

# Pro WPF 4.5 in C#



Matthew MacDonald

Apress®

## Pro WPF 4.5 in C#

Copyright © 2012 by Matthew MacDonald

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. Exempted from this legal reservation are brief excerpts in connection with reviews or scholarly analysis or material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work. Duplication of this publication or parts thereof is permitted only under the provisions of the Copyright Law of the Publisher's location, in its current version, and permission for use must always be obtained from Springer. Permissions for use may be obtained through RightsLink at the Copyright Clearance Center. Violations are liable to prosecution under the respective Copyright Law.

ISBN 978-1-4302-4365-6

ISBN 978-1-4302-4366-3 (eBook)

Trademarked names, logos, and images may appear in this book. Rather than use a trademark symbol with every occurrence of a trademarked name, logo, or image, we use the names, logos, and images only in an editorial fashion and to the benefit of the trademark owner, with no intention of infringement of the trademark.

The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

President and Publisher: Paul Manning

Lead Editor: Ewan Buckingham

Technical Reviewer: Fabio Claudio Ferracchiati

Editorial Board: Steve Anglin, Ewan Buckingham, Gary Cornell, Louise Corrigan, Morgan Ertel, Jonathan Gennick,

Jonathan Hassell, Robert Hutchinson, Michelle Lowman, James Markham, Matthew Moodie, Jeff Olson, Jeffrey

Pepper, Douglas Pundick, Ben Renow-Clarke, Dominic Shakeshaft, Gwenan Spearing, Matt Wade, Tom Welsh

Coordinating Editor: Mark Powers

Copy Editors: Sharon Wilkey and Linda Seifert

Compositor: Bytheway Publishing Services

Indexer: SPi Global

Artist: SPi Global

Cover Designer: Anna Ishchenko

Distributed to the book trade worldwide by Springer Science+Business Media New York, 233 Spring Street, 6th Floor, New York, NY 10013. Phone 1-800-SPRINGER, fax (201) 348-4505, e-mail [orders-ny@springer-sbm.com](mailto:orders-ny@springer-sbm.com), or visit [www.springeronline.com](http://www.springeronline.com).

For information on translations, please e-mail [rights@apress.com](mailto:rights@apress.com), or visit [www.apress.com](http://www.apress.com).

Apress and friends of ED books may be purchased in bulk for academic, corporate, or promotional use. eBook versions and licenses are also available for most titles. For more information, reference our Special Bulk Sales—eBook Licensing web page at [www.apress.com/bulk-sales](http://www.apress.com/bulk-sales).

Any source code or other supplementary materials referenced by the author in this text is available to readers at [www.apress.com/9781430243656](http://www.apress.com/9781430243656). For detailed information about how to locate your book's source code, go to [www.apress.com/source-code](http://www.apress.com/source-code).

*For my wonderful family,  
Faria, Maya, and Brenna*

# Contents at a Glance

■ About the Author .....	xxvi
■ About the Technical Reviewer.....	xxvii
■ Acknowledgments.....	xxviii
■ Introduction .....	xxix
■ Part I: Fundamentals .....	1
■ Chapter 1: Introducing WPF .....	3
■ Chapter 2: XAML .....	21
■ Chapter 3: Layout .....	53
■ Chapter 4: Dependency Properties .....	93
■ Chapter 5: Routed Events.....	105
■ Part II: Deeper Into WPF .....	141
■ Chapter 6: Controls.....	143
■ Chapter 7: The Application.....	195
■ Chapter 8: Element Binding .....	227
■ Chapter 9: Commands .....	243
■ Chapter 10: Resources .....	269
■ Chapter 11: Styles and Behaviors.....	283
■ Part III: Drawing and Animation.....	305
■ Chapter 12: Shapes, Brushes, and Transforms .....	307
■ Chapter 13: Geometries and Drawings.....	347
■ Chapter 14: Effects and Visuals.....	369
■ Chapter 15: Animation Basics.....	391

- **Chapter 16: Advanced Animation .....431**
- **Part IV: Templates and Custom Elements.....463**
- **Chapter 17: Control Templates.....465**
- **Chapter 18: Custom Elements.....505**
- **Part V: Data .....555**
- **Chapter 19: Data Binding .....557**
- **Chapter 20: Formatting Bound Data .....601**
- **Chapter 21: Data Views .....647**
- **Chapter 22: Lists, Trees, and Grids .....665**
- **Part VI: Windows, Pages, and Rich Controls .....705**
- **Chapter 23: Windows .....707**
- **Chapter 24: Pages and Navigation.....741**
- **Chapter 25: Menus, Toolbars, and Ribbons .....787**
- **Chapter 26: Sound and Video.....813**
- **Chapter 27: 3-D Drawing.....837**
- **Part VII: Documents and Printing.....881**
- **Chapter 28: Documents.....883**
- **Chapter 29: Printing .....935**
- **Part VIII: Additional Topics .....965**
- **Chapter 30: Interacting with Windows Forms.....967**
- **Chapter 31: Multithreading .....983**
- **Chapter 32: The Add-in Model .....997**
- **Chapter 33: ClickOnce Deployment .....1021**
- **Index .....1041**

# Contents

■ <b>About the Author</b> .....	<b>xxvi</b>
■ <b>About the Technical Reviewer</b> .....	<b>xxvii</b>
■ <b>Acknowledgments</b> .....	<b>xxviii</b>
■ <b>Introduction</b> .....	<b>xxix</b>
■ <b>Part I: Fundamentals</b> .....	<b>1</b>
■ <b>Chapter 1: Introducing WPF</b> .....	<b>3</b>
The Evolution of Windows Graphics .....	3
DirectX: The New Graphics Engine .....	4
Hardware Acceleration and WPF .....	4
WPF: A Higher-Level API .....	5
Resolution Independence .....	6
WPF Units .....	6
System DPI .....	7
Bitmap and Vector Graphics .....	10
The Architecture of WPF .....	11
The Class Hierarchy .....	12
WPF 4.5 .....	15
The WPF Toolkit .....	16
Visual Studio 2012 .....	16
The Last Word .....	18
■ <b>Chapter 2: XAML</b> .....	<b>21</b>
Understanding XAML .....	21
Graphical User Interfaces Before WPF .....	22

The Variants of XAML.....	23
XAML Compilation .....	23
<b>XAML Basics.....</b>	<b>24</b>
XAML Namespaces.....	25
The Code-Behind Class.....	26
<b>Properties and Events in XAML .....</b>	<b>29</b>
Simple Properties and Type Converters.....	30
Complex Properties .....	31
Markup Extensions .....	33
Attached Properties.....	34
Nesting Elements.....	35
Special Characters and Whitespace .....	38
Events.....	39
The Full Eight-Ball Example.....	40
<b>Using Types from Other Namespaces.....</b>	<b>41</b>
<b>Loading and Compiling XAML.....</b>	<b>43</b>
Code-Only .....	44
Code and Uncompiled XAML.....	46
Code and Compiled XAML.....	48
XAML Only .....	50
<b>The Last Word.....</b>	<b>51</b>
<b>■ Chapter 3: Layout .....</b>	<b>53</b>
<b>Understanding Layout in WPF.....</b>	<b>53</b>
The WPF Layout Philosophy.....	53
The Layout Process .....	54
The Layout Containers.....	55
<b>Simple Layout with the StackPanel.....</b>	<b>56</b>
Layout Properties.....	58
Alignment .....	59
Margin .....	60
Minimum, Maximum, and Explicit Sizes .....	62
The Border.....	64
<b>The WrapPanel and DockPanel.....</b>	<b>65</b>
The WrapPanel.....	65
The DockPanel.....	66
Nesting Layout Containers.....	68

<b>The Grid</b> .....	<b>70</b>
Fine-Tuning Rows and Columns .....	72
Layout Rounding .....	74
Spanning Rows and Columns .....	75
Splitting Windows .....	76
Shared Size Groups .....	79
The UniformGrid .....	82
<b>Coordinate-Based Layout with the Canvas</b> .....	<b>82</b>
Z-Order .....	84
The InkCanvas .....	84
<b>Layout Examples</b> .....	<b>86</b>
A Column of Settings .....	87
Dynamic Content .....	88
A Modular User Interface .....	90
<b>The Last Word</b> .....	<b>92</b>
<b>■ Chapter 4: Dependency Properties</b> .....	<b>93</b>
<b>Understanding Dependency Properties</b> .....	<b>93</b>
Defining a Dependency Property .....	94
Registering a Dependency Property .....	94
Adding a Property Wrapper .....	96
How WPF Uses Dependency Properties .....	97
Shared Dependency Properties .....	99
Attached Dependency Properties .....	99
<b>Property Validation</b> .....	<b>100</b>
The Validation Callback .....	101
The Coercion Callback .....	102
<b>The Last Word</b> .....	<b>104</b>
<b>■ Chapter 5: Routed Events</b> .....	<b>105</b>
<b>Understanding Routed Events</b> .....	<b>105</b>
Defining, Registering, and Wrapping a Routed Event .....	105
Sharing Routed Events .....	106
Raising a Routed Event .....	107
Handling a Routed Event .....	107
<b>Event Routing</b> .....	<b>109</b>
The RoutedEventArgs Class .....	110
Bubbling Events .....	111



Handling a Suppressed Event.....	114
Attached Events.....	114
Tunneling Events .....	116
<b>WPF Events.....</b>	<b>118</b>
Lifetime Events .....	118
Input Events.....	120
<b>Keyboard Input .....</b>	<b>121</b>
Handling a Key Press.....	122
Focus .....	125
Getting Key State.....	126
<b>Mouse Input.....</b>	<b>127</b>
Mouse Clicks .....	128
Capturing the Mouse .....	129
Drag-and-Drop.....	130
<b>Multitouch Input .....</b>	<b>132</b>
The Levels of Multitouch Support.....	133
Raw Touch .....	133
Manipulation.....	136
Inertia .....	139
<b>The Last Word.....</b>	<b>140</b>
<b>■ Part II: Deeper Into WPF .....</b>	<b>141</b>
<b>■ Chapter 6: Controls.....</b>	<b>143</b>
<b>The Control Class.....</b>	<b>144</b>
Background and Foreground Brushes.....	144
Fonts.....	146
Mouse Cursors.....	151
<b>Content Controls .....</b>	<b>152</b>
The Content Property.....	154
Aligning Content .....	156
The WPF Content Philosophy .....	157
Labels .....	158
Buttons .....	159
Tooltips .....	162
<b>Specialized Containers.....</b>	<b>169</b>
The ScrollViewer.....	170
The GroupBox .....	173

The TabItem .....	173
The Expander .....	175
<b>Text Controls .....</b>	<b>179</b>
Multiple Lines of Text .....	179
Text Selection .....	180
Spell Checking .....	181
The PasswordBox .....	183
<b>List Controls .....</b>	<b>183</b>
The ListBox .....	184
The ComboBox .....	187
<b>Range-Based Controls .....</b>	<b>188</b>
The Slider .....	188
The ProgressBar .....	190
<b>Date Controls .....</b>	<b>190</b>
<b>The Last Word .....</b>	<b>193</b>
<b>■ Chapter 7: The Application .....</b>	<b>195</b>
<b>The Application Life Cycle .....</b>	<b>195</b>
Creating an Application Object .....	195
Deriving a Custom Application Class .....	197
Application Shutdown .....	198
Application Events .....	199
<b>Application Tasks .....</b>	<b>201</b>
Showing a Splash Screen .....	202
Handling Command-Line Arguments .....	202
Accessing the Current Application .....	204
Interacting Between Windows .....	205
Single-Instance Applications .....	207
<b>Assembly Resources .....</b>	<b>212</b>
Adding Resources .....	213
Retrieving Resources .....	214
Resource-Aware Classes .....	215
Pack URIs .....	216
Resources in Other Assemblies .....	216
Content Files .....	217
<b>Localization .....</b>	<b>218</b>
Building Localizable User Interfaces .....	218

Preparing an Application for Localization .....	219
Managing the Translation Process.....	220
The Last Word.....	226
■ <b>Chapter 8: Element Binding</b> .....	<b>227</b>
Binding Elements Together.....	227
The Binding Expression .....	228
Binding Errors.....	229
Binding Modes.....	229
Creating Bindings with Code .....	232
Retrieving Bindings in Code.....	233
Multiple Bindings.....	234
Binding Updates .....	237
Binding Delays.....	238
Binding to Objects That Aren't Elements .....	238
Source .....	239
RelativeSource.....	239
DataContext .....	241
The Last Word.....	242
■ <b>Chapter 9: Commands</b> .....	<b>243</b>
Understanding Commands .....	243
The WPF Command Model.....	245
The ICommand Interface .....	245
The RoutedCommand Class.....	246
The RoutedUICommand Class .....	247
The Command Library .....	247
Executing Commands.....	249
Command Sources .....	249
Command Bindings .....	249
Using Multiple Command Sources.....	252
Fine-Tuning Command Text .....	253
Invoking a Command Directly.....	254
Disabling Commands.....	255
Controls with Built-in Commands.....	257
Advanced Commands.....	259
Custom Commands .....	259
Using the Same Command in Different Places.....	260

Using a Command Parameter .....	262
Tracking and Reversing Commands .....	263
The Last Word .....	268
■ <b>Chapter 10: Resources</b> .....	<b>269</b>
<b>Resource Basics</b> .....	<b>269</b>
The Resources Collection .....	270
The Hierarchy of Resources .....	271
Static and Dynamic Resources .....	272
Nonshared Resources .....	274
Accessing Resources in Code .....	275
Application Resources .....	275
System Resources .....	276
<b>Resource Dictionaries</b> .....	<b>277</b>
Creating a Resource Dictionary .....	277
Using a Resource Dictionary .....	278
Sharing Resources Between Assemblies .....	279
The Last Word .....	282
■ <b>Chapter 11: Styles and Behaviors</b> .....	<b>283</b>
<b>Style Basics</b> .....	<b>283</b>
Creating a Style Object .....	287
Setting Properties .....	288
Attaching Event Handlers .....	289
The Many Layers of Styles .....	291
Automatically Applying Styles by Type .....	292
<b>Triggers</b> .....	<b>294</b>
A Simple Trigger .....	294
An Event Trigger .....	296
<b>Behaviors</b> .....	<b>298</b>
Getting Support for Behaviors .....	298
Understanding the Behavior Model .....	299
Creating a Behavior .....	300
Using a Behavior .....	302
Design-Time Behavior Support in Blend .....	303
The Last Word .....	304
■ <b>Part III: Drawing and Animation</b> .....	<b>305</b>
■ <b>Chapter 12: Shapes, Brushes, and Transforms</b> .....	<b>307</b>

<b>Understanding Shapes .....</b>	<b>307</b>
The Shape Classes .....	308
Rectangle and Ellipse .....	310
Sizing and Placing Shapes .....	311
Scaling Shapes with a Viewbox.....	313
Line.....	316
Polyline.....	317
Polygon.....	318
Line Caps and Line Joins.....	320
Dashes.....	322
Pixel Snapping.....	324
<b>Using Brushes .....</b>	<b>325</b>
The SolidColorBrush.....	326
The LinearGradientBrush.....	326
The RadialGradientBrush.....	329
The ImageBrush .....	331
A Tiled ImageBrush.....	332
The VisualBrush.....	335
The BitmapCacheBrush.....	336
<b>Using Transforms.....</b>	<b>337</b>
Transforming Shapes.....	339
Transforming Elements.....	341
<b>Transparency .....</b>	<b>342</b>
Making an Element Partially Transparent.....	342
Using Opacity Masks .....	344
<b>The Last Word.....</b>	<b>346</b>
<b>■ Chapter 13: Geometries and Drawings.....</b>	<b>347</b>
<b>Paths and Geometries .....</b>	<b>347</b>
Line, Rectangle, and Ellipse Geometries.....	348
Combining Shapes with GeometryGroup.....	349
Fusing Geometries with CombinedGeometry .....	351
Drawing Curves and Lines with PathGeometry .....	354
Using the Geometry Mini-Language .....	359
Clipping with Geometry .....	361
<b>Drawings .....</b>	<b>363</b>
Displaying a Drawing.....	364

Exporting Clip Art.....	367
The Last Word.....	368
■ <b>Chapter 14: Effects and Visuals</b> .....	<b>369</b>
<b>Visuals</b> .....	<b>369</b>
Drawing Visuals.....	370
Wrapping Visuals in an Element.....	372
Hit Testing.....	375
Complex Hit Testing.....	377
<b>Effects</b> .....	<b>380</b>
BlurEffect.....	381
DropShadowEffect.....	382
ShaderEffect.....	383
<b>The WriteableBitmap Class</b> .....	<b>385</b>
Generating a Bitmap.....	385
Writing to a WriteableBitmap.....	386
Using More-Efficient Pixel Writing.....	387
The Last Word.....	390
■ <b>Chapter 15: Animation Basics</b> .....	<b>391</b>
<b>Understanding WPF Animation</b> .....	<b>391</b>
Timer-Based Animation.....	391
Property-Based Animation.....	392
<b>Basic Animation</b> .....	<b>393</b>
The Animation Classes.....	393
Animations in Code.....	396
Simultaneous Animations.....	401
Animation Lifetime.....	401
The Timeline Class.....	403
<b>Storyboards</b> .....	<b>406</b>
The Storyboard.....	406
Event Triggers.....	407
Overlapping Animations.....	409
Synchronized Animations.....	410
Controlling Playback.....	411
Monitoring Progress.....	415
<b>Animation Easing</b> .....	<b>417</b>
Using an Easing Function.....	418

Easing In and Easing Out.....	419
Easing Function Classes.....	420
Creating a Custom Easing Function.....	423
<b>Animation Performance.....</b>	<b>425</b>
Desired Frame Rate.....	425
Bitmap Caching.....	428
<b>The Last Word.....</b>	<b>430</b>
<b>■ Chapter 16: Advanced Animation.....</b>	<b>431</b>
<b>Animation Types Revisited.....</b>	<b>431</b>
Animating Transforms.....	432
Animating Brushes.....	437
Animating Pixel Shaders.....	440
<b>Key-Frame Animation.....</b>	<b>442</b>
Discrete Key-Frame Animations.....	443
Easing Key Frames.....	444
Spline Key-Frame Animations.....	444
<b>Path-Based Animation.....</b>	<b>446</b>
<b>Frame-Based Animation.....</b>	<b>448</b>
<b>Storyboards in Code.....</b>	<b>452</b>
Creating the Main Window.....	453
Creating the Bomb User Control.....	454
Dropping the Bombs.....	455
Intercepting a Bomb.....	458
Counting Bombs and Cleaning Up.....	460
<b>The Last Word.....</b>	<b>462</b>
<b>■ Part IV: Templates and Custom Elements.....</b>	<b>463</b>
<b>■ Chapter 17: Control Templates.....</b>	<b>465</b>
Understanding Logical Trees and Visual Trees.....	465
Understanding Templates.....	471
The Chrome Classes.....	473
Dissecting Controls.....	474
<b>Creating Control Templates.....</b>	<b>477</b>
A Simple Button.....	478
Template Bindings.....	479
Triggers That Change Properties.....	481

Triggers That Use Animation .....	484
<b>Organizing Template Resources .....</b>	<b>485</b>
Refactoring the Button Control Template .....	486
Applying Templates with Styles .....	488
Applying Templates Automatically .....	490
Working with User-Selected Skins .....	491
<b>Building More Complex Templates .....</b>	<b>493</b>
Nested Templates .....	494
Modifying the Scrollbar .....	496
Exploring the Control Template Examples .....	501
<b>Visual States .....</b>	<b>503</b>
<b>The Last Word .....</b>	<b>504</b>
<b>■ Chapter 18: Custom Elements .....</b>	<b>505</b>
<b>Understanding Custom Elements in WPF .....</b>	<b>506</b>
<b>Building a Basic User Control .....</b>	<b>508</b>
Defining Dependency Properties .....	509
Defining Routed Events .....	512
Adding Markup .....	513
Using the Control .....	515
Supporting Commands .....	516
Taking a Closer Look at User Controls .....	518
<b>Creating a Lookless Control .....</b>	<b>520</b>
Refactoring the Color Picker Code .....	520
Refactoring the Color Picker Markup .....	520
Streamlining the Control Template .....	524
<b>Supporting Visual States .....</b>	<b>527</b>
Starting the FlipPanel Class .....	528
Choosing Parts and States .....	530
The Default Control Template .....	532
Using the FlipPanel .....	538
Using a Different Control Template .....	539
<b>Creating Custom Panels .....</b>	<b>540</b>
The Two-Step Layout Process .....	541
The Canvas Clone .....	544
A Better Wrapping Panel .....	545
<b>Custom-Drawn Elements .....</b>	<b>548</b>



The OnRender() Method.....	548
Evaluating Custom Drawing .....	550
Creating a Custom-Drawn Element .....	551
Creating a Custom Decorator .....	553
The Last Word.....	554
■ <b>Part V: Data</b> .....	<b>555</b>
■ <b>Chapter 19: Data Binding</b> .....	<b>557</b>
<b>Binding to a Database with Custom Objects</b> .....	<b>557</b>
Building a Data Access Component.....	558
Building a Data Object.....	561
Displaying the Bound Object.....	562
Updating the Database .....	564
Change Notification .....	565
<b>Binding to a Collection of Objects</b> .....	<b>566</b>
Displaying and Editing Collection Items .....	567
Inserting and Removing Collection Items .....	572
Binding to the ADO.NET Objects .....	572
Binding to a LINQ Expression.....	574
<b>Improving Performance in Long Lists</b> .....	<b>576</b>
Virtualization.....	576
Item Container Recycling.....	578
Cache Length.....	578
Deferred Scrolling.....	579
<b>Validation</b> .....	<b>579</b>
Validation in the Data Object .....	580
Custom Validation Rules .....	585
Reacting to Validation Errors .....	587
Getting a List of Errors.....	588
Showing a DifferenError Indicator .....	589
Validating Multiple Values.....	592
<b>Data Providers</b> .....	<b>595</b>
The ObjectDataProvider.....	596
The XmlDataProvider .....	598
The Last Word.....	600
■ <b>Chapter 20: Formatting Bound Data</b> .....	<b>601</b>
Data Binding Redux.....	601

<b>Data Conversion .....</b>	<b>603</b>
Using the StringFormat Property .....	603
Introducing Value Converters.....	605
Formatting Strings with a Value Converter.....	605
Creating Objects with a Value Converter .....	608
Applying Conditional Formatting .....	610
Evaluating Multiple Properties.....	612
<b>List Controls .....</b>	<b>613</b>
<b>List Styles .....</b>	<b>615</b>
The ItemContainerStyle .....	615
A ListBox with Check Boxes or Radio Buttons.....	617
Alternating Item Style.....	620
Style Selectors.....	622
<b>Data Templates .....</b>	<b>625</b>
Separating and Reusing Templates .....	628
Using More Advanced Templates.....	629
Varying Templates .....	632
Template Selectors .....	633
Templates and Selection .....	636
Changing Item Layout.....	641
<b>The ComboBox .....</b>	<b>642</b>
<b>The Last Word.....</b>	<b>645</b>
<b>■ Chapter 21: Data Views .....</b>	<b>647</b>
<b>The View Object.....</b>	<b>647</b>
Retrieving a View Object.....	648
Navigating with a View .....	648
Creating a View Declaratively .....	651
<b>Filtering, Sorting, and Grouping.....</b>	<b>653</b>
Filtering Collections .....	653
Filtering the DataTable.....	656
Sorting .....	657
Grouping .....	658
Live Shaping .....	663
<b>The Last Word.....</b>	<b>664</b>
<b>■ Chapter 22: Lists, Trees, and Grids .....</b>	<b>665</b>
<b>The ListView .....</b>	<b>665</b>

Creating Columns with the GridView .....	666
Creating a Custom View.....	670
<b>The TreeView .....</b>	<b>678</b>
Creating a Data-Bound TreeView .....	679
Binding a DataSet to a TreeView.....	682
Just-in-Time Node Creation.....	683
<b>The DataGrid.....</b>	<b>686</b>
Resizing and Rearranging Columns.....	688
Defining Columns .....	689
Formatting and Styling Columns .....	694
Formatting Rows .....	696
Displaying Row Details .....	698
Freezing Columns .....	699
Selection.....	700
Sorting.....	700
Editing.....	700
<b>The Last Word.....</b>	<b>703</b>
<b>■ Part VI: Windows, Pages, and Rich Controls .....</b>	<b>705</b>
<b>■ Chapter 23: Windows .....</b>	<b>707</b>
<b>The Window Class .....</b>	<b>707</b>
Showing a Window .....	709
Positioning a Window .....	710
Saving and Restoring Window Location .....	711
<b>Window Interaction .....</b>	<b>713</b>
Window Ownership.....	715
The Dialog Model.....	715
Common Dialog Boxes.....	716
<b>Nonrectangular Windows .....</b>	<b>717</b>
A Simple Shaped Window.....	717
A Transparent Window with Shaped Content.....	721
Moving Shaped Windows .....	723
Resizing Shaped Windows.....	723
Putting It All Together: A Custom Control Template for Windows.....	725
<b>Programming the Windows Taskbar .....</b>	<b>728</b>
Using Jump Lists .....	729
Changing the Taskbar Icon and Preview.....	734

The Last Word.....	738
■ <b>Chapter 24: Pages and Navigation.....</b>	<b>741</b>
Page-Based Navigation .....	741
Page-Based Interfaces .....	742
Creating a Simple Page-Based Application with NavigationWindow.....	743
The Page Class .....	744
Hyperlinks.....	745
Hosting Pages in a Frame.....	748
Hosting Pages in Another Page .....	750
Hosting Pages in a Web Browser.....	751
The Page History .....	752
A Closer Look at URIs in WPF.....	752
Navigation History .....	753
Maintaining Custom Properties .....	754
The Navigation Service.....	755
Programmatic Navigation.....	755
Navigation Events.....	756
Managing the Journal.....	758
Adding Custom Items to the Journal .....	759
Using Page Functions .....	764
<b>XAML Browser Applications.....</b>	<b>767</b>
Creating an XBAP.....	768
Deploying an XBAP .....	769
Updating an XBAP.....	770
XBAP Security.....	771
Full-Trust XBAPs .....	772
Combination XBAP/Stand-Alone Applications.....	773
Coding for Different Security Levels.....	773
Embedding an XBAP in a Web Page .....	779
The WebBrowser Control.....	779
Navigating to a Page.....	780
Building a DOM Tree .....	781
Scripting a Web Page with .NET Code .....	784
The Last Word.....	786
■ <b>Chapter 25: Menus, Toolbars, and Ribbons .....</b>	<b>787</b>
Menus.....	787

The Menu Class .....	788
Menu Items .....	789
The ContextMenu Class .....	791
Menu Separators .....	792
<b>Toolbars and Status Bars.....</b>	<b>793</b>
The ToolBar .....	793
The StatusBar .....	796
<b>Ribbons .....</b>	<b>797</b>
Adding the Ribbon .....	798
The Application Menu .....	800
Tabs, Groups, and Buttons .....	802
Rich Tooltips .....	804
Keyboard Access with KeyTips .....	806
Ribbon Sizing.....	807
The Quick Access Toolbar .....	809
<b>The Last Word.....</b>	<b>811</b>
<b>■ Chapter 26: Sound and Video.....</b>	<b>813</b>
<b>Playing WAV Audio .....</b>	<b>813</b>
The SoundPlayer.....	813
The SoundPlayerAction.....	815
System Sounds.....	816
<b>The MediaPlayer .....</b>	<b>816</b>
<b>The MediaElement.....</b>	<b>818</b>
Playing Audio Programmatically.....	818
Handling Errors.....	819
Playing Audio with Triggers .....	820
Playing Multiple Sounds .....	822
Changing Volume, Balance, Speed, and Position .....	823
Synchronizing an Animation with Audio .....	825
Playing Video .....	827
Video Effects.....	827
<b>Speech.....</b>	<b>831</b>
Speech Synthesis .....	831
Speech Recognition.....	833
<b>The Last Word.....</b>	<b>835</b>

■ <b>Chapter 27: 3-D Drawing</b> .....	<b>837</b>
<b>3-D Drawing Basics</b> .....	<b>837</b>
The Viewport.....	838
3-D Objects.....	838
The Camera .....	846
<b>Deeper into 3-D</b> .....	<b>850</b>
Shading and Normals .....	852
More Complex Shapes.....	856
Model3DGroup Collections .....	857
Materials Revisited .....	858
Texture Mapping .....	861
<b>Interactivity and Animations</b> .....	<b>865</b>
Transforms.....	865
Rotations .....	866
A Flyover .....	868
The Trackball .....	870
Hit Testing.....	871
2-D Elements on 3-D Surfaces .....	875
<b>The Last Word</b> .....	<b>878</b>
■ <b>Part VII: Documents and Printing</b> .....	<b>881</b>
■ <b>Chapter 28: Documents</b> .....	<b>883</b>
<b>Understanding Documents</b> .....	<b>883</b>
<b>Flow Documents</b> .....	<b>884</b>
Understanding Flow Elements.....	885
Formatting Content Elements .....	887
Constructing a Simple Flow Document .....	888
Using Block Elements .....	890
Using Inline Elements .....	895
Interacting with Elements Programmatically .....	902
Text Justification .....	905
<b>Read-Only Flow Document Containers</b> .....	<b>906</b>
Zooming.....	907
Creating Pages and Columns.....	908
Loading Documents from a File.....	911
Printing .....	912
<b>Editing a Flow Document</b> .....	<b>912</b>

Loading a File .....	913
Saving a File .....	915
Formatting Selected Text.....	916
Getting Individual Words.....	919
<b>Fixed Documents.....</b>	<b>920</b>
<b>Annotations .....</b>	<b>921</b>
Understanding the Annotation Classes.....	922
Enabling the Annotation Service.....	923
Creating Annotations .....	924
Examining Annotations .....	928
Reacting to Annotation Changes.....	931
Storing Annotations in a Fixed Document.....	931
Customizing the Appearance of Sticky Notes.....	932
<b>The Last Word.....</b>	<b>933</b>
<b>■ Chapter 29: Printing .....</b>	<b>935</b>
<b>Basic Printing .....</b>	<b>935</b>
Printing an Element .....	936
Transforming Printed Output .....	938
Printing Elements Without Showing Them.....	941
Printing a Document.....	942
Manipulating the Pages in a Document Printout .....	945
<b>Custom Printing.....</b>	<b>948</b>
Printing with the Visual Layer Classes.....	948
Custom Printing with Multiple Pages .....	951
<b>Print Settings and Management.....</b>	<b>956</b>
Maintaining Print Settings .....	956
Printing Page Ranges .....	957
Managing a Print Queue .....	957
<b>Printing Through XPS.....</b>	<b>960</b>
Creating an XPS Document for a Print Preview .....	961
Writing to an In-Memory XPS Document .....	962
Printing Directly to the Printer via XPS .....	962
Asynchronous Printing.....	963
<b>The Last Word.....</b>	<b>964</b>
<b>■ Part VIII: Additional Topics.....</b>	<b>965</b>

- **Chapter 30: Interacting with Windows Forms**.....967
  - Assessing Interoperability .....967
  - Mixing Windows and Forms .....968
    - Adding Forms to a WPF Application.....968
    - Adding WPF Windows to a Windows Forms Application.....968
    - Showing Modal Windows and Forms .....969
    - Showing Modeless Windows and Forms .....969
    - Enabling Visual Styles for Windows Forms Controls.....970
  - Creating Windows with Mixed Content.....971
    - Understanding WPF and Windows Forms “Airspace” .....971
    - Hosting Windows Forms Controls in WPF.....973
    - Using WPF and Windows Forms User Controls.....975
    - Hosting WPF Controls in Windows Forms.....976
    - Access Keys, Mnemonics, and Focus.....978
    - Property Mapping .....980
  - The Last Word.....982
- **Chapter 31: Multithreading** .....983
  - Understanding the Multithreading Model .....983
    - The Dispatcher .....984
    - The DispatcherObject .....984
  - The BackgroundWorker.....987
    - A Simple Asynchronous Operation.....987
    - Creating the BackgroundWorker .....989
    - Running the BackgroundWorker.....990
    - Tracking Progress.....992
    - Supporting Cancellation .....993
  - The Last Word.....995
- **Chapter 32: The Add-in Model** .....997
  - Choosing Between MAF and MEF.....997
  - Understanding the Add-in Pipeline.....998
    - How the Pipeline Works.....999
    - The Add-in Folder Structure .....1001
    - Preparing a Solution That Uses the Add-in Model .....1002
  - Creating an Application That Uses Add-Ins.....1004
    - The Contract .....1004



The Add-in View.....	1005
The Add-In .....	1005
The Add-in Adapter .....	1006
The Host View .....	1007
The Host Adapter .....	1008
The Host .....	1008
More Add-Ins .....	1011
Interacting with the Host.....	1012
Visual Add-Ins.....	1017
The Last Word.....	1019
■ <b>Chapter 33: ClickOnce Deployment .....</b>	<b>1021</b>
Understanding Application Deployment .....	1021
The ClickOnce Installation Model .....	1023
ClickOnce Limitations .....	1024
Setting Up a Simple ClickOnce Publication .....	1024
Setting the Publisher and Production .....	1025
Starting the Publish Wizard .....	1027
Understanding the Deployed File Structure .....	1032
Installing a ClickOnce Application.....	1033
Updating a ClickOnce Application.....	1034
Additional ClickOnce Options .....	1035
Publish Version .....	1035
Updates.....	1036
File Associations.....	1037
Publish Options.....	1039
The Last Word.....	1040
■ <b>Index .....</b>	<b>1041</b>

# About the Author

---



■ **Matthew MacDonald** is an author, educator, and three-time Microsoft MVP. He's the author of more than a dozen books about .NET programming, including *Pro Silverlight 5 in C#* (Apress, 2012) and *Beginning ASP.NET 4.5 in C#* (Apress, 2012). He's also the author of *Your Brain: The Missing Manual* (O'Reilly Media, 2008), a popular look at getting the most from your squishy gray matter. Matthew lives in Toronto with his wife and two daughters.

# About the Technical Reviewer

■ **Fabio Claudio Ferracchiati**, a prolific writer on cutting-edge technologies, has contributed to more than a dozen books on .NET, C#, Visual Basic, and ASP.NET. He is a .NET Microsoft Certified Solution Developer and lives in Milan, Italy. You can read his blog at [Ferracchiati.com](http://Ferracchiati.com).

# Acknowledgments

No author can complete a book without a small army of helpful individuals. I'm deeply indebted to the whole Apress team, including Mark Powers, who shepherded this edition through production; Sharon Wilkey and Linda Seifert, who speedily performed the copy edit; and many other individuals who worked behind the scenes indexing pages, drawing figures, and proofreading the final copy.

Fabio Claudio Ferracchiati deserves my sincere thanks for his insightful and timely tech review comments. I'm also thankful for the legions of die-hard bloggers on the various WPF teams, who never fail to shed light on the deepest recesses of WPF. I encourage anyone who wants to learn more about the future of WPF to track them down. Finally, I'd never write any book without the support of my wife and these special individuals: Nora, Razia, Paul, and Hamid. Thanks everyone!

—Matthew MacDonald

# Introduction

When .NET first appeared, it introduced a small avalanche of new technologies. There was a whole new way to write web applications (ASP.NET), a whole new way to connect to databases (ADO.NET), new typesafe languages (C# and VB .NET), and a managed runtime (the CLR). Not least among these new technologies was Windows Forms, a library of classes for building Windows applications.

Although Windows Forms is a full-featured toolkit, it's hardwired to old, essential bits of Windows plumbing. Most significantly, Windows Forms relies on the Windows API to create the visual appearance of standard user interface elements such as buttons, text boxes, check boxes, and so on. As a result, these ingredients are essentially uncustomizable. For example, if you want to create a stylish glow button you need to create a custom control and paint every aspect of the button (in all its different states) using a lower-level drawing model. Even worse, ordinary windows are carved up into distinct regions, with each control getting its own piece of real estate. As a result, there's no good way for the painting in one control (for example, the glow effect behind a button) to spread into the area owned by another control. And don't even think about introducing animated effects such as spinning text, shimmering buttons, shrinking windows, or live previews because you'll have to paint every detail by hand.

The Windows Presentation Foundation (WPF) changed all this by introducing a model with entirely different plumbing. Although WPF includes the standard controls you're familiar with, it draws every text, border, and background fill *itself*. As a result, WPF can provide much more powerful features that let you alter the way any piece of screen content is rendered. Using these features, you can restyle common controls such as buttons, often without writing any code. Similarly, you can use transformation objects to rotate, stretch, scale, and skew anything in your user interface, and you can even use WPF's baked-in animation system to do it right before the user's eyes. And because the WPF engine renders the content for a window as part of a single operation, it can handle unlimited layers of overlapping controls, even if these controls are irregularly shaped and partially transparent.

Underlying WPF is a powerful infrastructure based on DirectX, the hardware-accelerated graphics API that's commonly used in cutting-edge computer games. This means that you can use rich graphical effects without incurring the performance overhead that you'd suffer with Windows Forms. In fact, you even get advanced features such as support for video files and 3-D content. Using these features (and a good design tool), it's possible to create eye-popping user interfaces and visual effects that would have been all but impossible with Windows Forms.

It's also important to note that you can use WPF to build an ordinary Windows application with standard controls and a straightforward visual appearance. In fact, it's just as easy to use common controls in WPF as it is in the older Windows Forms model. Even better, WPF enhances features that appeal directly to business developers, including a vastly improved data binding model, a set of classes for printing content and managing print queues, and a document feature for displaying large amounts of formatted text. You'll even get a model for building page-based applications that run seamlessly in Internet Explorer

and can be launched from a website, all without the usual security warnings and irritating installation prompts. Overall, WPF combines the best of the old world of Windows development with new innovations for building modern, graphically rich user interfaces.

## About This Book

This book is an in-depth exploration of WPF for professional developers who know the .NET platform, the C# language, and the Visual Studio development environment. Experience with previous versions of WPF is not required, although new features are highlighted with a “What’s New” box at the beginning of each chapter for more seasoned WPF developers.

This book provides a complete description of every major WPF feature, from XAML (the markup language used to define WPF user interfaces) to 3-D drawing and animation. Along the way, you’ll occasionally work with code that involves other features of the .NET Framework, such as the ADO.NET classes you use to query a database. These features aren’t discussed here. Instead, if you want more information about .NET features that aren’t specific to WPF, you can refer to one of the many dedicated .NET titles from Apress.

## Chapter Overview

This book includes 33 chapters. If you’re just starting out with WPF, you’ll find it’s easiest to read them in order, as later chapters often draw on the techniques demonstrated in earlier chapters.

The following list gives you a quick preview of each chapter:

**Chapter 1: Introducing WPF** describes the architecture of WPF, its DirectX plumbing, and the new device-independent measurement system that resizes user interfaces automatically.

**Chapter 2: XAML** describes the XAML standard that you use to define user interfaces. You’ll learn why it was created and how it works, and you’ll create a basic WPF window using different coding approaches.

**Chapter 3: Layout** delves into the layout panels that allow you to organize elements in a WPF window. You’ll consider different layout strategies, and you’ll build some common types of windows.

**Chapter 4: Dependency Properties** describes how WPF uses dependency properties to provide support for key features such as data binding and animation.

**Chapter 5: Routed Events** describes how WPF uses event routing to send events bubbling or tunneling through the elements in your user interface. It also describes the basic set of mouse, keyboard, and multitouch events that all WPF elements support.

**Chapter 6: Controls** considers the controls every Windows developer is familiar with, such as buttons, text boxes, and labels—and their WPF twists.

**Chapter 7: The Application** introduces the WPF application model. You’ll see how to create single-instance and document-based WPF applications.

**Chapter 8: Element Binding** introduces WPF data binding. You’ll see how to bind any type of object to your user interface.

**Chapter 9: Commands** introduces the WPF command model, which allows you to wire multiple controls to the same logical action.

**Chapter 10: Resources** describes how resources let you embed binary files in your assembly and reuse important objects throughout your user interface.

**Chapter 11: Styles and Behaviors** explains the WPF style system, which lets you apply a set of common property values to an entire group of controls.

**Chapter 12: Shapes, Brushes, and Transforms** introduces the 2-D drawing model in WPF. You'll learn to create shapes, alter elements with transforms, and paint exotic effects with gradients, tiles, and images.

**Chapter 13: Geometries and Drawings** delves deeper into 2-D drawing. You'll learn to create complex paths that incorporate arcs and curves and how to use complex graphics efficiently.

**Chapter 14: Effects and Visuals** describes lower-level graphics programming. You'll apply Photoshop-style effects with pixel shaders, build a bitmap by hand, and use WPF's visual layer for optimized drawing.

**Chapter 15: Animation Basics** explores WPF's animation framework, which lets you integrate dynamic effects into your application using straightforward, declarative markup.

**Chapter 16: Advanced Animations** explore more sophisticated animation techniques like key-frame animation, path-based animation, and frame-based animation. You'll also consider a detailed example that shows how to create and manage dynamic animations with code.

**Chapter 17: Control Templates** shows you how you can give any WPF control a dramatic new look (and new behavior) by plugging in a customized template. You'll also see how templates allow you to build a skinnable application.

**Chapter 18: Custom Elements** explores how you can extend the existing WPF controls and create your own. You'll see several examples, including a template-based color picker, a flippable panel, a custom layout container, and a decorator that performs custom drawing.

**Chapter 19: Data Binding** shows you how to fetch information from a database, insert it into a custom data objects, and bind these objects to WPF controls. You'll also learn how to improve the performance of huge data-bound lists with virtualization, and catch editing mistakes with validation.

**Chapter 20: Formatting Bound Data** shows some of the tricks for turning raw data into rich data displays that incorporate pictures, controls, and selection effects.

**Chapter 21: Data Views** explores how you use the view in a data-bound window to navigate through a list of data items, and to apply filtering, sorting, and grouping.

**Chapter 22: Lists, Grids, and Trees** gives you a tour of WPF's rich data controls, including the ListView, TreeView, and DataGrid.

**Chapter 23: Windows** examines how windows work in WPF. You'll also learn how to create irregularly shaped windows and use Vista glass effects. You'll also make the most of Windows 7 features by customizing taskbar jump lists, thumbnails, and icon overlays.

**Chapter 24: Pages and Navigation** describes how you can build pages in WPF and keep track of navigation history. You'll also see how to build a browser-hosted WPF application that can be launched from a website.

**Chapter 25: Menus, Toolbars, and Ribbons** considers command-oriented controls such as menus and toolbars. You'll also get a taste of more modern user interface with the freely downloadable Ribbon control.

**Chapter 26: Sound and Video** describes WPF's media support. You'll see how to control playback for sound and video, and how to throw in synchronized animations and live effects.

**Chapter 27: 3-D Drawing** explores the support for drawing 3-D shapes in WPF. You'll learn how to create, transform, and animate 3-D objects. You'll even see how to place interactive 2-D controls on

3-D surfaces.

**Chapter 28: Documents** introduces WPF's rich document support. You'll learn to use flow documents to present large amounts of text in the most readable way possible, and you'll use fixed documents to show print-ready pages. You'll even use the `RichTextBox` to provide document editing.

**Chapter 29: Printing** demonstrates WPF's printing model, which lets you draw text and shapes in a print document. You'll also learn how to manage page settings and print queues.

**Chapter 30: Interacting with Windows Forms** examines how you can combine WPF and Windows Forms content in the same application—and even in the same window.

**Chapter 31: Multithreading** describes how to create responsive WPF applications that perform time-consuming work in the background.

**Chapter 32: The Add-In Model** shows you how to create an extensible application that can dynamically discover and load separate components.

**Chapter 33: ClickOnce Deployment** shows how you can deploy WPF applications using the ClickOnce setup model.

## What You Need to Use This Book

In order to *run* a WPF 4.5 application, your computer must have Windows 7, Windows 8, or Windows Vista with Service Pack 2. You also need the .NET Framework 4.5. In order to *create* a WPF 4.5 application (and open the sample projects included with this book), you need Visual Studio 2012, which includes the .NET Framework 4.5.

There's one other option. Instead of using any version of Visual Studio, you can use Expression Blend—a graphically oriented design tool—to build and test WPF applications. Overall, Expression Blend is intended for graphic designers who spend their time creating serious eye candy, while Visual Studio is ideal for code-heavy application programmers. This book assumes you're using Visual Studio. If you do plan to use Expression Blend, make sure you are using a version that explicitly supports WPF (the version that's bundled with some versions of Visual Studio is for Metro development only, and doesn't support WPF). At the time of this writing, the version of Expression Blend that supports WPF is available as a preview called Blend + Sketchflow Preview for Visual Studio 2012, and it's available at <http://tinyurl.com/cgar5lz>.

## Code Samples and URLs

It's a good idea to check the Apress website or <http://www.prosetech.com> to download the most recent up-to-date code samples. You'll need to do this to test most of the more sophisticated code examples described in this book because the less significant details are usually left out. This book focuses on the most important sections so that you don't need to wade through needless extra pages to understand a concept.

To download the source code, surf to <http://www.prosetech.com> and look for the page for this book. You'll also find a list of links that are mentioned in this book, so you can find important tools and examples without needless typing.



## Feedback

This book has the ambitious goal of being the best tutorial and reference for programming WPF. Toward that end, your comments and suggestions are extremely helpful. You can send complaints, adulation, and everything in between directly to [apress@prosetech.com](mailto:apress@prosetech.com). I can't solve your .NET problems or critique your code, but I will benefit from information about what this book did right and wrong (or what it may have done in an utterly confusing way).