Contents

Windows Presentation Foundation

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Windows Presentation Foundation (WPF) in Visual Studio provides developers with a unified programming model for building line-of-business desktop applications on Windows.

Create Desktop Applications with Windows Presentation Foundation

Designing XAML in Visual Studio and Blend for Visual Studio

Get Visual Studio

Getting Started (WPF)

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Windows Presentation Foundation (WPF) is a UI framework that creates desktop client applications. The WPF development platform supports a broad set of application development features, including an application model, resources, controls, graphics, layout, data binding, documents, and security. It is a subset of the .NET Framework, so if you have previously built applications with the .NET Framework using ASP.NET or Windows Forms, the programming experience should be familiar. WPF uses the Extensible Application Markup Language (XAML) to provide a declarative model for application programming. This section has topics that introduce and help you get started with WPF.

Where Should I Start?

I want to jump right in...	Walkthrough: My first WPF desktop application
How do I design the application UI?	Designing XAML in Visual Studio
New to .NET?	Overview of the .NET Framework .NET Framework Application Essentials Getting Started with Visual C# and Visual Basic
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See also

- Class Library
- Application Development
- .NET Framework Developer Center

Application Development

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Windows Presentation Foundation (WPF) is a presentation framework that can be used to develop the following types of applications:

- Standalone Applications (traditional style Windows applications built as executable assemblies that are installed to and run from the client computer).
- XAML browser applications (XBAPs) (applications composed of navigation pages that are built as executable assemblies and hosted by Web browsers such as Microsoft Internet Explorer or Mozilla Firefox).
- Custom Control Libraries (non-executable assemblies containing reusable controls).
- Class Libraries (non-executable assemblies that contain reusable classes).

> **NOTE**
> Using WPF types in a Windows service is strongly discouraged. If you attempt to use these features in a Windows service, they may not work as expected.

To build this set of applications, WPF implements a host of services. This topic provides an overview of these services and where to find more information.

Application Management

Executable WPF applications commonly require a core set of functionality that includes the following:

- Creating and managing common application infrastructure (including creating an entry point method and a Windows message loop to receive system and input messages).
- Tracking and interacting with the lifetime of an application.
- Retrieving and processing command-line parameters.
- Sharing application-scope properties and UI resources.
- Detecting and processing unhandled exceptions.
- Returning exit codes.
- Managing windows in standalone applications.
- Tracking navigation in XAML browser applications (XBAPs), and standalone applications with navigation windows and frames.

These capabilities are implemented by the Application class, which you add to your applications using an *application definition*.

For more information, see Application Management Overview.

WPF Application Resource, Content, and Data Files

WPF extends the core support in the Microsoft .NET Framework for embedded resources with support for three kinds of non-executable data files: resource, content, and data. For more information, see WPF Application

Resource, Content, and Data Files.

A key component of the support for WPF non-executable data files is the ability to identify and load them using a unique URI. For more information, see Pack URIs in WPF.

Windows and Dialog Boxes

Users interact with WPF standalone applications through windows. The purpose of a window is to host application content and expose application functionality that usually allows users to interact with the content. In WPF, windows are encapsulated by the Window class, which supports:

- Creating and showing windows.
- Establishing owner/owned window relationships.
- Configuring window appearance (for example, size, location, icons, title bar text, border).
- Tracking and interacting with the lifetime of a window.

For more information, see WPF Windows Overview.

Window supports the ability to create a special type of window known as a dialog box. Both modal and modeless types of dialog boxes can be created.

For convenience, and the benefits of reusability and a consistent user experience across applications, WPF exposes three of the common Windows dialog boxes: OpenFileDialog, SaveFileDialog, and PrintDialog.

A message box is a special type of dialog box for showing important textual information to users, and for asking simple Yes/No/OK/Cancel questions. You use the MessageBox class to create and show message boxes.

For more information, see Dialog Boxes Overview.

Navigation

WPF supports Web-style navigation using pages (Page) and hyperlinks (Hyperlink). Navigation can be implemented in a variety of ways that include the following:

- Standalone pages that are hosted in a Web browser.
- Pages compiled into an XBAP that is hosted in a Web browser.
- Pages compiled into a standalone application and hosted by a navigation window (NavigationWindow).
- Pages that are hosted by a frame (Frame), which may be hosted in a standalone page, or a page compiled into either an XBAP or a standalone application.

To facilitate navigation, WPF implements the following:

- NavigationService, the shared navigation engine for processing navigation requests that is used by Frame, NavigationWindow, and XBAPs to support intra-application navigation.
- Navigation methods to initiate navigation.
- Navigation events to track and interact with navigation lifetime.
- Remembering back and forward navigation using a journal, which can also be inspected and manipulated.

For information, see Navigation Overview.

WPF also supports a special type of navigation known as structured navigation. Structured navigation can be used to call one or more pages that return data in a structured and predictable way that is consistent with calling

functions. This capability depends on the PageFunction<T> class, which is described further in Structured Navigation Overview. PageFunction<T> also serves to simplify the creation of complex navigation topologies, which are described in Navigation Topologies Overview.

Hosting

XBAPs can be hosted in Microsoft Internet Explorer or Firefox. Each hosting model has its own set of considerations and constraints that are covered in Hosting.

Build and Deploy

Although simple WPF applications can be built from a command prompt using command-line compilers, WPF integrates with Microsoft Visual Studio to provide additional support that simplified the development and build process. For more information, see Building a WPF Application.

Depending on the type of application you build, there are one or more deployment options to choose from. For more information, see Deploying a WPF Application.

Related Topics

TITLE	DESCRIPTION
Application Management Overview	Provides an overview of the Application class including managing application lifetime, windows, application resources, and navigation.
Windows in WPF	Provides details of managing windows in your application including how to use the Window class and dialog boxes.
Navigation Overview	Provides an overview of managing navigation between pages of your application.
Hosting	Provides an overview of XAML browser applications (XBAPs).
Build and Deploy	Describes how to build and deploy your WPF application.
Introduction to WPF in Visual Studio	Describes the main features of WPF.
Walkthrough: My first WPF desktop application	A walkthrough that shows how to create a WPF application using page navigation, layout, controls, images, styles, and binding.

Advanced (Windows Presentation Foundation)

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This section describes some of the advanced areas in WPF.

In This Section

Related Sections

Controls

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Windows Presentation Foundation (WPF) ships with many of the common UI components that are used in almost every Windows application, such as Button, Label, TextBox, Menu, and ListBox. Historically, these objects have been referred to as controls. While the WPF SDK continues to use the term "control" to loosely mean any class that represents a visible object in an application, it is important to note that a class does not need to inherit from the Control class to have a visible presence. Classes that inherit from the Control class contain a ControlTemplate, which allows the consumer of a control to radically change the control's appearance without having to create a new subclass. This topic discusses how controls (both those that do inherit from the Control class and those that do not) are commonly used in WPF.

Creating an Instance of a Control

You can add a control to an application by using either Extensible Application Markup Language (XAML) or code. The following example shows how to create a simple application that asks a user for their first and last name. This example creates six controls: two labels, two text boxes, and two buttons, in XAML. All controls can be created similarly.

```
<Grid>
  <Grid.RowDefinitions>
    <RowDefinition Height="30"/>
    <RowDefinition Height="30"/>
    <RowDefinition Height="30"/>
    <RowDefinition/>
  </Grid.RowDefinitions>
  <Grid.ColumnDefinitions>
    <ColumnDefinition/>
    <ColumnDefinition/>
  </Grid.ColumnDefinitions>

  <Label>
    Enter your first name:
  </Label>
  <TextBox Grid.Row="0" Grid.Column="1"
           Name="firstName" Margin="0,5,10,5"/>

  <Label Grid.Row="1" >
    Enter your last name:
  </Label>
  <TextBox Grid.Row="1" Grid.Column="1"
           Name="lastName" Margin="0,5,10,5"/>

  <Button Grid.Row="2" Grid.Column="0"
          Name="submit" Margin="2">
    View message
  </Button>

  <Button Grid.Row="2" Grid.Column="1"
          Name="Clear" Margin="2">
    Clear Name
  </Button>
</Grid>
```

The following example creates the same application in code. For brevity, the creation of the Grid, `grid1`, has been excluded from the sample. `grid1` has the same column and row definitions as shown in the preceding XAML

example.

```
Label firstNameLabel;
Label lastNameLabel;
TextBox firstName;
TextBox lastName;
Button submit;
Button clear;

void CreateControls()
{
    firstNameLabel = new Label();
    firstNameLabel.Content = "Enter your first name:";
    grid1.Children.Add(firstNameLabel);

    firstName = new TextBox();
    firstName.Margin = new Thickness(0, 5, 10, 5);
    Grid.SetColumn(firstName, 1);
    grid1.Children.Add(firstName);

    lastNameLabel = new Label();
    lastNameLabel.Content = "Enter your last name:";
    Grid.SetRow(lastNameLabel, 1);
    grid1.Children.Add(lastNameLabel);

    lastName = new TextBox();
    lastName.Margin = new Thickness(0, 5, 10, 5);
    Grid.SetColumn(lastName, 1);
    Grid.SetRow(lastName, 1);
    grid1.Children.Add(lastName);

    submit = new Button();
    submit.Content = "View message";
    Grid.SetRow(submit, 2);
    grid1.Children.Add(submit);

    clear = new Button();
    clear.Content = "Clear Name";
    Grid.SetRow(clear, 2);
    Grid.SetColumn(clear, 1);
    grid1.Children.Add(clear);

}
```

```
Private firstNameLabel As Label
Private lastNameLabel As Label
Private firstName As TextBox
Private lastName As TextBox
Private submit As Button
Private clear As Button

Sub CreateControls()
    firstNameLabel = New Label()
    firstNameLabel.Content = "Enter your first name:"
    grid1.Children.Add(firstNameLabel)

    firstName = New TextBox()
    firstName.Margin = New Thickness(0, 5, 10, 5)
    Grid.SetColumn(firstName, 1)
    grid1.Children.Add(firstName)

    lastNameLabel = New Label()
    lastNameLabel.Content = "Enter your last name:"
    Grid.SetRow(lastNameLabel, 1)
    grid1.Children.Add(lastNameLabel)

    lastName = New TextBox()
    lastName.Margin = New Thickness(0, 5, 10, 5)
    Grid.SetColumn(lastName, 1)
    Grid.SetRow(lastName, 1)
    grid1.Children.Add(lastName)

    submit = New Button()
    submit.Content = "View message"
    Grid.SetRow(submit, 2)
    grid1.Children.Add(submit)

    clear = New Button()
    clear.Content = "Clear Name"
    Grid.SetRow(clear, 2)
    Grid.SetColumn(clear, 1)
    grid1.Children.Add(clear)


End Sub 'CreateControls
```

Changing the Appearance of a Control

It is common to change the appearance of a control to fit the look and feel of your application. You can change the appearance of a control by doing one of the following, depending on what you want to accomplish:

- Change the value of a property of the control.
- Create a Style for the control.
- Create a new ControlTemplate for the control.

Changing a Control's Property Value

Many controls have properties that allow you to change how the control appears, such as the Background of a Button. You can set the value properties in both XAML and code. The following example sets the Background, FontSize, and FontWeight properties on a Button in XAML.

```
<Button FontSize="14" FontWeight="Bold">
  <!--Set the Background property of the Button to
    a LinearGradientBrush.-->
  <Button.Background>
    <LinearGradientBrush StartPoint="0,0.5"
                         EndPoint="1,0.5">
      <GradientStop Color="Green" Offset="0.0" />
      <GradientStop Color="White" Offset="0.9" />
    </LinearGradientBrush>

  </Button.Background>
  View message
</Button>
```

The following example sets the same properties in code.

```
LinearGradientBrush buttonBrush = new LinearGradientBrush();
buttonBrush.StartPoint = new Point(0, 0.5);
buttonBrush.EndPoint = new Point(1, 0.5);
buttonBrush.GradientStops.Add(new GradientStop(Colors.Green, 0));
buttonBrush.GradientStops.Add(new GradientStop(Colors.White, 0.9));

submit.Background = buttonBrush;
submit.FontSize = 14;
submit.FontWeight = FontWeights.Bold;
```

```
Dim buttonBrush As New LinearGradientBrush()
buttonBrush.StartPoint = New Point(0, 0.5)
buttonBrush.EndPoint = New Point(1, 0.5)
buttonBrush.GradientStops.Add(New GradientStop(Colors.Green, 0))
buttonBrush.GradientStops.Add(New GradientStop(Colors.White, 0.9))

submit.Background = buttonBrush
submit.FontSize = 14
submit.FontWeight = FontWeights.Bold
```

Creating a Style for a Control

WPF gives you the ability to specify the appearance of controls wholesale, instead of setting properties on each instance in the application, by creating a Style. The following example creates a Style that is applied to each Button in the application. Style definitions are typically defined in XAML in a ResourceDictionary, such as the Resources property of the FrameworkElement.

```
<Style TargetType="Button">
  <Setter Property="FontSize" Value="14"/>
  <Setter Property="FontWeight" Value="Bold"/>
  <Setter Property="Background">
    <Setter.Value>
      <LinearGradientBrush StartPoint="0,0.5"
                           EndPoint="1,0.5">
        <GradientStop Color="Green" Offset="0.0" />
        <GradientStop Color="White" Offset="0.9" />
      </LinearGradientBrush>

    </Setter.Value>
  </Setter>
</Style>
```

You can also apply a style to only certain controls of a specific type by assigning a key to the style and specifying that key in the `Style` property of your control. For more information about styles, see Styling and Templating.

Creating a ControlTemplate

A Style allows you to set properties on multiple controls at a time, but sometimes you might want to customize the appearance of a Control beyond what you can do by creating a Style. Classes that inherit from the Control class have a ControlTemplate, which defines the structure and appearance of a Control. The Template property of a Control is public, so you can give a Control a ControlTemplate that is different than its default. You can often specify a new ControlTemplate for a Control instead of inheriting from a control to customize the appearance of a Control.

Consider the very common control, Button. The primary behavior of a Button is to enable an application to take some action when the user clicks it. By default, the Button in WPF appears as a raised rectangle. While developing an application, you might want to take advantage of the behavior of a Button--that is, by handling the button's click event--but you might change the button's appearance beyond what you can do by changing the button's properties. In this case, you can create a new ControlTemplate.

The following example creates a ControlTemplate for a Button. The ControlTemplate creates a Button with rounded corners and a gradient background. The ControlTemplate contains a Border whose Background is a LinearGradientBrush with two GradientStop objects. The first GradientStop uses data binding to bind the Color property of the GradientStop to the color of the button's background. When you set the Background property of the Button, the color of that value will be used as the first GradientStop. For more information about data binding, see Data Binding Overview. The example also creates a Trigger that changes the appearance of the Button when IsPressed is `true`.

```
<!--Define a template that creates a gradient-colored button.-->
<Style TargetType="Button">
  <Setter Property="Template">
    <Setter.Value>
      <ControlTemplate TargetType="Button">
        <Border
          x:Name="Border"
          CornerRadius="20"
          BorderThickness="1"
          BorderBrush="Black">
          <Border.Background>
            <LinearGradientBrush StartPoint="0,0.5"
                                 EndPoint="1,0.5">
              <GradientStop Color="{Binding Background.Color,
                    RelativeSource={RelativeSource TemplatedParent}}"
                            Offset="0.0" />
              <GradientStop Color="White" Offset="0.9" />
            </LinearGradientBrush>
          </Border.Background>
          <ContentPresenter
            Margin="2"
            HorizontalAlignment="Center"
            VerticalAlignment="Center"
            RecognizesAccessKey="True"/>
        </Border>
        <ControlTemplate.Triggers>
          <!--Change the appearance of
          the button when the user clicks it.-->
          <Trigger Property="IsPressed" Value="true">
            <Setter TargetName="Border" Property="Background">
              <Setter.Value>
                <LinearGradientBrush StartPoint="0,0.5"
                                     EndPoint="1,0.5">
                  <GradientStop Color="{Binding Background.Color,
                    RelativeSource={RelativeSource TemplatedParent}}"
                                Offset="0.0" />
                  <GradientStop Color="DarkSlateGray" Offset="0.9" />
                </LinearGradientBrush>
              </Setter.Value>
            </Setter>
          </Trigger>

        </ControlTemplate.Triggers>
      </ControlTemplate>
    </Setter.Value>
  </Setter>
</Style>
```

```
<Button Grid.Row="2" Grid.ColumnSpan="2" Name="submitName"
        Background="Green">View message</Button>
```

> **NOTE**
>
> The Background property of the Button must be set to a SolidColorBrush for the example to work properly.

Subscribing to Events

You can subscribe to a control's event by using either XAML or code, but you can only handle an event in code. The following example shows how to subscribe to the `Click` event of a Button.

```
<Button Grid.Row="2" Grid.ColumnSpan="2" Name="submitName" Click="submit_Click"
  Background="Green">View message</Button>
```

```
submit.Click += new RoutedEventHandler(submit_Click);
```

```
AddHandler submit.Click, AddressOf submit_Click
```

The following example handles the `Click` event of a Button.

```
void submit_Click(object sender, RoutedEventArgs e)
{
    MessageBox.Show("Hello, " + firstName.Text + " " + lastName.Text);
}
```

```
Private Sub submit_Click(ByVal sender As Object, ByVal e As RoutedEventArgs)
    MessageBox.Show("Hello, " + firstName.Text + " " + lastName.Text)

End Sub 'submit_Click
```

Rich Content in Controls

Most classes that inherit from the Control class have the capacity to contain rich content. For example, a Label can contain any object, such as a string, an Image, or a Panel. The following classes provide support for rich content and act as base classes for most of the controls in WPF.

- ContentControl-- Some examples of classes that inherit from this class are Label, Button, and ToolTip.
- ItemsControl-- Some examples of classes that inherit from this class are ListBox, Menu, and StatusBar.
- HeaderedContentControl-- Some examples of classes that inherit from this class are TabItem, GroupBox, and Expander.
- HeaderedItemsControl--Some examples of classes that inherit from this class are MenuItem, TreeViewItem, and ToolBar.

For more information about these base classes, see WPF Content Model.

See also

- Styling and Templating
- Controls by Category
- Control Library
- Data Templating Overview
- Data Binding Overview
- Input
- Enable a Command
- Walkthroughs: Create a Custom Animated Button
- Control Customization

Data

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Windows Presentation Foundation (WPF) data binding provides a simple and consistent way for applications to present and interact with data. Elements can be bound to data from a variety of data sources in the form of common language runtime (CLR) objects and XML. Windows Presentation Foundation (WPF) also provides a mechanism for the transfer of data through drag-and-drop operations.

In This Section

Data Binding
Drag and Drop

Reference

System.Windows.Data

Binding

DataTemplate

DataTemplateSelector

Related Sections

Controls

Styling and Templating

Data Binding

See also

- Walkthrough: My first WPF desktop application
- Walkthrough: Caching Application Data in a WPF Application

Graphics and Multimedia

2/15/2019 • 4 minutes to read • Edit Online

Windows Presentation Foundation (WPF) provides support for multimedia, vector graphics, animation, and content composition, making it easy for developers to build interesting user interfaces and content. Using Microsoft Visual Studio, you can create vector graphics or complex animations and integrate media into your applications.

This topic introduces the graphics, animation, and media features of WPF, which enable you to add graphics, transition effects, sound, and video to your applications.

> **NOTE**
> Using WPF types in a Windows service is strongly discouraged. If you attempt to use WPF types in a Windows service, the service may not work as expected.

What's New with Graphics and Multimedia in WPF 4

Several changes have been made related to graphics and animations.

- Layout Rounding

  When an object edge falls in the middle of a pixel device, the DPI-independent graphics system can create rendering artifacts, such as blurry or semi-transparent edges. Previous versions of WPF included pixel snapping to help handle this case. Silverlight 2 introduced layout rounding, which is another way to move elements so that edges fall on whole pixel boundaries. WPF now supports layout rounding with the UseLayoutRounding attached property on FrameworkElement.

- Cached Composition

  By using the new BitmapCache and BitmapCacheBrush classes, you can cache a complex part of the visual tree as a bitmap and greatly improve rendering time. The bitmap remains responsive to user input, such as mouse clicks, and you can paint it onto other elements just like any brush.

- Pixel Shader 3 Support

  WPF 4 builds on top of the ShaderEffect support introduced in WPF 3.5 SP1 by allowing applications to write effects by using Pixel Shader (PS) version 3.0. The PS 3.0 shader model is more sophisticated than PS 2.0, which allows for even more effects on supported hardware.

- Easing Functions

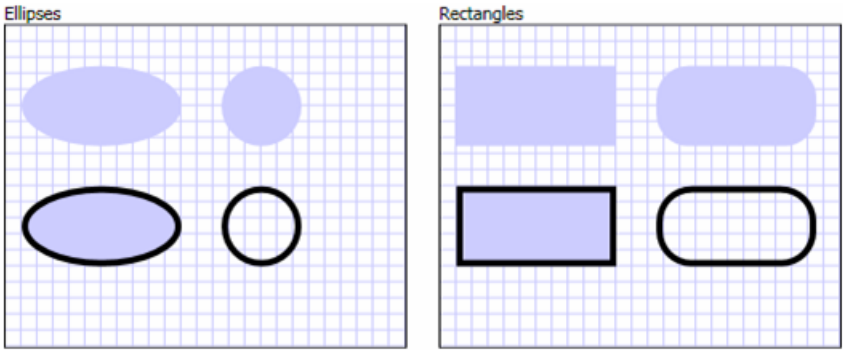
  You can enhance animations with easing functions, which give you additional control over the behavior of animations. For example, you can apply an ElasticEase to an animation to give the animation a springy behavior. For more information, see the easing types in the System.Windows.Media.Animation namespace.

Graphics and Rendering

WPF includes support for high quality 2-D graphics. The functionality includes brushes, geometries, images, shapes and transformations. For more information, see Graphics. The rendering of graphical elements is based on the Visual class. The structure of visual objects on the screen is described by the visual tree. For more information, see WPF Graphics Rendering Overview.

2-D Shapes

WPF provides a library of commonly used, vector-drawn 2-D shapes, such as rectangles and ellipses, which the following illustration shows.



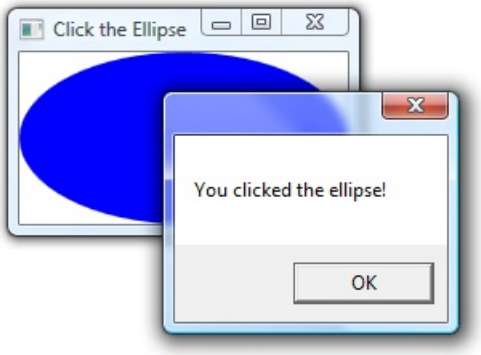
These intrinsic WPF shapes are not just shapes: they are programmable elements that implement many of the features that you expect from most common controls, which include keyboard and mouse input. The following example shows how to handle the MouseUp event raised by clicking an Ellipse element.

```
<Window
  xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
  xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
  x:Class="Window1" >
  <Ellipse Fill="LightBlue" MouseUp="ellipseButton_MouseUp" />
</Window>
```

```
public partial class Window1  : Window
{
    void ellipseButton_MouseUp(object sender, MouseButtonEventArgs e)
    {
        MessageBox.Show("You clicked the ellipse!");
    }
}
```

```
Partial Public Class Window1
    Inherits Window
    Private Sub ellipseButton_MouseUp(ByVal sender As Object, ByVal e As MouseButtonEventArgs)
        MessageBox.Show("You clicked the ellipse!")
    End Sub
End Class
```

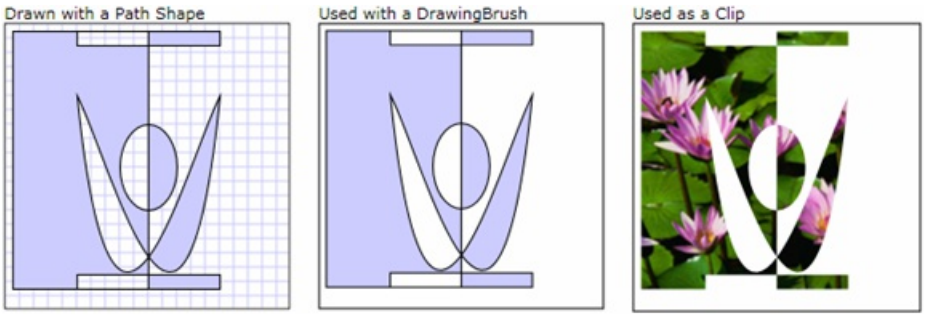
The following illustration shows the output for the preceding XAML markup and code-behind.



For more information, see Shapes and Basic Drawing in WPF Overview. For an introductory sample, see Shape Elements Sample.

2-D Geometries

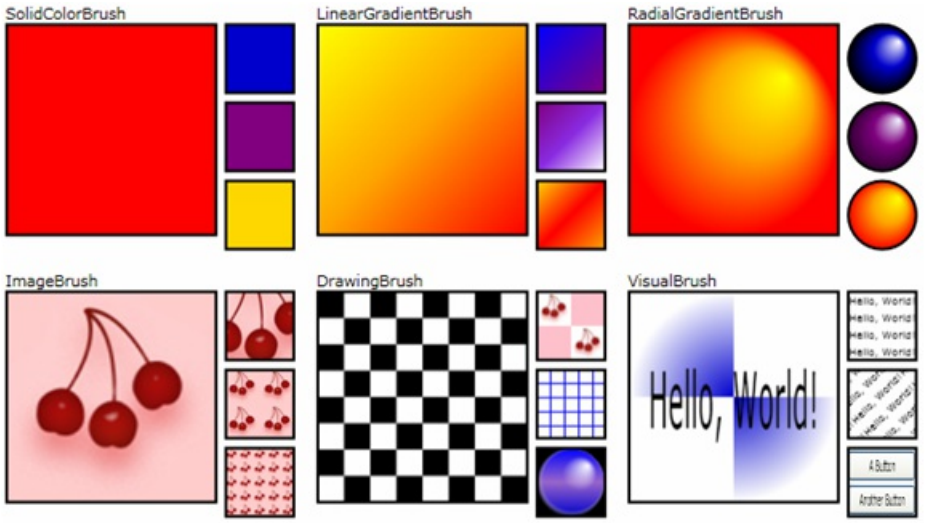
When the 2-D shapes that WPF provides are not sufficient, you can use WPF support for geometries and paths to create your own. The following illustration shows how you can use geometries to create shapes, as a drawing brush, and to clip other WPF elements.



For more information, see Geometry Overview. For an introductory sample, see Geometries Sample.

2-D Effects

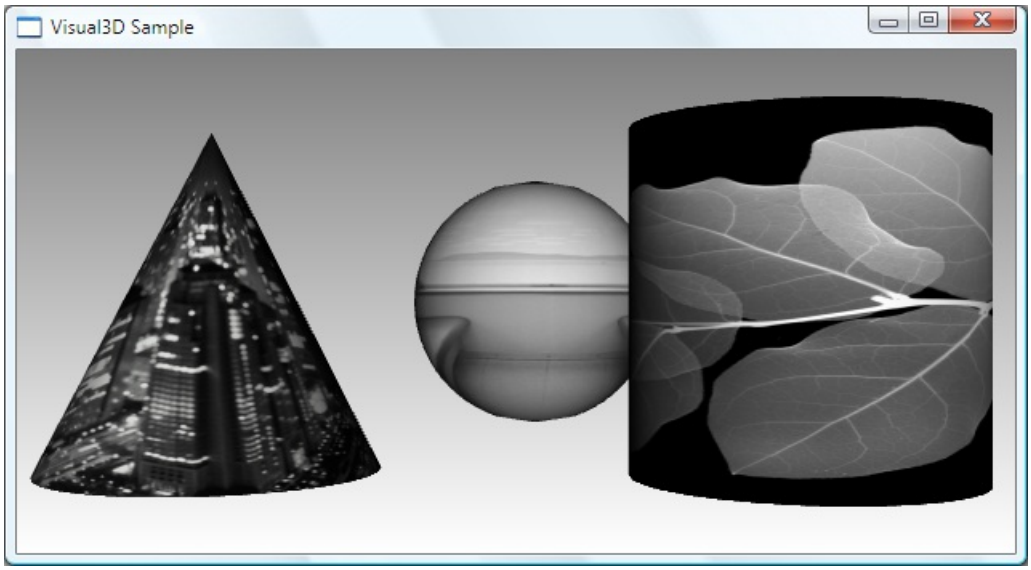
WPF provides a library of 2-D classes that you can use to create a variety of effects. The 2-D rendering capability of WPF provides the ability to paint UI elements that have gradients, bitmaps, drawings, and videos; and to manipulate them by using rotation, scaling, and skewing. The following illustration gives an example of the many effects you can achieve by using WPF brushes.



For more information, see WPF Brushes Overview. For an introductory sample, see Brushes Sample.

3-D Rendering

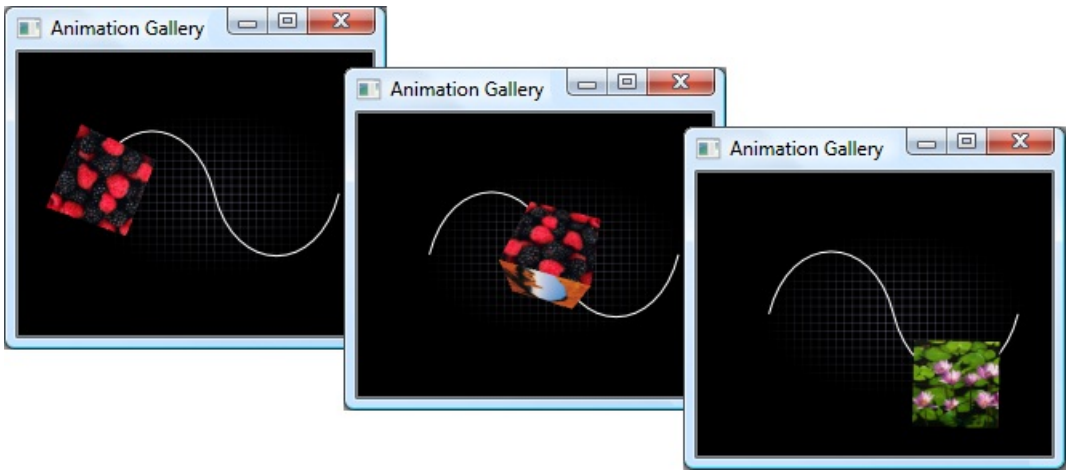
WPF provides a set of 3-D rendering capabilities that integrate with 2-D graphics support in WPF in order for you to create more exciting layout, UI, and data visualization. At one end of the spectrum, WPF enables you to render 2-D images onto the surfaces of 3-D shapes, which the following illustration demonstrates.



For more information, see 3-D Graphics Overview. For an introductory sample, see 3-D Solids Sample.

Animation

Use animation to make controls and elements grow, shake, spin, and fade; and to create interesting page transitions, and more. Because WPF enables you to animate most properties, not only can you animate most WPF objects, you can also use WPF to animate custom objects that you create.



For more information, see Animation Overview. For an introductory sample, see Animation Example Gallery.

Media

Images, video, and audio are media-rich ways of conveying information and user experiences.

Images

Images, which include icons, backgrounds, and even parts of animations, are a core part of most applications. Because you frequently need to use images, WPF exposes the ability to work with them in a variety of ways. The following illustration shows just one of those ways.

For more information, see Imaging Overview.

Video and Audio

A core feature of the graphics capabilities of WPF is to provide native support for working with multimedia, which includes video and audio. The following example shows how to insert a media player into an application.

```
<MediaElement Source="media\numbers.wmv" Width="450" Height="250" />
```

MediaElement is capable of playing both video and audio, and is extensible enough to allow the easy creation of custom UIs.

For more information, see the Multimedia Overview.

See also

- System.Windows.Media
- System.Windows.Media.Animation
- System.Windows.Media.Media3D
- 2D Graphics and Imaging
- Shapes and Basic Drawing in WPF Overview
- Painting with Solid Colors and Gradients Overview
- Painting with Images, Drawings, and Visuals
- Animation and Timing How-to Topics
- 3-D Graphics Overview
- Multimedia Overview

Security (WPF)

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When developing Windows Presentation Foundation (WPF) standalone and browser-hosted applications, you must consider the security model. WPF standalone applications execute with unrestricted permissions (CAS **FullTrust** permission set), whether deployed using Windows Installer (.msi), XCopy, or ClickOnce. Deploying partial-trust, standalone WPF applications with ClickOnce is unsupported. However, a full-trust host application can create a partial-trust AppDomain using the .NET Framework Add-in model. For more information, see WPF Add-Ins Overview.

WPF browser-hosted applications are hosted by Windows Internet Explorer or Firefox, and can be either XAML browser applications (XBAPs) or loose Extensible Application Markup Language (XAML) documents For more information, see WPF XAML Browser Applications Overview.

WPF browser-hosted applications execute within a partial trust security sandbox, by default, which is limited to the default CAS **Internet** zone permission set. This effectively isolates WPF browser-hosted applications from the client computer in the same way that you would expect typical Web applications to be isolated. An XBAP can elevate privileges, up to Full Trust, depending on the security zone of the deployment URL and the client's security configuration. For more information, see WPF Partial Trust Security.

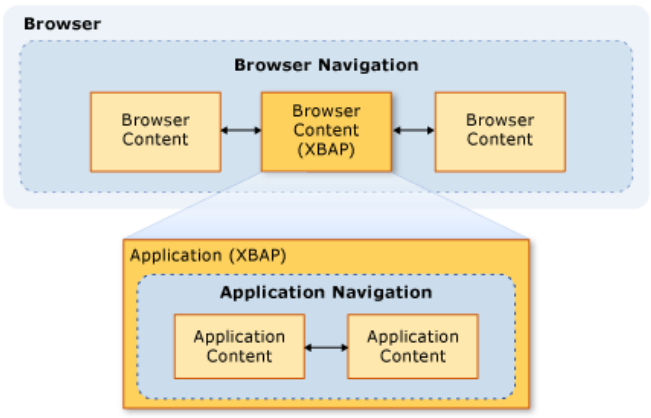
This topic discusses the security model for Windows Presentation Foundation (WPF) standalone and browser-hosted applications.

This topic contains the following sections:

Safe Navigation

For XBAPs, WPF distinguishes two types of navigation: application and browser.

Application navigation is navigation between items of content within an application that is hosted by a browser. *Browser navigation* is navigation that changes the content and location URL of a browser itself. The relationship between application navigation (typically XAML) and browser navigation (typically HTML) is shown in the following illustration:



The type of content that is considered safe for an XBAP to navigate to is primarily determined by whether application

navigation or browser navigation is used.

Application Navigation Security

Application navigation is considered safe if it can be identified with a pack URI, which supports four types of content:

CONTENT TYPE	DESCRIPTION	URI EXAMPLE
Resource	Files that are added to a project with a build type of **Resource**.	`pack://application:,,,/MyResourceFile.xaml`
Content	Files that are added to a project with a build type of **Content**.	`pack://application:,,,/MyContentFile.xaml`
Site of origin	Files that are added to a project with a build type of **None**.	`pack://siteoforigin:,,,/MySiteOfOriginFile.x`
Application code	XAML resources that have a compiled code-behind. -or- XAML files that are added to a project with a build type of **Page**.	`pack://application:,,,/MyResourceFile.xaml`

> **NOTE**
> For more information about application data files and pack URIs, see WPF Application Resource, Content, and Data Files.

Files of these content types can be navigated to by either the user or programmatically:

- **User Navigation**. The user navigates by clicking a Hyperlink element.
- **Programmatic Navigation**. The application navigates without involving the user, for example, by setting the NavigationWindow.Source property.

Browser Navigation Security

Browser navigation is considered safe only under the following conditions:

- **User Navigation**. The user navigates by clicking a Hyperlink element that is within the main NavigationWindow, not in a nested Frame.
- **Zone**. The content being navigated to is located on the Internet or the local intranet.
- **Protocol**. The protocol being used is either **http**, **https**, **file**, or **mailto**.

If an XBAP attempts to navigate to content in a manner that does not comply with these conditions, a SecurityException is thrown.

Web Browsing Software Security Settings

The security settings on your computer determine the access that any Web browsing software is granted. Web browsing software includes any application or component that uses the WinINet or UrlMon APIs, including Internet Explorer and PresentationHost.exe.

Internet Explorer provides a mechanism by which you can configure the functionality that is allowed to be executed by or from Internet Explorer, including the following:

- .NET Framework-reliant components
- ActiveX controls and plug-ins

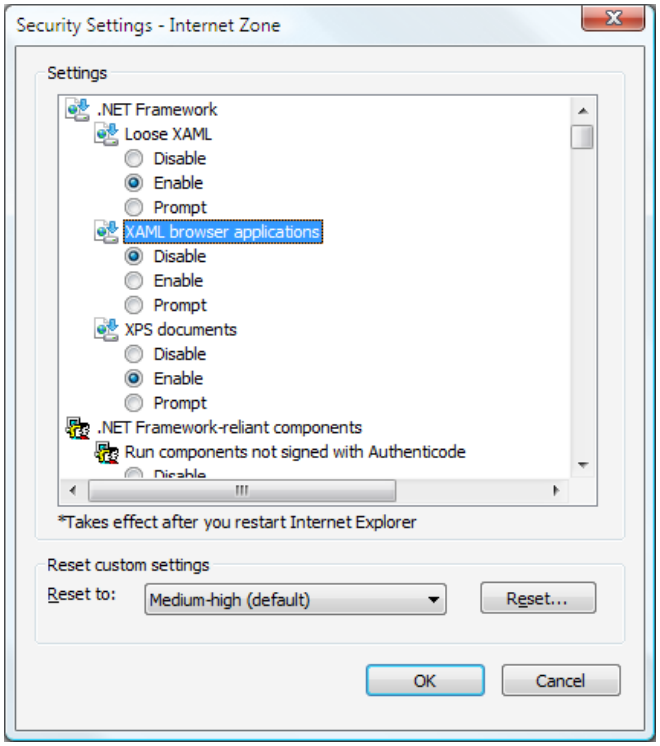
- Downloads
- Scripting
- User Authentication

The collection of functionality that can be secured in this way is configured on a per-zone basis for the **Internet**, **Intranet**, **Trusted Sites**, and **Restricted Sites** zones. The following steps describe how to configure your security settings:

1. Open **Control Panel**.
2. Click **Network and Internet** and then click **Internet Options**.

   The Internet Options dialog box appears.
3. On the **Security** tab, select the zone to configure the security settings for.
4. Click the **Custom Level** button.

   The **Security Settings** dialog box appears and you can configure the security settings for the selected zone.



> **NOTE**
> You can also get to the Internet Options dialog box from Internet Explorer. Click **Tools** and then click **Internet Options**.

Starting with Windows Internet Explorer 7, the following security settings specifically for .NET Framework are included:

- **Loose XAML**. Controls whether Internet Explorer can navigate to and loose XAML files. (Enable, Disable, and Prompt options).
- **XAML browser applications**. Controls whether Internet Explorer can navigate to and run XBAPs. (Enable, Disable, and Prompt options).

By default, these settings are all enabled for the **Internet**, **Local intranet**, and **Trusted sites** zones, and disabled for the **Restricted sites** zone.

Security-related WPF Registry Settings

In addition to the security settings available through the Internet Options, the following registry values are available for selectively blocking a number of security-sensitive WPF features. The values are defined under the following key:

```
HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\.NETFramework\Windows Presentation Foundation\Features
```

The following table lists the values that can be set.

VALUE NAME	VALUE TYPE	VALUE DATA
XBAPDisallow	REG_DWORD	1 to disallow; 0 to allow.
LooseXamlDisallow	REG_DWORD	1 to disallow; 0 to allow.
WebBrowserDisallow	REG_DWORD	1 to disallow; 0 to allow.
MediaAudioDisallow	REG_DWORD	1 to disallow; 0 to allow.
MediaImageDisallow	REG_DWORD	1 to disallow; 0 to allow.
MediaVideoDisallow	REG_DWORD	1 to disallow; 0 to allow.
ScriptInteropDisallow	REG_DWORD	1 to disallow; 0 to allow.

WebBrowser Control and Feature Controls

The WPF WebBrowser control can be used to host Web content. The WPF WebBrowser control wraps the underlying WebBrowser ActiveX control. WPF provides some support for securing your application when you use the WPF WebBrowser control to host untrusted Web content. However, some security features must be applied directly by the applications using the WebBrowser control. For more information about the WebBrowser ActiveX control, see WebBrowser Control Overviews and Tutorials.

> **NOTE**
> This section also applies to the Frame control since it uses the WebBrowser to navigate to HTML content.

If the WPF WebBrowser control is used to host untrusted Web content, your application should use a partial-trust AppDomain to help insulate your application code from potentially malicious HTML script code. This is especially true if your application is interacting with the hosted script by using the InvokeScript method and the ObjectForScripting property. For more information, see WPF Add-Ins Overview.

If your application uses the WPF WebBrowser control, another way to increase security and mitigate attacks is to enable Internet Explorer feature controls. Feature controls are additions to Internet Explorer that allow administrators and developers to configure features of Internet Explorer and applications that host the WebBrowser ActiveX control, which the WPF WebBrowser control wraps. Feature controls can be configured by using the CoInternetSetFeatureEnabled function or by changing values in the registry. For more information about feature controls, see Introduction to Feature Controls and Internet Feature Controls.

If you are developing a standalone WPF application that uses the WPF WebBrowser control, WPF automatically enables the following feature controls for your application.

FEATURE CONTROL
FEATURE_MIME_HANDLING
FEATURE_MIME_SNIFFING
FEATURE_OBJECT_CACHING

FEATURE CONTROL
FEATURE_SAFE_BINDTOOBJECT
FEATURE_WINDOW_RESTRICTIONS
FEATURE_ZONE_ELEVATION
FEATURE_RESTRICT_FILEDOWNLOAD
FEATURE_RESTRICT_ACTIVEXINSTALL
FEATURE_ADDON_MANAGEMENT
FEATURE_HTTP_USERNAME_PASSWORD_DISABLE
FEATURE_SECURITYBAND
FEATURE_UNC_SAVEDFILECHECK
FEATURE_VALIDATE_NAVIGATE_URL
FEATURE_DISABLE_TELNET_PROTOCOL
FEATURE_WEBOC_POPUPMANAGEMENT
FEATURE_DISABLE_LEGACY_COMPRESSION
FEATURE_SSLUX

Since these feature controls are enabled unconditionally, a full-trust application might be impaired by them. In this case, if there is no security risk for the specific application and the content it is hosting, the corresponding feature control can be disabled.

Feature controls are applied by the process instantiating the WebBrowser ActiveX object. Therefore, if you are creating a stand-alone application that can navigate to untrusted content, you should seriously consider enabling additional feature controls.

> **NOTE**
>
> This recommendation is based on general recommendations for MSHTML and SHDOCVW host security. For more information, see The MSHTML Host Security FAQ: Part I of II and The MSHTML Host Security FAQ: Part II of II.

For your executable, consider enabling the following feature controls by setting the registry value to 1.

FEATURE CONTROL
FEATURE_ACTIVEX_REPURPOSEDETECTION
FEATURE_BLOCK_LMZ_IMG
FEATURE_BLOCK_LMZ_OBJECT
FEATURE_BLOCK_LMZ_SCRIPT

FEATURE CONTROL
FEATURE_RESTRICT_RES_TO_LMZ
FEATURE_RESTRICT_ABOUT_PROTOCOL_IE7
FEATURE_SHOW_APP_PROTOCOL_WARN_DIALOG
FEATURE_LOCALMACHINE_LOCKDOWN
FEATURE_FORCE_ADDR_AND_STATUS
FEATURE_RESTRICTED_ZONE_WHEN_FILE_NOT_FOUND

For your executable, consider disabling the following feature control by setting the registry value to 0.

FEATURE CONTROL
FEATURE_ENABLE_SCRIPT_PASTE_URLACTION_IF_PROMPT

If you run a partial-trust XAML browser application (XBAP) that includes a WPF WebBrowser control in Windows Internet Explorer, WPF hosts the WebBrowser ActiveX control in the address space of the Internet Explorer process. Since the WebBrowser ActiveX control is hosted in the Internet Explorer process, all of the feature controls for Internet Explorer are also enabled for the WebBrowser ActiveX control.

XBAPs running in Internet Explorer also get an additional level of security compared to normal standalone applications. This additional security is because Internet Explorer, and therefore the WebBrowser ActiveX control, runs in protected mode by default on Windows Vista and Windows 7. For more information about protected mode, see Understanding and Working in Protected Mode Internet Explorer.

> **NOTE**
> If you try to run an XBAP that includes a WPF WebBrowser control in Firefox, while in the Internet zone, a SecurityException will be thrown. This is due to WPF security policy.

Disabling APTCA Assemblies for Partially Trusted Client Applications

When managed assemblies are installed into the global assembly cache (GAC), they become fully trusted because the user must provide explicit permission to install them. Because they are fully trusted, only fully trusted managed client applications can use them. To allow partially trusted applications to use them, they must be marked with the AllowPartiallyTrustedCallersAttribute (APTCA). Only assemblies that have been tested to be safe for execution in partial trust should be marked with this attribute.

However, it is possible for an APTCA assembly to exhibit a security flaw after being installed into the GAC. Once a security flaw is discovered, assembly publishers can produce a security update to fix the problem on existing installations, and to protect against installations that may occur after the problem is discovered. One option for the update is to uninstall the assembly, although that may break other fully trusted client applications that use the assembly.

WPF provides a mechanism by which an APTCA assembly can be disabled for partially trusted XBAPs without uninstalling the APTCA assembly.

To disable an APTCA assembly, you have to create a special registry key:

```
HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\.NETFramework\policy\APTCA\<AssemblyFullName>, FileVersion=
<AssemblyFileVersion>
```

The following shows an example:

```
HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\.NETFramework\policy\APTCA\aptcagac, Version=1.0.0.0, Culture=neutral,
PublicKeyToken=215e3ac809a0fea7, FileVersion=1.0.0.0
```

This key establishes an entry for the APTCA assembly. You also have to create a value in this key that enables or disables the assembly. The following are the details of the value:

- Value Name: **APTCA_FLAG**.
- Value Type: **REG_DWORD**.
- Value Data: **1** to disable; **0** to enable.

If an assembly has to be disabled for partially trusted client applications, you can write an update that creates the registry key and value.

> **NOTE**
> Core .NET Framework assemblies are not affected by disabling them in this way because they are required for managed applications to run. Support for disabling APTCA assemblies is primarily targeted to third-party applications.

Sandbox Behavior for Loose XAML Files

Loose XAML files are markup-only XAML files that do not depend on any code-behind, event handler, or application-specific assembly. When loose XAML files are navigated to directly from the browser, they are loaded in a security sandbox based on the default Internet zone permission set.

However, the security behavior is different when loose XAML files are navigated to from either a NavigationWindow or Frame in a standalone application.

In both cases, the loose XAML file that is navigated to inherits the permissions of its host application. However, this behavior may be undesirable from a security perspective, particularly if a loose XAML file was produced by an entity that is either not trusted or unknown. This type of content is known as *external content*, and both Frame and NavigationWindow can be configured to isolate it when navigated to. Isolation is achieved by setting the **SandboxExternalContent** property to true, as shown in the following examples for Frame and NavigationWindow:

```
<Frame
  Source="ExternalContentPage.xaml"
  SandboxExternalContent="True">
</Frame>
```

```
<!-- Sandboxing external content using NavigationWindow-->
<NavigationWindow
  xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
  Source="ExternalContentPage.xaml"
  SandboxExternalContent="True">
</NavigationWindow>
```

With this setting, external content will be loaded into a process that is separate from the process that is hosting the application. This process is restricted to the default Internet zone permission set, effectively isolating it from the hosting application and the client computer.

> **NOTE**
> Even though navigation to loose XAML files from either a NavigationWindow or Frame in a standalone application is implemented based on the WPF browser hosting infrastructure, involving the PresentationHost process, the security level is slightly less than when the content is loaded directly in Internet Explorer on Windows Vista and Windows 7 (which would still be through PresentationHost). This is because a standalone WPF application using a Web browser does not provide the additional Protected Mode security feature of Internet Explorer.

Resources for Developing WPF Applications that Promote Security

The following are some additional resources to help develop WPF applications that promote security:

AREA	RESOURCE
Managed code	Patterns and Practices Security Guidance for Applications
CAS	Code Access Security
ClickOnce	ClickOnce Security and Deployment
WPF	WPF Partial Trust Security

See also

- WPF Partial Trust Security
- WPF Security Strategy - Platform Security
- WPF Security Strategy - Security Engineering
- Patterns and Practices Security Guidance for Applications
- Code Access Security
- ClickOnce Security and Deployment
- XAML Overview (WPF)

WPF Partial Trust Security

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In general, Internet applications should be restricted from having direct access to critical system resources, to prevent malicious damage. By default, HTML and client-side scripting languages are not able to access critical system resources. Because Windows Presentation Foundation (WPF) browser-hosted applications can be launched from the browser, they should conform to a similar set of restrictions. To enforce these restrictions, WPF relies on both Code Access Security (CAS) and ClickOnce (see WPF Security Strategy - Platform Security). By default, browser-hosted applications request the Internet zone CAS set of permissions, irrespective of whether they are launched from the Internet, the local intranet, or the local computer. Applications that run with anything less than the full set of permissions are said to be running with partial trust.

WPF provides a wide variety of support to ensure that as much functionality as possible can be used safely in partial trust, and along with CAS, provides additional support for partial trust programming.

This topic contains the following sections:

WPF Feature Partial Trust Support

The following table lists the high-level features of Windows Presentation Foundation (WPF) that are safe to use within the limits of the Internet zone permission set.

Table 1: WPF Features that are Safe in Partial Trust

FEATURE AREA	FEATURE
General	Browser Window Site of Origin Access IsolatedStorage (512KB Limit) UIAutomation Providers Commanding Input Method Editors (IMEs) Tablet Stylus and Ink Simulated Drag/Drop using Mouse Capture and Move Events OpenFileDialog XAML Deserialization (via XamlReader.Load)

FEATURE AREA	FEATURE
Web Integration	Browser Download Dialog Top-Level User-Initiated Navigation mailto:links Uniform Resource Identifier Parameters HTTPWebRequest WPF Content Hosted in an IFRAME Hosting of Same-Site HTML Pages using Frame Hosting of Same Site HTML Pages using WebBrowser Web Services (ASMX) Web Services (using Windows Communication Foundation) Scripting Document Object Model
Visuals	2D and 3D Animation Media (Site Of Origin and Cross-Domain) Imaging/Audio/Video
Reading	FlowDocuments XPS Documents Embedded & System Fonts CFF & TrueType Fonts
Editing	Spell Checking RichTextBox Plaintext and Ink Clipboard Support User-Initiated Paste Copying Selected Content
Controls	General Controls

This table covers the WPF features at a high level. For more detailed information, the Windows Software Development Kit (SDK) documents the permissions that are required by each member in WPF. Additionally, the following features have more detailed information regarding partial trust execution, including special considerations.

- XAML (see XAML Overview (WPF)).

- Popups (see System.Windows.Controls.Primitives.Popup).
- Drag and Drop (see Drag and Drop Overview).
- Clipboard (see System.Windows.Clipboard).
- Imaging (see System.Windows.Controls.Image).
- Serialization (see XamlReader.Load, XamlWriter.Save).
- Open File Dialog Box (see Microsoft.Win32.OpenFileDialog).

The following table outlines the WPF features that are not safe to run within the limits of the Internet zone permission set.

Table 2: WPF Features that are Not Safe in Partial Trust

FEATURE AREA	FEATURE
General	Window (Application Defined Windows and Dialog Boxes) SaveFileDialog File System Registry Access Drag and Drop XAML Serialization (via XamlWriter.Save) UIAutomation Clients Source Window Access (HwndHost) Full Speech Support Windows Forms Interoperability
Visuals	Bitmap Effects Image Encoding
Editing	Rich Text Format Clipboard Full XAML support

Partial Trust Programming

For XBAP applications, code that exceeds the default permission set will have different behavior depending on the security zone. In some cases, the user will receive a warning when they attempt to install it. The user can choose to continue or cancel the installation. The following table describes the behavior of the application for each security zone and what you have to do for the application to receive full trust.

SECURITY ZONE	BEHAVIOR	GETTING FULL TRUST
Local computer	Automatic full trust	No action is needed.

SECURITY ZONE	BEHAVIOR	GETTING FULL TRUST
Intranet and trusted sites	Prompt for full trust	Sign the XBAP with a certificate so that the user sees the source in the prompt.
Internet	Fails with "Trust Not Granted"	Sign the XBAP with a certificate.

> **NOTE**
> The behavior described in the previous table is for full trust XBAPs that do not follow the ClickOnce Trusted Deployment model.

In general, code that may exceed the allowed permissions is likely to be common code that is shared between both standalone and browser-hosted applications. CAS and WPF offer several techniques for managing this scenario.

Detecting Permissions Using CAS

In some situations, it is possible for shared code in library assemblies to be used by both standalone applications and XBAPs. In these cases, code may execute functionality that could require more permissions than the application's awarded permission set allows. Your application can detect whether or not it has a certain permission by using Microsoft .NET Framework security. Specifically, it can test whether it has a specific permission by calling the Demand method on the instance of the desired permission. This is shown in the following example, which has code that queries for whether it has the ability to save a file to the local disk:

```
using System.IO;
using System.IO.IsolatedStorage;
using System.Security;
using System.Security.Permissions;
using System.Windows;

namespace SDKSample
{
    public class FileHandling
    {
        public void Save()
        {
            if (IsPermissionGranted(new FileIOPermission(FileIOPermissionAccess.Write, @"c:\newfile.txt")))
            {
                // Write to local disk
                using (FileStream stream = File.Create(@"c:\newfile.txt"))
                using (StreamWriter writer = new StreamWriter(stream))
                {
                    writer.WriteLine("I can write to local disk.");
                }
            }
            else
            {
                MessageBox.Show("I can't write to local disk.");
            }
        }

        // Detect whether or not this application has the requested permission
        bool IsPermissionGranted(CodeAccessPermission requestedPermission)
        {
            try
            {
                // Try and get this permission
                requestedPermission.Demand();
                return true;
            }
            catch
            {
                return false;
            }
        }
```

```
Imports System.IO
Imports System.IO.IsolatedStorage
Imports System.Security
Imports System.Security.Permissions
Imports System.Windows

Namespace SDKSample
    Public Class FileHandling
        Public Sub Save()
            If IsPermissionGranted(New FileIOPermission(FileIOPermissionAccess.Write, "c:\newfile.txt")) Then
                ' Write to local disk
                Using stream As FileStream = File.Create("c:\newfile.txt")
                Using writer As New StreamWriter(stream)
                    writer.WriteLine("I can write to local disk.")
                End Using
                End Using
            Else
                MessageBox.Show("I can't write to local disk.")
            End If
        End Sub

        ' Detect whether or not this application has the requested permission
        Private Function IsPermissionGranted(ByVal requestedPermission As CodeAccessPermission) As Boolean
            Try
                ' Try and get this permission
                requestedPermission.Demand()
                Return True
            Catch
                Return False
            End Try
        End Function
```

```
    }
}
```

```
    End Class
End Namespace
```

If an application does not have the desired permission, the call to Demand will throw a security exception. Otherwise, the permission has been granted. `IsPermissionGranted` encapsulates this behavior and returns `true` or `false` as appropriate.

Graceful Degradation of Functionality

Being able to detect whether code has the permission to do what it needs to do is interesting for code that can be executed from different zones. While detecting the zone is one thing, it is far better to provide an alternative for the user, if possible. For example, a full trust application typically enables users to create files anywhere they want, while a partial trust application can only create files in isolated storage. If the code to create a file exists in an assembly that is shared by both full trust (standalone) applications and partial trust (browser-hosted) applications, and both applications want users to be able to create files, the shared code should detect whether it is running in partial or full trust before creating a file in the appropriate location. The following code demonstrates both.

```
using System.IO;
using System.IO.IsolatedStorage;
using System.Security;
using System.Security.Permissions;
using System.Windows;

namespace SDKSample
{
    public class FileHandlingGraceful
    {
        public void Save()
        {
            if (IsPermissionGranted(new FileIOPermission(FileIOPermissionAccess.Write, @"c:\newfile.txt")))
            {
                // Write to local disk
                using (FileStream stream = File.Create(@"c:\newfile.txt"))
                using (StreamWriter writer = new StreamWriter(stream))
                {
                    writer.WriteLine("I can write to local disk.");
                }
            }
            else
            {
                // Persist application-scope property to
                // isolated storage
                IsolatedStorageFile storage = IsolatedStorageFile.GetUserStoreForApplication();
                using (IsolatedStorageFileStream stream =
                    new IsolatedStorageFileStream("newfile.txt", FileMode.Create, storage))
                using (StreamWriter writer = new StreamWriter(stream))
                {
                    writer.WriteLine("I can write to Isolated Storage");
                }
            }
        }

        // Detect whether or not this application has the requested permission
        bool IsPermissionGranted(CodeAccessPermission requestedPermission)
        {
            try
            {
                // Try and get this permission
                requestedPermission.Demand();
                return true;
            }
            catch
            {
                return false;
            }
        }
```

```
Imports System.IO
Imports System.IO.IsolatedStorage
Imports System.Security
Imports System.Security.Permissions
Imports System.Windows

Namespace SDKSample
    Public Class FileHandlingGraceful
        Public Sub Save()
            If IsPermissionGranted(New FileIOPermission(FileIOPermissionAccess.Write, "c:\newfile.txt")) Then
                ' Write to local disk
                Using stream As FileStream = File.Create("c:\newfile.txt")
                Using writer As New StreamWriter(stream)
                    writer.WriteLine("I can write to local disk.")
                End Using
                End Using
            Else
                ' Persist application-scope property to
                ' isolated storage
                Dim storage As IsolatedStorageFile = IsolatedStorageFile.GetUserStoreForApplication()
                Using stream As New IsolatedStorageFileStream("newfile.txt", FileMode.Create, storage)
                Using writer As New StreamWriter(stream)
                    writer.WriteLine("I can write to Isolated Storage")
                End Using
                End Using
            End If
        End Sub

        ' Detect whether or not this application has the requested permission
        Private Function IsPermissionGranted(ByVal requestedPermission As CodeAccessPermission) As Boolean
            Try
                ' Try and get this permission
                requestedPermission.Demand()
                Return True
            Catch
                Return False
            End Try
        End Function
```

```
    }
}
```

```
    End Class
End Namespace
```

In many cases, you should be able to find a partial trust alternative.

In a controlled environment, such as an intranet, custom managed frameworks can be installed across the client base into the global assembly cache (GAC). These libraries can execute code that requires full trust, and be referenced from applications that are only allowed partial trust by using AllowPartiallyTrustedCallersAttribute (for more information, see Security and WPF Security Strategy - Platform Security).

Browser Host Detection

Using CAS to check for permissions is a suitable technique when you need to check on a per-permission basis. Although, this technique depends on catching exceptions as a part of normal processing, which is not recommended in general and can have performance issues. Instead, if your XAML browser application (XBAP) only runs within the Internet zone sandbox, you can use the BrowserInteropHelper.IsBrowserHosted property, which returns true for XAML browser applications (XBAPs).

NOTE

IsBrowserHosted only distinguishes whether an application is running in a browser, not which set of permissions an application is running with.

Managing Permissions

By default, XBAPs run with partial trust (default Internet zone permission set). However, depending on the requirements of the application, it is possible to change the set of permissions from the default. For example, if an XBAPs is launched from a local intranet, it can take advantage of an increased permission set, which is shown in the following table.

Table 3: LocalIntranet and Internet Permissions

PERMISSION	ATTRIBUTE	LOCALINTRANET	INTERNET
DNS	Access DNS servers	Yes	No
Environment Variables	Read	Yes	No
File Dialogs	Open	Yes	Yes
File Dialogs	Unrestricted	Yes	No
Isolated Storage	Assembly isolation by user	Yes	No
Isolated Storage	Unknown isolation	Yes	Yes
Isolated Storage	Unlimited user quota	Yes	No
Media	Safe audio, video, and images	Yes	Yes
Printing	Default printing	Yes	No
Printing	Safe printing	Yes	Yes
Reflection	Emit	Yes	No
Security	Managed code execution	Yes	Yes
Security	Assert granted permissions	Yes	No
User Interface	Unrestricted	Yes	No
User Interface	Safe top level windows	Yes	Yes
User Interface	Own Clipboard	Yes	Yes
Web Browser	Safe frame navigation to HTML	Yes	Yes

> **NOTE**
>
> Cut and Paste is only allowed in partial trust when user initiated.

If you need to increase permissions, you need to change the project settings and the ClickOnce application manifest. For more information, see WPF XAML Browser Applications Overview. The following documents may also be helpful.

- Mage.exe (Manifest Generation and Editing Tool).
- MageUI.exe (Manifest Generation and Editing Tool, Graphical Client).
- Securing ClickOnce Applications.

If your XBAP requires full trust, you can use the same tools to increase the requested permissions. Although an XBAP will only receive full trust if it is installed on and launched from the local computer, the intranet, or from a URL that is listed in the browser's trusted or allowed sites. If the application is installed from the intranet or a trusted site, the user will receive the standard ClickOnce prompt notifying them of the elevated permissions. The user can choose to continue or cancel the installation.

Alternatively, you can use the ClickOnce Trusted Deployment model for full trust deployment from any security zone. For more information, see Trusted Application Deployment Overview and Security.

See also

- Security
- WPF Security Strategy - Platform Security
- WPF Security Strategy - Security Engineering

WPF Security Strategy - Platform Security

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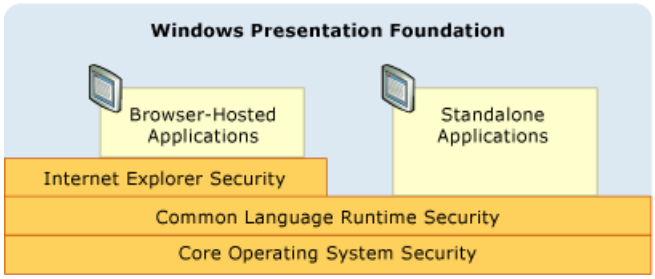
While Windows Presentation Foundation (WPF) provides a variety of security services, it also leverages the security features of the underlying platform, which includes the operating system, the CLR, and Internet Explorer. These layers combine to provide WPF a strong, defense-in-depth security model that attempts to avoid any single point of failure, as shown in the following figure:



The remainder of this topic discusses the features in each of these layers that pertain to WPF specifically.

Operating System Security

The minimum level of operating system that is required by WPF is Windows XP SP2. The core of Windows XP SP2 provides several security features that form the security foundation for all Windows applications, including those built with WPF. Windows Vista incorporates the security features of WPF and extends them further. This topic discusses the breadth of these security features that are important to WPF, as well as how WPF integrates with them to provide further defense-in-depth.

Microsoft Windows XP Service Pack 2 (SP2)

In addition to a general review and strengthening of Windows, there are three key features from Windows XP SP2 that we will discuss in this topic:

- /GS compilation
- Microsoft Windows Update.

/GS Compilation

Windows XP SP2 provides protection by recompiling many core system libraries, including all of the WPF dependencies such as the CLR, to help mitigate buffer overruns. This is achieved by using the /GS parameter with the C/C++ command-line compiler. Although buffer overruns should be explicitly avoided, /GS compilation provides an example of a defense-in-depth against potential vulnerabilities that are inadvertently or maliciously created by them.

Historically, buffer overruns have been the cause of many high-impact security exploits. A buffer overrun occurs when an attacker takes advantage of a code vulnerability that allows the injection of malicious code that writes past the boundaries of a buffer. This then allows an attacker to hijack the process in which the code is executing by overwriting the return address of a function to cause the execution of the attacker's code. The result is malicious code that executes arbitrary code with the same privileges as the hijacked process.

At a high level, the /GS compiler flag protects against some potential buffer overruns by injecting a special security cookie to protect the return address of a function that has local string buffers. After a function returns, the security cookie is compared with its previous value. If the value has changed, a buffer overrun may have occurred and the process is stopped with an error condition. Stopping the process prevents the execution of potentially malicious code. See /GS (Buffer Security Check) for more details.

WPF is compiled with the /GS flag to add yet another layer of defense to WPF applications.

Microsoft Windows Update Enhancements

Microsoft Windows Update was also improved in Windows XP SP2 to simplify the process for downloading and installing updates. These changes significantly enhance security for WPF customers by helping to ensure that their systems are up-to-date, particularly with respect to security updates.

Windows Vista

WPF users on Windows Vista will benefit from the operating system's additional security enhancements, including "Least-Privilege User Access", code integrity checks, and privilege isolation.

User Account Control (UAC)

Today, Windows users tend to run with administrator privileges because many applications require them for either installation or execution, or both. Being able to write default application settings to the Registry is one example.

Running with administrator privileges really means that applications execute from processes that are granted administrator privileges. The security impact of this is that any malicious code that hijacks a process running with administrator privileges will automatically inherit those privileges, including access to critical system resources.

One way to protect against this security threat is to run applications with the least amount of privileges that are required. This is known as the principle of least privilege, and is a core feature of the Windows Vista operating system. This feature is called User Account Control (UAC), and is used by Windows Vista UAC in two key ways:

- To run most applications with UAC privileges by default, even if the user is an administrator; only applications that need administrator privileges will run with administrator privileges. To run with administrative privileges, applications must be explicitly marked in either their application manifest or as an entry in security policy.
- To provide compatibility solutions like virtualization. For example, many applications try to write to restricted locations like C:\Program Files. For applications executing under UAC, an alternative per-user location exists that does not require administrator privileges to write to. For applications running under UAC, UAC virtualizes C:\Program Files so that applications who think they are writing to it are actually writing to the alternative, per-user location. This kind of compatibility work enables the operating system to run many applications that couldn't previously run in UAC.

Code Integrity Checks

Windows Vista incorporates deeper code integrity checks to help prevent malicious code from being injected into system files or into the kernel at load/run time. This goes beyond system file protection.

Limited Rights Process for Browser-Hosted Applications

Browser-hosted WPF applications execute within the Internet zone sandbox. WPF integration with Microsoft Internet Explorer extends this protection with additional support.

Internet Explorer 6 Service Pack 2 and Internet Explorer 7 for XP

WPF leverages operating system security by limiting process privileges for XAML browser applications (XBAPs) for further protection. Before a browser-hosted WPF application is launched, the operating system creates a host process that removes unnecessary privileges from the process token. Some examples of privileges that are removed include the ability to shut down the user's machine, load drivers, and read access to all files on the machine.

Internet Explorer 7 for Vista

In Windows Internet Explorer 7, WPF applications run in protected mode. Specifically, XAML browser applications (XBAPs) run with medium-level integrity.

Defense-In-Depth Layer

Since XAML browser applications (XBAPs) are generally sandboxed by the Internet zone permission set,

removing these privileges does not harm XAML browser applications (XBAPs) from a compatibility perspective. Instead, an additional defense-in-depth layer is created; if a sandboxed application is able to exploit other layers and hijack the process, the process will still only have limited privileges.

See Using a Least-Privileged User Account.

Common Language Runtime Security

The common language runtime (CLR) offers a number of key security benefits that include validation and verification, Code Access Security (CAS), and the Security Critical Methodology.

Validation and Verification

To provide assembly isolation and integrity, the CLR uses a process of validation. CLR validation ensures that assemblies are isolated by validating their Portable Executable (PE) file format for addresses that point outside the assembly. CLR validation also validates the integrity of the metadata that is embedded within an assembly.

To ensure type safety, help prevent common security issues (e.g. buffer overruns), and enable sandboxing through sub-process isolation, CLR security uses the concept of verification.

Managed applications are compiled into Microsoft Intermediate Language (MSIL). When methods in a managed application are executed, its MSIL is compiled into native code through Just-In-Time (JIT) compilation. JIT compilation includes a verification process that applies many safety and robustness rules that ensure code does not:

- Violate type contracts
- Introduce buffer overruns
- Wildly access memory.

Managed code that does not conform to verification rules is not allowed to execute, unless it is considered trusted code.

The advantage of verifiable code is a key reason why WPF builds on the .NET Framework. To the extent that verifiable code is used, the possibility of exploiting possible vulnerabilities is greatly lowered.

Code Access Security

A client machine exposes a wide variety of resources that a managed application can have access to, including the file system, the Registry, printing services, the user interface, reflection, and environment variables. Before a managed application can access any of the resources on a client machine, it must have .NET Framework permission to do so. A permission in CAS is a subclass of the CodeAccessPermission; CAS implements one subclass for each resource that managed applications can access.

The set of permissions that a managed application is granted by CAS when it starts executing is known as a permission set and is determined by evidence provided by the application. For WPF applications, the evidence that is provided is the location, or zone, from which the applications are launched. CAS identifies the following zones:

- **My Computer**. Applications launched from the client machine (Fully Trusted).
- **Local Intranet**. Applications launched from the intranet. (Somewhat Trusted).
- **Internet**. Applications launched from the Internet. (Least Trusted).
- **Trusted Sites**. Applications identified by a user as being trusted. (Least Trusted).
- **Untrusted Sites**. Applications identified by a user as being untrusted. (Untrusted).

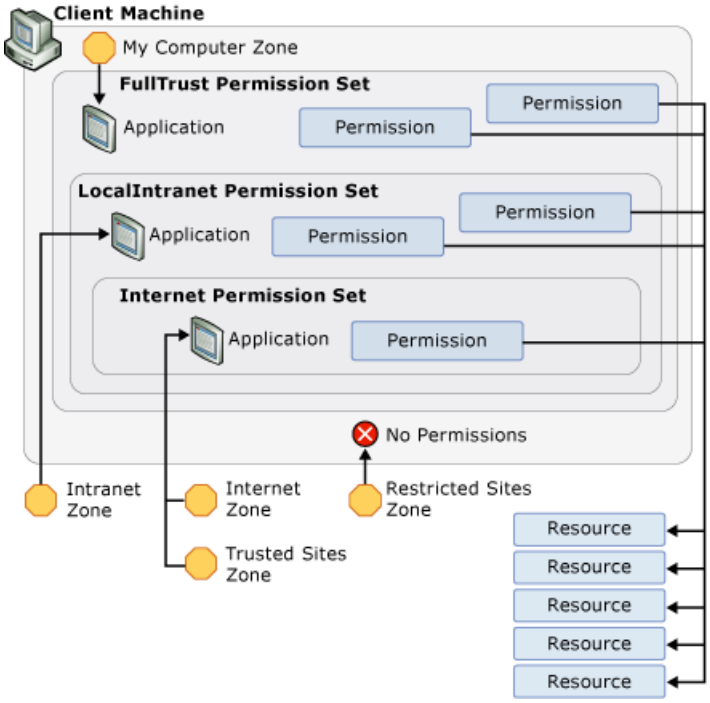
For each of these zones, CAS provides a predefined permission set that includes the permissions which matches

the level of trust associated with each. These include:

- **FullTrust**. For applications launched from the **My Computer** zone. All possible permissions are granted.
- **LocalIntranet**. For applications launched from the **Local Intranet** zone. A subset of permissions are granted to provide moderate access to a client machine's resources, including isolated storage, unrestricted UI access, unrestricted file dialogs, limited reflection, limited access to environment variables. Permissions for critical resources like the Registry are not provided.
- **Internet**. For applications launched from the **Internet** or **Trusted Sites** zone. A subset of permissions are granted to provided limited access to a client machine's resources, including isolated storage, file open only, and limited UI. Essentially, this permission sets isolates applications from the client machine.

Applications identified as being from the **Untrusted Sites** zone are granted no permissions by CAS at all. Consequently, a predefined permission set does not exist for them.

The following figure illustrates the relationship between zones, permission sets, permissions, and resources.



The restrictions of the Internet zone security sandbox apply equally to any code that a XBAP imports from a system library, including WPF. This ensures that every bit of the code is locked down, even WPF. Unfortunately, to be able to execute, a XBAP needs to execute functionality that requires more permissions than those enabled by the Internet zone security sandbox.

Consider a XBAP application that includes the following page:

```
FileIOPermission fp = new FileIOPermission(PermissionState.Unrestricted);
fp.Assert();

// Perform operation that uses the assert

// Revert the assert when operation is completed
CodeAccessPermission.RevertAssert();
```

```
Dim fp As New FileIOPermission(PermissionState.Unrestricted)
fp.Assert()

' Perform operation that uses the assert

' Revert the assert when operation is completed
CodeAccessPermission.RevertAssert()
```

To execute this XBAP, the underlying WPF code must execute more functionality than is available to the calling XBAP, including:

- Creating a window handle (hWnd) for rendering
- Dispatching messages
- Loading the Tahoma font

From a security point of view, allowing direct access to any of these operations from the sandboxed application would be catastrophic.

Fortunately, WPF caters to this situation by allowing these operations to execute with elevated privileges on behalf of the sandboxed application. While all WPF operations are checked against the limited Internet zone security permissions of the application domain of the XBAP, WPF (as with other system libraries) is granted a permission set that includes all possible permissions

This requires that WPF receives elevated privileges while preventing those privileges from being governed by the Internet zone permission set of the host application domain.

WPF does this by using the **Assert** method of a permission. The following code shows how this happens.

```
FileIOPermission fp = new FileIOPermission(PermissionState.Unrestricted);
fp.Assert();

// Perform operation that uses the assert

// Revert the assert when operation is completed
CodeAccessPermission.RevertAssert();
```

```
Dim fp As New FileIOPermission(PermissionState.Unrestricted)
fp.Assert()

' Perform operation that uses the assert

' Revert the assert when operation is completed
CodeAccessPermission.RevertAssert()
```

The **Assert** essentially prevents the unlimited permissions required by WPF from being restricted by the Internet zone permissions of the XBAP.

From a platform perspective, WPF is responsible for using **Assert** correctly; an incorrect use of **Assert** could enable malicious code to elevate privileges. Consequently, it is important then to only call **Assert** when needed, and to ensure that sandbox restrictions remain intact. For example, sandboxed code is not allowed to open random files, but it is allowed to use fonts. WPF enables sandboxed applications to use font functionality by calling **Assert**, and for WPF to read files known to contain those fonts on behalf of the sandboxed application.

ClickOnce Deployment

ClickOnce is a comprehensive deployment technology that is included with .NET Framework, and integrates with Microsoft Visual Studio (see ClickOnce Deployment Overview for detailed information). Standalone WPF

applications can be deployed using ClickOnce, while browser-hosted applications must be deployed with ClickOnce.

Applications deployed using ClickOnce are given an additional security layer over Code Access Security (CAS); essentially, ClickOnce deployed applications request the permissions that they need. They are granted only those permissions if they do not exceed the set of permissions for the zone from which the application is deployed. By reducing the set of permissions to only those that are needed, even if they are less than those provided by the launch zone's permission set, the number of resources that the application has access to is reduce to a bare minimum. Consequently, if the application is hijacked, the potential for damage to the client machine is reduced.

Security-Critical Methodology

The WPF code that uses permissions to enable the Internet zone sandbox for XBAP applications must be held to highest possible degree of security audit and control. To facilitate this requirement, .NET Framework provides new support for managing code that elevates privilege. Specifically, the CLR enables you to identify code that elevates privilege and mark it with the SecurityCriticalAttribute; any code not marked with SecurityCriticalAttribute becomes *transparent* using this methodology. Conversely, managed code that is not marked with SecurityCriticalAttribute is prevented from elevating privilege.

The Security-Critical Methodology allows the organization of WPF code that elevates privilege into *security-critical kernel*, with the remainder being transparent. Isolating the security-critical code enables the WPF engineering team focus an additional security analysis and source control on the security-critical kernel above and beyond standard security practices (see WPF Security Strategy - Security Engineering).

Note that .NET Framework permits trusted code to extend the XBAP Internet zone sandbox by allowing developers to write managed assemblies that are marked with AllowPartiallyTrustedCallersAttribute (APTCA) and deployed to the user's Global Assembly Cache (GAC). Marking an assembly with APTCA is a highly sensitive security operation as it allows any code to call that assembly, including malicious code from the Internet. Extreme caution and best practices must be used when doing this and users must choose to trust that software in order for it to be installed.

Microsoft Internet Explorer Security

Beyond reducing security issues and simplifying security configuration, Microsoft Internet Explorer 6 (SP2) contains several features that security improvements that enhance security for users of XAML browser applications (XBAPs). The thrust of these features attempts to allow users greater control over their browsing experience.

Prior to IE6 SP2, users could be subject to any of the following:

- Random popup windows.
- Confusing script redirection.
- Numerous security dialogs on some Web sites.

In some cases, untrustworthy Web sites would try to trick users by spoofing installation user interface (UI) or repeatedly showing a Microsoft ActiveX installation dialog box, even though the user may have canceled it. Using these techniques, it is possible that a significant number of users have been tricked into making poor decisions that resulted with the installation of spyware applications.

IE6 SP2 includes several features to mitigate these types of issues, which revolve around the concept of user initiation. IE6 SP2 detects when a user has clicked on a link or page element prior to an action, which is known as *user initiation*, and treats it differently than when a similar action is instead triggered by the script on a page. As an example, IE6 SP2 incorporates a **Pop-Up Blocker** that detects when a user clicks a button prior to the page creating a pop-up. This enables IE6 SP2 to allow most innocuous pop-ups while preventing pop-ups that users neither ask for nor want. Blocked pop-ups are trapped under the new **Information Bar**, which allows the user to

manually override the block and view the pop-up.

The same user-initiation logic is also applied to **Open**/**Save** security prompts. ActiveX installation dialog boxes are always trapped under the Information Bar unless they represent an upgrade from a previously installed control. These measures combine to give users a safer, more controlled user experience since they are protected against sites which harass them to install either unwanted or malicious software.

These features also protect customers who use IE6 SP2 to browse to web sites that allow them to download and install WPF applications. In particular, this is because IE6 SP2 offers a better user experience that reduces the chance for users to install malicious or devious applications irrespective of what technology was used to build it, including WPF. WPF adds to these protections by using ClickOnce to facilitate downloading of its applications over the Internet. Since XAML browser applications (XBAPs) execute within an Internet zone security sandbox, they can be seamlessly launched. On the other hand, standalone WPF applications require full trust to execute. For these applications, ClickOnce will display a security dialog box during the launch process to notify the use of the application's additional security requirements. However, this must be user-initiated, will also be governed by user initiated logic, and can be canceled.

Internet Explorer 7 incorporates and extends the security capabilities of IE6 SP2 as part of an ongoing commitment to security.

See also

- Understanding Security in Microsoft Internet Explorer 6 in Windows XP SP2
- Understanding and Working in Protected Mode Internet Explorer
- Windows XP Service Pack 3
- Windows Vista Security Guide
- Code Access Security
- Security
- WPF Partial Trust Security
- WPF Security Strategy - Security Engineering

WPF Security Strategy - Security Engineering

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Trustworthy Computing is a Microsoft initiative for ensuring the production of secure code. A key element of the Trustworthy Computing initiative is the Microsoft Security Development Lifecycle (SDL). The SDL is an engineering practice that is used in conjunction with standard engineering processes to facilitate the delivery of secure code. The SDL consists of ten phases that combine best practices with formalization, measurability, and additional structure, including:

- Security design analysis
- Tool-based quality checks
- Penetration testing
- Final security review
- Post release product security management

WPF Specifics

The WPF engineering team both applies and extends the SDL, the combination of which includes the following key aspects:

Threat Modeling

Security Analysis and Editing Tools

Testing Techniques

Critical Code Management

Threat Modeling

Threat modeling is a core component of the SDL, and is used to profile a system to determine potential security vulnerabilities. Once the vulnerabilities are identified, threat modeling also ensures that appropriate mitigations are in place.

At a high level, threat modeling involves the following key steps by using a grocery store as an example:

1. **Identifying Assets**. A grocery store's assets might include employees, a safe, cash registers, and inventory.
2. **Enumerating Entry Points**. A grocery store's entry points might include the front and back doors, windows, the loading dock, and air conditioning units.
3. **Investigating Attacks against Assets using Entry Points**. One possible attack could target a grocery store's *safe* asset through the *air conditioning* entry point; the air conditioning unit could be unscrewed to allow the safe to be pulled up through it and out of the store.

Threat modeling is applied throughout WPF and includes the following:

- How the XAML parser reads files, maps text to corresponding object model classes, and creates the actual code.
- How a window handle (hWnd) is created, sends messages, and is used for rendering the contents of a window.

- How data binding obtains resources and interacts with the system.

These threat models are important for identifying security design requirements and threat mitigations during the development process.

Source Analysis and Editing Tools

In addition to the manual security code review elements of the SDL, the WPF team uses several tools for source analysis and associated edits to decrease security vulnerabilities. A wide range of source tools are used, and include the following:

- **FXCop**: Finds common security issues in managed code ranging from inheritance rules to code access security usage to how to safely interoperate with unmanaged code. See FXCop.
- **Prefix/Prefast**: Finds security vulnerabilities and common security issues in unmanaged code such as buffer overruns, format string issues, and error checking.
- **Banned APIs**: Searches source code to identify accidental usage of functions that are well-known for causing security issues, such as `strcpy`. Once identified, these functions are replaced with alternatives that are more security.

Testing Techniques

WPF uses a variety of security testing techniques that include:

- **Whitebox Testing**: Testers view source code, and then build exploit tests
- **Blackbox Testing**: Testers try to find security exploits by examining the API and features, and then try to attack the product.
- **Regressing Security Issues from other Products**: Where relevant, security issues from related products are tested. For example, appropriate variants of approximately sixty security issues for Internet Explorer have been identified and tried for their applicability to WPF.
- **Tools-Based Penetration Testing through File Fuzzing**: File fuzzing is the exploitation of a file reader's input range through a variety of inputs. One example in WPF where this technique is used is to check for failure in image decoding code.

Critical Code Management

For XAML browser applications (XBAPs), WPF builds a security sandbox by using .NET Framework support for marking and tracking security-critical code that elevates privileges (see **Security-Critical Methodology** in WPF Security Strategy - Platform Security). Given the high security quality requirements on security critical code, such code receives an additional level of source management control and security audit. Approximately 5% to 10% of WPF consists of security-critical code, which is reviewed by a dedicated reviewing team. The source code and check-in process is managed by tracking security critical code and mapping each critical entity (i.e. a method that contains critical code) to its sign off state. The sign off state includes the names of one or more reviewers. Each daily build of WPF compares the critical code to that in previous builds to check for unapproved changes. If an engineer modifies critical code without approval from the reviewing team, it is identified and fixed immediately. This process enables the application and maintenance of an especially high level of scrutiny over WPF sandbox code.

See also

- Security
- WPF Partial Trust Security
- WPF Security Strategy - Platform Security
- Trustworthy Computing
- Application Threat Modeling

- Security Guidelines: .NET Framework 2.0

WPF Samples

11/10/2018 • 2 minutes to read • Edit Online

For samples that demonstrate Windows Presentation Foundation (WPF), see the Microsoft/WPF-Samples repo on GitHub.

Class Library (WPF)

5/4/2018 • 2 minutes to read • Edit Online

The following links refer to namespaces that contain Windows Presentation Foundation (WPF) APIs.

In This Section

Reference

- Microsoft.Build.Tasks.Windows
- Microsoft.Win32 (shared)
- Microsoft.Windows.Themes
- System.Collections.ObjectModel (shared)
- System.Collections.Specialized (shared)
- System.ComponentModel (shared)
- System.Diagnostics (shared)
- System.IO (shared)
- System.IO.Packaging
- System.Printing
- System.Printing.IndexedProperties
- System.Printing.Interop
- System.Security.Permissions (shared)
- System.Security.RightsManagement
- System.Windows
- System.Windows.Annotations
- System.Windows.Annotations.Storage
- System.Windows.Automation
- System.Windows.Automation.Peers
- System.Windows.Automation.Provider
- System.Windows.Automation.Text
- System.Windows.Controls
- System.Windows.Controls.Primitives
- System.Windows.Converters
- System.Windows.Data

- System.Windows.Documents
- System.Windows.Documents.DocumentStructures
- System.Windows.Documents.Serialization
- System.Windows.Forms.Integration
- System.Windows.Ink
- System.Windows.Input
- System.Windows.Input.StylusPlugIns
- System.Windows.Interop
- System.Windows.Markup (shared)
- System.Windows.Markup.Localizer
- System.Windows.Markup.Primitives
- System.Windows.Media
- System.Windows.Media.Animation
- System.Windows.Media.Converters
- System.Windows.Media.Effects
- System.Windows.Media.Imaging
- System.Windows.Media.Media3D
- System.Windows.Media.Media3D.Converters
- System.Windows.Media.TextFormatting
- System.Windows.Navigation
- System.Windows.Resources
- System.Windows.Shapes
- System.Windows.Threading
- System.Windows.Xps
- System.Windows.Xps.Packaging
- System.Windows.Xps.Serialization
- UIAutomationClientsideProviders

XAML Support in .NET 4

The following namespaces contain types from the System.Xaml assembly. System.Xaml provides common XAML language support for frameworks such as WPF that are built on .NET Framework 4.

- System.Windows.Markup (shared)
- System.Xaml
- System.Xaml.Permissions

- System.Xaml.Schema