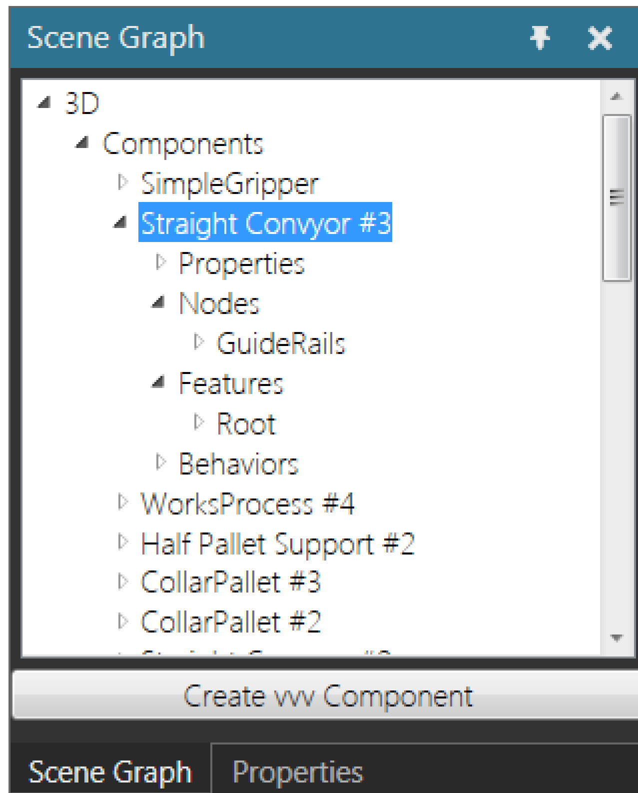
Adding plugins to Essentials

Essentials | Version: August 4, 2016



Essentials supports the development of system components which can be deployed as plugins that add functionality.

At its core, an Essentials plugin implements and is exported as a type of **IPlugin** interface. The plugin can operate in the background or be deployed with a user interface during runtime. In terms of object manipulation, the data of a simulation can be manipulated and stored in collections, which can be updated using event handlers tied to methods. Components and other objects native to Essentials can be created entirely using API.

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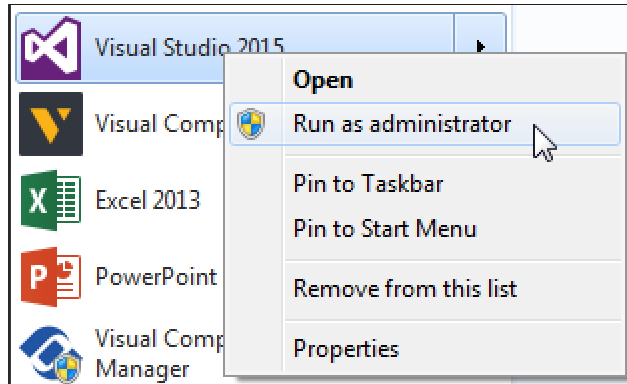
Step 1. Create a project in Visual Studio

Visual Studio 2015 and Visual C# are used to create a plugin that displays the data structure of simulated environments.

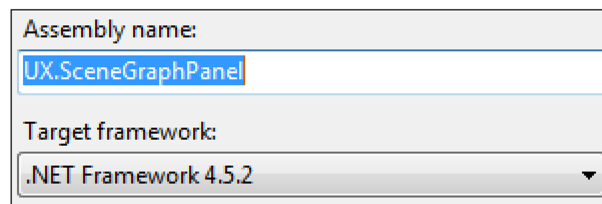
1. Run Visual Studio as an administrator.



2. Create a new **Class Library** project that uses a version of .NET Framework 4.5 and name the library **SceneGraphPanel**.

3. Access the properties of the project, and then do all of the following:

   - In the Application tab, set **Assembly name** to have a "UX." prefix in order to identify the assembly as an extension of the VisualComponents.UX namespace.

   - In the Build tab, under Output, set **Output path** to be the same directory as your Essentials program files.

   - In the Debug tab, under Start Action, set **Start external program** to be the executable file of Essentials.

4. Add references to the following assemblies and namespaces:

   - **Create3D.Shared** and **UX.Shared** which are available in your Essentials program files.

   - **System.ComponentModel.Composition** that is available in the .NET Framework.

5. (Optional) Delete the **Class1.cs** item from your project.

Step 2. Develop a simple plugin

It is important to understand that an Essentials plugin does not require a user interface. Any client object (plugin) that implements and is exported as a type of **IPlugin** interface can be automatically imported by Essentials. To demonstrate this concept, complete the following steps.

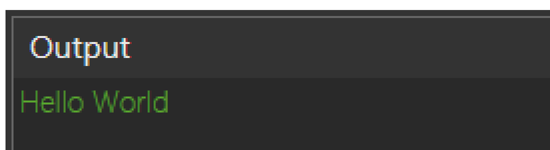
1. In your project, add a new **Class** item and name it **HelloWorld**.

2. In the Code view for HelloWorld, type the following code to define a simple plugin that prints "Hello World" in the Output panel of Essentials.

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;

namespace SceneGraphPanel
{
    using System.ComponentModel.Composition;
    using VisualComponents.Create3D;
    using VisualComponents.UX.Shared;

    [Export(typeof(IPlugin))]
    class HelloWorld : IPlugin
    {
        [Import]
        private Lazy<IApplication> _application = null;

        public void Exit()
        {
        }

        public void Initialize()
        {
            this._application.Value.WriteLine("Hello World");
        }
    }
}
```

NOTE! You can use the Initialize() and Exit() methods to receive notifications about the application's lifecycle.

3. Start debugging your project, and then verify the "Hello World" message is printed in the Output panel of Essentials, and then stop debugging your project.



Step 3. Collect simulation data

The hierarchy of the 3D world, drawing world and components are tree structures. Therefore, you can collect and sort this data in collections as well as visualize the data and its hierarchy in TreeView controls.

1. In your project, add a reference to **Caliburn.Micro** which is available in your Essentials program files. Next, add a new **Class** item and name it **TreeNodeViewModel**.

2. In the Code view for TreeNodeViewModel, type the following code to complete the TreeNodeViewModel class which is declared as public.

```
namespace SceneGraphPanel
{
    using Caliburn.Micro;
    using System.Collections.Generic;
    using System.Collections.ObjectModel;
    using VisualComponents.Create3D;

    public class TreeNodeViewModel : PropertyChangedBase
    {
        protected string _header;
        public string Header
        {
            get { return _header; }
            set
            {
                if (value != _header)
                {
                    _header = value;
                    NotifyOfPropertyChange(() => Header);
                }
            }
        }

        protected ObservableCollection<TreeNodeViewModel> _children;
        public ObservableCollection<TreeNodeViewModel> Children
        {
            get { return _children; }
        }

        public TreeNodeViewModel()
        {
            _children = new ObservableCollection<TreeNodeViewModel>();
        }

        public TreeNodeViewModel(string name)
            : this()
        {
            _header = name;
        }
    }
```

NOTE! The TreeNodeView class inherits the PropertyChangeBase class available in the Caliburn.Micro assembly. This will help you implement the functionality for updating your TreeView control.

The remainder of this section is mostly about implementing a set of collections to be binded to a TreeView control. Therefore, instructions and explanations are kept to a minimum; study the provided code as needed.

3. In the Code view for TreeNodeViewModel, add the following code to define a class for handling the properties of components.

```
public class PropertyNodeViewModel : TreeNodeViewModel
{
    private IProperty _property;

    public PropertyNodeViewModel(IProperty property)
    {
        _property = property;
        string value = property.Value != null ? property.Value.ToString() : "NULL";
        _header = String.Format("{0} = {1}", property.Name, value);
    }
}
```

4. In the Code view for TreeNodeViewModel, add the following code to define a class for handling the features of components.

```
public class FeatureTreeNodeViewModel : TreeNodeViewModel
{
    private IFeature _feature;

    public FeatureTreeNodeViewModel(IFeature feature)
    {
        _feature = feature;
        _header = feature.Name;

        foreach (IFeature child in feature.Children)
        {
            _children.Add(new FeatureTreeNodeViewModel(child));
        }

        TreeNodeViewModel propertiesGroup = new TreeNodeViewModel("Properties");
        foreach (IProperty property in feature.Properties.Where(p => p.IsVisible))
        {
            propertiesGroup.Children.Add(new PropertyNodeViewModel(property));
        }
        _children.Add(propertiesGroup);
    }
}
```

5. In the Code view for TreeNodeViewModel, add the following code to define a class for handling the behaviors of components.

```
public class BehaviorTreeNodeViewModel : TreeNodeViewModel
{
    private IBehavior _behavior;
    public IBehavior Behavior
    {
        get { return _behavior; }
    }

    public BehaviorTreeNodeViewModel(IBehavior behavior)
    {
        _header = behavior.Name;
        _behavior = behavior;

        TreeNodeViewModel propertiesGroup = new TreeNodeViewModel("Properties");
        foreach (IProperty property in _behavior.Properties.Where(p => p.IsVisible))
        {
            propertiesGroup.Children.Add(new PropertyNodeViewModel(property));
        }

        this.Children.Add(propertiesGroup);
    }
}
```

6. In the Code view for TreeNodeViewModel, add the following code to define a class for handling layout items.

```
public class LayoutItemTreeNodeViewModel : TreeNodeViewModel
{
    private ILayoutItem _layoutItem;
    public ILayoutItem LayoutItem
    {
        get { return _layoutItem; }
    }

    public LayoutItemTreeNodeViewModel(ILayoutItem layoutItem)
    {
        _layoutItem = layoutItem;
        _header = layoutItem.Name;

        TreeNodeViewModel propertiesGroup = new TreeNodeViewModel("Properties");
        foreach (IProperty property in _layoutItem.Properties.Where(p => p.IsVisible))
        {
            propertiesGroup.Children.Add(new PropertyNodeViewModel(property));
        }

        this.Children.Add(propertiesGroup);
    }
}
```

7. In the Code view for TreeNodeViewModel, add the following code to define a class for handling the nodes of components.

```
public class SimTreeNodeViewModel : TreeNodeViewModel
 {
    private ISimNode _node;
    public ISimNode Node
    {
        get { return _node; }
    }

    public SimTreeNodeViewModel(ISimNode simNode)
    {
        _node = simNode;
        _header = simNode.Name;

        if (simNode.IsComponentRoot)
        {
            ISimComponent component = simNode.Component;
            TreeNodeViewModel propertiesGroup = new TreeNodeViewModel("Properties");
            foreach (IProperty property in component.Properties.Where(p => p.IsVisible))
            {
                propertiesGroup.Children.Add(new PropertyNodeViewModel(property));
            }
            _children.Add(propertiesGroup);
        }

        TreeNodeViewModel nodeGroup = new TreeNodeViewModel("Nodes");

        foreach (ISimNode child in simNode.Children)
        {
            if (!child.IsComponentRoot)
            {
                nodeGroup.Children.Add(new SimTreeNodeViewModel(child));
            }
        }

        if (nodeGroup.Children.Count == 0)
        {
            nodeGroup.Children.Add(new TreeNodeViewModel("<empty>"));
        }
        _children.Add(nodeGroup);

        TreeNodeViewModel featureGroup = new TreeNodeViewModel("Features");
        featureGroup.Children.Add(new FeatureTreeNodeViewModel(simNode.RootFeature));

        if (featureGroup.Children.Count == 0)
        {
            featureGroup.Children.Add(new TreeNodeViewModel("<empty>"));
        }
        _children.Add(featureGroup);
…
```

```
...
            TreeNodeViewModel behaviorGroup = new TreeNodeViewModel("Behaviors");
            foreach (IBehavior behavior in _node.Behaviors)
            {
                behaviorGroup.Children.Add(new BehaviorTreeNodeViewModel(behavior));
            }

            if (behaviorGroup.Children.Count == 0)
            {
                behaviorGroup.Children.Add(new TreeNodeViewModel("<empty>"));
            }
            _children.Add(behaviorGroup);
        }
    }
```

8. In the Code view for TreeNodeViewModel, add the following code to define a class for handling components and layout items in the 3D world and drawing world.

```
    public class WorldTreeNodeViewModel : TreeNodeViewModel
    {
        private ISimWorld _world;

        private TreeNodeViewModel _componentGroup;
        public TreeNodeViewModel ComponentGroup
        {
            get { return _componentGroup; }
        }

        private TreeNodeViewModel _layoutItemGroup;
        public TreeNodeViewModel LayoutItemGroup
        {
            get { return _layoutItemGroup; }
        }

        public WorldTreeNodeViewModel(ISimWorld world, string name)
        {
            _world = world;
            _header = name;

            _componentGroup = new TreeNodeViewModel("Components");
            this.Children.Add(_componentGroup);
            foreach (ISimComponent component in _world.Components)
            {
                _componentGroup.Children.Add(new SimTreeNodeViewModel(component.RootNode));
            }

            _layoutItemGroup = new TreeNodeViewModel("Layout Items");
            this.Children.Add(_layoutItemGroup);
            foreach (ILayoutItem layoutItem in _world.LayoutItems)
            {
                _layoutItemGroup.Children.Add(new TreeNodeViewModel(layoutItem.Name));
            }
        }
    }
```

Step 4. Create ViewModel

A plugin can be designed to have a user interface and code-behind logic that follows the MVVM design pattern. In this case, a ViewModel-View pair can be created to define a dockable, scene graph panel for Essentials.

1. In your project, add a new **Class** item and name it **SceneGraphPanelViewModel**. The "ViewModel" suffix is a way to identify the class as the logic for a user control with the same name that has a "View" suffix, for example SceneGraphPanelView.

2. In the Code view for SceneGraphPanelViewModel, type the following code to define a dockable panel and initialize a World tree node collection.

```
using Caliburn.Micro;
using System;
using System.Collections.Generic;
using System.Collections.ObjectModel;
using System.ComponentModel.Composition;
using System.Linq;
using System.Text;
using System.Threading.Tasks;
using VisualComponents.Create3D;
using VisualComponents.UX.Shared;
namespace SceneGraphPanel
{
    [Export(typeof(IPlugin))]
    [Export(typeof(IDockableScreen))]
    public class SceneGraphPanelViewModel : DockableScreen, IPlugin
    {
        private ObservableCollection<TreeNodeViewModel> _worldNodes;
        public ObservableCollection<TreeNodeViewModel> WorldNodes
        {
            get { return _worldNodes; }
        }

        public SceneGraphPanelViewModel()
        {
            _worldNodes = new ObservableCollection<TreeNodeViewModel>();
            this.DisplayName = "Scene Graph";
        }

        // IPlugin.Initialize() implementation
        public void Initialize()
        {
        }

        public void Exit()
        {
        }
    }
}
```

3. Add the following code to define properties and methods for adding and removing objects from your tree node collections.

```
    private WorldTreeNodeViewModel _3dWorldNode;
    private WorldTreeNodeViewModel _drawingWorldNode;

    // To keep the example simple this flag prevents the created component from being
    // added to the tree, we will add it manually after the component has been completely built
    private bool _isCreatingComponent;
...
    private void ComponentAdded(object sender, ComponentAddedEventArgs e)
    {
        if (!_isCreatingComponent)
        {
            _3dWorldNode.ComponentGroup.Children.Add(new SimTreeNodeViewModel(
                    e.Component.RootNode));
        }
    }

    void ComponentRemoving(object sender, ComponentRemovingEventArgs e)
    {
        RemoveComponentNode(_3dWorldNode, e.Component);
    }

    void LayoutItemAdded(object sender, LayoutItemAddedEventArgs e)
    {
        _3dWorldNode.LayoutItemGroup.Children.Add(new LayoutItemTreeNodeViewModel(
                e.LayoutItem));
    }

    void LayoutItemRemoving(object sender, LayoutItemRemovingEventArgs e)
    {
        RemoveLayoutItemNode(_3dWorldNode, e.LayoutItem);
    }

    void DrawingWorld_ComponentAdded(object sender, ComponentAddedEventArgs e)
    {
        _drawingWorldNode.ComponentGroup.Children.Add(new SimTreeNodeViewModel(
                e.Component.RootNode));
    }

    void DrawingWorld_ComponentRemoving(object sender, ComponentRemovingEventArgs e)
    {
        RemoveComponentNode(_drawingWorldNode, e.Component);
    }

    void DrawingWorld_LayoutItemAdded(object sender, LayoutItemAddedEventArgs e)
    {
        _drawingWorldNode.LayoutItemGroup.Children.Add(new LayoutItemTreeNodeViewModel(
                e.LayoutItem));
    }
...
```

```
...
    void DrawingWorld_LayoutItemRemoving(object sender, LayoutItemRemovingEventArgs e)
    {
        RemoveLayoutItemNode(_drawingWorldNode, e.LayoutItem);
    }

    private void RemoveComponentNode(
       WorldTreeNodeViewModel worldNode, ISimComponent component)
    {
        TreeNodeViewModel treeNode = worldNode.ComponentGroup.
        Children.
        Cast<SimTreeNodeViewModel>().
        FirstOrDefault(n => n.Node == component.RootNode);
        if (treeNode != null)
        {
            worldNode.ComponentGroup.Children.Remove(treeNode);
        }
    }

    private void RemoveLayoutItemNode(WorldTreeNodeViewModel worldNode, ILayoutItem item)
    {
        TreeNodeViewModel treeNode = worldNode.LayoutItemGroup.
        Children.
        Cast<LayoutItemTreeNodeViewModel>().
        FirstOrDefault(n => n.LayoutItem == item);
        if (treeNode != null)
        {
            worldNode.LayoutItemGroup.Children.Remove(treeNode);
        }
    }
```

NOTE! A method signature must match the signature of an event handler in order to be added and executed when the event occurs during runtime.

4. Add the following code to add your methods to event handlers when the plugin is initialized during runtime.

```
public class SceneGraphPanelViewModel : DockableScreen, IPlugin
{
    [Import]
    Lazy<IApplication> _application = null;
...
    public void Initialize()
    {
        IApplication app = _application.Value;
        app.World.ComponentAdded += ComponentAdded;
        app.World.ComponentRemoving += ComponentRemoving;
        app.World.LayoutItemAdded += LayoutItemAdded;
        app.World.LayoutItemRemoving += LayoutItemRemoving; ;
        app.DrawingWorld.ComponentAdded += DrawingWorld_ComponentAdded;
        app.DrawingWorld.ComponentRemoving += DrawingWorld_ComponentRemoving;
        app.DrawingWorld.LayoutItemAdded += DrawingWorld_LayoutItemAdded;
        app.DrawingWorld.LayoutItemRemoving += DrawingWorld_LayoutItemRemoving;

        _3dWorldNode = new WorldTreeNodeViewModel(app.World, "3D");
        _drawingWorldNode = new WorldTreeNodeViewModel(app.DrawingWorld, "Drawing");

        _worldNodes.Add(_3dWorldNode);
        _worldNodes.Add(_drawingWorldNode);
    }
```

Step 5. Create View

The user interface of a plugin must use WPF and follow a naming convention to associate the logic of controls with a ViewModel.

1. In your project, add a **WPF User Control** item and name it **SceneGraphPanelView**. Next, add a reference to **System.Xaml**.

2. In the XAML editor, type the following markup to define a TreeView control which is binded to your tree node collections in the SceneGraphPanelViewModel class.

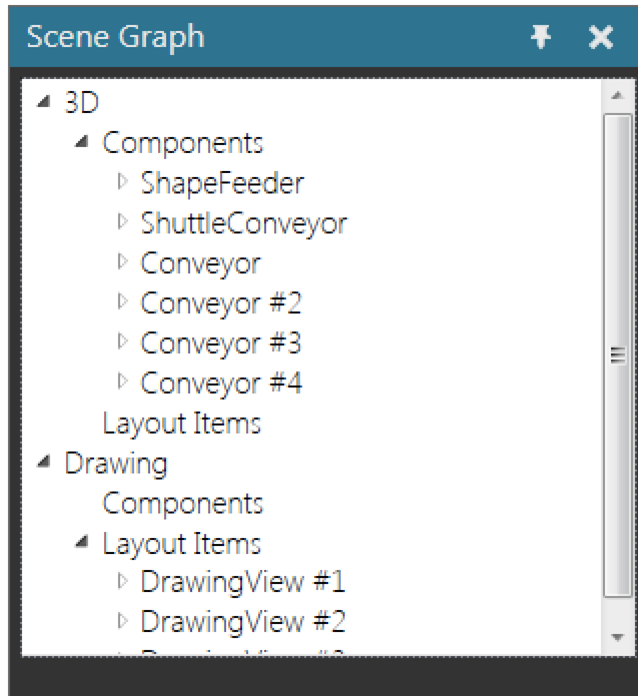
```
<UserControl x:Class="SceneGraphPanel.SceneGraphPanelView"
xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
xmlns:mc="http://schemas.openxmlformats.org/markup-compatibility/2006"
xmlns:d="http://schemas.microsoft.com/expression/blend/2008"
mc:Ignorable="d"
d:DesignHeight="300" d:DesignWidth="300">
    <Grid>
        <Grid.RowDefinitions>
            <RowDefinition Height="300"/>
            <RowDefinition Height="*"/>
        </Grid.RowDefinitions>
        <TreeView Margin="5" Grid.Row="0" ItemsSource="{Binding WorldNodes}">
            <TreeView.ItemTemplate>
                <HierarchicalDataTemplate ItemsSource="{Binding Children}">
                    <TextBlock Text="{Binding Header}" />
                </HierarchicalDataTemplate>
            </TreeView.ItemTemplate>
        </TreeView>
    </Grid>
</UserControl>
```

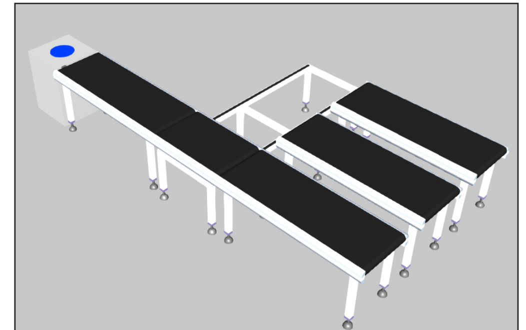
Step 6. Test data collection and visualization

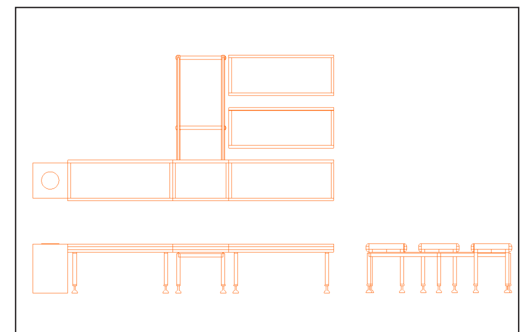
Your project is now in a state to be tested by adding and removing components from the 3D world and drawing world of Essentials.

1. Start debugging your project. If you encounter any errors, handle those issues, and then resume debugging your project.

2. In Essentials, open a layout, create some drawings, and delete one or more items in order to verify your Scene Graph panel plugin is working properly.







3. Stop debugging your project.

Step 7. Create components and other objects

In some cases, you may want to create components and other objects using API.

1. In the Code view for SceneGraphPanelViewModel, add the following code to define a method for creating a component that has a joint driven by a servo controller.

```
public void CreateComponent()
{
    _isCreatingComponent = true;
    ISimComponent component = _application.Value.World.CreateComponent("NewComponent");

    IProperty<int> length = (IProperty<int>)component.CreateProperty(typeof(int),
    PropertyConstraintType.AllValuesAllowed, "BlockLength");
    length.Value = 1000;

    IProperty<int> height = (IProperty<int>)component.CreateProperty(typeof(int),
    PropertyConstraintType.AllowedRangeOnly, "BlockHeight");
    height.AllowedMinimum = 100;
    height.AllowedMaximum = 1000;
    height.Value = 100;

    IProperty<int> width = (IProperty<int>)component.CreateProperty(typeof(int),
    PropertyConstraintType.AllowedValueSetOnly, "BlockWidth");
    width.AllowedValues.Add(new PropertyAllowedValue<int>() { Value = 100 });
    width.AllowedValues.Add(new PropertyAllowedValue<int>() { Value = 200 });
    width.AllowedValues.Add(new PropertyAllowedValue<int>() { Value = 300 });
    width.Value = 100;

    IBlockFeature blockFeature = component.RootNode.RootFeature.CreateFeature<IBlockFeature>();
    blockFeature.GetProperty("Length").Value = "BlockLength";
    blockFeature.GetProperty("Height").Value = "BlockHeight";
    blockFeature.GetProperty("Width").Value = "BlockWidth";

    ISimNode link1 = component.RootNode.AddChild("Link1");
    link1.DofType = JointType.Translational;
    IDof dof = link1.Dof;
    dof.JointAxis = JointAxis.PositiveX;
    dof.MinLimitExpression = "0";
    dof.MaxLimitExpression = "1000";
    IServoController servo = component.RootNode.CreateBehaviorByType(
                BehaviorType.ServoController) as IServoController;
    servo.Dofs.Add(dof);

    ITransformFeature transformFeature = link1.RootFeature.CreateFeature<ITransformFeature>();
    transformFeature.GetProperty("Expression").Value = "Tz(BlockHeight).Ty(BlockWidth/2)";
...
```

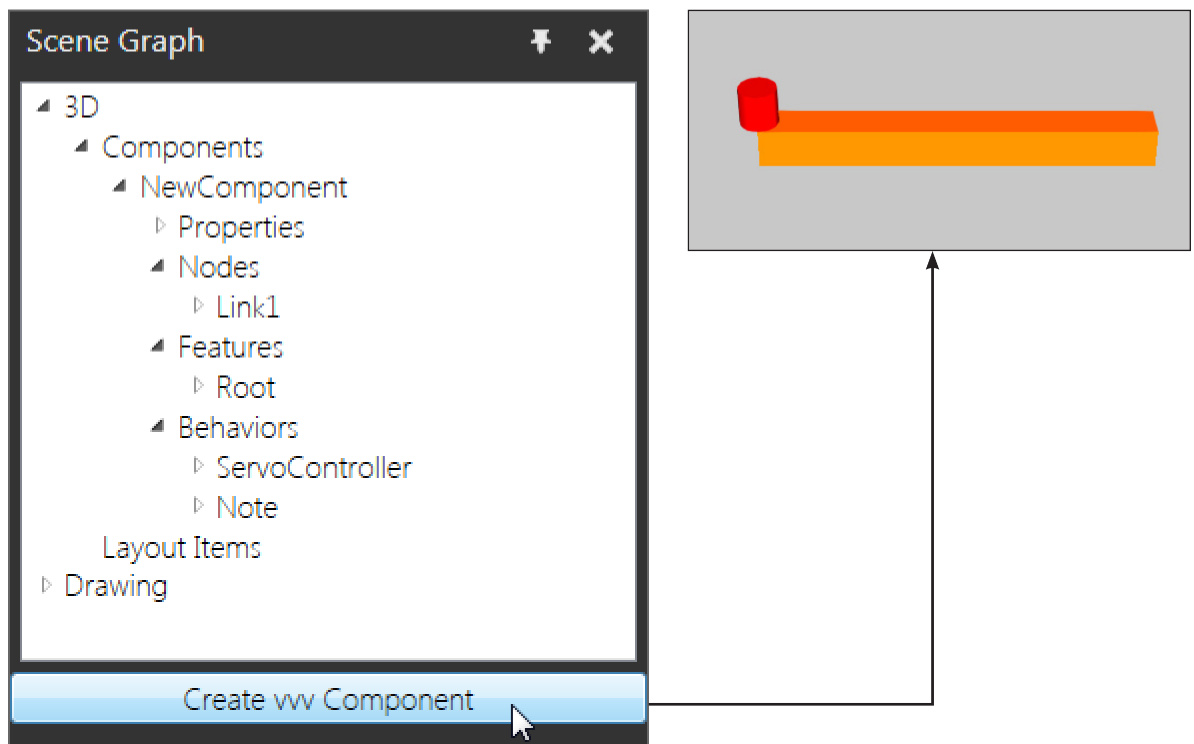
```
...
        ICylinderFeature cylinderFeature = transformFeature.CreateFeature<ICylinderFeature>();
        cylinderFeature.GetProperty("Height").Value = "100";
        cylinderFeature.GetProperty("Radius").Value = "50";
        link1.Material = _application.Value.Materials.FirstOrDefault(m => m.Name == "red");
        link1.MaterialInheritance = MaterialInheritance.ForceInheritNode;

        INote note = component.RootNode.CreateBehaviorByType(BehaviorType.Note) as INote;
        note.Note = "Press 'Interact' to reposition the cylinder";
        component.Rebuild();

        _isCreatingComponent = false;
    _3dWorldNode.ComponentGroup.Children.Add(new SimTreeNodeViewModel(component.RootNode));
    }
```

2. In the XAML editor for SceneGraphPanelView, add the following markup to create a button which is binded to the method used for creating new components.

```
...
    </TreeView>
     <Button Grid.Row="1" VerticalAlignment="Top"
                    x:Name="CreateComponent">Create vvv Component</Button>
   </Grid>
</UserControl>
```

3. Start debugging your project.

4. In Essentials, verify the button in your plugin creates a new component and its data structure is listed in the TreeView control.



5. Stop debugging your project, and then save your work to complete the tutorial.