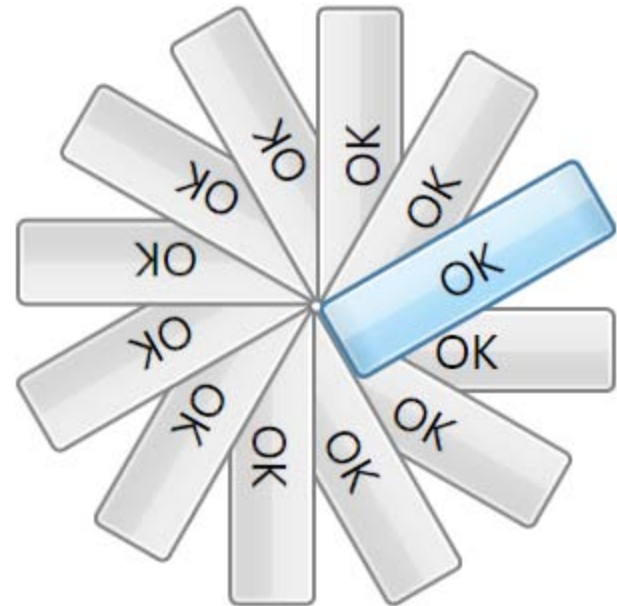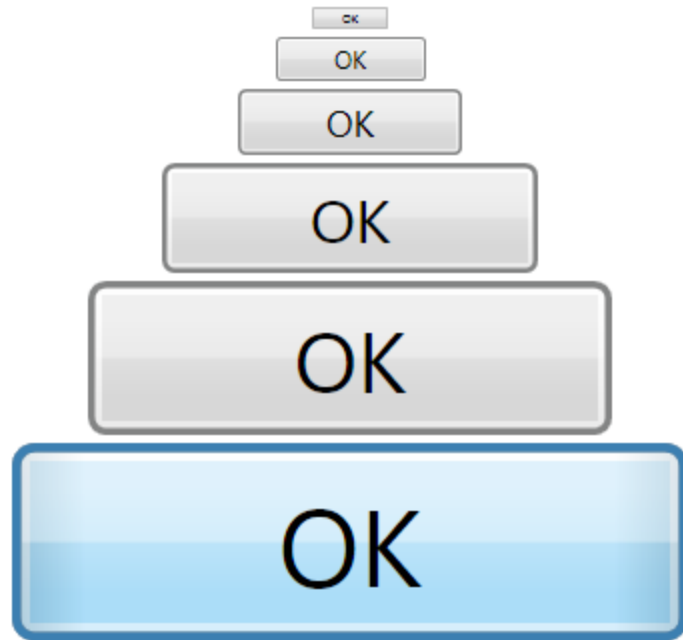# Graphics

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Outline

- **Graphics architecture**

- **Drawing primitives**

- **Imaging and video**

- **Transforms**

- **Effects**

WPF and Modern Graphics Cards

.NET   WPF

MIL

Accelerated 3D
rendering pipeline   DirectX
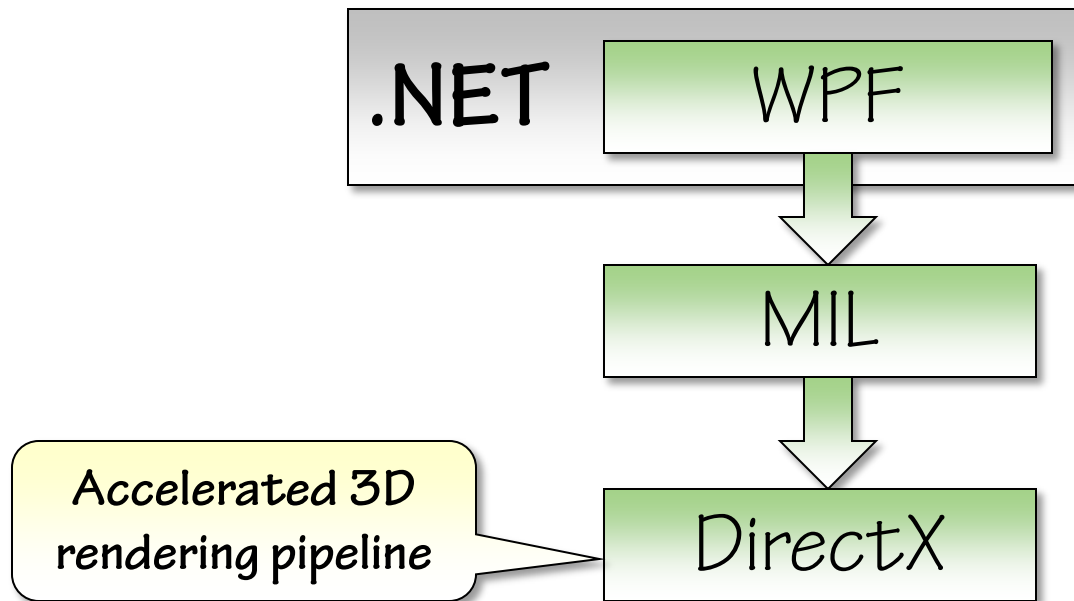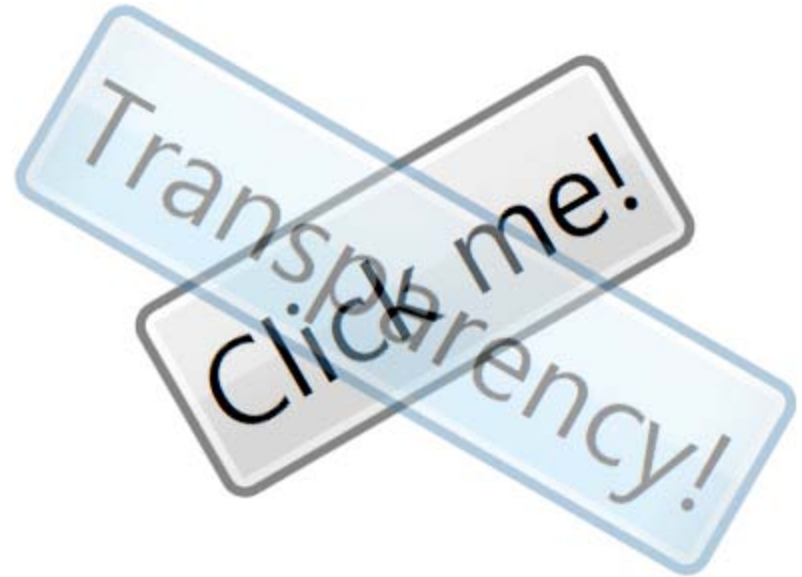
Transformability

Composition and Integration

Procedural vs. Declarative

```csharp
public class CustomRender : FrameworkElement
{
  protected override void OnRender(DrawingContext drawingContext)
  {
    Rect r = new Rect(0, 0, ActualWidth, ActualHeight);
    drawingContext.DrawRectangle(Brushes.Red, null, r);

    Point ellipseCenter = new Point(Actu
    drawingContext.DrawEllipse(Brushes.Y
        ellipseCenter, ActualWidth / 2 -
  }
}
```

```csharp
public class Declarative : Grid
{
  public Declarative()
  {
    Rectangle r = new Rectangle();
    r.Fill = Brushes.Red;
    Children.Add(r);
    Ellipse e = new Ellipse();
    e.Fill = Brushes.Yellow;
    e.Stroke = Brushes.Black;
    e.StrokeThickness = 2;
    Children.Add(e);
  }
}
```

```xml
<Grid>
  <Rectangle Fill="Red" />
  <Ellipse Fill="Yellow" Stroke="Black"
          StrokeThickness="2" />
</Grid>
```

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Primitives vs. Shape

Low-level
Brush
Pen
Point
Rect
Geometry

Lightweight
Transient

Shape
Line
Rectangle
Ellipse
Polyline
Polygon
Path

Modifiable
Events
Data binding
Layout
Styling
Animation

Basic brushes

SolidColorBrush

LinearGradientBrush

RadialGradientBrush
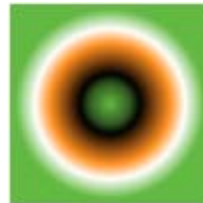
Pens

Any Brush +

Thickness	
Dash pattern	
Join style	
End caps	

Geometries

```xml
<Path Stroke="Black" Fill="Green">
  <Path.Data>
    <PathGeometry>
      <PathFigure StartPoint="50,0"
                  IsClosed="True">
        <LineSegment Point="100,50" />
        <LineSegment Point="50,100" />
        <LineSegment Point="0,50" />
      </PathFigure>
    </PathGeometry>
  </Path.Data>
</Path>
```
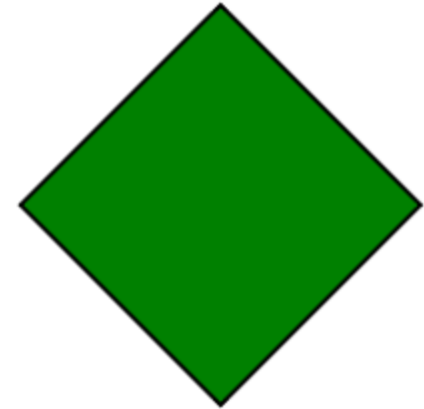
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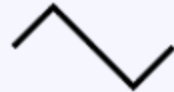
Multi-figure PathGeometry

```xml
<Path Stroke="Black" Fill="Green">
  <Path.Data>
    <PathGeometry>
      <PathFigure StartPoint="50,0"
                  IsClosed="True">
        <LineSegment Point="100,50" />
        <LineSegment Point="50,100" />
        <LineSegment Point="0,50" />
      </PathFigure>

      <PathFigure StartPoint="10,10"
                  IsClosed="True">
        <LineSegment Point="90,10" />
        <LineSegment Point="90,90" />
        <LineSegment Point="10,90" />
      </PathFigure>
    </PathGeometry>
  </Path.Data>
</Path>
```
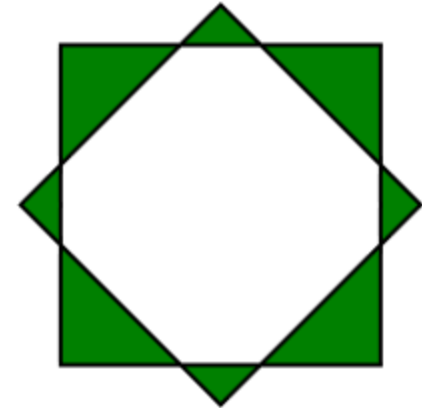
PathGeometry Segment Types

LineSegment	
PolyLineSegment	
ArcSegment	
QuadraticBezierSegment	
PolyQuadraticBezierSegment	
BezierSegment	
PolyBezierSegment	

Simple Geometries

LineGeometry	
RectangleGeometry	
EllipseGeometry	

GeometryGroup

```xml
<Path Stroke="Black" StrokeThickness="7" Fill="White">
  <Path.Data>
    <GeometryGroup>
      <PathGeometry>
        <PathFigure StartPoint="5,26" IsClosed="True">
          <BezierSegment Point1="24,55" Point2="76,55" Point3="95,26" />
          <BezierSegment Point1="76,-3" Point2="24,-3" Point3="5,26" />
        </PathFigure>
      </PathGeometry>

      <EllipseGeometry Center="50,26" RadiusX="21" RadiusY="21" />
    </GeometryGroup>
  </Path.Data>
</Path>
```
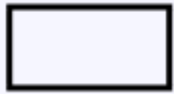
Path Syntax

```xml
<Path Stroke="Black" StrokeThickness="7" Fill="White">
  <Path.Data>
    <GeometryGroup>
      <PathGeometry
            Figures="M5,26 C 24,55 76,55 95,26  76,-3 24,-3 5,26 z" />

      <EllipseGeometry Center="50,26" RadiusX="21" RadiusY="21" />
    </GeometryGroup>
  </Path.Data>
</Path>
```

```xml
<Path Stroke="Black" StrokeThickness="7" Fill="White"
      Data="M5,26 C 24,55 76,55 95,26  76,-3 24,-3 5,26 z
            M29,26 A21,21 0 1,1 29,26.1 z" />
```

StreamGeometry

CombinedGeometry

GeometryCombineMode	
Exclude	
Intersect	
Union	
Xor	

+

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Drawings

```xml
<DrawingGroup>
  <GeometryDrawing Brush="#63B941">
    <GeometryDrawing.Geometry>
      <RectangleGeometry Rect="32,8,19,36" />
    </GeometryDrawing.Geometry>
  </GeometryDrawing>
...
  <GeometryDrawing Brush="White">
    <GeometryDrawing.Pen>
      <Pen Brush="Black" Thickness="7" />
    </GeometryDrawing.Pen>
    <GeometryDrawing.Geometry>
      <GeometryGroup>
        <StreamGeometry>
          M5,26 C 24,55 76,55 95,26 76,-3 24,-3 5,26 z
        </StreamGeometry>
        <EllipseGeometry Center="50,26" RadiusX="21" RadiusY="21" />
      </GeometryGroup>
    </GeometryDrawing.Geometry>
  </GeometryDrawing>
  <GeometryDrawing Brush="Black">
    <GeometryDrawing.Geometry>
      <GeometryGroup>
        <EllipseGeometry Center="50,4"  RadiusX="4" RadiusY="4" />
        <EllipseGeometry Center="50,15" RadiusX="4" RadiusY="4" />

...
```
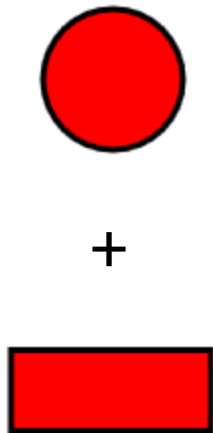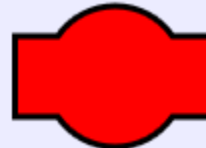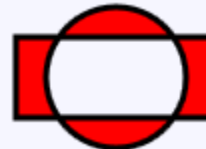

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Composite Brushes

```xml
<Grid>
  <Grid.Background>
    <DrawingBrush>
      <DrawingBrush.Drawing>
        <DrawingGroup>
          ...
        </DrawingGroup>
      </DrawingBrush.Dr
    </DrawingBrush>
  </Grid.Background>
...
```

```xml
<Grid x:Name="myElement">
  ...
</Grid>
...
<Grid>
  <Grid.Background>
    <VisualBrush
      Visual="{Binding ElementName=myElement}" />
  </Grid.Background>
...
```

Imaging

- **Image and ImageBrush**

- **ImageSource**
  - DrawingImage
  - BitmapSource

- **BitmapEncoder and BitmapDecoder**
  - Bmp, Gif, Icon, Jpeg, Png, Tiff, Wmp

```xml
<Image Source="MyBitmap.jpg" />
```

```xml
<Rectangle ...>
  <Rectangle.Fill>
    <ImageBrush
      ImageSource="Bmp.jpg" />
  </Rectangle.Fill>
</Rectangle>
```

Video

- **MediaElement and VideoDrawing**
    - VisualBrush and DrawingBrush

```
<MediaElement
    Source="Source.wmv" />
```

TileBrush

- **ImageBrush, DrawingBrush, VisualBrush**
- **Stretch**
- **TileMode**
- **Viewport and Viewbox**

Transforms

- **FrameworkElement**
  - RenderTransform
  - LayoutTransform

- **Geometry**

- **Brush**
  - RelativeTransform
  - Transform

ScaleTransform
TranslateTransform
RotateTransform
SkewTransform
TransformGroup
MatrixTransform

Clipping and OpacityMask

```xml
<Button Content="Click me!">
  <Button.Clip>
    <EllipseGeometry Center="28,12"
          RadiusX="30" RadiusY="10" />
  </Button.Clip>
</Button>
```



```xml
<Button Content="Click me!">
  <Button.OpacityMask>
    <RadialGradientBrush>
      <GradientStop Color="Transparent"
                    Offset="0" />
      <GradientStop Color="White"
                    Offset="0.4" />
      <GradientStop Color="White"
                    Offset="0.8" />
      <GradientStop Color="#2000"
                    Offset="1" />
    </RadialGradientBrush>
  </Button.OpacityMask>
</Button>
```

Bitmap Effects

Shadow

Emboss

Blur

Bevel

Glow

DropShadowBitmapEffect

BlurBitmapEffect

EmbossBitmapEffect

BevelBitmapEffect

OuterGlowBitmapEffect

BitmapEffectGroup

Animation

- **Any property of any FrameworkElement**

```xml
<Rectangle Fill="Green" HorizontalAlignment="Left" Height="24">
  <Rectangle.Triggers>
    <EventTrigger RoutedEvent="Rectangle.Loaded">
      <BeginStoryboard>
        <Storyboard>

          <DoubleAnimation From="10" To="100" Duration="0:0:10"
                  Storyboard.TargetProperty="(Rectangle.Width)" />


        </Storyboard>
      </BeginStoryboard>
    </EventTrigger>
  </Rectangle.Triggers>
</Rectangle>
```

3D

```xml
<Viewport3D>
  <Viewport3D.Camera>
    <PerspectiveCamera Position="2,0,10" LookDirection="0.2,0.4,-1"
                       FieldOfView="65" UpDirection="0,1,0" />
  </Viewport3D.Camera>
  <ModelVisual3D>
    <ModelVisual3D.Content>
      <Model3DGroup>
        <AmbientLight Color="#fff" />
        <GeometryModel3D>
          <GeometryModel3D.Geometry>
            <MeshGeometry3D
              Positions="0,0,0 0,10,0 10,0,0 10,10,0"
              Normals="0,0,1 0,0,1 0,0,1 0,0,1"
              TriangleIndices="0,2,1 1,2,3"/>
          </GeometryModel3D.Geometry>
          <GeometryModel3D.Material>
            <DiffuseMaterial Brush="Red" />
          </GeometryModel3D.Material>
        </GeometryModel3D>
      </Model3DGroup>
    </ModelVisual3D.Content>
  </ModelVisual3D>
</Viewport3D>
```

Summary

- **Graphics architecture**

- **Drawing primitives**

- **Imaging and video**

- **Transforms**

- **Effects**