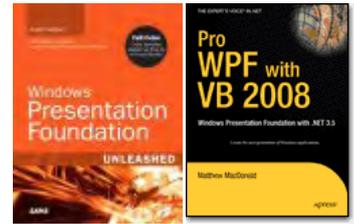


# Lectures on WPF

## Logical And Visual Trees

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

## Layout

The WPF layout system arranges a window by placing elements into specialized layout containers such as Button, StackPanel, DockPanel, Grid etc.

Even a simple window breaks down in a nested series of such containers.

And more than that: Each container breaks down in even smaller parts: background, foreground, border, picture, strings, vector shapes etc. This filigree of nested contents is very flexible at the price of complexity.

The WPF layout process takes place at run time in two stages: **a) measure stage** and **b) arrange stage**.

a) loops through its child elements and asks them for their preferred sizes.

b) creates a compromise of the conflicting wishes, decides about the distribution of limited space and arranges the children at appropriate positions.

Graphical User Interfaces consist of nested controls.

Sample: A windows contains a StackPanel and the Stackpanel contains a Label and two Buttons and each of them contains a String.

XAML is the ideal language to nest such elements and the logical structure of nesting is called the **Logical Tree**.

## The Visual Tree

The **Visual Tree** is an expanded version of the Logical Tree because it breaks down the nested elements into smaller pieces.

It unveils that a simple control as `Button` is just the name of a black box which hides strange elements such as `ButtonChrome` and `ContentPresenter`.

In most cases we use the black boxes as they are. We write logical trees in XAML and/or in C# and do not care what's going on inside the black boxes of our controls.

WPF doesn't force us to look deeper as long we use the standard **Template** of a control which per default defines the inner wiring of our control.

The `Control` class defines its appearance by the `Template` property. If you want to change the appearance of a control but retain its functionality, you should create a new `ControlTemplate` instead of creating a new `Control`.

A `Control` that does not have a `ControlTemplate` is not visible, and setting the following properties has no effect unless the `ControlTemplate` references them explicitly: `Foreground`, `Background`, `HorizontalAlignment`, `VerticalContentAlignment`, `BorderBrush`, `BorderThickness`, `FontFamily`, `FontSize`, `FontStretch`, `FontWeight`.

It's important to realize that the finally resulting control depends on several things:

a) on its `Template` which defines its Visual Tree,

b) on `Styles`,

c) on properties and

d) on the operating system (Vista-buttons look different to XP-buttons and both change when you change your current Window theme.)

The visual tree allows us to do two things:

a) to alter one of its elements by changing its `Style.TargetType`-property. It can be changed forever or at run time by using triggers. Sample: A button can change its background or its border on mouse entering and leaving.

b) to write new `Templates` that change the look and feel of our controls.

## Preliminaries

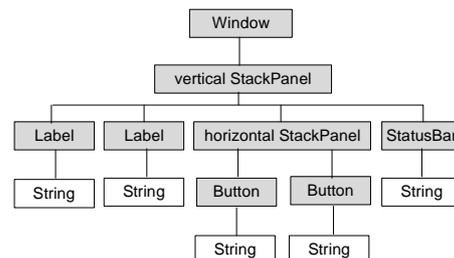
Guidance for **Visual Studio 2008**:

- 1) Main Menu after start of VS 2008: File → New Project... → Project Types: Visual C# → Visual Studio installed templates: Empty project Name: introduction1 → Location: C:\temp → Create directory for solution: switch off → OK.
- 2) In the window titled: Solution Explorer -Solution 'introduction1' (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 **introduction1**. A drop-down menu appears. Click Add and select New Item... An Add New Item - introduction1- window appears. Select the template Code File and give it the Name: introduction1.cs. Quit the Add New Item - introduction1- window with the button Add.
  - 2.3 **Right-click** the branch **introduction1**. A drop-down menu appears. Click Add and select New Item... An Add New Item - introduction1- window appears. Select the template Text File and give it the Name: introduction1.xaml. Quit the Add New Item - introduction1- window with the button Add. Check the properties of introduction1.xaml. The Build Action-property should be set to Page.
- 3) Main menu of Visual Studio 2008 → Project → introduction1 Properties... → Application → Output type: Change from Console Application to Windows Application.

## LogicalAndVisualTree1.xaml

Write the following code into the empty LogicalAndVisualTree1.xaml:

```
<Window
  xmlns="http://schemas.microsoft.com/winfx/2006/xaml/
    presentation"
  xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
  x:Class="myWindow"
  Title="Trees" SizeToContent="WidthAndHeight"
  Background="Khaki">
  <StackPanel>
    <Label FontWeight="Bold" FontSize="20" Foreground="Red"
      Content="A useless window"/>
    <Label Content="A useless label" Background="Gray"/>
    <StackPanel Orientation="Horizontal"
      HorizontalAlignment="Center">
      <Button>Button1</Button>
      <Label Width="20"/><!--empty space-->
      <Button>Button2</Button>
    </StackPanel>
    <StatusBar>This is a Status Bar.</StatusBar>
  </StackPanel>
</Window>
```



## LogicalAndVisualTree1.cs

Write the following code into the empty LogicalAndVisualTree1.cs:

```
using System;
using System.Diagnostics;
using System.Windows;
using System.Windows.Media;

public partial class myWindow : Window
{ [STAThread] static void Main() { new Application().Run( new myWindow() ); }

    public myWindow()
    { InitializeComponent();
      Debug.WriteLine("Here begins the logical tree.");
      PrintLogicalTree(0, this);
      Debug.WriteLine("Here ends the logical tree.");
    }

    protected override void OnContentRendered( EventArgs e )
    { base.OnContentRendered( e );
      Debug.WriteLine("Here begins the visual tree.");
      PrintVisualTree(0, this);
      Debug.WriteLine("Here ends the visual tree.");
    }

    void PrintLogicalTree( int depth, object obj )
    { // Print the object with preceding spaces that represent its depth
      Debug.WriteLine(new string( ' ', depth ) + obj);
      // Sometimes leaf nodes aren't DependencyObjects (e.g. strings)
      if (!(obj is DependencyObject)) return;
      // Check if this element contains other elements
      foreach (object child in LogicalTreeHelper.GetChildren( obj as DependencyObject ))
      { // process each contained element recursively
        PrintLogicalTree( depth + 1, child );
      }
    }

    void PrintVisualTree( int depth, DependencyObject obj )
    { // Print the object with preceding spaces that represent its depth
      Debug.WriteLine(new string( ' ', depth ) + obj );
      // Check if this element contains other elements
      for (int i = 0; i < VisualTreeHelper.GetChildrenCount( obj ); i++)
      { // process each contained element recursively
        PrintVisualTree( depth + 1, VisualTreeHelper.GetChild( obj, i ) );
      }
    }
}
```

Although the logical tree can be traversed within the Window's constructor, the visual tree is empty until the Window undergoes layout at least once. That is why PrintVisualTree is called within OnContentRendered, which doesn't get called until after layout occurs.

## The logical and visual tree output

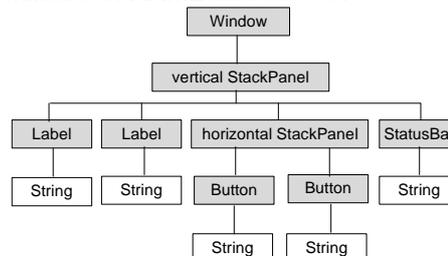
In the main menu of Visual Studio 2008 click `View` → `Output`.

The Output window of `LogicalAndVisualTree1` appears at the bottom and shows compiling infos together with the `Debug.WriteLine( ... )` results:

```
Here begins the logical tree.
myWindow
  System.Windows.Controls.StackPanel
    System.Windows.Controls.Label: A useless window
      A useless window
    System.Windows.Controls.Label: A useless label
      A useless label
    System.Windows.Controls.StackPanel
      System.Windows.Controls.Button: Button1
        Button1
      System.Windows.Controls.Label
        System.Windows.Controls.Button: Button2
          Button2
    System.Windows.Controls.Primitives.StatusBar
      Items.Count:1
        This is a Status Bar.
Here ends the logical tree.
```

```
Here begins the visual tree.
myWindow
  System.Windows.Controls.Border
    System.Windows.Documents.AdornerDecorator
      System.Windows.Controls.ContentPresenter
        System.Windows.Controls.StackPanel
          System.Windows.Controls.Label: A useless window
            System.Windows.Controls.Border
              System.Windows.Controls.ContentPresenter
                System.Windows.Controls.TextBlock
          System.Windows.Controls.Label: A useless label
            System.Windows.Controls.Border
              System.Windows.Controls.ContentPresenter
                System.Windows.Controls.TextBlock
        System.Windows.Controls.StackPanel
          System.Windows.Controls.Button: Button1
            Microsoft.Windows.Themes.ButtonChrome
              System.Windows.Controls.ContentPresenter
                System.Windows.Controls.TextBlock
          System.Windows.Controls.Label
            System.Windows.Controls.Border
              System.Windows.Controls.ContentPresenter
                System.Windows.Controls.Button: Button2
                  Microsoft.Windows.Themes.ButtonChrome
                    System.Windows.Controls.ContentPresenter
                      System.Windows.Controls.TextBlock
          System.Windows.Controls.Primitives.StatusBar
            Items.Count:1
              System.Windows.Controls.Border
                System.Windows.Controls.ItemsPresenter
                  System.Windows.Controls.DockPanel
                    System.Windows.Controls.Primitives.StatusBarItem: ...
                      System.Windows.Controls.Border
                        System.Windows.Controls.ContentPresenter
                          System.Windows.Controls.TextBlock
                    System.Windows.Documents.AdornerLayer
                      System.Windows.Controls.Border
                        System.Windows.Controls.ContentPresenter
                          System.Windows.Controls.TextBlock
Here ends the visual tree.
```

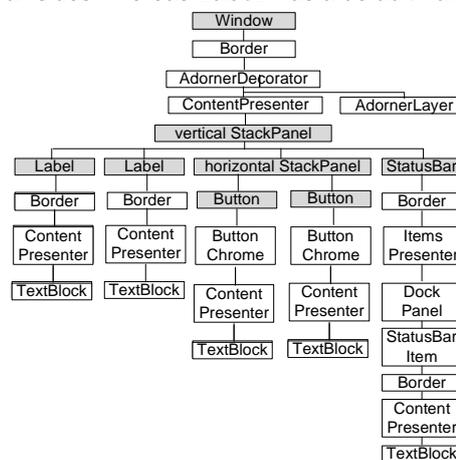
Nested objects form a **Logical Tree** where property values can be propagated down to child elements and events can be propagated up and down. Mostly logical trees are coded in XAML but they can be written in C# or in any mixture of XAML and C# too.



The **Visual Tree** is more complicated than its corresponding logical tree. It expands the logical tree to its inner components that derive from `System.Windows.Media.Visual` or `System.Windows.Media.Visual3D`.

Other elements as simple string content are not included because they don't have inherent rendering behavior of their own. It reveals that `Button` and `Label` are comprised of the same elements, except `Button` uses an obscure `ButtonChrome` element rather than a `Border`.

These controls have different default property values. For example, `Button` has a default `Margin` of 10 on all sides whereas `Label` has a default `Margin` of 0.



Explanations and Links:

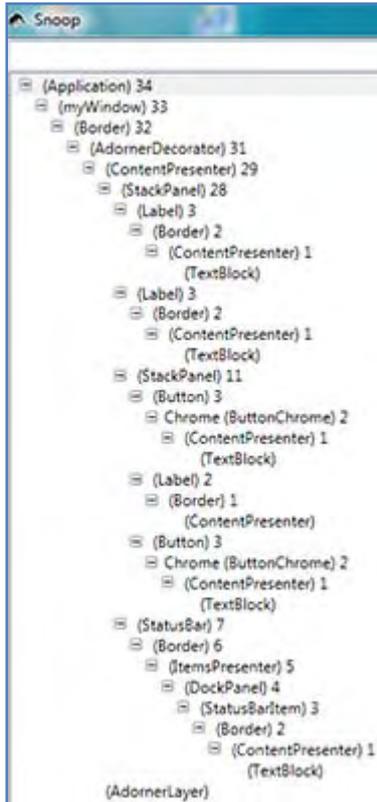
An **Adorner** overlays visual decorations on a control.

The **ContentPresenter** renders the surface of the control.

Every **ContentControl** has a `ControlPresenter` within its **ControlTemplate**. **ButtonChrome** creates a theme-specific look for all `Button`-elements written with the .NET Framework.

A **Theme** is defined by Windows Vista and influences the collective appearance of all controls and other visual elements.

# The Snoop Utility



Snoop is a wonderful utility (incorporated into Expression Blend) but available separately at <http://blois.us/Snoop/> to inspect Visual Trees.

It inspects all running WPF applications and furnishes the tree view on the left for LogicalAndVisualTree1.

There is no need to download Snoop's source code. Just download and install the Installer Zip-file.

Explanations:

