Chapter 8

Code and XAML in Harmony

A code file and a XAML file always exist as a pair. The two files complement each other. Despite being referred to as the "code-behind" file to the XAML, very often the code is prominent in taking on the more active and interactive parts of the application. This implies that the code-behind file must be able to refer to elements defined in XAML with as much ease as objects instantiated in code. Likewise, elements in XAML must be able to fire events that are handled in code-based event handlers. That's what this chapter is all about.

But first let's explore a couple of unusual techniques for instantiating objects in a XAML file.

Passing Arguments

As you've seen, the XAML parser instantiates elements by calling the parameterless constructor of the corresponding class or structure, and then initializes the resultant object by setting properties from attribute values. This seems reasonable. However, developers using XAML sometimes have a need to instantiate objects with constructors that require arguments, or by calling a static creation method. These needs usually didn't involve the API itself, but instead involve external data classes referenced by the XAML file and which interact with the API.

The 2009 XAML specification introduced an x:Arguments element and an x:FactoryMethod attribute for these cases, and Xamarin.Forms supports them. These techniques are not often used in ordinary circumstances, but you should see how they work in case the need arises.

Constructors with Arguments

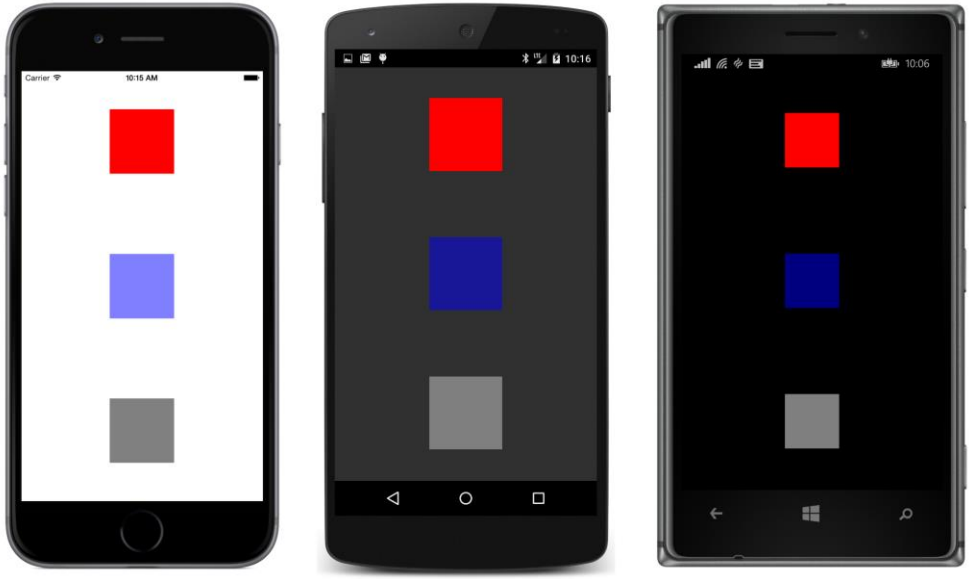
To pass arguments to a constructor of an element in XAML, the element must be separated into start and end tags. Follow the start tag of the element with x:Arguments start and end tags. Within those x:Arguments tags, include one or more constructor arguments.

The **ParameteredConstructorDemo** sample demonstrates this technique using three different constructors of the Color structure. The constructor with three parameters requires red, green, and blue values ranging from 0 to 1. The constructor with four parameters adds an alpha channel as the fourth parameter (which is set here to 0.5), and the constructor with a single parameter indicates a gray shade form 0 (black) to 1 (white):

```
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             x:Class="ParameteredConstructorDemo.ParameteredConstructorDemoPage">
```

```
    <StackLayout>
        <BoxView WidthRequest="100"
                 HeightRequest="100"
                 HorizontalOptions="Center"
                 VerticalOptions="CenterAndExpand">
            <BoxView.Color>
                <Color>
                    <x:Arguments>
                        <x:Double>1</x:Double>
                        <x:Double>0</x:Double>
                        <x:Double>0</x:Double>
                    </x:Arguments>
                </Color>
            </BoxView.Color>
        </BoxView>

        <BoxView WidthRequest="100"
                 HeightRequest="100"
                 HorizontalOptions="Center"
                 VerticalOptions="CenterAndExpand">
            <BoxView.Color>
                <Color>
                    <x:Arguments>
                        <x:Double>0</x:Double>
                        <x:Double>0</x:Double>
                        <x:Double>1</x:Double>
                        <x:Double>0.5</x:Double>
                    </x:Arguments>
                </Color>
            </BoxView.Color>
        </BoxView>

        <BoxView WidthRequest="100"
                 HeightRequest="100"
                 HorizontalOptions="Center"
                 VerticalOptions="CenterAndExpand">
            <BoxView.Color>
                <Color>
                    <x:Arguments>
                        <x:Double>0.5</x:Double>
                    </x:Arguments>
                </Color>
            </BoxView.Color>
        </BoxView>
    </StackLayout>
</ContentPage>
```

The number of elements within the x:Arguments tags, and the types of these elements, must match one of the constructors of the class or structure. You can't just separate arguments with commas or something similar, so the datatype tags defined in the XAML 2009 specification really help. Here's the result:



The blue BoxView is light against the light background and dark against the dark background because it's 50% transparent and lets the background show through.

Can I Call Methods from XAML?

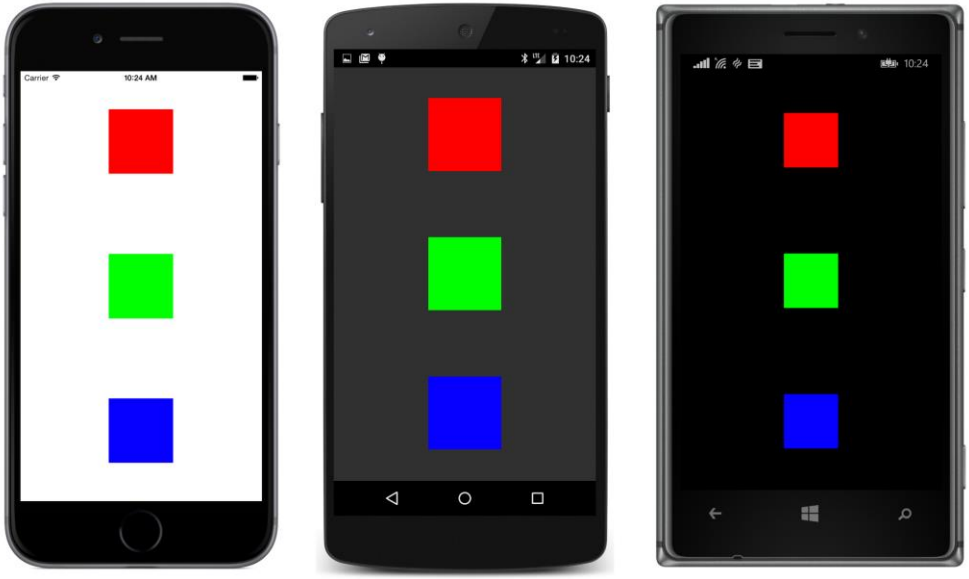
At one time, the answer to this question was "Don't be ridiculous," but now it's a qualified "Yes." Don't get too excited, though. The only methods you can call in XAML are those that return objects (or values) of the same type as the class (or structure) that defines the method. These methods must be public (obviously) and static. They are sometimes called *creation methods* or *factory methods*. You can instantiate an element in XAML through a call to one of these methods by specifying the method's name using the x:FactoryMethod attribute, and its arguments using the x:Arguments element.

The Color structure defines seven static methods that return Color values, so these qualify. This XAML file makes use of three of them:

```
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             x:Class="FactoryMethodDemo.FactoryMethodDemoPage">

    <StackLayout>
        <BoxView WidthRequest="100"
                 HeightRequest="100"
                 HorizontalOptions="Center"
                 VerticalOptions="CenterAndExpand">
            <BoxView.Color>
                <Color x:FactoryMethod="FromRgb">
                    <x:Arguments>
                        <x:Int32>255</x:Int32>
                        <x:Int32>0</x:Int32>
```

```
                    <x:Int32>0</x:Int32>
                </x:Arguments>
            </Color>
        </BoxView.Color>
    </BoxView>

    <BoxView WidthRequest="100"
             HeightRequest="100"
             HorizontalOptions="Center"
             VerticalOptions="CenterAndExpand">
        <BoxView.Color>
            <Color x:FactoryMethod="FromRgb">
                <x:Arguments>
                    <x:Double>0</x:Double>
                    <x:Double>1.0</x:Double>
                    <x:Double>0</x:Double>
                </x:Arguments>
            </Color>
        </BoxView.Color>
    </BoxView>

    <BoxView WidthRequest="100"
             HeightRequest="100"
             HorizontalOptions="Center"
             VerticalOptions="CenterAndExpand">
        <BoxView.Color>
            <Color x:FactoryMethod="FromHsla">
                <x:Arguments>
                    <x:Double>0.67</x:Double>
                    <x:Double>1.0</x:Double>
                    <x:Double>0.5</x:Double>
                    <x:Double>1.0</x:Double>
                </x:Arguments>
            </Color>
        </BoxView.Color>
    </BoxView>
  </StackLayout>
</ContentPage>
```

The first two static methods invoked here are both named Color.FromRgb, but the types of elements within the x:Arguments tags distinguish between int arguments that range from 0 to 255 and double argument that range from 0 to 1. The third one is the Color.FromHsla method that creates a Color value from hue, saturation, luminosity, and alpha components. Interestingly, this is the only way to define a Color value from HSL values in a XAML file using the Xamarin.Forms API. Here's the result:



The x:Name Attribute

In most real applications, the code-behind file needs to reference elements defined in the XAML file. You saw one way to do it in the **CodePlusXaml** program in the previous chapter: If the code-behind file has knowledge of the layout of the visual tree defined in the XAML file, it can start from the root element (the page itself) and locate specific elements within the tree. This process is called "walking the tree" and can be useful for locating particular elements on a page.

Generally a better approach is to give elements in the XAML file a name similar to a variable name. To do this you use an attribute that is intrinsic to XAML called Name. Because the prefix x is almost universally used for attributes intrinsic to XAML, this Name attribute is commonly referred to as x:Name.

The **XamlClock** project demonstrates the use of x:Name. Here is the XamlClockPage.xaml file containing two Label controls named timeLabel and dateLabel:

```
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             x:Class="XamlClock.XamlClockPage">
    <StackLayout>
        <Label x:Name="timeLabel"
               FontSize="Large"
               HorizontalOptions="Center"
               VerticalOptions="EndAndExpand" />

        <Label x:Name="dateLabel"
               HorizontalOptions="Center"
               VerticalOptions="StartAndExpand" />
```

```
    </StackLayout>
</ContentPage>
```

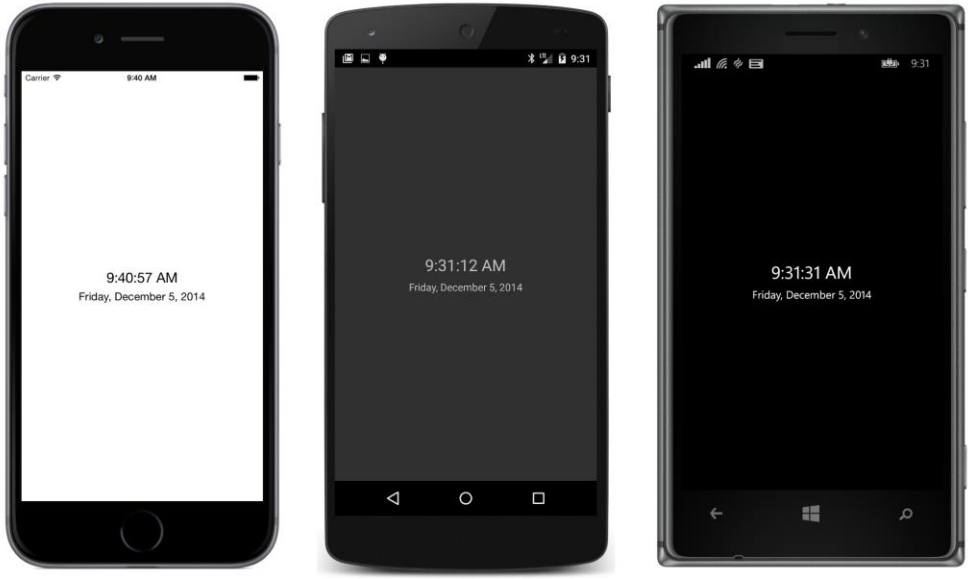
The rules for x:Name are the same as for C# variable names. (You'll see why shortly). The name must begin with a letter or underscore, and must contain only letters, underscores, and numbers.

Like the clock program in Chapter 5, **XamlClock** uses Device.StartTimer to fire a periodic event for updating the time and date. Here's the XamlClockPage code-behind file:

```
namespace XamlClock
{
    public partial class XamlClockPage
    {
        public XamlClockPage()
        {
            InitializeComponent();

            Device.StartTimer(TimeSpan.FromSeconds(1), OnTimerTick);
        }

        bool OnTimerTick()
        {
            DateTime dt = DateTime.Now;
            timeLabel.Text = dt.ToString("T");
            dateLabel.Text = dt.ToString("D");
            return true;
        }
    }
}
```

This timer callback method is called once per second. The method must return true to continue the timer. If it returns false, the timer stops and must be restarted with another call to Device.StartTimer.

The callback method references timeLabel and dateLabel as if they were normal variables, and sets the Text properties of each:



This is not a visually impressive clock, but it's definitely functional.

How is it that the code-behind file can reference the elements identified with x:Name? Is it magic? Of course not. The mechanism is very evident when you examine the XamlClockPage.xaml.g.cs file that the XAML parser generates from the XAML file as the project is being built:

```
//------------------------------------------------------------------------------
// <auto-generated>
//     This code was generated by a tool.
//     Runtime Version:4.0.30319.35317
//
//     Changes to this file may cause incorrect behavior and will be lost if
//     the code is regenerated.
// </auto-generated>
//------------------------------------------------------------------------------

namespace XamlClock {
    using System;
    using Xamarin.Forms;
    using Xamarin.Forms.Xaml;

    public partial class XamlClockPage : ContentPage {

        private Label timeLabel;

        private Label dateLabel;

        private void InitializeComponent() {
            this.LoadFromXaml(typeof(XamlClockPage));
            timeLabel = this.FindByName<Label>("timeLabel");
            dateLabel = this.FindByName<Label>("dateLabel");
```

```
        }
    }
}
```

As the build-time XAML parser chews through the XAML file, every x:Name attribute becomes a private field in this generated code file. This allows code in the code-behind file to reference these names as if they were normal fields—which they definitely are. However, the fields are initially null. Only when InitializeComponent is called at runtime are the two fields set via the FindByName method, which is defined in the NameScopeExtensions class. If the constructor of your code-behind file tries to reference these two fields prior to the InitializeComponent call, they will have null values.

This generated code file also implies another rule for x:Name values that is now very obvious but rarely stated explicitly: The names cannot duplicate names of fields or properties defined in the code-behind file.

Because these are private fields, they can only be accessed from the code-behind file and not from other classes. If a ContentPage derivative must expose public fields or properties to other classes, you must define those yourself.

Obviously x:Name values must be unique within a XAML page. This can sometimes be a problem if you're using OnPlatform for platform-specific elements in the XAML file. For example, here's a XAML file that expresses the iOS, Android, and WinPhone properties of OnPlatform as property elements to select one of three Label views:

```
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             x:Class="PlatformSpecificLabels.PlatformSpecificLabelsPage">

    <OnPlatform x:TypeArguments="View">
        <OnPlatform.iOS>
            <Label Text="This is an iOS device"
                   HorizontalOptions="Center"
                   VerticalOptions="Center" />
        </OnPlatform.iOS>

        <OnPlatform.Android>
            <Label Text="This is an Android device"
                   HorizontalOptions="Center"
                   VerticalOptions="Center" />
        </OnPlatform.Android>

        <OnPlatform.WinPhone>
            <Label Text="This is an Windows Phone device"
                   HorizontalOptions="Center"
                   VerticalOptions="Center" />
        </OnPlatform.WinPhone>
    </OnPlatform>
</ContentPage>
```

The x:TypeArguments attribute of OnPlatform must match the type of the target property exactly. This OnPlatform element is implicitly being set to the Content property of ContentPage, and this Content

property is of type View, so the x:TypeArguments attribute of OnPlatform must specify View. However, the properties of OnPlatform can be set to any class that derives from that type. The objects set to the iOS, Android, and WinPhone properties can in fact be different types just as long as they derive from View.

Although that XAML file works, it's not exactly optimum. All three Label views are instantiated and initialized but only one is set to the Content property of the ContentPage. The problem with this approach arises if you need to refer to the Label from the code-behind file and you give each of them the same name like so:

The following XAML file does not work!

```
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             x:Class="PlatformSpecificLabels.PlatformSpecificLabelsPage">

    <OnPlatform x:TypeArguments="View">
        <OnPlatform.iOS>
            <Label x:Name="deviceLabel"
                   Text="This is an iOS device"
                   HorizontalOptions="Center"
                   VerticalOptions="Center" />
        </OnPlatform.iOS>

        <OnPlatform.Android>
            <Label x:Name="deviceLabel"
                   Text="This is an Android device"
                   HorizontalOptions="Center"
                   VerticalOptions="Center" />
        </OnPlatform.Android>

        <OnPlatform.WinPhone>
            <Label x:Name="deviceLabel"
                   Text="This is a Windows Phone device"
                   HorizontalOptions="Center"
                   VerticalOptions="Center" />
        </OnPlatform.WinPhone>
    </OnPlatform>
</ContentPage>
```

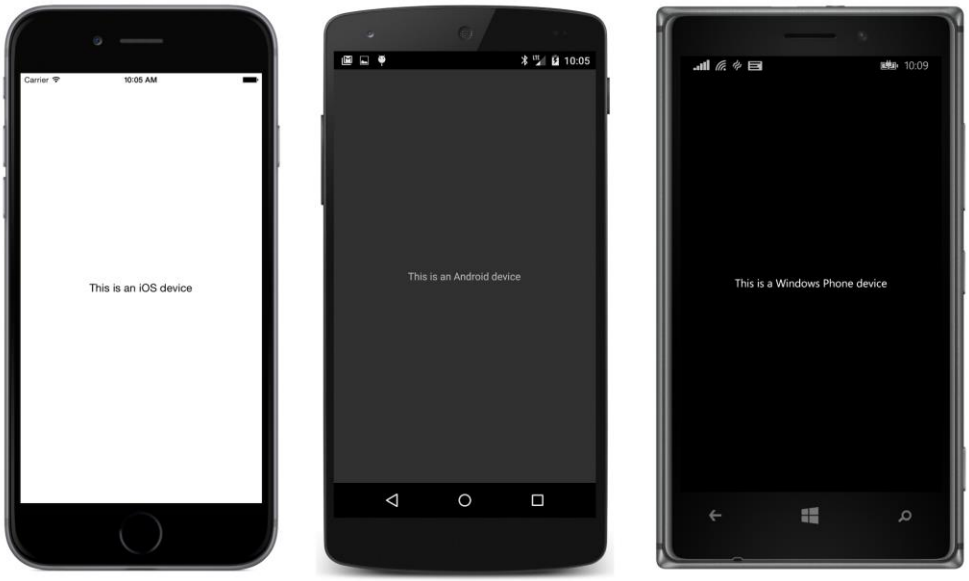
This will not work because multiple elements have the same name.

You could give them different names and handle the three names in the code-behind file using Device.OnPlatform, but a better solution is to keep the platform specificities as small as possible. Here's the version of the **PlatformSpecificLabels** program actually included among the sample code for this chapter. It has a single Label and everything is platform-independent except for the Text property:

```
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             x:Class="PlatformSpecificLabels.PlatformSpecificLabelsPage">

    <Label x:Name="deviceLabel"
           HorizontalOptions="Center"
```

```
            VerticalOptions="Center">
        <Label.Text>
            <OnPlatform x:TypeArguments="x:String"
                        iOS="This is an iOS device"
                        Android="This is an Android device"
                        WinPhone="This is a Windows Phone device" />
        </Label.Text>
    </Label>
</ContentPage>
```

Here's what it looks like:



The Text property is the content property for Label, so you don't need the Label.Text tags in the previous example. This works as well:

```
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             x:Class="PlatformSpecificLabels.PlatformSpecificLabelsPage">

    <Label x:Name="deviceLabel"
           HorizontalOptions="Center"
           VerticalOptions="Center">
        <OnPlatform x:TypeArguments="x:String"
                    iOS="This is an iOS device"
                    Android="This is an Android device"
                    WinPhone="This is a Windows Phone device" />
    </Label>
</ContentPage>
```

Unlike some of the examples shown in the **TextVariations** sample in the previous chapter, there's no problem with superfluous whitespace or end-of-line characters here. All the text strings are delimited

by quotation marks within the OnPlatform tag.

Custom XAML-Based Views

The **ScaryColorList** program in the previous chapter listed a few colors in a StackLayout using Frame, BoxView and Label. With even just three colors, the repetitive markup was starting to look very ominous. Unfortunately there is no XAML markup that duplicates the C# for and while loops, so your choice is to use code for generating multiple similar items, or to find a better way to do it in markup.

In this book you'll be seeing several ways to list colors in XAML, and eventually this job will become very clean and elegant. But that requires a few more steps into learning Xamarin.Forms. Until then, we'll be looking at some other approaches that you might find useful in similar circumstances.

One strategy is to create a custom view that has the sole purpose of displaying a color with a name and a colored box. And while we're at it, let's display the hexadecimal RGB values of the colors as well. Then use that custom view in a XAML page file for the individual colors.

What might this look like in XAML?

Or the better question is: How would you *like* it to look?

If the markup looked something like this, the repetition is not bad at all, and not so much worse than explicitly defining an array of Color values in code:

```
<StackLayout>
    <MyColorView Color="Red" />
    <MyColorView Color="Green" />
    <MyColorView Color="Blue" />
    …
</StackLayout>
```

Well, actually it won't look exactly like that. MyColorView is obviously a custom class and not part of the Xamarin.Forms API. Therefore it cannot appear in the XAML file without a namespace prefix that is defined in an XML namespace declaration.

With this XML prefix applied, there won't be any confusion about this custom view being part of the Xamarin.Forms API, so let's give it a more dignified name of ColorView rather than MyColorView.

This hypothetical ColorView class is an example of a fairly easy custom view because it consists solely of existing views—specifically Label, Frame, and BoxView—arranged in a particular way using StackLayout. Xamarin.Forms defines a view designed specifically for the purpose of parenting such an arrangement of views, and it's called ContentView. Like ContentPage, ContentView has a Content property that you can set to a visual tree of other views. You can define the contents of the ContentView in code, but it's more fun to do it in XAML.

Let's put together a solution named **ColorViewList**. This solution will have two sets of XAML and code-behind files: one for a class named ColorViewListPage that derives from ContentPage (as usual), and

the second for a class named ColorView that derives from ContentView.

To create the ColorView class in Visual Studio, use the same procedure as when adding a new XAML page to the ColorViewList project. Right-click the project name in the solution explorer, and select **Add > New Item** from the context menu. In the **Add New Item** dialog, select **Visual C# > Code** at the left and **Forms Xaml Page**. Enter the name ColorView.cs. But right away, before you forget, go into the ColorView.xaml file and change ContentPage in the start and end tags to ContentView. In the ColorView.xaml.cs file, change the base class to ContentView.

The process is a little easier in Xamarin Studio. From the tool menu for the **ColorViewList** project, select **Add > New File**. In the **New File** dialog, select **Forms** at the left and **Forms ContentView Xaml** (not **Forms ContentPage Xaml**). Give it a name of ColorView.

You'll also need to create a XAML file and code-behind file for the ColorViewListPage class, as usual.

The ColorView.xaml file describes the layout of the individual color items but without any actual color values. Instead, the BoxView and two Label views are given names:

```
<ContentView xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             x:Class="ColorViewList.ColorView">

    <Frame OutlineColor="Accent">
        <StackLayout Orientation="Horizontal">
            <BoxView x:Name="boxView"
                     WidthRequest="70"
                     HeightRequest="70" />

            <StackLayout>
                <Label x:Name="colorNameLabel"
                       FontSize="Large"
                       VerticalOptions="CenterAndExpand" />

                <Label x:Name="colorValueLabel"
                       VerticalOptions="CenterAndExpand" />
            </StackLayout>
        </StackLayout>
    </Frame>
</ContentView>
```

In a real-life program, you'll have plenty of time later to fine-tune the visuals. Initially you'll just want to get all the named views in there.

Besides the visuals, this ColorView class will need a new property to set the color. This property must be defined in the code-behind file. At first, it seems reasonable to give ColorView a property named Color of type Color (as the earlier XAML snippet with MyColorView seems to suggest). But if this property were of type Color, how would the code get the name of the color from that Color value? It can't.

Instead, it makes more sense to define a property named ColorName of type string. The code-behind file can then use reflection to obtain the static field of the Color class corresponding to that name.

But wait: Xamarin.Forms includes a public ColorTypeConverter class that the XAML parser uses to convert a text color name like "Red" or "Blue" into a Color value. Why not take advantage of that?

Here's the code-behind file for ColorView. It defines a ColorName property with a set accessor that sets the Text property of the colorNameLabel to the color name, and then uses ColorTypeConverter to convert the name to a Color value. This Color value is then used to set the Color property of boxView and the Text property of the colorValueLabel to the RGB values:

```
public partial class ColorView : ContentView
{
    string colorName;
    ColorTypeConverter colorTypeConv = new ColorTypeConverter();

    public ColorView()
    {
        InitializeComponent();
    }

    public string ColorName
    {
        set
        {
            // Set the name.
            colorName = value;
            colorNameLabel.Text = value;

            // Get the actual Color and set the other views.
            Color color = (Color)colorTypeConv.ConvertFrom(colorName);
            boxView.Color = color;
            colorValueLabel.Text = String.Format("{0:X2}-{1:X2}-{2:X2}",
                                                 (int)(255 * color.R),
                                                 (int)(255 * color.G),
                                                 (int)(255 * color.B));
        }
        get
        {
            return colorName;
        }
    }
}
```

The ColorView class is finished. Now let's look at ColorViewListPage. The ColorViewListPage.xaml file must list multiple ColorView instances, so it needs a new XML namespace declaration with a new namespace prefix to reference the ColorView element.

The ColorView class is part of the same project as ColorViewListPage. Generally programmers use an XML namespace prefix of local for such cases. The new namespace declaration appears in the root element of the XAML file (like the other two) with the following format:

```
xmlns:local="clr-namespace:ColorViewList;assembly=ColorViewList"
```

A custom XML namespace declaration for XAML must specify a Common Language Runtime (CLR)

namespace—also known as the .NET namespace—and an assembly. The keywords to specify these are clr-namespace and assembly. Often the CLR namespace is the same as the assembly, as they are in this case, but they don't need to be. The two parts are connected by a semi-colon.

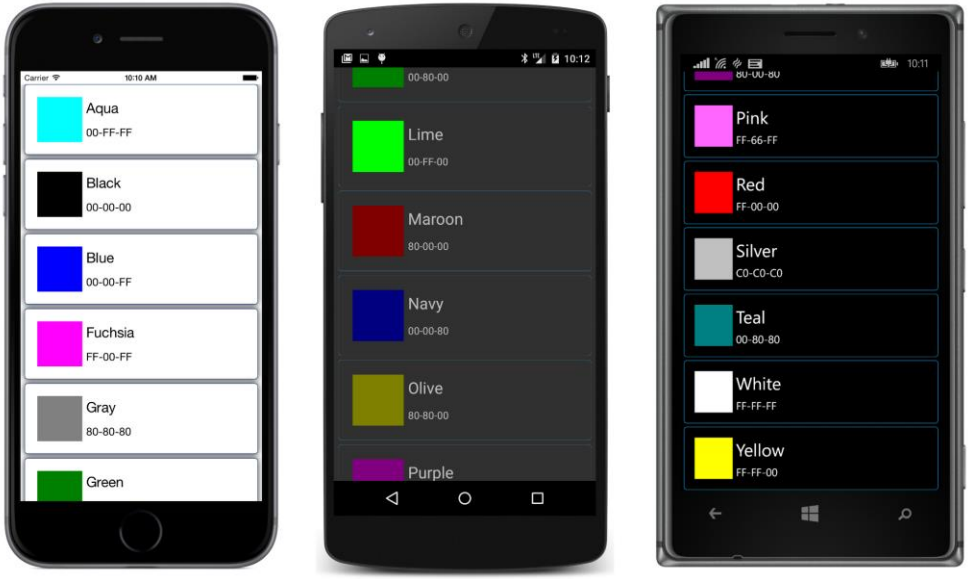
Notice that a colon follows clr-namespace but an equal sign follows assembly. This apparent inconsistency is deliberate: The format of the namespace declaration is intended to mimic a URI found in conventional namespace declarations, in which a colon follows the URI scheme name.

You use the same syntax for referencing objects in external portable class libraries. The only difference in those cases is that the project also needs a reference to that external PCL. (You'll see an example in a later chapter).

Here's the XAML for the ColorViewListPage class. The code-behind file contains nothing beyond the InitializeComponent call:

```
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             xmlns:local="clr-namespace:ColorViewList;assembly=ColorViewList"
             x:Class="ColorViewList.ColorViewListPage">

    <ContentPage.Padding>
        <OnPlatform x:TypeArguments="Thickness"
                    iOS="0, 20, 0, 0" />
    </ContentPage.Padding>

    <ScrollView>
        <StackLayout Padding="6, 0">
            <local:ColorView ColorName="Aqua" />
            <local:ColorView ColorName="Black" />
            <local:ColorView ColorName="Blue" />
            <local:ColorView ColorName="Fuchsia" />
            <local:ColorView ColorName="Gray" />
            <local:ColorView ColorName="Green" />
            <local:ColorView ColorName="Lime" />
            <local:ColorView ColorName="Maroon" />
            <local:ColorView ColorName="Navy" />
            <local:ColorView ColorName="Olive" />
            <local:ColorView ColorName="Purple" />
            <local:ColorView ColorName="Pink" />
            <local:ColorView ColorName="Red" />
            <local:ColorView ColorName="Silver" />
            <local:ColorView ColorName="Teal" />
            <local:ColorView ColorName="White" />
            <local:ColorView ColorName="Yellow" />
        </StackLayout>
    </ScrollView>
</ContentPage>
```

This is not quite as odious as the earlier example seemed to suggest, and it demonstrates how you can encapsulate visuals in their own XAML-based classes. Notice that the StackLayout is the child of a ScrollView, so the list can be scrolled:



However, there is one aspect of the **ColorViewList** project that does not qualify as a "best practice." It is the definition of the ColorName property in ColorView. This should really be implemented as a BindableProperty object. Delving into bindable objects and bindable properties is a high priority for a later chapter.

Events and Handlers

When you tap a Xamarin.Forms Button, it fires a Clicked event. You can instantiate a Button in XAML but the Clicked event handler itself must reside in the code-behind file. The Button is only one of a bunch of views that exist primarily to generate events, so the process of handling events is crucial to coordinating XAML and code files.

Attaching an event handler to an event in XAML is as simple as setting a property, and in fact, is visually indistinguishable from a property setting. The **XamlKeypad** project is a XAML version of the **PersistentKeypad** project from Chapter 6. It illustrates setting event handlers in XAML and handling these events in the code-behind file, and also includes logic to save keypad entries when the program is terminated.

If you take look back at the constructor code of the SimplestKeypadPage or PersistentKeypadPage classes, you'll see a couple loops to create the buttons that make up the numeric part of the keypad. Of course, this is precisely the type of thing you can't do in XAML, but look at how much cleaner the markup in XamlKeypadPage is when compared to that code:

```
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
```

```
            x:Class="XamlKeypad.XamlKeypadPage">

    <StackLayout VerticalOptions="Center"
                 HorizontalOptions="Center">

        <Label x:Name="displayLabel"
               Font="Large"
               VerticalOptions="Center"
               XAlign="End" />

        <Button x:Name="backspaceButton"
                Text="&#x21E6;"
                Font="Large"
                IsEnabled="False"
                Clicked="OnBackspaceButtonClicked" />

        <StackLayout Orientation="Horizontal">
            <Button Text="7" StyleId="7" Font="Large"
                    Clicked="OnDigitButtonClicked" />
            <Button Text="8" StyleId="8" Font="Large"
                    Clicked="OnDigitButtonClicked" />
            <Button Text="9" StyleId="9" Font="Large"
                    Clicked="OnDigitButtonClicked" />
        </StackLayout>

        <StackLayout Orientation="Horizontal">
            <Button Text="4" StyleId="4" Font="Large"
                    Clicked="OnDigitButtonClicked" />
            <Button Text="5" StyleId="5" Font="Large"
                    Clicked="OnDigitButtonClicked" />
            <Button Text="6" StyleId="6" Font="Large"
                    Clicked="OnDigitButtonClicked" />
        </StackLayout>

        <StackLayout Orientation="Horizontal">
            <Button Text="1" StyleId="1" Font="Large"
                    Clicked="OnDigitButtonClicked" />
            <Button Text="2" StyleId="2" Font="Large"
                    Clicked="OnDigitButtonClicked" />
            <Button Text="3" StyleId="3" Font="Large"
                    Clicked="OnDigitButtonClicked" />
        </StackLayout>

        <Button Text="0" StyleId="0" Font="Large"
                Clicked="OnDigitButtonClicked" />

    </StackLayout>
</ContentPage>
```

The file is a lot shorter than it would have been had the three properties on each numeric Button been formatted into three lines, but packing these all together makes the uniformity of the markup very obvious, and provides clarity rather than obscurity.

The big question is: Which would you rather maintain and modify? The code in the SimplestKey-

padPage or PersistentKeypadPage constructors or the markup in the XamlKeypadPage XAML file?

Here's the screenshot. You'll see that these keys are now arranged in calculator order rather than telephone order:

The **Backspace** button has its Clicked event set to the OnBackspaceButtonClicked handler, while the digit buttons share the OnDigitButtonClicked handler. As you'll recall, the StyleId property is often used to distinguish views sharing the same event handler, which means that the two event handlers can be implemented in the code-behind file exactly the same as the code-only program:

```
public partial class XamlKeypadPage
{
    App app = Application.Current as App;

    public XamlKeypadPage()
    {
        InitializeComponent();

        displayLabel.Text = app.DisplayLabelText;
        backspaceButton.IsEnabled = displayLabel.Text != null &&
                                    displayLabel.Text.Length > 0;
    }

    void OnDigitButtonClicked(object sender, EventArgs args)
    {
        Button button = (Button)sender;
        displayLabel.Text += (string)button.StyleId;
        backspaceButton.IsEnabled = true;

        app.DisplayLabelText = displayLabel.Text;
```

```
    }

    void OnBackspaceButtonClicked(object sender, EventArgs args)
    {
        string text = displayLabel.Text;
        displayLabel.Text = text.Substring(0, text.Length - 1);
        backspaceButton.IsEnabled = displayLabel.Text.Length > 0;

        app.DisplayLabelText = displayLabel.Text;
    }
}
```

Part of the job of the LoadFromXaml method called by InitializeComponent involves attaching these event handlers to the objects instantiated from the XAML file.

The **XamlKeypad** project includes the code that was added to the page and App classes in **PersistentKeypad** to save the keypad text when the program is terminated. The App class in **XamlKeypad** is basically the same as the one in **PersistentKeypad**.

Tap Gestures

The Xamarin.Forms Button responds to finger taps, but you can actually get finger taps from any class that derives from View, including Label, BoxView, and Frame. These tap events are not built into the View class but the View class also defines a property named GestureRecognizers. Taps are enabled by adding an object to this GestureRecognizers collection. An instance of any class that derives from GestureRecognizer can be added to this collection, but so far there's only one: TapGestureRecognizer.

Here's how to add a TapGestureRecognizer to a BoxView in code:

```
BoxView boxView = new BoxView
{
    Color = Color.Blue
};
TapGestureRecognizer tapGesture = new TapGestureRecognizer();
tapGesture.Tapped += OnBoxViewTapped;
boxView.GestureRecognizers.Add(tapGesture);
```

TapGestureRecognizer also defines a NumberOfTapsRequired property with a default value of 1.

To generate Tapped events, the View object must have its IsEnabled property set to true, its IsVisible property set to true (or it won't be visible at all), and its InputTransparent property set to false. These are all default conditions.

The Tapped handler looks just like the Clicked handler for the Button:

```
void OnBoxViewTapped(object sender, EventArgs args)
{
    …
}
```

Normally, the sender argument of an event handler is the object that fires the event, which in this case would be the TapGestureRecognizer object. That would not be of much use. Instead, the sender argument to the Tapped handler is the view being tapped, in this case the BoxView. That's *much* more useful!

Like Button, TapGestureRecognizer also defines Command and CommandParameter properties; these are used when implementing the MVVM design pattern, and they are discussed in a later chapter.

TapGestureRecognizer also defines properties named TappedCallback and TappedCallbackParameter, and a constructor that includes a TappedCallback argument. These are all deprecated and should not be used.

In XAML, you can attach a TapGestureRecognizer to a view by expressing the GestureRecognizers collection as a property element:

```
<BoxView Color="Blue">
    <BoxView.GestureRecognizers>
        <TapGestureRecognizer Tapped="OnBoxViewTapped" />
    </BoxView.GestureRecognizers>
</BoxView>
```

As usual, the XAML is a little shorter than the equivalent code.

Let's make a program that's inspired by one of the first standalone computer games.

The Xamarin.Forms version of this game is called **MonkeyTap** because it's an imitation game. It contains four BoxView elements, colored red, blue, yellow, green. When the game begins, one of the BoxView elements flashes, and you must then tap that BoxView. That BoxView flashes again followed by another one, and now you must tap both in sequence. Then those two flashes are followed by a third, and so forth. (The original had sound as well, but **MonkeyTap** does not.) It's a rather cruel game because there is no way to win. The game just keeps on getting harder and harder until you lose.

The MonkeyTapPage.xaml file instantiates the four BoxView elements and a Button in the center labeled "Begin."

```
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             x:Class="MonkeyTap.MonkeyTapPage">

    <ContentPage.Padding>
        <OnPlatform x:TypeArguments="Thickness"
                    iOS="0, 20, 0, 0" />
    </ContentPage.Padding>

    <StackLayout>
        <BoxView x:Name="boxview0"
                 VerticalOptions="FillAndExpand">
            <BoxView.GestureRecognizers>
                <TapGestureRecognizer Tapped="OnBoxViewTapped" />
            </BoxView.GestureRecognizers>
        </BoxView>
```

```
        <BoxView x:Name="boxview1"
                 VerticalOptions="FillAndExpand">
            <BoxView.GestureRecognizers>
                <TapGestureRecognizer Tapped="OnBoxViewTapped" />
            </BoxView.GestureRecognizers>
        </BoxView>

        <Button x:Name="startGameButton"
                Text="Begin"
                Font="Large"
                HorizontalOptions="Center"
                Clicked="OnStartGameButtonClicked" />

        <BoxView x:Name="boxview2"
                 VerticalOptions="FillAndExpand">
            <BoxView.GestureRecognizers>
                <TapGestureRecognizer Tapped="OnBoxViewTapped" />
            </BoxView.GestureRecognizers>
        </BoxView>

        <BoxView x:Name="boxview3"
                 VerticalOptions="FillAndExpand">
            <BoxView.GestureRecognizers>
                <TapGestureRecognizer Tapped="OnBoxViewTapped" />
            </BoxView.GestureRecognizers>
        </BoxView>
    </StackLayout>
</ContentPage>
```

All three BoxView elements here have a TapGestureRecognizer attached but they aren't yet assigned colors. That's handled in the code-behind file because the colors won't stay constant. The colors need to be changed for the flashing effect.

The code-behind file begins with some constants and variable fields. (You'll notice that one of them is flagged as protected; in the next chapter a class will derive from this one and need access to this field. Some methods are defined as protected as well.)

```
public partial class MonkeyTapPage
{
    const int sequenceTime = 750;      // in msec
    protected const int flashDuration = 250;

    const double offLuminosity = 0.4;   // somewhat dimmer
    const double onLuminosity = 0.75;   // much brighter

    BoxView[] boxViews;
    Color[] colors = { Color.Red, Color.Blue, Color.Yellow, Color.Green };
    List<int> sequence = new List<int>();
    int sequenceIndex;
    bool awaitingTaps;
    bool gameEnded;
    Random random = new Random();
```

```
    public MonkeyTapPage()
    {
        InitializeComponent();
        boxViews = new BoxView[] { boxview0, boxview1, boxview2, boxview3 };
        InitializeBoxViewColors();
    }

    void InitializeBoxViewColors()
    {
        for (int index = 0; index < 4; index++)
            boxViews[index].Color = colors[index].WithLuminosity(offLuminosity);
    }
    …
}
```

The constructor puts all four BoxView elements in an array; this allows them to be referenced by a simple index that has values of 0, 1, 2, and 3. The InitializeBoxViewColors method sets all the BoxView elements to their slightly dimmed non-flashed state.

The program is now waiting for the user to press the **Begin** button to start the first game. The same Button handles replays, so it includes a redundant initialization of the BoxView colors. The Button handler also prepares for building the sequence of flashed BoxView elements by clearing the sequence list and calling StartSequence:

```
public partial class MonkeyTapPage
{
    …
    protected void OnStartGameButtonClicked(object sender, EventArgs args)
    {
        gameEnded = false;
        startGameButton.IsVisible = false;
        InitializeBoxViewColors();
        sequence.Clear();
        StartSequence();
    }

    void StartSequence()
    {
        sequence.Add(random.Next(4));
        sequenceIndex = 0;
        Device.StartTimer(TimeSpan.FromMilliseconds(sequenceTime), OnTimerTick);
    }
    …
}
```

StartSequence adds a new random integer to the sequence list, initializes sequenceIndex to 0, and starts the timer going.

In the normal case, the timer tick handler is called for each index in the sequence list and causes the corresponding BoxView to flash with a call to FlashBoxView. The timer handler returns false when the sequence is at an end, also indicating by setting awaitingTaps that it's time for the user to imitate the sequence:

```
public partial class MonkeyTapPage
{
    …
    bool OnTimerTick()
    {
        if (gameEnded)
            return false;

        FlashBoxView(sequence[sequenceIndex]);
        sequenceIndex++;
        awaitingTaps = sequenceIndex == sequence.Count;
        sequenceIndex = awaitingTaps ? 0 : sequenceIndex;
        return !awaitingTaps;
    }

    protected virtual void FlashBoxView(int index)
    {
        boxViews[index].Color = colors[index].WithLuminosity(onLuminosity);
        Device.StartTimer(TimeSpan.FromMilliseconds(flashDuration), () =>
            {
                if (gameEnded)
                    return false;

                boxViews[index].Color = colors[index].WithLuminosity(offLuminosity);
                return false;
            });
    }
    …
}
```

The flash is just a quarter second in duration. The FlashBoxView method first sets the luminosity for a bright color and creates a "one-shot" timer, so called because the timer callback method (here expressed as a lambda function) returns false and shuts off the timer after restoring the color's luminosity.

The Tapped handler for the BoxView elements ignores the tap if the game is already ended (which only happens with a mistake by the user), and ends the game if the user taps prematurely without waiting for the program to go through the sequence. Otherwise, it just compares the tapped BoxView with the next one in the sequence, flashes that BoxView if correct, or ends the game if not:

```
public partial class MonkeyTapPage
{
    …
    protected void OnBoxViewTapped(object sender, EventArgs args)
    {
        if (gameEnded)
            return;

        if (!awaitingTaps)
        {
            EndGame();
            return;
        }
```

```
        BoxView tappedBoxView = (BoxView)sender;
        int index = Array.IndexOf(boxViews, tappedBoxView);

        if (index != sequence[sequenceIndex])
        {
            EndGame();
            return;
        }

        FlashBoxView(index);

        sequenceIndex++;
        awaitingTaps = sequenceIndex < sequence.Count;

        if (!awaitingTaps)
            StartSequence();
    }

    protected virtual void EndGame()
    {
        gameEnded = true;

        for (int index = 0; index < 4; index++)
            boxViews[index].Color = Color.Gray;

        startGameButton.Text = "Try again?";
        startGameButton.IsVisible = true;
    }
}
```

If the user manages to "ape" the sequence all the way through, another call to StartSequence adds a new index to the sequence list and starts playing that new one. Eventually, though, there will be a call to EndGame, which colors all the boxes gray to emphasize the end, and re-enables the Button for a chance to try it again.

Here's the program after the Button has been clicked and hidden:

I know, I know. The game is a real drag without sound.

Let's take the opportunity in the next chapter to fix that.