Module 1

"A Quick Tour of WPF Fundamentals"

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Agenda

- **WPF = XAML + Code**
- Controls and Layout
- Resources
- Styles and Triggers
- Animations

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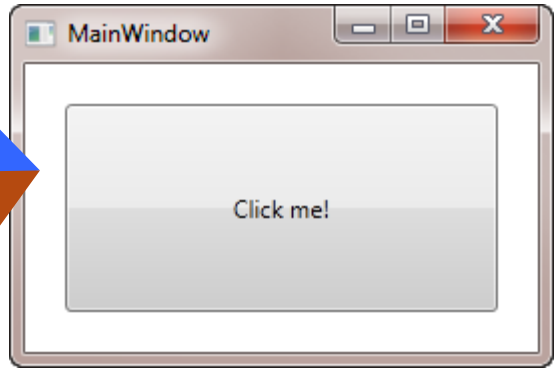
WPF = XAML + Code

- XAML
- Code-Behind
- Complex compilation process
  - `*.g.cs`

```
<Window x:Class="MyWindow"
        Title="MainWindow">
   <Grid>
      <
</Wi
```

```
public partial class MyWindow : Window
{
   private void ButtonClick(
      object sender, RoutedEventArgs e)
      {
         // Handle click
      }
   }
}
```



Dual Capabilities

```
<Button
   RenderTransformOrigin="0.5,0.5"
    Width="200" Height="100"
    Content="Click me!">
  <Button.RenderTransform>
    <RotateTransform Angle="315" />
  </Button.RenderTransform>
</Button>
```


```
Button btn = new Button();
btn.Width = 200;
btn.Height = 100;
btn.Content =
   "Click me!";
btn.RenderTransformOrigin =
    new Point(0.5,0.5);

Transform rt =
    new RotateTransform();
rt.Angle = 315;
btn.RenderTransform = rt;
```

Introducing Dependency Properties

- New type of property specific to WPF
  - Rich functionality directly from XAML
  - Change notification
  - Property value inheritance
  - Depend on multiple providers

- Dependency properties =
  .NET properties + additional WPF infrastructure

Dependency Property Example

```
public class Button : ButtonBase
{
   public static readonly DependencyProperty IsDefaultProperty;  // The dependency property

   static Button()
   {
      // Register the property
      Button.IsDefaultProperty = DependencyProperty.Register(
         "IsDefault", typeof(bool), typeof(Button),
         new FrameworkPropertyMetadata(false,
            new PropertyChangedCallback(OnIsDefaultChanged)));
   }

   public bool IsDefault  // A .NET property wrapper (optional)
   {
      get { return (bool)GetValue(Button.IsDefaultProperty); }
      set { SetValue(Button.IsDefaultProperty, value); }
   }

   // A property changed callback (optional)
   private static void OnIsDefaultChanged( DependencyObject o,
      DependencyPropertyChangedEventArgs e) { ... }
}
```

Dependency Property Features

- Many features of WPF are only for dependency properties
  - Animations
  - Triggers
  - …
- Attached properties
  - E.g. `DockPanel.Dock`

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Introducing Content Controls

- All content controls derive from **`ContentControl`**

- Contain single nested element
  - **`Content`** property
  - Content can be any type…!
    - **`UIElement`**s are rendered
    - Other elements are rendered as **`TextBlock`** via **`object.ToString()`**

Introducing Items Controls

- All item controls derive from `ItemsControl`

- Contains a collection of elements
  - `Items` property of type `ItemCollection`
  - `ItemsSource`
  - Items can be of any type…!
    - `UIElement`s are rendered
    - Other elements are rendered as `TextBlock` via `object.ToString()`

Virtualizing Item Controls

- Some item controls can be virtualized for performance reasons
- Set **`ItemsControl.ItemsPanel`** to e.g. **`VirtualizingStackPanel`**
  - Only creates the items necessary!
- Turn virtualization on/off via
  - **`VirtualizingStackPanel.IsVirtualizing`**
- Note:
  - Virtualization in fact only happens when the **`VirtualizingStackPanel`** itself creates its own item containers! (e.g. when data binding)
- See https://docs.microsoft.com/en-us/dotnet/framework/wpf/advanced/optimizing-performance-controls

WPF Layout System

- Two-pass layout system in WPF
  - 1. Measurement Pass
    - Evaluate **`Children`** for **`DesiredSize`**
  - 2. Arrangement Pass
    - Determine final size of each child and place in layout control

- Two distinct transformation properties on all `FrameworkElements`
  - `LayoutTransform`
  - `RenderTransform`
    - `RenderTransformOrigin`

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Control Properties for Layout

- `FrameworkElement`
  - `Margin` "spacing outside"
  - `HorizontalAlignment`
  - `VerticalAlignment`
  - `FlowDirection`
- `Control : FrameworkElement`
  - `Padding` "spacing inside"
  - `HorizontalContentAlignment`
  - `VerticalContentAlignment`
- `FrameworkElement.HorizontalAlignment` must be set in order to size to content in e.g. `StackPanel`

Layout Controls (or "Panels")

- `StackPanel`
- `DockPanel`
- `WrapPanel`
- `Grid`
- `UniformGrid`
- `Canvas`
- …

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WPF Control Hierarchy

- `object`
  - `DispatcherObject`
    - `DependencyObject`
      - `Freezable`
      - `Visual` — Has 2D representation, drawing etc.
        - `UIElement` — Has routed events, layout, command bindings etc.
          - `FrameworkElement` — Has styles, data binding, resources etc.
            - `Control` — Has Control templates, Foreground, Background etc.
      - `Visual3D`
        - `UIElement3D`
      - `ContentElement` — Parallel to **`UIElement`** (for Content)
        - `FrameworkContentElement`

- See e.g.
  - [Nathan, Chapter 3]
  - http://2000thingswpf.files.wordpress.com/2010/12/classhierarchy.png

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- **Resources**
- Styles and Triggers
- Animations

Introducing Logical Resources

- Logical resources can be defined in
  - `App.Resources` or
  - `FrameworkElement.Resources`
  - `FrameworkContentElement.Resources`
- Declare a logical resource with `x:Key` in the resource dictionary
- Resource Lookup
  - "Cascading" fashion
  - `StaticResource` or `DynamicResource`

Static and Dynamic Resources

- Two markup extensions
  - `StaticResource`
    - The resource is applied only once
  - `DynamicResource`
    - The resource is reapplied every time it changes

- Programmatic access in code as well
  - Access Resources directly
    - `Lookup()`
    - `Add()`
  - `FindResource()`, `TryFindResource()` static
  - `SetResourceReference()` dynamic

Resource Dictionaries

- The `Resources` property is in fact a `ResourceDictionary` object
- `ResourceDictionary`
  - Can be defined in separate XAML files
    - "Add ResourceDictionary"
  - Can be merged when needed
    - Merge rules apply
- System Resources
  - Use `x:Static` to refer
  - Make reference dynamic!
- Note
  - Resource dictionaries can be changed without recompiling the application by loading them dynamically with `XamlReader.Load()` in `System.Windows.Markup` and setting resources programmatically

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- WPF = XAML + Code
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- Resources
- **Styles and Triggers**
- Animations

Introducing Styles

- A style is basically a group of property values

- `Style`
  - `Setters`
    - (Property) Setter
    - Event Setter
  - `Triggers`
    - Property Trigger
    - Data Trigger
    - Event Trigger

Setters

- Styles can be defined as resource or set directly
  - Work for heterogenous elements
  - Can be overridden locally…

- `Setters`
  - (Property) `Setter`
    - `Property`, `Value`
  - `EventSetter`
    - `Event`, `Handler`

Implicit and Inherited Styles

- Styles can be set
  - Declaratively
  - Programmatically

- Styles can be defined
  - Explicitly
    - `Style` property
  - Implicitly
    - `Style.TargetType`
  - Inherited
    - `BasedOn`

Introducing Triggers

- `Style.Triggers` contain a "triggered" collection of setters and actions
  - (`Property`)`Trigger` *WPF dependency properties*
    - `Property`, `Value`
    - `Setters`
    - `EnterActions`
    - `ExitActions`
  - `DataTrigger` *CLR properties*
    - `Binding`, `Value`
    - `Setters`
  - `EventTrigger` *Event occurrences*
    - `RoutedEvent`
    - `Actions`

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- **Animations**

Introducing Animations

- Animations
  - Can vary the value of dependency properties
- Three categories
  - Linear animations, i.e. *TypeName*`Animation`,
    - `DoubleAnimation`
    - `ColorAnimation`
    - …
  - Key frame-based animations
  - Path-based animations

Animation Basics

- `Animation`
  - `BeginTime`
  - `Duration`
  - `RepeatBehavior` "`Forever`", "`3x`", …
  - `AutoReverse`
  - `AccelerationRatio`
  - `DecelerationRatio`
  - …
- Linear animations
  - `From`
  - `To`, `By`
- Can programmatically be defined and started directly on controls

Storyboards

- `Storyboard` structures sets of animations in XAML
  - Attached `TargetName`
  - Attached `TargetProperty`
- Storyboards are controlled by `Trigger` actions in
  - Styles (as seen earlier)
  - Element Triggers
- Storyboard-related actions include e.g.
  - `BeginStoryboard`
  - `PauseStoryboard`
  - `ResumeStoryboard`
  - `StopStoryboard`
  - …
- Note: "target" storyboard must be defined in same `Triggers` collection

More Triggers and Styles

- Storyboard actions can also be triggered by
  - (`Property`)`Trigger`
  - `MultiTrigger`
  - `DataTrigger`
  - `MultiDataTrigger`

- Common example: Triggers in styles

Easing Functions

- Easing Functions help creating good-looking animations in a pre-built manner
  - http://msdn.microsoft.com/en-us/library/ee308751(VS.100).aspx

- `IEasingFunction`
  - `QuadraticEase`, `CubicEase`, `QuarticEase`, `QuinticEase`, `PowerEase`
  - `BackEase`
  - `BounceEase`
  - `CircleEase`
  - `ElasticEase`
  - `ExponentialEase`
  - `SineEase`

- `EasingMode`
  - `EaseIn` default
  - `EaseOut`
  - `EaseInOut`

Summary

- WPF = XAML + Code
- Controls and Layout
- Resources
- Styles and Triggers
- Animations


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