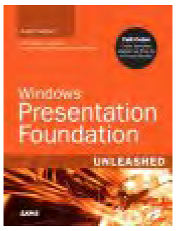
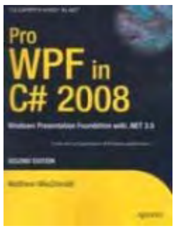
Lectures on WPF
Routed Events

This lecture is based on the books of Nathan&Lehenbauer and MacDonald:





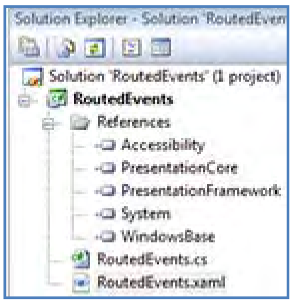
Why Routed Events ?

A Routed evenet originates in one element but is raised by another one.
For example a Window contains many StackPanels and each StackPanel many buttons.
A click occurs in a button and rises up to its StackPanel and then to the containing window where one code handles all clicks.
Routed events give us the flexibility to write our event handler code in the most convenaint place.
In the same way as WPF extends normal Properties to **Dependency Properties** it expands Events to **Routed Events**. Both Dependency Properties and Routed Events are designed to work inside trees of elements. DependencyProperties just travel down the tree to nested elements but RoutedEvents mostly travel up. Therefore, you can embed arbitrarily complex content inside a single button or give it an arbitrarily complex visual tree, and a mouse left-click on any of the internal elements still travels up.
Advantage: Event routing helps WPF applications remain oblivious to the depth, expansions, cuts and any details of their visual tree.
The events will reach their event handlers regardless of how far away in the tree the destination may be.

A Routed Events Sample

Guidance for **Visual Studio 2008**:
`1)` Main Menu after start of VS 2008: `File` → `New Project...` → `Project Types: Visual C#` → `Visual Studio installed templates: Empty project` `Name: RoutedEvents` → `Location: C:\temp` → `Create directory for solution:` switch off → `OK`.

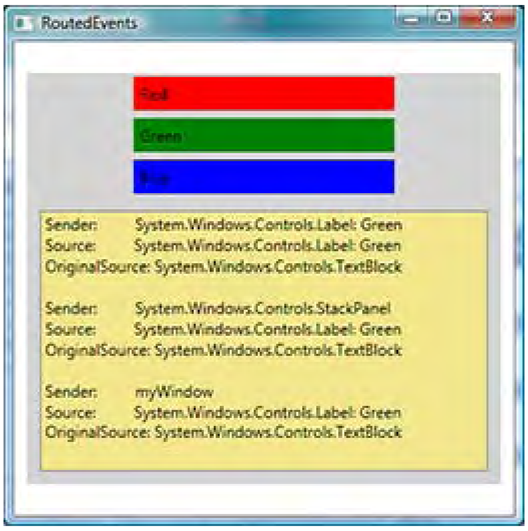
`2)` In the window titled: `Solution Explorer -Solution 'RoutedEvents' (1 project)` we have to add 4 `References` and 2 code files:
`2.1` **Right**-click the branch `References`. A drop-down menu appears.
Click `Add Reference...`. An `Add Reference`- window appears.
Scroll down to the Component Names `Presentation Core` and `Presentation Framework` and select them by `Strg`+click.
Continue scrolling and `Strg`+click two more Component Names: `System` and `WindowsBase`. Quit the `Add Reference`- window with the button `OK`.
`2.2` **Right**-click the branch **`RoutedEvents`**. A drop-down menu appears.
Click `Add` and select `New Item...`.
An `Add New Item - RoutedEvents`- window appears.
Select the template `Code File` and give it the Name: `RoutedEvents.cs`.
Quit the `Add New Item - RoutedEvents`- window with the button `Add`.
`2.3` **Right**-click the branch **`RoutedEvents`**. A drop-down menu appears.
Click `Add` and select `New Item...`.
An `Add New Item - RoutedEvents`- window appears.
Select the template `Text File` and give it the Name: `RoutedEvents.xaml`.
Quit the `Add New Item - RoutedEvents`- window with the button `Add`.



```
Solution Explorer - Solution 'RoutedEven
Solution 'RoutedEvents' (1 project)
  RoutedEvents
    References
      Accessibility
      PresentationCore
      PresentationFramework
      System
      WindowsBase
    RoutedEvents.cs
    RoutedEvents.xaml
```

Write the following code into the empty RoutedEvents.cs:

```
using System;
using System.Windows;
using System.Windows.Controls;
public partial class myWindow : Window
{ [STAThread] static void Main() { new
Application().Run( new myWindow() ); }
  public myWindow() { InitializeComponent(); }
  private void OnMouseDown( object sender,
RoutedEventArgs e )
  { string message = "Sender:         " +
                     sender.ToString() + "\r\n" +
                    "Source:         " +
                     e.Source         + "\r\n" +
                    "OriginalSource: " +
                     e.OriginalSource  + "\r\n";
    listBox.Items.Add( message );
  }
  private void OnMouseUp(object sender, RoutedEventArgs e)
  { listBox.Items.Clear();
  }
}
```



```
Sender:         System.Windows.Controls.Label: Green
Source:         System.Windows.Controls.Label: Green
OriginalSource: System.Windows.Controls.TextBlock

Sender:         System.Windows.Controls.StackPanel
Source:         System.Windows.Controls.Label: Green
OriginalSource: System.Windows.Controls.TextBlock

Sender:         myWindow
Source:         System.Windows.Controls.Label: Green
OriginalSource: System.Windows.Controls.TextBlock
```

Write the following code into the empty RoutedEvents.xaml:

```
<Window
 xmlns  ="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
 xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
 x:Class="myWindow"
 Title="RoutedEvents"
 Width="400" Height="400" FontSize="12" MouseDown="OnMouseDown" MouseUp="OnMouseUp">
 <Window.Resources>
  <Style TargetType="{x:Type Label}">
   <Setter Property="HorizontalAlignment" Value="Center"/>
   <Setter Property="Margin" Value="3"/>
   <Setter Property="Width" Value="200"/>
   <EventSetter Event="MouseDown" Handler="OnMouseDown"/>
  </Style>
 </Window.Resources>
 <StackPanel VerticalAlignment="Center" Margin="10" Background="LightGray"
             MouseDown="OnMouseDown">
  <Label Content="Red"    Background="Red"   />
  <Label Content="Green"  Background="Green"/>
  <Label Content="Blue"   Background="Blue" />
  <ListBox Name="listBox" Background="Khaki" Height="200" Margin="10"/>
 </StackPanel>
</Window>
```

Event Routing

Let's imagine a complicated label, which contains a stack panel which contains an images and a text box.
The stack panel, the image and the text box derive from `UIElement` and `UIElement` defines (among others) a `MouseDown`- and a `MouseUp`-event. Thus, there are 4 possible sources of the `MouseDown`-event of our label:
1. the label itself (when somebody clicks the blank space inside the label border),
2. the stack panel (when somebody clicks the blank space inside the stack panel border),
3. the image,
4. the text box.
Mostly you want to treat all these `MouseDowns` the same way.
The old fashioned method is to wire up all 4 `MouseDowns` to the same event handler.
WPF provides a better solution with its routed event model.
It handles the `MouseDowns` as `Bubbling Events` that travel automatically up the containment hierarchy.
When the image is clicked, n `MouseDowns` fire in this order:
1. `Image.MouseDown`
2. `StackPanel.MouseDown`
3. `Label.MouseDown`
4. the parent of the label fires its `MouseDown`
... every intermediary `UIElement` fires its `MouseDown`
n. finally the top of the element tree fires its `Window.MouseDown` or `Page.MouseDown`.

If the user releases the mouse button, the MouseUp-events fire again in the same order.
Any mouse action produces an avalanche of events !
Advantage: You can handle the event at the most appropriate level and stop the avalanche.

Routing Strategies and Event Handlers

Every routed event chooses one of three routing strategies = the way in which the event raising travels through the element tree.
These strategies are exposed as values of a `RoutingStrategy` enumeration:

`1. Direct`	The event is only raised on the source element. This is the same behavior as a plain .NET event.
`2. Bubbling`	The event is first raised on the source element, then on each element up the tree until the root is reached. `Bubbling` is the most popular strategy.
`3. Tunneling`	The event is first raised on the highrst element of the tree (`Window` or `Page`), then on each element down the tree until the source element is reached. `Tunneling` is a merely exotic strategy.

Handlers for routed events have the same signature as all .NET event handlers.
Sample: `private void OnMouseDown( object sender, MouseButtonEventArgs e );`

`sender`	Is a `System.Object` typically named `sender` pointing to the element to which the handler was attached.
`e`	Is a class that derives from `System.EventArgs`. It is (or derives from) an instance of `RoutedEventArgs`, a subclass of `EventArgs` that exposes four useful properties:
`e.Source`	The element in the logical tree that originally raised the event.
`e.OriginalSource`	The element in the visual tree that originally raised the event (for example, the `TextBlock` or `ButtonChrome` child of a standard `Button`).
`e.Handled`	A Boolean that can be set to true to mark the event as handled. This is precisely what halts any tunneling or bubbling.
`e.RoutedEvent`	The actual routed event object (such as `Button.ClickEvent`), which can be helpful for identifying the raised event when the same handler is used for multiple routed events.

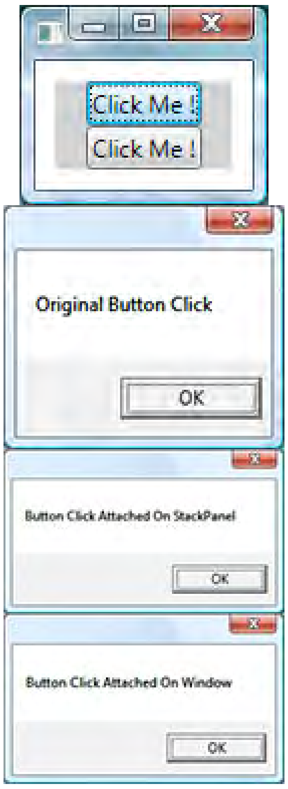
The presence of both `e.Source` and `e.OriginalSource` enable you to work with the higher-level logical tree or the lower-level visual tree.
For more abstract events that don't necessarily have a direct relationship with an element in the visual tree (like keyboard events), the same object is passed for both.

Attached Events

The tunneling and bubbling of a routed event is natural when every element in the tree exposes that event.
But WPF supports tunneling and bubbling of routed events through elements that don't even define that event!
This is possible thanks to the notion of **attached events**.
Attached events operate much like attached properties (and their use with tunneling or bubbling is very similar to using attached properties with property value inheritance).
Sample: Let's define a StackPanel containing 2 Buttons. Both Buttons define a `Click`-event but StackPanel doesn't have such a `Click`-event. (Just derivatives of `ButtonBase` as `Button`, `CheckBox` and `RadioButton` have `Click`-events.)
Nevertheless we can attach an artificial `Click`-event to the StackPanel and to `Page` by using the following attached event syntax:

```
<Window
 xmlns  ="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
 xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
 x:Class="myWindow"
 Title="RoutedEvents"
 Width="100" Height="100" Button.Click="ButtonClickAttachedOnWindow">
 <StackPanel VerticalAlignment="Center" Margin="10" Background="LightGray"
  Button.Click="ButtonClickAttachedOnStackPanel">
  <Button HorizontalAlignment="Center" Content="Click Me !"
          Click="ButtonClick"/>
  <Button HorizontalAlignment="Center" Content="Click Me !"
          Click="ButtonClick"/>
 </StackPanel>
</Window>

using System;
using System.Windows;
public partial class myWindow : Window
{ [STAThread] static void Main()
  { new Application().Run( new myWindow() ); }
  public myWindow() { InitializeComponent(); }
  private void ButtonClickAttachedOnWindow(object sender, RoutedEventArgs e)
  { MessageBox.Show( "Button Click Attached On Window" ); }
  private void ButtonClickAttachedOnStackPanel(object sender, RoutedEventArgs e)
  { MessageBox.Show( "Button Click Attached On StackPanel" ); }
  private void ButtonClick( object sender, RoutedEventArgs e )
  { MessageBox.Show( "Original Button Click" ); }
}
```



Original Button Click

Button Click Attached On StackPanel

Button Click Attached On Window

The sample handles the bubbling `Click` event raised by one of its Buttons on the `StackPanel` and on the root `Window` level. Because neither `StackPanel` nor `Window` define their own `Click` events,
the event attribute names `Click` must be prefixed with the class name `Button.Click`.
The event handlers simply show a MessageBox with information about what just happened.
Every routed event can be used as an attached event.
Therefore you can handle every event that tunnels or bubbles with one top-level "megahandler".