include only integrated devices. The resulting values are then queried to see if any of the desired device types are present.

[1] USB HID information, www.usb.org/developers/hidpage

LISTING 13.1 Determining Device Availability

```
var devices = PointerDevice.GetPointerDevices();
if (PointerIntegratedDevicesOnly)
{
    devices = devices.Where(x => x.IsIntegrated).ToList();
}
IsTouchAvailable
    = devices.Any(x => x.PointerDeviceType == PointerDeviceType.Touch);
IsMouseAvailable
    = devices.Any(x => x.PointerDeviceType == PointerDeviceType.Mouse);
IsPenAvailable
    = devices.Any(x => x.PointerDeviceType == PointerDeviceType.Pen);
```

The `MouseCapabilities` and `TouchCapabilities` classes obtain higher-level system-wide information about the available mouse and touch device support. When an instance of one of these types is created, its properties provide access to information about the respective device availability.

For `MouseCapabilities`:

- The `MousePresent` property is set to a value of `1` if one or more mouse devices are currently available.
- The `NumberOfButtons` value indicates the highest value available for any given device.
- The `VerticalWheelPresent` or `HorizontalWheelPresent` properties is set to a value of `1` to indicate whether a device is connected that has each respective feature.
- The `SwapButtons` property is set to `1` if the mouse buttons have been swapped in the system settings.

For `TouchCapabilities`:

- The `TouchPresent` property returns a value of `1` if a touch digitizer is present.
- The `Contacts` property indicates the highest number of concurrent contacts that are supported.

The example application uses these values to populate the message boxes that display when the user clicks the **Details** buttons next to the check boxes that it provides to enable or disable mouse and touch input (see Listings 13.2 and 13.3).

LISTING 13.2 Displaying Mouse Capabilities

```
var capabilities = new MouseCapabilities();
String message;
if (capabilities.MousePresent == 1)
{
    var rawMessage =
        "There is a mouse present. " +
        "The connected mice have a max of {0} buttons. " +
        "There {1} a vertical wheel present. " +
        "There {2} a horizontal wheel present. "  +
        "Mouse buttons {3} been swapped.";

    message = String.Format(rawMessage
        , capabilities.NumberOfButtons
        , capabilities.VerticalWheelPresent == 1 ? "is" : "is not"
        , capabilities.HorizontalWheelPresent == 1 ? "is" : "is not"
        , capabilities.SwapButtons == 1 ? "have" : "have not"
        );
}
else
{
    message = "There are no mice present.";
}
ShowMessage(message, "Mouse Properties");
```

LISTING 13.3 Displaying Touch Capabilities

```
var capabilities = new TouchCapabilities();
String message;
if (capabilities.TouchPresent == 1)
{
    var rawMessage =
        "Touch support is available. " +
        "Up to {0} touch points are supported.";

    message = String.Format(rawMessage, capabilities.Contacts);
}
else
{
    message = "Touch support is not available.";
}
ShowMessage(message, "Touch Properties");
```

Pointer, Manipulation, and Gesture Events

Instead of having a separate set of input events for touch, mouse, and pen inputs, the Windows Runtime API combines input from these devices and provides several distinct tiers of events that can be raised in response to input from any of these devices. At the lowest tier are the pointer events, which are raised for each press, move, release, or other simple interaction. Next are the manipulation events, which track and consolidate actions from one or more pointers into higher-level events related to motion, scale, rotation, and inertia. Finally, the gesture events consolidate pointer actions into even higher-level gesture abstractions, such as tapping, double-tapping, and holding.

In the example application, all the support for working with input device pointer, manipulation, and gesture events has been consolidated into a single `InputEventHandler` class. This class handles the subscriptions to the desired events and provides the event handler implementations for these subscriptions.

> **NOTE**
>
> Chapter 2 introduced you to the Visual Studio simulator for Windows Store Apps, which enables you to run and test your Windows 8.1 app within a simulated environment on your development system. Ultimately, testing touch support in an application is best done with a device that actually has touch support. However, if you happen to be using a development environment that does not provide this support, using the simulator's touch-emulation features is a good start toward exercising this kind of functionality in your app. Ultimately, however, it is a good idea to make sure your app is exercised for some amount of time in an actual touch environment.

Pointer Events

The Windows Runtime combines input from touch, mouse, or stylus devices into the abstract concept of a pointer. Each contact point from each device is represented by a unique pointer instance. For example, imagine an app running on a touch-enabled tablet that supports multiple touch points, and imagine that multiple fingers are pressing the screen simultaneously. In this case, each finger touching the screen is treated as a unique pointer. The same holds true if the touch actions include a combination of several fingers, as well as a click by a mouse or screen contact with a stylus. The mouse and/or stylus inputs are treated as additional unique pointers.

In Windows 8 XAML apps, the most common way to subscribe to pointer events is through events that individual `UIElement` objects expose. An alternative approach involves subscribing to similar events exposed by an `ICoreWindow` instance, which can be obtained through the `Window.Current.CoreWindow` property. This latter approach is primarily used by DirectX WinRT games when `UIElement` objects aren't readily available. Table 13.1 summarizes the pointer events that are available when a `UIElement` is used.

TABLE 13.1 Pointer Events

Event	Description
`PointerEntered`	A pointer has moved into the item's bounding area. For mouse and stylus input, this does not require a press. For touch input, because there is no "hover" support, an actual touch is required; it results in an immediate subsequent `PointerPressed` event, unless cancelled in this event's handler.
`PointerExited`	A pointer that was in an element's bounding area has left that area. For touch input, this event immediately follows a `PointerReleased` event.
`PointerPressed`	A pointer has been pressed while within the bounding area for an item. Note that a `PointerPressed` is not always terminated by a `PointerRelased` event, but it can instead be ended by `PointerCanceled` or `PointerCaptureLost` events.
`PointerMoved`	A pointer that has entered an item's bounding area is being moved within that area, or a pointer that has been captured by an item is moving, even if its position is beyond the item's bounding area.
`PointerReleased`	A pointer that was pressed has been released, usually within an item's bounding area. This occurs if the pointer was pressed while inside the item's bounding area; a corresponding `PointerPressed` event then has been raised, or if the pointer was already pressed when it moved into the item's bounding area, the `PointerPressed` event might have occurred elsewhere. If the pointer is currently captured by an item, this event can also be raised when the pointer is released outside the item's boundary.

Event	Description
`PointerCanceled`	A pointer has lost contact with an item in an unexpected way. This event can fire instead of the `PointerReleased` event. Potential reasons for unexpected contact loss include changes in an app's display size, the user logging off, or the depletion of available contact points. Note that this event is only part of the `UIElement` events, and the `ICoreWindow` interface does not provide or raise it.
`PointerCapture-Lost`	A pointer capture that the event source item obtained has been released either programmatically or because a corresponding `PointerPressed` has been released.

Several of the pointer events in Table 13.1 either are directly related to or have side effects that are related to the idea of a pointer being captured. When a pointer is captured, only the element that captured it receives any of the input events related to that pointer until the capture has been released. Typically, a pointer is captured within the handler for a `PointerPressed` event because a pointer must be pressed to be captured. To capture a pointer, the `UIElement` class includes a `CapturePointer` method that takes a `Pointer` class instance that identifies the pointer to capture. It just so happens that the `PointerRoutedEventArgs` that are passed to the `UIElement` pointer event handlers include this pointer object, as the following code illustrates:

```
private void HandlePointerPressed(Object sender,
    PointerRoutedEventArgs args)
{
    _eventSourceElement.CapturePointer(args.Pointer);
}
```

The `Pointer` object includes a `PointerId`, which is simply a unique integer that is assigned to the current pointer and identifies it throughout the various subsequent pointer events. It also includes a `PointerDeviceType` property that returns a value of the `PointerDeviceType` enumeration and indicates whether the current pointer is related to input from a touch device, a mouse device, or a pen device. In the example project, this value is used to ignore processing in the pointer events when a particular device type is deselected in the user interface.

```
if (!IsValidDevice(args.Pointer.PointerDeviceType)) return;
```

The Pointer object also includes a pair of flags to indicate the position of the pointer relative to the touch sensor. IsInContact indicates whether the device is actually contacting the sensor, such as whether a stylus is in direct contact with the screen when using a touchscreen tablet. In the case of a mouse device, this is true when one of its buttons is being pressed. IsInRange indicates whether the device is within detection range but not touching; it is primarily meant for pen devices because, unlike touch devices, they can usually be detected before they make physical contact. Generally, mouse devices always return True for this value, and touch devices return True only when a touch is actually occurring.

In addition to the Pointer object, the arguments passed to the pointer events include a KeyModifiers property that indicates whether one or more of the Control, Menu, Shift, or Windows special keyboard keys was pressed at the time of the event.

Finally, the event arguments include a pair of methods that obtain additional information about the input pointer associated with the current interaction. The GetCurrentPoint and GetIntermediatePoints methods both accept a UIElement to provide a frame of reference for any of the coordinate properties included in the method results. If this value is null, the coordinate values that are returned are relative to the app itself. Whereas GetCurrentPoint returns a single PointerPoint instance, the GetIntermediatePoints returns a collection of PointerPoint instances from the last pointer event through the current one. In addition to being able to obtain PointerPoint information from the pointer event arguments, the PointerPoint class itself includes static methods that accept a PointerId value and return the current or intermediate PointerPoint values, with coordinates relative to the app.

The PointerPoint class includes a lot of information about the current interaction. At the root, it includes the PointerId value, a Position value indicating the Point where the pointer event occurred, and a PointerDevice property that provides the same PointerDevice value discussed in the earlier section "Identifying Connected Input Devices." It also includes a

`Properties` value that provides access to significantly more detailed information. Among the properties provided, this value includes touch information, such as the contact rectangle value; mouse information, such as whether the left, middle, right, first extended, or second extended buttons are pressed; and pen information, including several values that describe the physical position of the pen, whether it is inverted, and the amount of pressure being applied to its tip. Furthermore, the `HasUsage` and `GetUsage` methods are useful in obtaining HID value information from the device for the current interaction. These are the same HID values that can be enumerated with the `SupportedUsages` method that `PointerDevice` class instances mentioned earlier provide. The following code shows how to request the amount of tip pressure (`usageId` value `0x30`) applied to a digitizer stylus device (`usagePage` value `0x0D`).

```
if (pointerDetails.Properties.HasUsage(0x0D, 0x30))
{
    pressure = pointerDetails.Properties.GetUsageValue(0x0D, 0x30);
}
```

Although the amount of detail provided by the pointer events can harness a lot of power, the information provided is at a very low level. For most application needs, this information needs to be synthesized into more abstract concepts. Examples might include recognizing a pair of `PointerPressed` and `PointerReleased` events potentially as either a single tap or a hold action, depending on how much time elapses between the two pointer actions, or perhaps tracking multiple pointer actions to determine whether pinch or rotation actions are occurring. Fortunately, you will most likely not need to write and maintain the state-tracking code required to achieve this level of abstraction; these kinds of events are already calculated and provided for you in the form of the manipulation events and gesture events.

Manipulation Events

Manipulation events are the result of grouping and translating several pointer events associated to an item that originate from either one or several pointers. During a manipulation, changes to translation (position), scale (size), and rotation are computed, tracked, and made available via the event argument parameters provided by these events. A manipulation also tracks the velocities with which these changes are occurring and includes the capability to optionally calculate and apply inertia based on these velocities when the pointer events complete.

In Windows 8.1 XAML apps, the most common way you subscribe to manipulation events is through the events that individual `UIElement` objects expose. For a `UIElement` to generate manipulation events, the element needs to have its `ManipulationMode` property set to a value of the `ManipulationModes` enumeration other than `None` or `System`. The default value for most controls is `System`, and it enables the `UIElement` to process manipulations internally, whereas a value of `None` suppresses all manipulations. Other significant values include `TranslateX` and `TranslateY` to track movement on the x- and y-axis, `Rotate` to track rotation, and `Scale` to track stretching or pinching. Values for `TranslateInertia`, `RotateInertia`, and `ScaleInertia` are also available to indicate that these manipulations should trigger inertia calculations. Table 13.2 summarizes the manipulation events exposed by the `UIElement` class.

TABLE 13.2 Manipulation Events

Event	Description
`ManipulationStarting`	A `PointerPressed` event has occurred, and manipulation processing starts looking for the pointer to move, to actually start tracking a manipulation.
`ManipulationStarted`	A pressed pointer has moved. This marks the beginning of the manipulation, which contains some number of `ManipulationDelta` events and is concluded with a `ManipulationCompleted` event.
`ManipulationDelta`	One or more of the pressed pointers have moved or inertia is being applied.
`ManipulationInertiaStarting`	The manipulation has been configured to support inertia, and the last pointer was released while the manipulation still had a velocity. `ManipulationDelta` events are raised until velocity falls below the inertia-defined threshold.
`ManipulationCompleted`	The last pointer is no longer pressed, and any inertia calculations have completed.

The first event received during a manipulation is the ManipulationStarting event. This event includes a Mode property that initially matches the ManipulationMode value set on the UIElement object. It allows the types of manipulations that will be tracked to be modified one last time before the manipulation tracking actually starts. If a pressed pointer is moved, the ManipulationStarted event is fired, followed by one or more ManipulationDelta events as the pointer continues to move.

The arguments provided to the ManipulationDelta event handler provide the information that can be used to react to the manipulation. The arguments contain some general-purpose informational properties that include the PointerDeviceType, which is the same as it was for the pointer events (note that this implies that a manipulation cannot span device types, such as a pinch occurring with both a finger and a mouse); a Container value that indicates the UIElement on which the manipulation is occurring; and an IsInertial flag that specifies whether the ManipulationDelta event is a result of inertia that occurs after pointers have been released. Of particular interest, however, are the Delta, Cumulative, and Velocity values.

The Delta property provides the changes in the values for Translation, Expansion, Scale, and Rotation that have occurred since the last ManipulationDelta event occurred. Translation indicates how much movement occurred on the x- and y-axis. Expansion specifies how far the distance grew or shrank between touch contacts. Scale is similar to Expansion, but it specifies the change in distance as a percentage. Finally, Rotation specifies the change in the rotation degrees. The Cumulative property returns the same items, except that the values returned are the overall changes that have occurred since the manipulation started instead of since the previous ManipulationDelta event. Finally, the Velocity provides a Linear property that contains the x and y velocities specified in pixels/milliseconds, an Expansion property that specifies the scaling change in pixels/ milliseconds, and an Angular property that specifies the rotational velocity in degrees/ milliseconds.

In the example application, the delta values are applied to the shape being manipulated to move it onscreen, resize it, or rotate it (rotation is better seen with the square shape than the circular one). Listing 13.4 shows the event handler in the InputEventHandler class for the ManipulationDelta event.

LISTING 13.4 Handling Manipulation Changes

```
private void HandleManipulationDelta
    (Object sender, ManipulationDeltaRoutedEventArgs args)
{
    // Check to see if this kind of device is being ignored
    if (!IsValidDevice(args.PointerDeviceType)) return;

    // Update the shape display based on the delta values
    var delta = args.Delta;
    _shapeModel.MoveShape(delta.Translation.X, delta.Translation.Y);
    _shapeModel.ResizeShape(delta.Scale);
    _shapeModel.RotateShape(delta.Rotation);
}
```

The processing in the ShapeModel class is fairly straightforward. The MoveShape method simply makes sure that adding the offset values to the current position doesn't move the shape beyond the current borders and adjusts the resulting position value accordingly. ResizeShape multiplies the current shape scale by the provided percentage and then makes sure the resulting shape size is within the minimum and maximum boundaries established for a shape. RotateShape simply adds the degree value to the current Rotation property. A TranslateTransform is bound to the shape position values. A RotateTransform has its Angle value bound to the rotation angle, as well as its CenterX and CenterY values bound to the position of the shape. Finally, a ScaleTransform has its ScaleX and ScaleY values bound to the scale of the shape, with the CenterX and CenterY values also bound to the shape position.

The final manipulation concept to be discussed is inertia. If one or more of the inertia ManipulationMode values is specified, the manipulation processing can include the application of inertia, depending on whether the last pointer involved in the manipulation was removed following an action that had a velocity. In the example app, this occurs when a shape is being dragged from one side of the screen to another and, halfway through, the finger/mouse/pen is suddenly released. In the physical world, the object would tend to continue to slide along until slowed by friction. With manipulation support for inertia, your app can include similar behavior without any extra work on your part.

When inertia starts, the `ManipulationInertiaStarting` event is raised. The arguments for this event include the arguments that were discussed for the `ManipulationDelta` event, as well as `TranslationBehavior`, `ExpansionBehavior`, and `RotationBehavior` arguments to control the behavior of the inertia effect. Each of these values includes a value called `DesiredDeceleration` that defines the deceleration rate, as well as a value to indicate the final desired value for each property, respectively named `DesiredDisplacement`, `DesiredExpansion`, and `DesiredRotation`. You can either leave the default values in place or replace them with your own value for more control over the inertia behavior. After the handler for this event has completed, the manipulation processor automatically raises `ManipulationDelta` events with values based on the application of inertia to the current state until either the desired value is reached (if specified) or deceleration results in a velocity of zero.

When the last pointer has been released, or when inertia has completed (when specified through the `ManipulationMode` setting), the `ManipulationCompleted` event is raised, signaling that the manipulation is now complete. The arguments to this event include the general-purpose informational properties that were discussed previously, as well as the `Cumulative` and `Velocities` information that was also provided to the `ManipulationDelta` event.

NOTE

Although the manipulation and gesture events the `UIElement` class provides will take care of most needs, more control or additional gesture types are required in some cases. The Windows Runtime provides the `Windows.UI.Input.GestureRecognizer` class, which can directly process pointer events to generate these high-level events.

Gesture Events

Gesture events are similar to manipulation events, in that they are the result of grouping and interpreting several pointer events. However, a few key differences set them apart. First, gesture events communicate more abstract and discrete concepts than manipulation events. Manipulation events communicate information about the beginning, middle, and end of a manipulation and include arguments that provide information about the different kind of changes that have occurred. Gesture events each relay information about the occurrence of a single, isolated event, such as a tap or a double-tap. Second, manipulation events provide information that synthesizes input from several pointers, whereas gesture events are concerned with the action of only one pointer at a given time.

As with manipulation events, the `UIElement` class provides the most commonly used access to gesture events and related configuration settings. Table 13.3 summarizes the gesture events made available by `UIElement` instances.

TABLE 13.3 Gesture Events Defined in `UIElement`

Event	Description
`Tapped`	A tap has occurred, defined by a quick pointer press and release (where a long press followed by a release results in `Holding` and `RightTapped` events). This is equivalent to a mouse `Click` event.
`DoubleTapped`	A second tap has occurred after a first tap event, within a system-setting defined time. This is equivalent to a mouse `DoubleClick` event.
`Holding`	A long-duration press is occurring or has completed. The event is raised when the long-press is initially detected, and once again when the long-press is either completed or cancelled. Mouse devices generally do not raise this event.
`RightTapped`	A right-tap has occurred, defined by either the completion of a holding gesture (for touch and pen devices) or a click with the right button (for mouse devices). This is equivalent to a mouse `RightClick` event.

All the gesture events include a PointerDeviceType property that indicates the type of device that generated the event, as well as a GetPosition method that returns the coordinates of the action that led to the event, relative to the UIElement argument in the method call. If a null value is provided to GetPosition, the coordinates returned are relative to the app itself. The Holding event also includes a HoldingState property that is discussed shortly. Note that the Tapped and Holding events are mutually exclusive. Also, when a double-tap occurs, a Tapped event is raised for the first interaction, but the second one generates only the DoubleTapped event.

The UIElement class also provides the IsTapEnabled, IsDoubleTapEnabled, IsHoldingEnabled, and IsRightTapEnabled properties. By default, they are all set to true; setting them to false prevents the corresponding event from being raised.

The Tapped, DoubleTapped, and RightTapped events are similar, but the Holding event behaves a little differently. As Table 13.3 mentioned, the Tapped event is usually generated only by interaction with touch and stylus devices, not by mouse devices. It is also the only event that is raised when the pointer involved in the event is in a pressed state. When a pointer is pressed and held steady, and after the initial hold time interval has passed, the Holding event is raised with its HoldingState property set to a value of Started. After the hold has begun, if the pointer is moved or the same element captures another pointer, the hold is considered to have been cancelled and the Holding event is raised once again, with the HoldingState property set to a value of Cancelled. Otherwise, when the pressed pointer is lifted, the Holding event is raised again with a HoldingState property set to a value of Completed. If the hold was successfully completed, the RightTapped event follows.

In the example application, the tap-related gesture events cause different actions to happen to the shapes they occur on. The Tapped event changes the shape color to a random value, the DoubleTapped event causes the shape to take a new randomly calculated direction, and the RightTapped event causes the shape to be reset to its original color, size, and rotation. The code in Listing 13.5 illustrates this interaction for a Tapped event.

LISTING 13.5 Processing a Gesture Event

```
private void HandleTapped(Object sender, TappedRoutedEventArgs args)
{
    // Check to see if this kind of device is being ignored
    if (!IsValidDevice(args.PointerDeviceType)) return;

    // Examine the current position
    var position = args.GetPosition(_eventSourceElement);
    Debug.WriteLine("Tapped at X={0}, Y={1}", position.X, position.Y);

    // Alter the shape based on the gesture performed
    _shapeModel.SetRandomColor();
}
```

Keyboard Input

In addition to the pointer-based input devices, the Windows Runtime includes support for working with input gathered from keyboards. To obtain information about the available keyboard support, you can use the `KeyboardCapabilities` class. Similar to the `MouseCapabilities` and `TouchCapabilities` counterparts, it includes a `KeyboardPresent` property that is set to a value of `1` if one or more keyboards are currently available. The example application uses this value to provide the text for a message box that displays when the user clicks the Details button next to the Keyboard header, as in Listing 13.6.

LISTING 13.6 Displaying Keyboard Capabilities

```
var keyboardCapabilities = new KeyboardCapabilities();
var message = keyboardCapabilities.KeyboardPresent == 1
    ? "There is a keyboard present."
    : "There is no keyboard present.";

ShowMessage(message, "Keyboard Properties");
```

The `UIElement` class provides two available keyboard events. The `KeyDown` event is raised when a key is pressed, and the `KeyUp` event is raised when a pressed key is released. These events are raised by a control only when the control has the input focus, either when the user taps inside the control or uses the Tab key to rotate focus to that control, or when the control's `Focus` method has been called programmatically.

As an alternative, the CoreWindow class provides three events related to keyboard interactions. Similar to the UIElement, it provides KeyDown and KeyUp events. However, these events are raised regardless of which control currently has input focus. The CoreWindow class also includes a CharacterReceived event, which is discussed in more detail shortly.

In the case of the UIElement, both the KeyDown and KeyUp events provide KeyRoutedEventArgs arguments; for the CoreWindow class, the KeyDown and KeyUp events provide KeyEventArgs arguments. The most significant difference between these argument types is the naming of the property used to identify the key involved in the action that led to the event being raised. KeyRoutedEventArgs provides a property named Key that returns a value of the VirtualKey enumeration indicating the specific key on the keyboard that was pressed or released. In the KeyEventArgs class, the corresponding property is named VirtualKey.

In either case, the KeyStatus property contains additional information about the key event. For KeyDown events, its WasKeyDown property is particularly interesting because it indicates whether the event is being raised in response to a key being held down. In this case, several KeyDown events usually are raised, followed by a single KeyUp event. The first KeyDown event has its WasKeyDown value set to false, with the subsequent KeyDown events setting the value to true.

The CharacterReceived event of the CoreWindow class was previously mentioned. This event is fired between the KeyDown and KeyUp events and provides access to the actual interpreted character resulting from the current key combination. This value is returned as an unsigned integer in the CharacterReceivedEventArgs KeyCode property. It can be converted to the corresponding Char character using the Convert.ToChar function:

```
var interpretedChar = Convert.ToChar(args.KeyCode);
```

To put this in perspective, with a standard U.S. keyboard, pressing the equals (=) key while the Shift key is also pressed is interpreted to result in the plus (+) character. The KeyDown and KeyUp events understand this key only as VirtualKey 187, regardless of whether the Shift key is pressed. However, the KeyCode value provided in the arguments to the CharacterReceived event provides either a value of 61 for the equals key or a value of 43 for the plus key.

To illustrate the use of the keyboard input events, the main page in the example application listens for KeyUp events via the CoreWindow class to add either a new ball or a square shape whenever the B or S keys are pressed, respectively. The following code illustrates this:

```
if (args.VirtualKey == VirtualKey.B)
    CreateShape(ShapeModel.ShapeType.Ball);
```

Note that if you are interested in key combinations in which a "modifier key," such as one or more of the Shift, Control, or Alt keys pressed in concert with another key, you have two options. First, you can track the individual key down and key up events to determine which keys are up or down at any given instant. Second, you can actively interrogate the state of a given key by using the GetKeyState method that the CoreWindow class provides. Because the result of GetKeyState returns a flag value, it is a best practice to mask the result value before comparing it with the desired value. Also note that the Alt key corresponds to the Menu member of the VirtualKey enumeration. Listing 13.7 shows this approach.

LISTING 13.7 Checking for Modifier Keys

```
 // Check for shift, control, alt (AKA VirtualKey.Menu)
var currentWindow = CoreWindow.GetForCurrentThread();
var ctrlState = currentWindow.GetKeyState(VirtualKey.Control);
var shftState = currentWindow.GetKeyState(VirtualKey.Shift);
var altState = currentWindow.GetKeyState(VirtualKey.Menu);
var isControlKeyPressed =
  (ctrlState & CoreVirtualKeyStates.Down) == CoreVirtualKeyStates.Down;
var isShiftKeyPressed =
  (shftState & CoreVirtualKeyStates.Down) == CoreVirtualKeyStates.Down;
var isAltKeyPressed =
  (altState & CoreVirtualKeyStates.Down) == CoreVirtualKeyStates.Down;
```

Sensor Input

Devices such as touchscreens, mouse devices, styluses, and keyboards provide interactivity by allowing an app to respond to their interactions with components shown on their device displays. Users tap elements drawn to the screen or type characters that will appear inside onscreen text regions. However, a class of input devices known as sensors can give a running app information about the device's relationship to its physical environment. Examples of the information sensors gather include details about which way the device is facing, its velocity in any particular direction, its position on the globe, and how much light is shining on it at a given moment. Devices might or might not include one or more of these kinds of sensors.

The Windows Runtime API includes support for working with several different kinds of sensors and relaying the information they gather. These APIs not only enable an app to ask for sensor measurements, but they also provide events that can be subscribed to and, in most cases, the capability to throttle how often these events can be raised. Some of the environmental information that can be obtained through these APIs includes information about a device's physical location, its movement and orientation, and how bright of an environment it is in.

The Example App

The **SensorsExample** project highlights a few different ways sensors can be used from within an application. The app features an instance of the interactive Bing Maps control surrounded by boxes that show information from and allow interaction with each of the various sensors. The boxes along the left side also allow the app to coordinate the information it receives from the sensors with the display of the Bing Maps control. The Location section allows the map to be centered at the current geolocation coordinates and also offers support for working with geofencing (the upcoming sections explain geofencing). The Compass section enables the app to set the map's orientation to approximate the current compass heading (although the support offered for setting a specified heading in the Bing Maps control is currently somewhat limited). The Inclinometer section allows the map to be panned in concert with the direction in which the device itself is being tilted.

Working with the Bing Maps Control

The Bing Maps control in the example project is part of the Bing Maps platform, which includes the Windows control, controls for other platforms, and several related data services. You can access information about the Bing Maps control and the related services and the tools and resources you need to include in your project through the Bing Maps Platform Portal.[2] Although the control and the related services offer a tremendous amount of functionality, you need to be aware of some important license-related and technical considerations for this example application and in case you are considering their use in your own app.

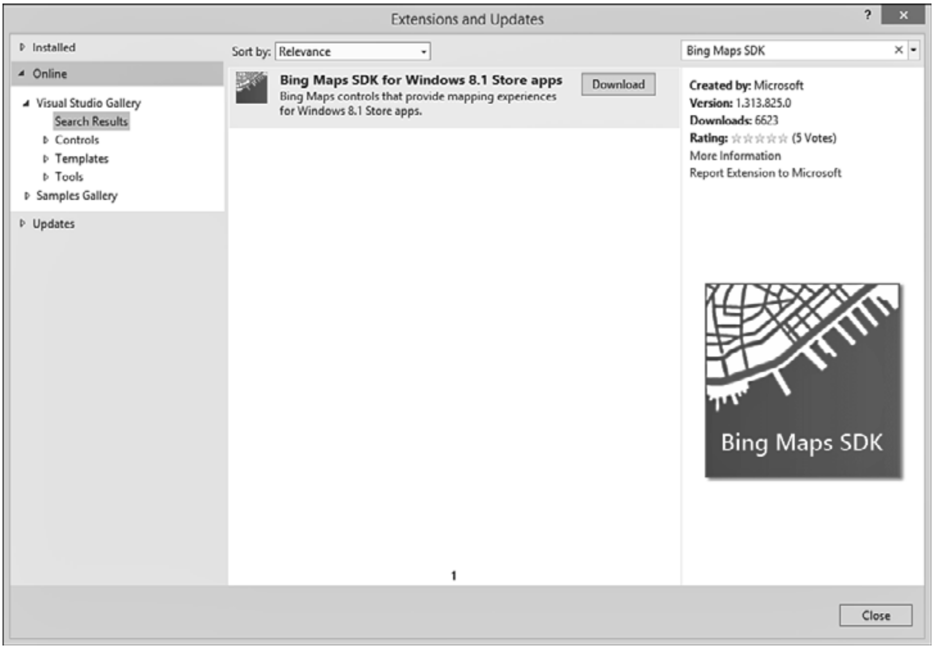
From a licensing standpoint, some restrictions govern how this control can be used. The Bing Maps Platform Portal includes a Licensing Options page that explains how the restrictions apply to your app, under what circumstances the tools can be used for free, and when a fee needs to be paid to license the use of the control. As of this writing, you can access this page by clicking the Licensing link from the Bing Maps Platform Portal page. If you will use the Bing Maps control in your Windows Store App, be sure to look over the restrictions and conditions for use in the context of your application needs and ensure that you are abiding by the appropriate terms of use.

From a technical standpoint, before you can build the **SensorsExample** project, you need to download and install the Bing Maps SDK. You can get to the latest SDK installer by following links on the Bing Maps Platform Portal. Alternatively, you can use the Visual Studio Extension Manager to obtain the SDK.

To use the Extension Manager, launch Visual Studio and select **Extensions and Updates** from the **Tools** menu. In the **Extensions and Updates** dialog box, select the **Online** node and then select **Visual Studio Gallery**. Then type **Bing Maps SDK** into the search box in the upper-right corner (see Figure 13.1). In the search results, select the entry for **Bing Maps SDK for Windows 8.1 Store Apps** and click the **Download** button; then click the **Install** button in the ensuing dialog box after you have read and reviewed the included license agreement. After the installation has

[2] Bing Maps Platform Portal, www.microsoft.com/maps/

completed, you will most likely be instructed to restart Visual Studio so that you can use the installed SDK components.



Sort by: Relevance

Bing Maps SDK

Bing Maps SDK for Windows 8.1 Store apps
Bing Maps controls that provide mapping experiences for Windows 8.1 Store apps.

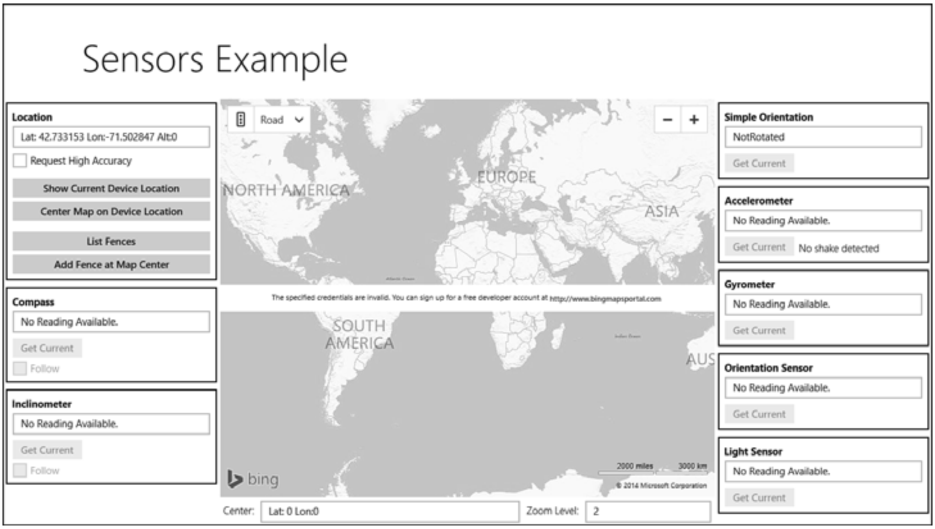
Created by: Microsoft
Version: 1.313.825.0
Downloads: 6623
Rating: ☆☆☆☆☆ (5 Votes)
More Information
Report Extension to Microsoft

FIGURE 13.1 Locating the Bing Maps SDK Visual Studio extension

Because this additional download and installation is required to build the example project, the build configuration in the **WinRTByExample** solution has been configured to not include the **SensorsExample** project as part of the solution build by default. To build the project, you need to either select the project in the **Solution Explorer** and choose **Build** from the project file's context menu, or choose **Build SensorsExample** from the **Build** menu. Another option is to open the **Configuration Manager** entry from the **Build** menu and check the **Build** entry next to the **SensorsExample** project in the **Configuration Manager** dialog box that appears; the **SensorsExample** project then is built along with the other projects in the solution.

Another consideration when building a project that includes the Bing Maps control is the selection of a target platform. Most Windows Store apps are built with the target set to Any CPU. However, the Bing Maps control relies on the Visual C++ Runtime, which requires selecting a specific processor architecture to build a project that references it. You can set this value in the Configuration Manager dialog box. Select the appropriate Platform for your build either for the entire solution or for the **SensorsExample** project. For example, you need to select a value of **ARM** to create a version of the resulting app that will run on Windows RT devices. Note that in order to work with the XAML designer in Visual Studio, you need to select the value **x86**. If you prefer to have the interactive designer available, you can always set the value temporarily to x86 and then set it to your desired target platform when you have finished working in the XAML designer.

To deploy an app that includes the Bing Maps control, you need to specify a value for the map's `Credentials` property. If you do not specify a valid map key for the map `Credentials` property, the map control displays with a banner indicating that invalid credentials are being used, as you can see in the example app screen in Figure 13.2.



Sensors Example

Location: Lat: 42.733153 Lon:-71.502847 Alt:0

□ Request High Accuracy

The specified credentials are invalid. You can sign up for a free developer account at http://www.bingmapsportal.com

Compass: No Reading Available.

Inclinometer: No Reading Available.

Simple Orientation: NotRotated

Accelerometer: No Reading Available.

No shake detected

Gyrometer: No Reading Available.

Orientation Sensor: No Reading Available.

Light Sensor: No Reading Available.

Center: Lat: 0 Lon:0

Zoom Level: 2

FIGURE 13.2 The Bing Maps control displayed without valid credentials

The following markup shows the credentials being set in the example project:

```
<maps:Map Credentials="{StaticResource MapKey}"/>
```

In this example, the credentials are located in the resource defined by the value `MapKey`, which is defined in the project's `App.xaml` file. The map key is a value you obtain from the Bing Maps Account Center.[3] Sign into the account center with your Microsoft Account credentials and select **Create or View Keys**. At this point, you can define a new key by specifying information about your application or retrieve a previously defined key. Place this key value into the `MapKey` resource in your project, and build and run your project to make sure that the warning message from Figure 13.2 no longer displays.

TIP

After you deal with the logistics related to licensing for the Bing Maps control and the mechanics related to installing the SDK, configuring the project build, and obtaining and configuring the map key, you will likely find that the Bing Maps control offers a tremendous amount of functionality. The Bing Maps Platform Portal includes both development guides and MSDN API documentation that covers the available functionality. Another helpful resource in the interactive SDK is provided for the Bing Maps AJAX control at www.bingmapsportal.com/isdk/ajaxv7: It provides an interactive map and the JavaScript and related HTML. Many of the concepts and much of the code illustrated in this tool translate readily to the corresponding .NET API.

Geolocation

Geolocation refers to information about an item's geographic location. In the Windows Runtime, one of two data sources provides this location information. The first data source for location information is the Windows Location Provider. The Windows Location Provider obtains its information from a couple different data sources. The first source it attempts to use is Wi-Fi triangulation, in which the proximity to different known Wi-Fi hotspots is used to determine a position. If Wi-Fi data is not available, IP

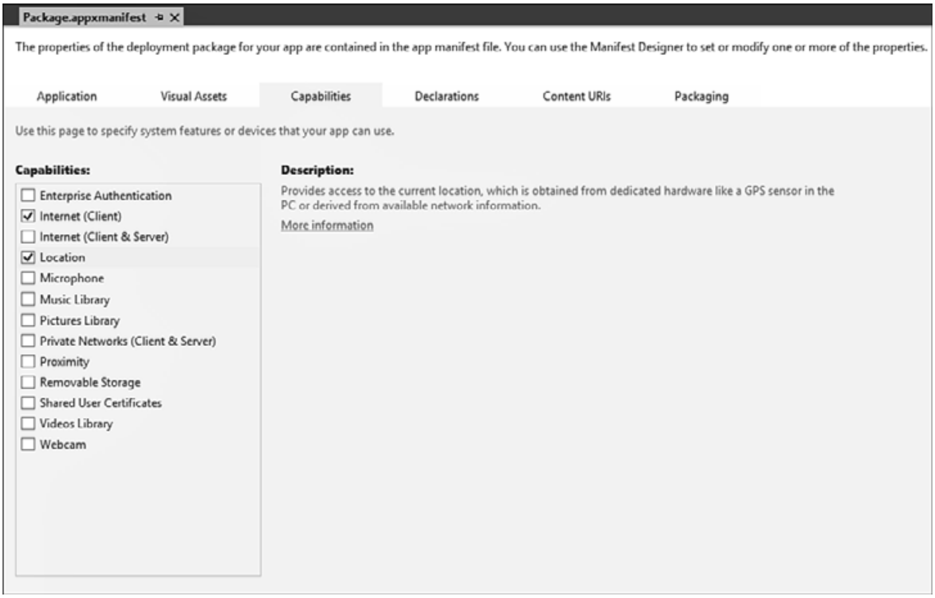
[3] Bing Maps Account Center, https://www.bingmapsportal.com/

address resolution is then used. The second data source that the Windows Runtime can use to obtain location information is available if the device optionally includes one or more Global Positioning System (GPS) sensors.

The network-based information that the Windows Location Provider gathers is limited in both accuracy and amount of available detail because only latitude, longitude, and accuracy information are made available. An installed GPS sensor most likely provides more accurate information (different sensors have different resolution capabilities) and also gives more location information than the Windows Location Service, potentially including details about direction, speed, and altitude. Note, however, that the additional detail afforded by GPS sensors tends to come with additional power use and, therefore, reduced battery life.

Getting Started

To start working with location information in a Windows 8.1 application, you first need to declare that the app will be accessing this information. Location information is considered to be personally identifiable information (PII), so any app that will access this information needs to explicitly declare its intent to do so. The App Store's certification process will refuse an app that includes use of the geolocation APIs if it does not provide such a declaration; if the app does provide the declaration, the app's entry in the store will indicate its intent to access this information. As an additional measure meant to protect users, Windows notifies users the first time an app accesses location information and prompts them to either allow or block access. Windows also provides several places where the user can choose to toggle this same permission on or off, as will be discussed shortly. To declare that an app will attempt to access location information, open the app manifest file, select the **Capabilities** panel, and check the **Location** entry under the **Capabilities** list (see Figure 13.3).



The properties of the deployment package for your app are contained in the app manifest file. You can use the Manifest Designer to set or modify one or more of the properties.

Use this page to specify system features or devices that your app can use.

Capabilities:

- ☐ Enterprise Authentication
- ☑ Internet (Client)
- ☐ Internet (Client & Server)
- ☑ Location
- ☐ Microphone
- ☐ Music Library
- ☐ Pictures Library
- ☐ Private Networks (Client & Server)
- ☐ Proximity
- ☐ Removable Storage
- ☐ Shared User Certificates
- ☐ Videos Library
- ☐ Webcam

Description:

Provides access to the current location, which is obtained from dedicated hardware like a GPS sensor in the PC or derived from available network information.

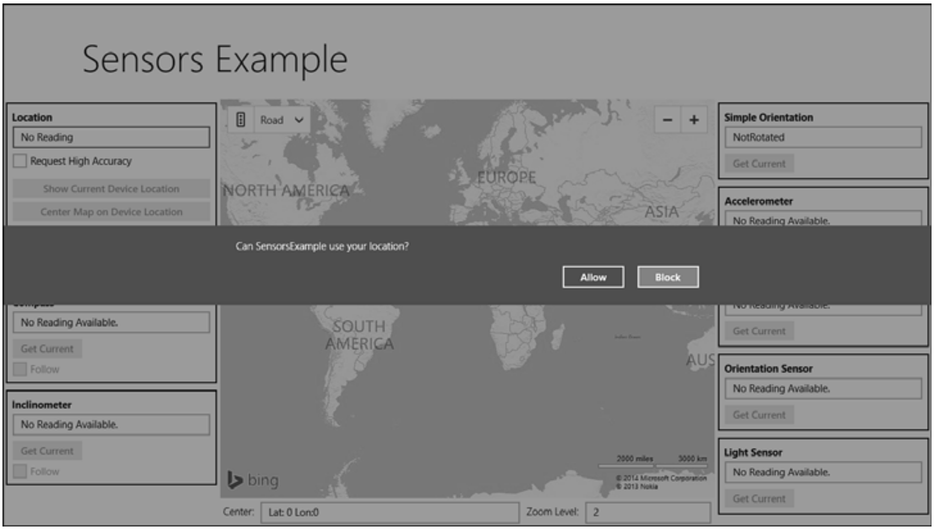
More information

FIGURE 13.3 Setting the location capability in the app manifest

Using the Geolocator

The `Geolocator` class provides location information in the Windows Runtime. You can obtain the current position value from this class in two ways. The first option is to directly request the current position with the `GetGeopositionAsync` method. The second option is to provide a handler for the `PositionChanged` event that is called when a position change is detected, depending on the configuration of the `Geolocator` instance.

The first time an app calls the `GetGeopositionAsync` method or registers an event handler for the `PositionChanged` event, the user is prompted to grant permission for the app to access location information, as Figure 13.4 illustrates. Because this step might display a user interface element, it is important to make sure that this first call takes place on the UI thread; otherwise, an unexpected cross-thread exception might occur whose cause can be difficult to diagnose.



Sensors Example

Location: No Reading

□ Request High Accuracy

Can SensorsExample use your location?

No Reading Available.

Inclinometer: No Reading Available.

Simple Orientation: NotRotated

Accelerometer: No Reading Available.

Orientation Sensor: No Reading Available.

Light Sensor: No Reading Available.

Center: Lat: 0 Lon:0 Zoom Level: 2

FIGURE 13.4 Windows prompting the user for location information permission

The value selected in the prompt is reflected in the **Permissions** panel that you can access through the app's **Settings Charm**, as well as within the **Location** panel in the **Privacy** section located in **PC Settings**. This system-wide location privacy screen lists all the applications that are registered to access position information and states whether access is currently blocked or enabled. It also includes a system-wide switch to disable access to location information for all apps that request it. However they access it, when users choose to block the app's access to location information, the `LocationStatus` property on the `Geolocator` instance returns a value of `PositionStatus.Disabled`. The potential consequences of this `LocationStatus` value and other values that can appear in this property are discussed shortly.

In the example app, interactions with the `Geolocator` are handled in the `GeolocationHelper` class. The code in Listing 13.8 shows the `Geolocator` initialization and subscription to the available events.

LISTING 13.8 Geolocator Initialization and Event Subscription

```
_geolocator = new Geolocator();

// Listen for status change events, but also immediately get the status.
// This is in case it is already at its end-state and therefore
// won't generate a change event.
_geolocator.StatusChanged +=
    (o, e) => SetGeoLocatorReady(e.Status == PositionStatus.Ready);
SetGeoLocatorReady(_geolocator.LocationStatus == PositionStatus.Ready);

// Set the desired accuracy. Alternatively, can use
// DesiredAccuracyInMeters, where < 100 meters ==> high accuracy
_geolocator.DesiredAccuracy = GetDesiredPositionAccuracy();

// Listen for position changed events.
// Set to not report more often than once every 10 seconds
// and only when movement exceeds 50 meters
_geolocator.ReportInterval = 10000; // Value in ms
_geolocator.MovementThreshold = 50; // Value in meters
_geolocator.PositionChanged += GeolocatorOnPositionChanged;
```

The first task in the code in Listing 13.8 is to work with the `LocationStatus` value. The `Disabled` status was previously mentioned, but it is important to note that an attempt to request the current position from a `Disabled` instance results in an `UnauthorizedAccessException`. If location access has not been blocked, the `LocationStatus` property has a value of `NoData` either before the first call to `GetGeopositionAsync` or before the first time an event handler is provided for `PositionChanged`. When either of these happens, the Windows Runtime might trigger a startup sequence that takes a little time to complete. During that time, the `LocationStatus` returns a value of `NotInitialized`. Additionally, if location data is coming from a GPS sensor, the sensor tries to retrieve information from some required minimum number of satellites. Until the device reaches this number, the `LocationStatus` has a value of `Initializing`. When the `Geolocator` instance is ready, the `LocationStatus` returns a value of `Ready`. With all that in mind, when including the `Geolocator` in your project, be sure to account for the fact that, even under ideal circumstances, a lag might occur before it is ready to be used; you need to check to ensure that it has reached the `Ready` status.

In the example code, the `SetGeoLocatorReady` function is called with a value of `true` only when the sensor is in a `Ready` state. It is used to set the

SensorSettings IsLocationAvailable property, which the application user interface uses to disable access to location retrieval functions. It also sets a local flag that prevents direct calls to get the current position through the GetCoordinate function from actually making the request through the Geolocator until it is in the Ready state.

The next step after working with initialization and status information involves establishing the desired accuracy for the Geolocator instance. The DesiredAccuracy property can be set to either PositionAccuracy.High or PositionAccuracy.Default. A value of High instructs WinRT to always try to use a GPS for its data if one is available, and to otherwise use the Windows Location Provider. A value of Default instructs WinRT to make use of only GPS sensors if it cannot obtain a value from the Windows Location Provider, such as when no Wi-Fi signals exist for triangulation (or the device is either not equipped or not configured to work with Wi-Fi) and when the device does not have an IP address that can be looked up for location information. Ultimately, setting either of these values does not guarantee how the WinRT will make use of GPS devices; it just indicates a preference for how it should behave.

NOTE

The Windows Runtime also includes a DesiredAccuracyInMeters property. When this property is set to a non-null value, it resets the DesiredAccuracy property value. A DesiredAccuracyInMeters value of less than 100 meters results in a DesiredAccuracy value of High; a value of 100 meters or higher sets DesiredAccuracy to Default.

The final task in Listing 13.8 is to configure how the Geolocator will go about raising PositionChanged events, which is controlled with the ReportInterval and MovementThreshold properties. Each of these properties limits how often the Geolocator instance can raise the PositionChanged events. Whereas the ReportInterval property specifies the minimum amount of time that must elapse between instances of the Windows Runtime attempting to obtain location information values, the MovementThreshold property indicates how much distance must pass before a subsequent event is raised. In the example code, the ReportInterval property is set to ensure that at least 10 seconds (10,000 milliseconds) pass between event updates. The MovementThreshold value is set to ensure that the position has changed by at least 50 meters. (The sensor is checked every 10 seconds, and the class instance raises an event only if the distance between checks exceeds 50 meters.) A value of 0 for ReportInterval generates events at whatever the maximum frequency is for the most accurate location source, and it should be used only for apps that require near-real-time position updates. Because it affects how often the location hardware is queried and, therefore, can impact battery life, it is important to set the ReportInterval to the maximum value possible for the needs of your app. Also note that not every scenario involving the Geolocator needs to subscribe to the PositionChanged event; some cases are served just fine by requesting the position directly only when it is needed. Each application has different needs in terms of how frequently to update position information and whether to individually request it with the GetGeopositionAsync method or use change events.

Working with Geocoordinate Values

An instance of the Geoposition class is returned both from a call to GetGeopostionAsync and within the Position member of the PositionChangedEventArgs event arguments that are provided to PositionChanged event handlers. Although the Geoposition class contains both Coordinate and CivicAddress properties, the CivicAddress values are not populated in Windows 8.1 (the only member that is set is the Country property, which is obtained from the country value set in the Windows region settings instead of the location information data sources that were previously mentioned). The Coordinate property is an instance of the Geocoordinate class and contains several different kinds of position information that are returned either from the Windows Location Provider or from GPS sensors (as you have seen, this depends on how the Geolocator is configured).

At its root, the Geocoordinate object provides a PositionSource property that either indicates how the location information was obtained or includes a value of Unknown if information about the source is not available. It also include an Accuracy property that indicates how accurate (in meters) the latitude and longitude position information are believed to be. If the location information is being obtained from a GPS sensor, values for the Speed, Heading, AltitudeAccuracy, and SatelliteData properties might also be included, depending on the sensor's capabilities.

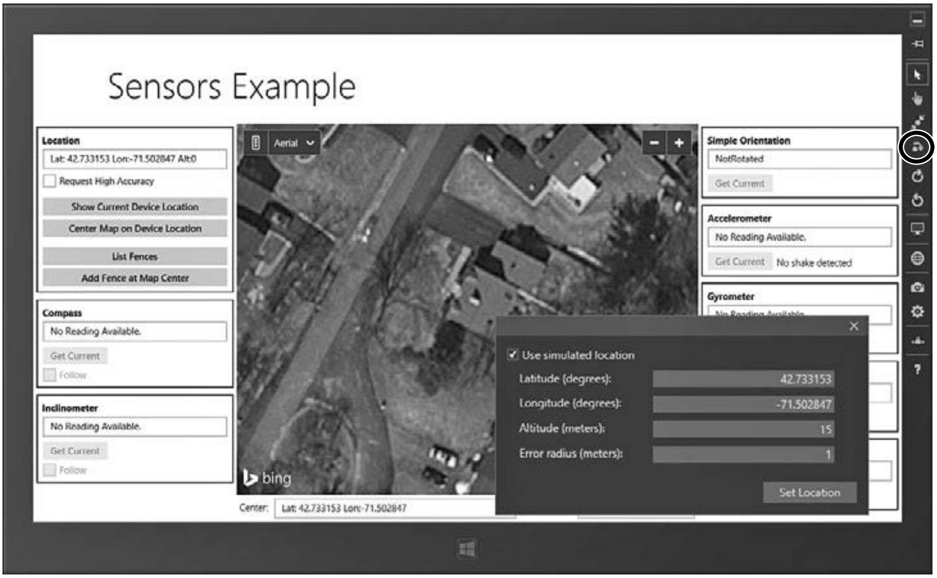
The actual position information provided is a little buried in the object hierarchy. It is actually returned in the Position property within the Point property of the Geocoordinate instance. Regardless of whether the location information is obtained from a GPS sensor or the Windows Location Provider, values for Latitude and Longitude (measured in degrees) are provided in this Point property. If the information is obtained from a GPS sensor, the Altitude value might be provided as well.

To show how this information looks in practice, the example application includes the capability to display all the fields of the Geocoordinate object for the current location. Clicking the **ShowCurrent** button in the app's **Location** box displays a pop-up that contains these values, as provided by a call to the GetGeoPositionAsync method. The **Center Map on Current** button also makes a call to the GetGeopositionAsync method and sets a viewmodel property from the previously discussed Point property. The property in the ViewModel is data bound to the Bing Maps control so that when the value changes, the map centers itself at the Latitude and Longitude coordinates specified in the position value.

Using the Simulator Location Tools

Chapter 2 introduced you to the Visual Studio simulator for Windows Store Apps (the Simulator), which enables you to run and test your Windows 8.1 app within a simulated environment on your development system. In addition to being able to emulate various screen sizes and resolutions (along with the other functionality it provides), the simulator can be used to provide simulated geolocation values to a running app, which can help you test your location-aware app. To use the simulator's location functions, several requirements must be met, primarily related to Location Settings enabled on the local system. When you first try to use the location functions, you are prompted and instructed to take corrective action if your system does not meet the necessary requirements for the location simulator to run.

To use the location functions of the simulator with your location-aware app, start debugging in the simulator following the instructions in Chapter 2. When the app is running in the simulator, clicking the icon in the simulator toolbar that resembles a globe displays the location simulation dialog box (see Figure 13.5). When the Use Simulated Location check box is checked, it provides access to text boxes for setting location values such as Latitude, Longitude, and Altitude.



Sensors Example

Location: Lat: 42.733153 Lon:-71.502847 Alt:0

□ Request High Accuracy

Compass: No Reading Available.

Inclinometer: No Reading Available.

Simple Orientation: NotRotated

Accelerometer: No Reading Available. No shake detected

Center: Lat: 42.733153 Lon:-71.502847

☑ Use simulated location

Latitude (degrees): 42.733153

Longitude (degrees): -71.502847

Altitude (meters): 15

Error radius (meters): 1

FIGURE 13.5 Using location tools in the Windows simulator

When the Set Location button is clicked, the `Geolocator` API methods and events that are used by the app running in the simulator use those values for their position information. Removing the check from the Use Simulated Location check box returns the simulator to using the host system values for its current position values.

Geofencing

Geofencing enables your Windows 8.1 app to define geographic boundaries (known as geofences) and monitor a device's position relative to those boundaries. Your app then produces notification events when the device enters or exits those boundaries. For applications that need to be alerted when a device has moved into or beyond one of these boundaries, this provides a much more efficient solution than polling the geolocation APIs and making the determinations programmatically. To support geofencing, the Windows Runtime includes APIs that allow registering and managing geofences, as well subscribing to and processing the related notifications.

Getting Started

The geofencing support the Windows Runtime provides is closely related to the geolocation support and includes several of the same restrictions and conditions related to working with personally identifiable information. To use geofencing, you must set the Location capability in the app manifest and set both the app-specific and system-wide permission settings to allow the app to access location information.

The `GeofenceMonitor` class provides geofencing support in the Windows Runtime. Unlike using the `Geolocator`, where you create a new instance of the class to access the functionality, a reference to the `GeofenceMonitor` is accessed through its static `Current` property:

```
var geofenceMonitor = GeofenceMonitor.Current;
```

The following sections discuss the functionality that the `GeofenceMonitor` exposes.

NOTE

Unlike with geolocation, accessing the geofencing properties and events does not automatically prompt the user to grant permission to location information. You might have to check to see if location functionality is currently disabled by checking the `GeofenceMonitor Status` property and instructing the user to access the permissions property in the Settings Charm. If your app also uses the `Geolocator` to potentially access the user's current location (perhaps to obtain the center point for a fence), that class access provides the necessary request for permissions.

Defining a Fence

The GeofenceMonitor works with a collection of Geofence instances. Each Geofence object describes the region the fence covers, the types of events to provide, and the conditions under which it indicates that an event has occurred. Table 13.4 describes the settings provided by the Geofence class. Be aware that these values must be set through one of the Geofence constructors and cannot be changed after the geofence has been defined.

Table 13.4 Geofence Settings

Setting	Description
Id	Specifies the ID for the fence. The ID is a String that must be unique within the scope of the current app, and it must be a maximum of 64 characters long. This value is required.
Geoshape	Specifies the geofence boundary. Currently supports being set to only a Geocircle instance, which defines the boundary via a center point and a radius. This value is required.
MonitoredStates	Specifies which events the GeofenceMonitor raises for this fence. Can be set to a combination of the MonitoredGeofenceStates enumeration values, which includes Entered, Exited, and Removed, but must minimally include either Entered or Exited. This value is optional and, by default, is set to the combination of Entered and Exited.
SingleUse	Specifies whether the fence is automatically removed. If set, when each of the MonitoredStates (with the exception of Removed) is reached at least once, the fence is automatically removed from the GeofenceMonitor collection. This value is optional and, by default, is set to false.
DwellTime	Specifies the time that must elapse when a geofence condition is met before an event is raised. This value is optional and, by default, is set to 10 seconds.
StartTime	Specifies the time at which the geofence monitoring begins. This value is optional and, by default, is set to a minimal value of January 1, 1601 (which is the base value for the Windows FILETIME structure).

Setting	Description
Duration	Specifies the amount of time following StartTime during which the fence should be monitored. This value is optional and, by default, is set to TimeSpan.Zero, which indicates an indefinite duration.

After a Geofence instance has been defined, the GeofenceMonitor begins tracking it when it is added to its Geofences collection.

In the example app, the code for working with the GeofenceMonitor has been consolidated into the GeofenceHelper class. This class provides an AddGeofence method used to add new fences (see Listing 13.9). Clicking the Add Fence at Map Center button in the example application produces a flyout that enables the user to define a name for the geofence. The center point is retrieved from the map's current center point, and the radius is hardcoded to 20KM. Pressing the flyout's Add Fence button calls this method with the values in the flyout. This method then creates a Geocircle with the specified center and radius, which is provided to the Geofence constructor along with indications that the GeofenceMonitor should listen to Entering, Exited, and Removed events (the next section covers the events) and that the geofence is not configured to be single use. Default values are accepted for the remaining parameters. The resulting Geofence instance is then added to the GeofenceMonitor collection and returned so that it can be used to include a UI entry on the Bing Maps control.

Listing 13.9 Adding a Geofence

```
public Geofence AddGeofence(
    String fenceId,
    BasicGeoposition fenceCenter,
    Double radiusInMeters)
{
    var fenceCircle = new Geocircle(fenceCenter, radiusInMeters);

    const MonitoredGeofenceStates states =
        MonitoredGeofenceStates.Entered |
        MonitoredGeofenceStates.Exited |
        MonitoredGeofenceStates.Removed;

    // Create the fence with the desired states and not single-use
    var fence = new Geofence(fenceId, fenceCircle, states, false);
    GeofenceMonitor.Current.Geofences.Add(fence);
    return fence;
}
```

When defining a geofence boundary, keep in mind the limitations of the accuracy of the various location providers available to the Windows Runtime. Depending on sensor capabilities and network connectivity, extremely small fences might not be all that useful.

Geofence Events

You can receive notifications that geofencing events have occurred in two ways. Foreground notifications are configured when an app registers an event handler for the `GeofenceStateChanged` event provided by the `GeofenceMonitor` class. Alternatively, you can set up a background task to process geofence notifications even when the app is not running in the foreground. To configure geofencing background task notifications, the `LocationTrigger` class needs to be provided to a `BackgroundTaskBuilder`, and that builder instance needs to be configured and then registered. Chapter 15, "Background Tasks," covers this in more detail.

As previously discussed, the `GeofenceMonitor` events can be triggered in response to the device entering or exiting a geofence, depending on the combination of the `Entered` or `Exited` `GeofenceState` enumeration values provided in the `MonitoredStates` value when the `Geofence` instance was defined. Additionally, the event can occur in response to the geofence being automatically removed from the list of monitored fences and depending on whether the `Removed` enumeration value was specified.

Automatic removal of a `Geofence` occurs in response to the values set in its `Duration` and `SingleUse` properties. `Duration` is the easiest to understand. When the time window indicated by the combination of the `StartTime` and `Duration` properties has expired, a geofence event is recorded indicating that this fence is no longer being monitored. In this case, the event includes a `RemovalReason` value that is set to `Expired`.

The other option for automatic removal relates to the `SingleUse` property. When this value is set to `true`, a geofence is removed after all its `MonitoredStates` have occurred. If a `Geofence` instance is defined with only

Entered or Exited specified, then as soon as the corresponding event takes place, the geofence is removed. If both Entered and Exited are specified, the geofence is removed only after both have occurred. In this case, the Removed state is accompanied by a RemovalReason value of Used.

When a geofence notification event is received, the app should call the ReadReports method of the GeofenceMonitor instance, which returns the collection of all notification reports that have accumulated since the last call to ReadReports was made. Each report is actually indicated in an individual GeoStateChangedEventReport, and a single GeofenceMonitor event can encompass multiple reports, especially in the case of background tasks, which run only periodically.

The example app subscribes to geofence notifications only in the foreground. To do so, the GeofenceHelper class registers its HandleGeofenceStateChanged method as a handler for the GeofenceStateChanged event (see Listing 13.10).

LISTING 13.10 Processing Geofence Events

```
private void HandleGeofenceStateChanged(GeofenceMonitor monitor,Object o)
{
    // Iterate over and process the accumulated reports
    var reports = monitor.ReadReports();
    foreach (var report in reports)
    {
        switch (report.NewState)
        {
            case GeofenceState.Entered:
            case GeofenceState.Exited:
                var updateArgs = new FenceUpdateEventArgs
                {
                    FenceId = report.Geofence.Id,
                    Reason = report.NewState.ToString(),
                    Timestamp = report.Geoposition.Coordinate.Timestamp,
                    Position =
                            report.Geoposition.Coordinate.Point.Position
                };
                OnFenceUpdated(updateArgs);
                break;
            case GeofenceState.Removed:
                var removedArgs = new FenceRemovedEventArgs
                {
                    FenceId = report.Geofence.Id,
                    WhyRemoved = report.RemovalReason.ToString()
                };
                OnFenceRemoved(removedArgs);

                break;
        }
    }
}
```

The event handler retrieves the reports from the provided GeofenceMonitor instance and then iterates over the individual report instances. In the case of Entered and Exited events, information is gathered about which fence caused the event, whether it was triggered on enter or exit, what position caused the event to be triggered, and when exactly the reported event occurred. This information is then used to relay an event out of the GeofenceHelper that displays the event's occurrence in the app UI. In the case of a Removed event, the event ID and Removal reason are obtained, and a similar event is raised to provide notification as well as remove the geofence entry from the Bing Maps control.

Be aware that because the GeofenceStateChanged events are raised from an external entity, the handler will not run on the UI thread. Any reaction to these events that affects the application UI needs to be marshalled to the proper thread using either the Dispatcher or a valid SynchronizationContext, as discussed in the section "Accessing the UI Thread" in Chapter 9, "Model-View-ViewModel."

Managing Geofences

You can manage geofences by working directly with the Geofences collection that the GeofenceMonitor instance provides. The example app enumerates these instances in two places. First, on app startup, the existing collection is obtained to put markers on the Bing Maps control for each geofence. Second, clicking the List Fences button shows a flyout that lists all the currently defined geofences. This flyout includes the option to remove the selected Geofence instance from the Geofences collection. Note that programmatically removing a fence from the collection in this way does not generate the previously discussed Removed events. Those occur only when the removal happens automatically in response to the conditions that the Geofence instance's settings identify.

TIP

Testing geofence functionality directly with a device can be perhaps more tricky than testing general geolocation functionality. An alternative to the potentially difficult, distraction-prone, and ultimately dangerous option of mounting a tablet in a car and driving around town (please do not do this) is to use the techniques discussed in the previous section "Using the Simulator Location Tools." From the simulator′s location tools, you can set positions with coordinates that are inside or outside a particular geofence by setting the location to a particular latitude and longitude combination. The simulator then properly emulates the position changes along with the appropriate resulting geofence reactions.

Motion and Orientation Sensors

In addition to using the `Geolocator` and related APIs to obtain information about a device's physical location, the Windows Runtime provides APIs for interacting with a class of sensors related to the movement and positioning of the device itself. Table 13.5 lists the kinds of sensors these APIs can interact with and the kind of data they gather.

TABLE 13.5 Motion and Orientation Sensor Types

Sensor	Description
Simple Orientation	Reports the current orientation of the device based on values from the `SimpleOrientation` enumeration.
Compass	Provides information about the position of the device in relation to magnetic north. This is actually a composite sensor whose output is based on combined input from magnetometer and gyrometer sensors.
Inclinometer	Provides information about the pitch, yaw, and roll state of a device. This is a composite sensor whose output is based on combined input from accelerometer, gyrometer, and magnetometer sensors.
Accelerometer	Provides information about the G-forces affecting the device's x-, y-, and z-axes.
Gyrometer	Provides information about the angular velocity along the device's x-, y-, and z-axes.

Sensor	Description
Orientation Sensor	Provides detailed information about how a device is situated in space. This is a composite sensor whose output is based on combined input from accelerometer, gyrometer, and magnetometer sensors.
Light Sensor	Provides information about the amount of light currently striking the device display.

You might have noticed that several of these sensors' values are determined in part from a magnetometer, which is itself a sensor whose purpose is to measure the strength of magnetic fields. However, the Windows Runtime does not provide any APIs that allow direct access to output from magnetometers.

For the most part, the API for interacting with sensors is similar across all the different kinds. They all basically offer the capability to obtain a reference to a class instance that provides access to the sensor, as well as methods for obtaining the current sensor value. In addition, they provide events that you can subscribe to for notifications when the value changes. The majority of the sensor APIs define properties that specify the minimum interval with which the sensor can raise these change events, as well as properties that specify the requested interval for reporting value changes.

Most of the code for working with sensors in the example project resides in the `SensorHelper` class. You might be relieved to know that, unlike the location information, the information these sensors return is not considered to be personally identifiable information. As a result, you do not have to indicate entries in the application manifest, prompt the user for permission, or deal with users blocking access to the sensors if you include code to make use of them in your application.

Simple Orientation Sensor

The simple orientation sensor is the simplest of the available sensors. It does not work with the concept of a reporting interval for its change events, and the data values that it reports are simply members of the `SimpleOrientation` enumeration. When available, the purpose of this sensor is to describe which way the device is facing. The values it can return are `NotRotated`, for when the device is sitting in a "natural" landscape orientation; Rotated90, Rotated180, and Rotated270, to indicate that the device has been rotated to stand on one of its other edges; and FaceUp and FaceDown, to indicate that the device is lying flat.

The code in Listing 13.11 shows how the example project is configured to work with the simple orientation sensor, which is exposed via the SimpleOrientationSensor class. The GetDefault static method obtains a reference to the sensor, the value of which is null if the sensor is not available. After that, it simply provides a handler for the OrientationChanged event and then uses the GetCurrentOrientation method to obtain the current sensor value.

LISTING 13.11 Configuring the Simple Orientation Sensor

```
// Get the reference to the sensor and see if it is available
_simpleOrientation = SimpleOrientationSensor.GetDefault();
if (_simpleOrientation == null) return;

_sensorSettings.IsSimpleOrientationAvailable = true;

// NOTE - Simple Orientation does not offer a minimum interval setting
_simpleOrientation.OrientationChanged
    += SimpleOrientationOnOrientationChanged;

// Read the initial sensor value
_sensorSettings.LatestSimpleOrientationReading
    = _simpleOrientation.GetCurrentOrientation();
```

The Visual Studio simulator for Windows Store Apps, which the preceding section "Using the Simulator Location Tools" discussed, also includes support for simulating device rotation by providing buttons that rotate the simulator in 90-degree increments clockwise or counterclockwise.

Compass

The compass provides information about the current heading of the device relative to magnetic north. When available, this sensor returns readings as instances of the CompassReading type, which includes both HeadingMagneticNorth and HeadingTrueNorth properties, indicating degrees to magnetic north and degrees to true north, respectively. HeadingMagneticNorth always is provided; the availability of HeadingTrueNorth values depends on the individual capabilities of the actual sensor hardware. HeadingTrueNorth returns a value of null if it is not available.

Listing 13.12 shows how the example project is configured to work with the compass, which is exposed via the Compass class. The GetDefault static method obtains a reference to the sensor, the value of which is null if the sensor is not available. It next proceeds to set the sensor's reporting interval.

LISTING 13.12 Configuring the Compass

```
// Get the reference to the sensor and see if it is available
_compass = Compass.GetDefault();
if (_compass == null) return;

_sensorSettings.IsCompassAvailable = true;

// Set the minimum report interval. Care must be taken to ensure
// it is not set to a value smaller than the device minimum
var minInterval = _compass.MinimumReportInterval;
_compass.ReportInterval
    = Math.Max(_sensorSettings.SensorReportInterval, minInterval);
_compass.ReadingChanged += CompassOnReadingChanged;

// Read the initial sensor value
_sensorSettings.LatestCompassReading = _compass.GetCurrentReading();
```

The ReportInterval property is common to most of the available sensors. The purpose of the property is to provide access to the minimum time (in milliseconds) that must elapse between ReadingChanged events. Take care when setting this value; setting it to a value below the minimum value that the sensor can support can result in either an exception or unpredictable behavior, depending on the sensor. You can obtain the minimum allowable report interval value through the MinimumReportInterval property. Note that the ReportInterval setting has some of the characteristics of a request rather than a certain value. Several factors can influence how the actual sensor handles the ReportInterval setting. For example, when other apps on the system that make use of the same sensor set their own values for this property, the sensor might simply elect to use whichever is the smallest defined value. Also be aware that the ReadingChanged event is raised only when the reading actually changes, regardless of the ReportInterval setting. It is important to not confuse the ReportInterval value with a frequency value that somehow guarantees that the `ReadingChanged` event will be raised repeatedly in a steady cadence. After the `ReportInterval` is set, the code simply provides a handler for the `ReadingChanged` event and then uses the `GetCurrentReading` method to obtain the current sensor value.

Another important note is that the value the compass returns is relative to the device being in a regular landscape orientation, with the device base sitting at the bottom. (If the device is a tablet device built with Portrait as its primary orientation, this sensor landscape condition still applies; the "natural" landscape mode is the one where the hardware Windows button ends up on the right side of the display.) Figure 13.6 shows devices in natural landscape orientation.

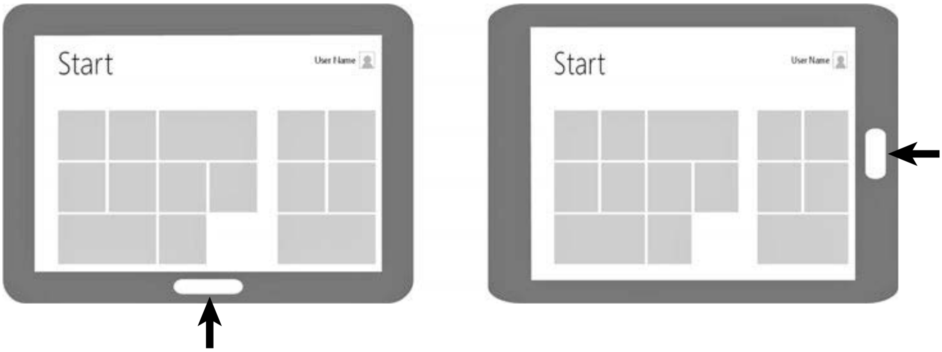


FIGURE 13.6 Devices in natural landscape orientation

If the device is in a different orientation, the value the sensor returns needs to be adjusted to account for this. The example project includes a `CompassOffset` extension method for the `DisplayOrientations` class that you can use to obtain the offset to apply to a compass direction based on a provided orientation value. This method simply returns a value of `0`, `90`, `180`, or `270`, depending on what is needed to correct the compass reading for the given orientation. You obtain the `DisplayOrientations` value to use from the `CurrentOrientation` property of the `DisplayInformation` class. After you determine the offset, you can add it to the `HeadingMagneticNorth` or `HeadingTrueNorth` values, using modular arithmetic to constrain the resulting value between `0` and `360` degrees, as follows:

```
(LatestCompassReading.HeadingMagneticNorth + offset)%360
```

The example project includes a Sensor Settings flyout that you can bring up using the Settings Charm. The panel includes a slider for updating the minimum reporting interval for the sensors. It also includes a check box that corresponds to a flag that the app uses to decide whether to compensate for orientation changes when using and displaying sensor values. By toggling these values and switching the orientation of the device on which the app is running from a landscape to an inverted landscape orientation, you can see the effect that changing an orientation has on sensor values, as well as how the compensation code will correct them to their expected state.

Another feature present in the example app is the capability for the Bing Maps control to "follow" the compass sensor value. Note that the current version of the Bing Maps control supports rotating its display contents only when viewed at high zoom levels (and to only one of four discrete views), so this behavior is best viewed when the map is set to display and is zoomed in enough to show bird's-eye imagery. To enable this feature, check the **Follow** box in the **Compass** panel in the app, and then point the device in different directions. When the Follow box is checked, the `Tick` event handler for a timer on the display page periodically polls the `SensorSettings` class for the `LatestCompassReading` value, which is set by the `ReadingChanged` handler for the compass. This value then is set to a view-model property that is data bound to the Bing Maps control. This approach of using a timer to check for the most recent value is used because the `ReadingChanged` event is fired only when a compass value actually changes, as previously discussed. Listing 13.13 shows the code in the timer event handler that obtains and applies the compass value.

LISTING 13.13 Applying the Compass Orientation to the Map Display

```
if (_sensorSettings.IsFollowingCompass)
{
    // Get the latest compass reading
    var compassReading = _sensorSettings.LatestCompassReading;

    // Adjust the reading based on the display orientation, if necessary
    var displayOffset = _sensorSettings.CompensateForDisplayOrientation
        ? _sensorSettings.DisplayOrientation.CompassOffset()
        : 0;
    var heading
        = (compassReading.HeadingMagneticNorth + displayOffset)%360;
    // Set the value used by data binding to update the map's heading
    DefaultViewModel["Heading"] = heading;
}
```

Inclinometer

The inclinometer provides information about the current pitch, yaw, and roll of the device. Pitch represents the degrees of rotation around the x-axis, yaw represents degrees of rotation around the z-axis, and roll represents degrees of rotation around the y-axis. Figure 13.7 illustrates how these values map to the physical position of a tablet device. When available, this sensor returns readings as instances of the `InclinometerReading` type, which provides its results in `PitchDegrees`, `RollDegrees`, and `YawDegrees` properties.

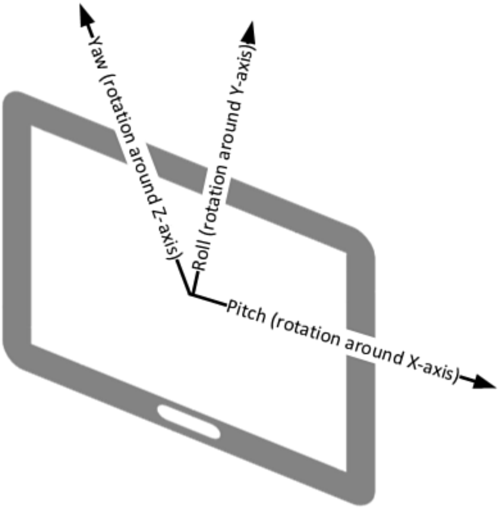

Yaw (rotation around Z-axis)
Roll (rotation around Y-axis)
Pitch (rotation around X-axis)

FIGURE 13.7 Pitch, roll, and yaw relative to a tablet device

Listing 13.14 shows how the example project is configured to work with the inclinometer, which is exposed via the `Inclinometer` class. The steps involved in configuring the inclinometer are basically identical to those shown in Listing 13.12 for configuring the compass.

LISTING 13.14 Configuring the Inclinometer

```
// Get the reference to the sensor and see if it is available
_inclinometer = Inclinometer.GetDefault();
if (_inclinometer == null) return;

_sensorSettings.IsInclinometerAvailable = true;

// Set the minimum report interval. Care must be taken to ensure
// it is not set to a value smaller than the device minimum
var minInterval = _inclinometer.MinimumReportInterval;
_inclinometer.ReportInterval
    = Math.Max(_sensorSettings.SensorReportInterval, minInterval);
_inclinometer.ReadingChanged += InclinometerOnReadingChanged;

// Read the initial sensor value
_sensorSettings.LatestInclinometerReading = GetInclinometerReading();
```

Much like the compass, the values the inclinometer returns are relative to the device being in a regular landscape orientation, and the resulting values also need to be normalized if the device is being used from any other orientation. The example project includes an `AxisAdjustmentFactor` extension method for the `DisplayOrientations` class that you can use to obtain the factors to apply to the x-, y-, and z-axis results, based on the current device orientation.

The example app includes a fun feature that you can enable by checking the **Follow** box in the **Inclinometer** panel in the app. When this box is checked, the content of Bing Maps control slides based on the Inclinometer readings, allowing you to navigate the map simply by tilting your device back and forth or left and right.

NOTE

If you find that tilting your device is causing your screen orientation to be toggled, you can disable the automatic screen rotation feature that Windows provides by bringing up the Settings Charm, selecting Screen, and tapping the rectangular icon above the brightness adjustment slider. If that icon has a pair of arrows next to it, automatic rotation is enabled. If it has a small padlock next to it, the current screen orientation is locked and will not automatically adjust as you tilt your device.

As with the Follow feature discussed previously for the compass sensor, implementation for this feature simply polls the `SensorSettings` class in response to the same timer `Tick` event. In this case, the value used to obtain the current device orientation is the `LatestInclinometerReading` value, which the inclinometer's `ReadingChanged` handler sets. The `displayAdjustment` value used to compensate for device orientation changes returns per-axis values of +1 or –1 that are multiplied to the sensor result to normalize the value.

Listing 13.15 shows the calculations that move the map. First, the inclinometer reading is obtained and normalized, depending on the value of the compensation setting and the device orientation. Next, a rate of one full screen per timer tick was found to be a good maximum rate of traversal, so the number of x- and y-axis pixels to move are obtained from the map control. Then trigonometric functions convert the adjusted pitch and roll values to percentage values so that the traversal is nearly nothing when the device is lying flat and is full-value when it is held vertically. This percentage determines the actual number of x and y pixels to move in the current tick, which is applied to the center point to determine the equivalent destination point. From here, the Bing Maps `TryPixelToLocation` utility function converts a pixel onscreen to equivalent latitude and longitude values, which then set the new map position.

LISTING 13.15 Applying the Inclinometer Reading to the Map Display

```
if (_sensorSettings.FollowInclinometer)
{
    var inclinometerReading = _sensorSettings.LatestInclinometerReading;

    // Optionally normalize the sensor reading values
    var displayAdjustment
        = _sensorSettings.CompensateForDisplayOrientation
            ? _sensorSettings.DisplayOrientation.AxisAdjustmentFactor()
            : SensorExtensions.AxisOffset.Default;
    var adjustedPitchDegrees
        = inclinometerReading.PitchDegrees * displayAdjustment.X;
    var adjustedRollDegrees
        = inclinometerReading.RollDegrees * displayAdjustment.Y;

    // At full speed/inclination, move 100% map size per tick
    const Double maxScreensPerTick = 1.00;
    var mapWidth = ExampleMap.ActualWidth;
    var xFullRateTraversalPerTick = mapWidth * maxScreensPerTick;
    var mapHeight = ExampleMap.ActualHeight;
    var yFullRateTraversalPerTick = mapHeight * maxScreensPerTick;
    // Turn rotation angles into percentages
    var xTraversalPercentage
        = Math.Sin(adjustedRollDegrees*Math.PI/180);
    var yTraversalPercentage
        = Math.Sin(adjustedPitchDegrees*Math.PI/180);

    // Compute the final traversal amounts based on the percentages
    // and compute the new destination center point
    var xTraversalAmount
        = xTraversalPercentage*xFullRateTraversalPerTick;
    var yTraversalAmount
        = yTraversalPercentage*yFullRateTraversalPerTick;
    var destinationPoint = new Point(
        mapWidth/2 + xTraversalAmount,
        mapHeight/2 + yTraversalAmount);

    // Use the Bing Maps methods to convert pixel pos to Lat/Lon
    // rather than trying to figure out Mercator map math
    Location location;
    if (ExampleMap.TryPixelToLocation(destinationPoint, out location))
    {
        // Obtain the current map position (for altitude)
        var position = (BasicGeoposition)DefaultViewModel["Position"];

        var newPosition = new BasicGeoposition
        {
            Altitude = position.Altitude,
            Latitude = location.Latitude,
            Longitude = location.Longitude
        };

        DefaultViewModel["Position"] = newPosition;
    }
}
```

Accelerometer

The accelerometer provides information about the current G-forces acting on the device in the x, y, and z directions. At rest, the most significant G-force affecting a device is the force of gravity, which pulls down along whichever axis corresponds to the bottom edge of the device with a value of –1.0. For example, if a device is standing up on its bottom edge in a landscape profile, the y value has a value of approximately –1.0. When available, this sensor returns readings as instances of the `AccelerometerReading` type, which provides its results in AccelerationX, AcclerationY, and AccelerationZ properties.

Listing 13.16 shows how the example project is configured to work with the accelerometer, which is exposed via the Accelerometer class. The steps involved in configuring the accelerometer are otherwise identical to those shown previously for configuring the other sensors, with one notable exception. The accelerometer sensor includes an additional Shaken event that is raised when the sensor detects that the device is being subjected to several quick back-and-forth motions.

LISTING 13.16 Configuring the Accelerometer

```
// Get the reference to the sensor and see if it is available
_accelerometer = Accelerometer.GetDefault();
if (_accelerometer == null) return;

_sensorSettings.IsAccelerometerAvailable = true;

// Set the minimum report interval. Care must be taken to ensure
// it is not set to a value smaller than the device minimum
var minInterval = _accelerometer.MinimumReportInterval;
_accelerometer.ReportInterval
    = Math.Max(_sensorSettings.SensorReportInterval, minInterval);
_accelerometer.ReadingChanged += AccelerometerOnReadingChanged;
_accelerometer.Shaken += AccelerometerOnShaken;

// Read the initial sensor value
_sensorSettings.LatestAccelerometerReading = GetAccelerometerReading();
```

Gyrometer

The gyrometer provides information about the device's current rate of rotation around the x-, y-, and z-axes, measured in degrees per second. When available, this sensor returns readings as instances of the GyrometerReading type, which provides its results in AngularVelocityX, AngularVelocityY, and AngularVelocityZ properties.

Listing 13.17 shows how the example project is configured to work with the gyrometer, which is exposed via the Gyrometer class. The steps involved in configuring the gyrometer are otherwise identical to those shown previously for configuring the other sensors.

LISTING 13.17 Configuring the Gyrometer

```
// Get the reference to the sensor and see if it is available
_gyrometer = Gyrometer.GetDefault();
if (_gyrometer == null) return;

_sensorSettings.IsGyrometerAvailable = true;

// Set the minimum report interval. Care must be taken to ensure
// it is not set to a value smaller than the device minimum
var minInterval = _gyrometer.MinimumReportInterval;
_gyrometer.ReportInterval
    = Math.Max(_sensorSettings.SensorReportInterval, minInterval);
_gyrometer.ReadingChanged += GyrometerOnReadingChanged;

// Read the initial sensor value
_sensorSettings.LatestGyrometerReading = GetGyrometerReading();
```

Orientation Sensor

The last sensor directly related to motion and/or orientation to be discussed is the orientation sensor. As Table 13.4 described, the orientation sensor is a composite sensor whose output consists of information gathered from accelerometer, gyrometer, and magnetometer data. As you can see in Listing 13.18, the orientation sensor is configured using the `OrientationSensor` class in the same way the rest of the sensors have been in this section. Its results are returned in an instance of the `OrientationSensorReading` class, which contains properties for `Quaternion` and `RotationMatrix` values, structures that 3D and gaming apps often use.

LISTING 13.18 Configuring the Orientation Sensor

```
// Get the reference to the sensor and see if it is available
_orientationSensor = OrientationSensor.GetDefault();
if (_orientationSensor == null) return;

_sensorSettings.IsOrientationSensorAvailable = true;

// Set the minimum report interval. Care must be taken to ensure
// it is not set to a value smaller than the device minimum
var minInterval = _orientationSensor.MinimumReportInterval;
_orientationSensor.ReportInterval
    = Math.Max(_sensorSettings.SensorReportInterval, minInterval);
_orientationSensor.ReadingChanged += OrientationSensorOnReadingChanged;
```

```
// Read the initial sensor value
_sensorSettings.LatestOrientationSensorReading
    = GetOrientationSensorReading();
```

Light Sensor

The light sensor isn't actually a motion-/orientation-related sensor, but it is included as an honorable mention with these sensors because the APIs for working with this sensor are closely related to the rest of the APIs in this section. The light sensor reports the intensity of the light shining on the current device display in units of lux, is accessed through the `LightSensor` class, and returns its values in a `LightSensorReading` instance (which contains the property `IlluminanceInLux`). Listing 13.19 shows how the example project is configured to work with the light sensor.

LISTING 13.19 Configuring the Light Sensor

```
// Get the reference to the sensor and see if it is available
_lightSensor = LightSensor.GetDefault();
if (_lightSensor == null) return;

_sensorSettings.IsLightSensorAvailable = true;

// Set the minimum report interval. Care must be taken to ensure
// it is not set to a value smaller than the device minimum
var minInterval = _lightSensor.MinimumReportInterval;
_lightSensor.ReportInterval
    = Math.Max(_sensorSettings.SensorReportInterval, minInterval);
_lightSensor.ReadingChanged += LightSensorOnReadingChanged;

// Read the initial sensor value
_sensorSettings.LatestLightSensorReading = GetLightSensorReading();
```

Summary

In this chapter, you learned how to work with several different user input devices, including pointer-based devices such as touch inputs, mouse devices, stylus devices, and keyboards. You saw how the Windows Runtime provides the capability to determine which devices are connected, as well as how adding the capability to interact with the various different kinds of pointer devices has coalesced into a set of APIs that are differentiated more by the level of abstraction than the characteristics of a specific device type.

You also saw how the Windows Runtime provides the capability to work with sensors that supply information about how the device is interacting with its physical environment. This includes working with the geolocation APIs to obtain device position information. It also includes the related geofencing APIs for defining geographic boundaries that can result in app notifications when a device either enters or exits those boundaries. You also worked with the motion and orientation sensor APIs that provide insight into the device's physical position and movement.

In the next chapter, you learn about the support the Windows Runtime offers for working with these peripheral devices. This includes a discussion about how you can add the capability to scan from your Windows Store apps. You also see how you can print from your app, including how to generate content and layouts specifically for printing, as well as how to customize and interact with the Print Settings and Print Preview experiences.

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