Part 5. From Data Bindings to MVVM

An Introduction to the Model-View-ViewModel Architecture

A Simple ViewModel

As an introduction to ViewModels, let’s first look at a program without one. Earlier you saw how to define a new XML namespace declaration to allow a XAML file to reference classes in other assemblies. Here’s a program that defines an XML namespace declaration for the `System` namespace:

```
xmlns:sys="clr-namespace:System;assembly=mscorlib"
```

The program then uses `x:Static` to obtain the current date and time from the static `DateTime.Now` property and sets that `DateTime` value to the `BindingContext` on a `StackLayout`:

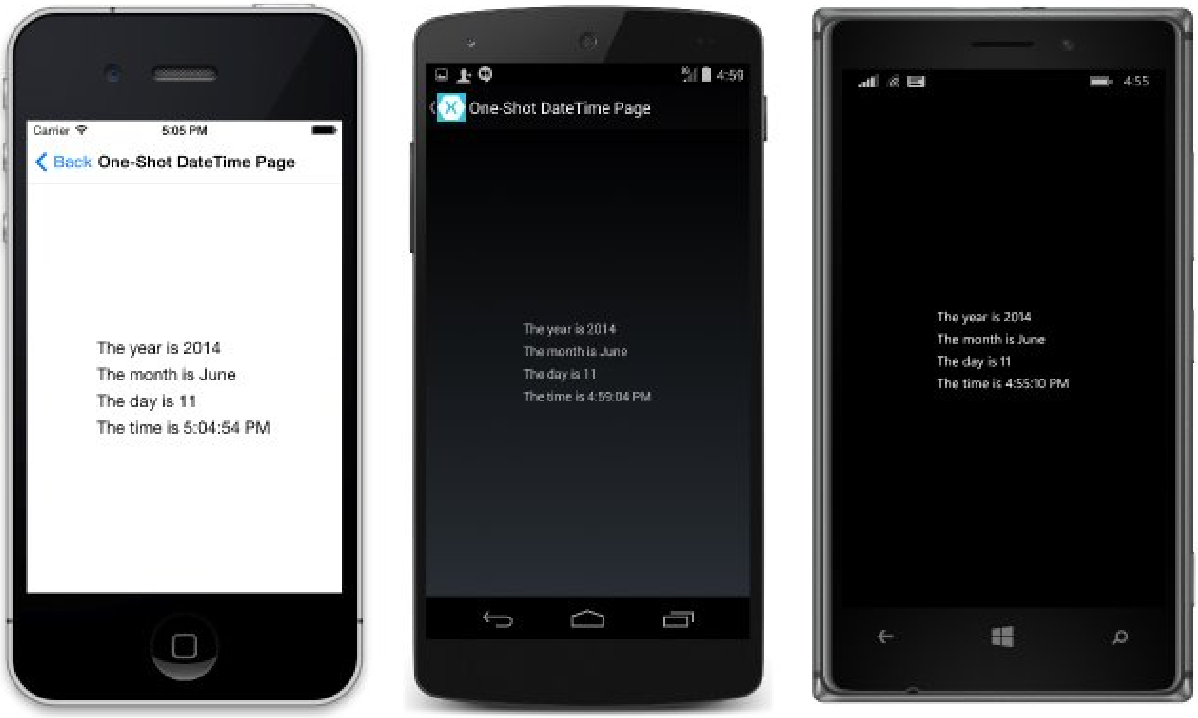
```
<StackLayout BindingContext="{x:Static sys:DateTime.Now}" …>
```

`BindingContext` is a very special property: It is inherited by all its children. This means that all the children of the `StackLayout` have this same `BindingContext`, and they can contain simple bindings to properties of that object.

In this program, two of the children contain bindings to properties of that `DateTime` value, but two other children contain bindings that seem to be missing a binding path. This actually means that the `DateTime` value itself is used for the `StringFormat`:

```
<?xml version="1.0" encoding="utf-8" ?>
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             xmlns:sys="clr-namespace:System;assembly=mscorlib"
             x:Class="XamlSamples.OneShotDateTimePage"
             Title="One-Shot DateTime Page">

  <StackLayout BindingContext="{x:Static sys:DateTime.Now}"
               HorizontalOptions="Center"
               VerticalOptions="Center">

    <Label Text="{Binding Year, StringFormat='The year is {0}'}" />
    <Label Text="{Binding StringFormat='The month is {0:MMMM}'}" />
    <Label Text="{Binding Day, StringFormat='The day is {0}'}" />
    <Label Text="{Binding StringFormat='The time is {0:T}'}" />

  </StackLayout>
</ContentPage>
```

Of course, the big problem is that the date and time are set once when the page is first built, and never change:



The year is 2014
The month is June
The day is 11
The time is 5:04:54 PM

The year is 2014
The month is June
The day is 11
The time is 4:59:04 PM

The year is 2014
The month is June
The day is 11
The time is 4:55:10 PM

A XAML file can display a clock that always shows the current time, but it needs some code to help out. When thinking in terms of MVVM, the Model and ViewModel are classes written entirely in code. The View is often a XAML file that references properties defined in the ViewModel through data bindings.

A proper Model is ignorant of the ViewModel, and a proper ViewModel is ignorant of the View. However, very often a programmer tailors the data types exposed by the ViewModel to the data types associated with particular user interfaces. For example, if a Model accesses a database that contains 8-bit character ASCII strings, the ViewModel would need to convert between those strings and Unicode strings to accommodate the exclusive use of Unicode in the user interface.

In simple examples of MVVM (such as those shown here), often there is no Model at all, and the pattern involves just a View and ViewModel linked with data bindings.

Here's a ViewModel for a clock with just a single property named `DateTime`, but which updates that `DateTime` property every second:

```
using System;
using System.ComponentModel;
using Xamarin.Forms;

namespace XamlSamples
{
    class ClockViewModel : INotifyPropertyChanged
    {
        DateTime dateTime;

        public event PropertyChangedEventHandler PropertyChanged;

        public ClockViewModel()
        {
            this.DateTime = DateTime.Now;

            Device.StartTimer(TimeSpan.FromSeconds(1), () =>
                {
                    this.DateTime = DateTime.Now;
                    return true;
                });
        }

        public DateTime DateTime
        {
            set
            {
                if (dateTime != value)
                {
                    dateTime = value;

                    if (PropertyChanged != null)
                    {
                        PropertyChanged(this,
                            new PropertyChangedEventArgs("DateTime"));
                    }
                }
            }
            get
            {
                return dateTime;
            }
        }
    }
}
```

ViewModels generally implement the `INotifyPropertyChanged` interface. Such a class fires a `PropertyChanged` event whenever one of their properties change. The data binding mechanism in Xamarin.Forms attaches a handler to this `PropertyChanged` event so it can be notified when a property changes and keep the target updated with the new value.

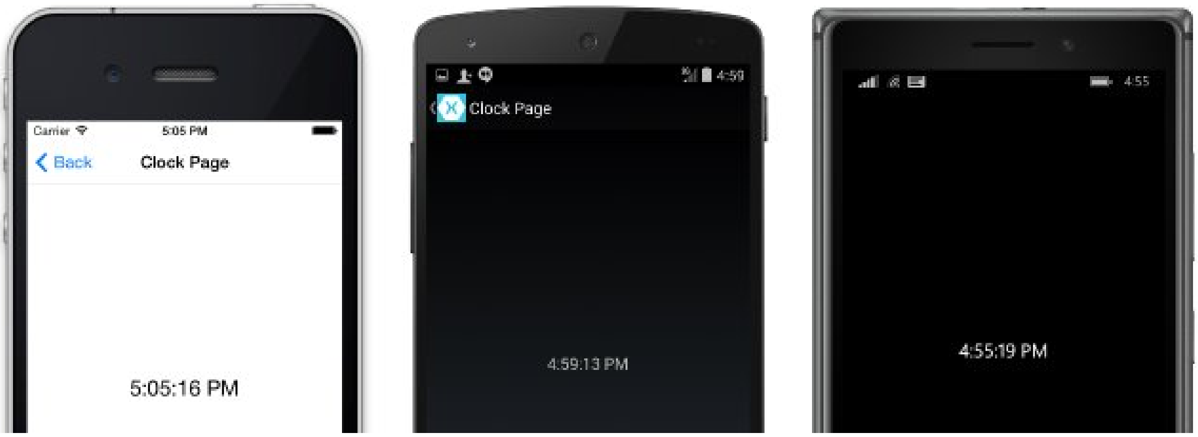
A clock based on this ViewModel can be as simple as this:

```
<?xml version="1.0" encoding="utf-8" ?>
```

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

  <Label Text="{Binding DateTime,
                        StringFormat='{0:T}'}"
         FontSize="Large"
         HorizontalOptions="Center"
         VerticalOptions="Center">
    <Label.BindingContext>
      <local:ClockViewModel />
    </Label.BindingContext>
  </Label>
</ContentPage>
```

Notice how the `ClockViewModel` is set to the `BindingContext` of the `Label` using property element tags. Alternatively, you can instantiate the `ClockViewModel` in a `Resources` collection and set it to the `BindingContext` via a `StaticResource` markup extension. Or, the code-behind file can instantiate the ViewModel.

The `Binding` markup extension on the `Text` property of the `Label` formats the `DateTime` property. Here's the display:



It’s also possible to access individual properties of the `DateTime` property of the ViewModel by separating the properties with periods:

```
<Label Text="{Binding DateTime.Second,
                      StringFormat='{0}'}" …>
```

Interactive MVVM

MVVM is used quite often with two-way data bindings for an interactive view based on an underlying data model.

Here’s a class named `HslViewModel` that converts a `Color` value into `Hue`, `Saturation`, and `Luminosity` values, and vice versa:

```
using System;
using System.ComponentModel;
using Xamarin.Forms;

namespace XamlSamples
{
    public class HslViewModel : INotifyPropertyChanged
    {
        double hue, saturation, luminosity;
        Color color;

        public event PropertyChangedEventHandler PropertyChanged;
        public double Hue
        {
            set
            {
                if (hue != value)
                {
                    hue = value;
                    OnPropertyChanged("Hue");
                    SetNewColor();
                }
            }
            get
            {
                return hue;
            }
        }

        public double Saturation
        {
            set
            {
                if (saturation != value)
                {
                    saturation = value;
                    OnPropertyChanged("Saturation");
                    SetNewColor();
                }
            }
            get
            {
                return saturation;
            }
        }
```

```
public double Luminosity
{
    set
    {
        if (luminosity != value)
        {
            luminosity = value;
            OnPropertyChanged("Luminosity");
            SetNewColor();
        }
    }
    get
    {
        return luminosity;
    }
}

public Color Color
{
    set
    {
        if (color != value)
        {
            color = value;
            OnPropertyChanged("Color");

            this.Hue = value.Hue;
            this.Saturation = value.Saturation;
            this.Luminosity = value.Luminosity;
        }
    }
    get
```

```
            {
                return color;
            }
        }

        void SetNewColor()
        {
            this.Color = Color.FromHsla(this.Hue,
                                        this.Saturation,
                                        this.Luminosity);
        }

        protected virtual void OnPropertyChanged(string propertyName)
        {
            if (PropertyChanged != null)
            {
                PropertyChanged(this,
                    new PropertyChangedEventArgs(propertyName));
            }
        }
    }
}
```

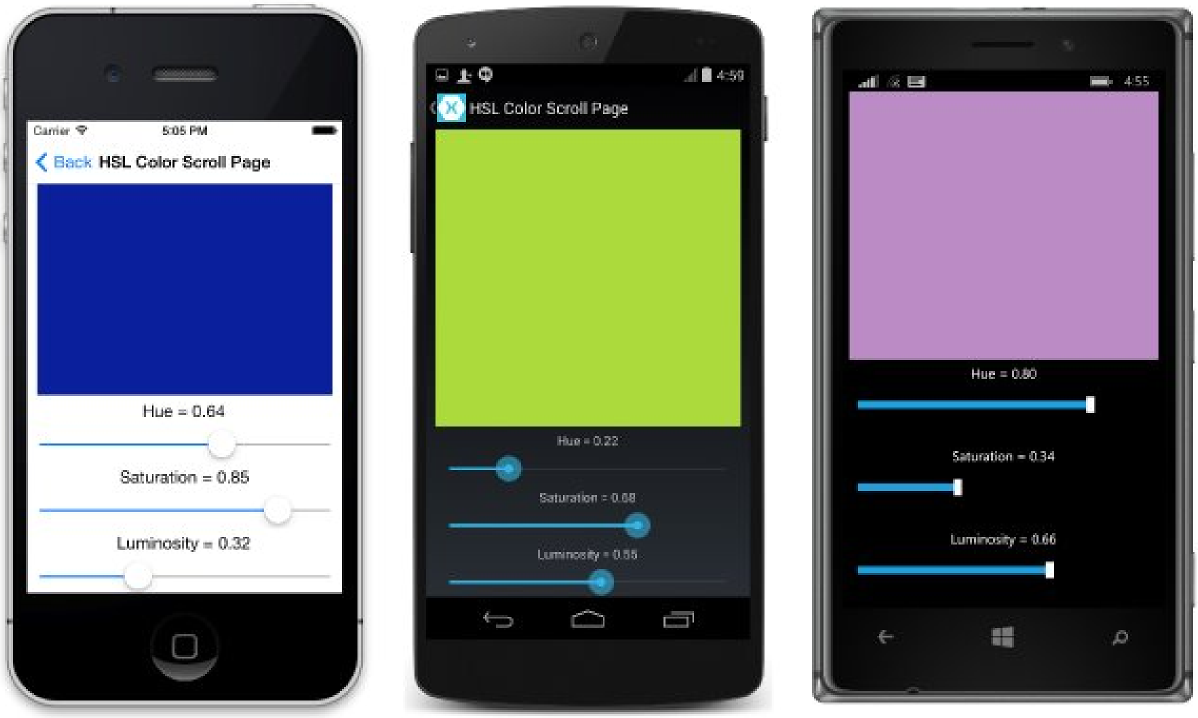
Changes to the `Hue`, `Saturation`, and `Luminosity` properties cause the `Color` property to change, and changes to `Color` causes the other three properties to change. This might seem like an infinite loop, except that the `PropertyChanged` event isn’t fired unless the property has actually changed. This puts an end to the otherwise uncontrollable feedback loop.

The XAML file contains a `BoxView` whose `Color` property is bound to the `Color` property of the ViewModel, and three `Slider` and three `Label` views bound to the `Hue`, `Saturation`, and `Luminosity` properties:

```
<?xml version="1.0" encoding="utf-8" ?>
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
```

```
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             xmlns:local="clr-
namespace:XamlSamples;assembly=XamlSamples"
             x:Class="XamlSamples.HslColorScrollPage"
             Title="HSL Color Scroll Page">
  <ContentPage.BindingContext>
    <local:HslViewModel Color="Aqua" />
  </ContentPage.BindingContext>

  <StackLayout Padding="10, 0">
    <BoxView Color="{Binding Color}"
             VerticalOptions="FillAndExpand" />

    <Label Text="{Binding Hue,
                      StringFormat='Hue = {0:F2}'}"
           HorizontalOptions="Center" />

    <Slider Value="{Binding Hue, Mode=TwoWay}" />

    <Label Text="{Binding Saturation,
                      StringFormat='Saturation = {0:F2}'}"
           HorizontalOptions="Center" />

    <Slider Value="{Binding Saturation, Mode=TwoWay}" />

    <Label Text="{Binding Luminosity,
                      StringFormat='Luminosity = {0:F2}'}"
           HorizontalOptions="Center" />

    <Slider Value="{Binding Luminosity, Mode=TwoWay}" />
  </StackLayout>
</ContentPage>
```

The binding on each `Label` is a default `OneWay`. It only needs to display the value. But the binding on each `Slider` is `TwoWay`: It's good if the `Slider` is initialized from the ViewModel—notice the `Color` property is set to `Blue` when the ViewModel is instantiated—but a change in the `Slider` also needs to set a new property in the ViewModel, which then calculates a new color.



Hue = 0.64

Saturation = 0.85

Luminosity = 0.32

Hue = 0.22

Saturation = 0.68

Luminosity = 0.55

Hue = 0.80

Saturation = 0.34

Luminosity = 0.66

Commanding with ViewModels

In many cases, the MVVM pattern is restricted to the manipulation of data items: User-interface objects in the View parallel data objects in the ViewModel.

Sometimes, however, the View needs to contain buttons that trigger various actions in the ViewModel. But the ViewModel must not contain `Clicked` handlers for the buttons because that would tie the ViewModel to a particular user-interface paradigm.

To allow ViewModels to be more independent of particular user interface objects but still allow methods to be called within the ViewModel, a *command* interface was developed. This command interface is supported by the following elements in Xamarin.Forms:

- `Button`

- `MenuItem`
- `ToolbarItem`
- `SearchBar`
- `TextCell` (and hence also `ImageCell`)
- `ListView`
- `TapGestureRecognizer`

With the exception of the `SearchBar` and `ListView` element, these elements define two properties:

- `Command` of type `System.Windows.Input.ICommand`
- `CommandParameter` of type `Object`

Similarly, the `SearchBar` defines `SearchCommand` and `SearchCommandParameter` properties, while the `ListView` defines a `RefreshCommand` property of type `ICommand`.

The `ICommand` interface defines two methods and one event:

- `void Execute(object arg)`
- `bool CanExecute(object arg)`
- `event EventHandler CanExecuteChanged`

The idea is that the ViewModel has one or more properties of type `ICommand`. These properties are bound to the `Command` properties of each `Button` (or other element, or perhaps a custom view that implements this interface). The CommandParameter property is optionally set to identify each particular `Button` (or whatever) that is bound to this ViewModel property. The `Button` then calls the `Execute` method whenever the user taps the `Button`, passing to the `Execute` method its `CommandParameter`.

The `CanExecute` method and `CanExecuteChanged` event are used for cases where a `Button` tap might be currently invalid, in which case the `Button` should disable itself. The `Button` calls `CanExecute` when the `Command` property is first set and whenever the `CanExecuteChanged` event is fired. If `CanExecute` returns `false`, the `Button` disables itself and doesn’t generate `Execute` calls.

For help in adding commanding to your ViewModels, Xamarin.Forms defines two classes that implement `ICommand`: `Command` and `Command<T>` where `T` is the type of the arguments to `Execute` and `CanExecute`. These two classes define a bunch of constructors plus a `ChangeCanExecute` method that the ViewModel can call to force the `Command` object to fire the `CanExecuteChanged` event.

Here is a ViewModel for a simple keypad that is intended for entering telephone numbers. Notice that the `Execute` and `CanExecute` method are defined as lambda functions right in the constructor:

```
using System;
using System.ComponentModel;
using System.Windows.Input;
using Xamarin.Forms;

namespace XamlSamples
{
    class KeypadViewModel : INotifyPropertyChanged
    {
        string inputString = "";
        string displayText = "";
        char[] specialChars = { '*', '#' };

        public event PropertyChangedEventHandler PropertyChanged;

        // Constructor
        public KeypadViewModel()
        {
            this.AddCharCommand = new Command<string>((key) =>
                {
                    // Add the key to the input string.
                    this.InputString += key;
                });
            this.DeleteCharCommand = new Command((nothing) =>
                {
                    // Strip a character from the input string.
                    this.InputString = this.InputString.Substring(0,
                                        this.InputString.Length - 1);
                },
                (nothing) =>
                {
                    // Return true if there's something to delete.
                    return this.InputString.Length > 0;
                });
        }

        // Public properties
        public string InputString
        {
            protected set
            {
                if (inputString != value)
                {
                    inputString = value;
                    OnPropertyChanged("InputString");
                    this.DisplayText = FormatText(inputString);

                    // Perhaps the delete button must be
enabled/disabled.

((Command)this.DeleteCharCommand).ChangeCanExecute();
                }
            }

            get { return inputString; }
        }
```

```
public string DisplayText
{
    protected set
    {
        if (displayText != value)
        {
            displayText = value;
            OnPropertyChanged("DisplayText");
        }
    }
    get { return displayText; }
}

// ICommand implementations
public ICommand AddCharCommand { protected set; get; }

public ICommand DeleteCharCommand { protected set; get; }

string FormatText(string str)
{
    bool hasNonNumbers = str.IndexOfAny(specialChars) != -1;
    string formatted = str;

    if (hasNonNumbers || str.Length < 4 || str.Length > 10)
    {
    }
    else if (str.Length < 8)
    {
        formatted = String.Format("{0}-{1}",
                                  str.Substring(0, 3),
                                  str.Substring(3));
    }
```

```
            else
            {
                formatted = String.Format("({0}) {1}-{2}",
                                          str.Substring(0, 3),
                                          str.Substring(3, 3),
                                          str.Substring(6));
            }
            return formatted;
        }

        protected void OnPropertyChanged(string propertyName)
        {
            if (PropertyChanged != null)
                PropertyChanged(this,
                    new PropertyChangedEventArgs(propertyName));
        }
    }
}
```

This ViewModel assumes that the `AddCharCommand` property is bound to the `Command` property of a bunch of buttons (or anything else that has a command interface), each of which is identified by the `CommandParameter`. These buttons add characters to an `InputString` property, which is then formatted as a phone number for the `DisplayText` property.

There is also a second property of type `ICommand` named `DeleteCharCommand`. This should be bound to a back-spacing button, but the button should be disabled if there are no characters to delete.

The following keypad is not as visually sophisticated as it might be. Instead, the markup has been reduced to a minimum to demonstrate more clearly the use of the command interface:

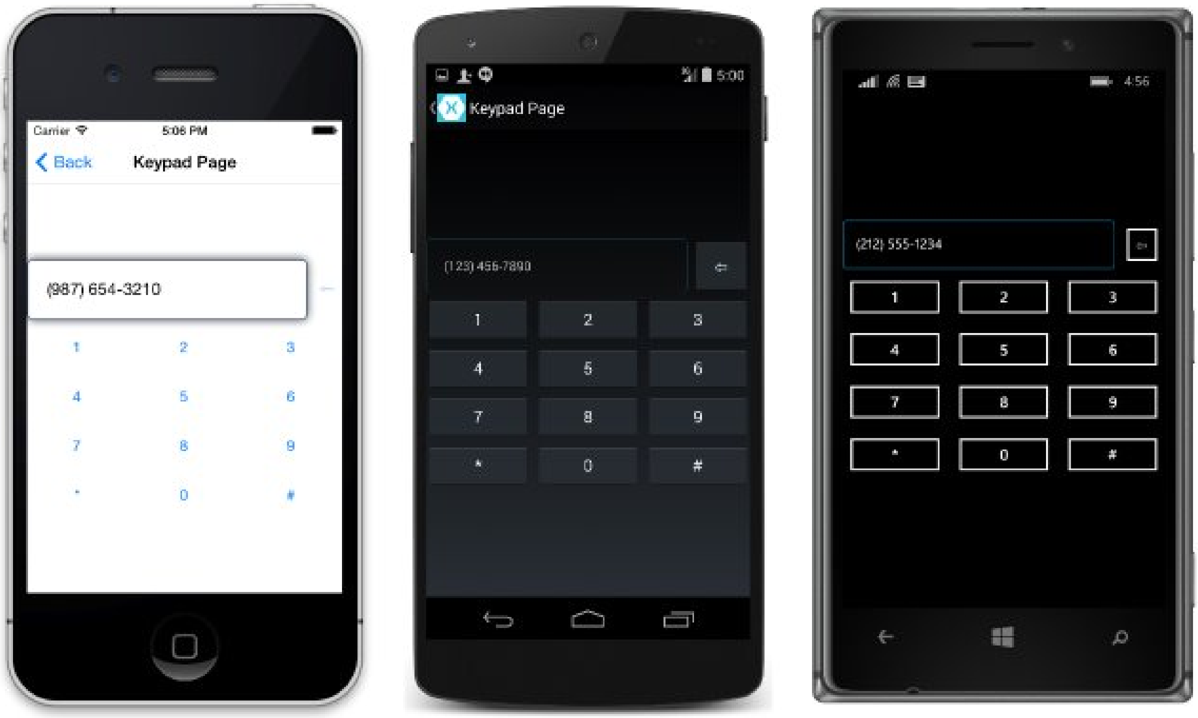
```
<?xml version="1.0" encoding="utf-8" ?>
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             xmlns:local="clr-
```

```
namespace:XamlSamples;assembly=XamlSamples"
             x:Class="XamlSamples.KeypadPage"
             Title="Keypad Page">

    <Grid HorizontalOptions="Center"
          VerticalOptions="Center">
      <Grid.BindingContext>
        <local:KeypadViewModel />
      </Grid.BindingContext>

      <Grid.RowDefinitions>
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
      </Grid.RowDefinitions>

      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="*" />
        <ColumnDefinition Width="*" />
        <ColumnDefinition Width="*" />
      </Grid.ColumnDefinitions>

      <!-- Internal Grid for top row of items -->
      <Grid Grid.Row="0" Grid.Column="0" Grid.ColumnSpan="3">
        <Grid.ColumnDefinitions>
          <ColumnDefinition Width="*" />
          <ColumnDefinition Width="Auto" />
        </Grid.ColumnDefinitions>

        <Frame Grid.Column="0"
               OutlineColor="Accent">
          <Label Text="{Binding DisplayText}" />
        </Frame>

        <Button Text="⇦"
                Command="{Binding DeleteCharCommand}"
                Grid.Column="1"
                BorderWidth="0" />
      </Grid>

      <Button Text="1"
              Command="{Binding AddCharCommand}"
              CommandParameter="1"
              Grid.Row="1" Grid.Column="0" />

      <Button Text="2"
              Command="{Binding AddCharCommand}"
              CommandParameter="2"
              Grid.Row="1" Grid.Column="1" />

      <Button Text="3"
              Command="{Binding AddCharCommand}"
              CommandParameter="3"
              Grid.Row="1" Grid.Column="2" />

      <Button Text="4"
              Command="{Binding AddCharCommand}"
              CommandParameter="4"
              Grid.Row="2" Grid.Column="0" />

      <Button Text="5"
              Command="{Binding AddCharCommand}"
              CommandParameter="5"
              Grid.Row="2" Grid.Column="1" />
```

```
<Button Text="6"
        Command="{Binding AddCharCommand}"
        CommandParameter="6"
        Grid.Row="2" Grid.Column="2" />

<Button Text="7"
        Command="{Binding AddCharCommand}"
        CommandParameter="7"
        Grid.Row="3" Grid.Column="0" />

<Button Text="8"
        Command="{Binding AddCharCommand}"
        CommandParameter="8"
        Grid.Row="3" Grid.Column="1" />

<Button Text="9"
        Command="{Binding AddCharCommand}"
        CommandParameter="9"
        Grid.Row="3" Grid.Column="2" />

<Button Text="*"
        Command="{Binding AddCharCommand}"
        CommandParameter="*"
        Grid.Row="4" Grid.Column="0" />

<Button Text="0"
        Command="{Binding AddCharCommand}"
        CommandParameter="0"
        Grid.Row="4" Grid.Column="1" />

<Button Text="#"
        Command="{Binding AddCharCommand}"
```

```
              CommandParameter="#"
              Grid.Row="4" Grid.Column="2" />
    </Grid>
</ContentPage>
```

The `Command` property of the first `Button` that appears in this markup is bound to the `DeleteCharCommand`; the rest are bound to the `AddCharCommand` with a `CommandParameter` that is the same as the character that appears on the `Button` face. Here's the program in action:



(987) 654-3210

(123) 456-7890

(212) 555-1234

Invoking Asynchronous Methods

Commands can also invoke asynchronous methods. This is achieved by using the `async` and `await` keywords when specifying the `Execute` method:

```
DownloadCommand = new Command (async () => await DownloadAsync ());
```

This indicates that the `DownloadAsync` method is a `Task` and should be awaited:

```
async Task DownloadAsync ()
```

```
{
  await Task.Run (() => Download ());
}

void Download ()
{
  ...
}
```

Summary

XAML is a powerful tool for defining user interfaces in Xamarin.Forms applications, particularly when data-binding and MVVM are required. The result is a clean, elegant, and potentially toolable representation of a user interface with all the background support in code.