AUTODESK UNIVERSITY

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Code Blocks Not Required—Dynamo for the Rest of Us

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Learning Objectives

- Learn how to use Dynamo to input parameters in custom Revit families
- Learn how to apply sequential numbering to model elements
- Learn how to export Revit data to Excel, manipulate it, and write it back to Revit
- Learn how to manage sheets and views in a Revit project

Description

If you use Revit software every day as your primary production tool, you may often run into tedious tasks that you wish you could accomplish more quickly and efficiently. Have you heard that the Dynamo extension can help? But what if you're not a programmer? Far too many tutorials start by dragging nodes and then end up writing code. If you've been frustrated trying to learn Dynamo because it seems all you ever see are code blocks, do not fear—this class uses NO code blocks. We will explore some very practical things you can do to automate your Revit software workflow, all with existing nodes. I repeat, there are no code blocks in this session. Just nodes and wires (and some logic). So, if you want to get a solid introduction to Dynamo for Revit software and come away with some practical examples that you can do back in the office without learning a ton of code, this is the class for you! This session features Revit, Dynamo, and Revit Architecture.

Your AU Expert

Paul F. Aubin is the author of many Revit book titles including the widely acclaimed: The Aubin Academy Series, Renaissance Revit and Revit video training at www.lynda.com/paulaubin. Paul is an independent architectural consultant providing Revit® for Architecture implementation, training, and support services. Paul's involvement in the architectural profession spans over 25 years, with experience in design, production, CAD management, mentoring, coaching and training. He is an active member of the Autodesk user community, an Expert Elite and is a top-rated repeat speaker at Autodesk University, Revit Technology Conference and Midwest University. His diverse experience in architectural firms, as a CAD manager, and an educator gives his writing and his classroom instruction a fresh and credible focus. Paul is an associate member of the American Institute of Architects and lives in Chicago with his wife and three children.

Introduction

This session is for beginners. This means that I will start here with some of the basics. If you are already using Dynamo and creating your own graphs, then this first topic and many of the examples that follow will be review for you. But if you are like me, there are always tidbits you can learn even when reviewing familiar material.

Dynamo Interface

This topic will cover the critical aspects of the Dynamo interface, starting with installing, launching and running the program and then looking at the key aspects of using the Dynamo environment.

Installing Dynamo

Dynamo comes in two varieties. There is a stand-alone version called: Dynamo Studio. This product is available from Autodesk on a subscription model. You pay an annual fee and it runs as a stand-alone application. Dynamo Studio does *not* interface directly with Revit. Therefore, we will not be using Dynamo Studio in this session.

Dynamo for Revit installs as an add-in to the Revit application. If you have Revit 2017, it is already installed and is accessed from the Manage tab. If you have 2016 or 2015, you can download Dynamo for Revit for free and install it. It will show up on the Add-ins tab in these versions.

Visit: http://dynamobim.com/ and then click the "Download Dynamo" link to learn more.

This session will focus on Dynamo for Revit and will showcase Dynamo version 1.2 running in Revit 2017.

Running Dynamo

To run Dynamo, you first launch Revit, open a project or family document and then click the Dynamo button on the Manage tab (Add-ins in versions prior to 2017) (see Figure 1). This will launch Dynamo in a separate window. Dynamo requires an active Revit document, and it will "attach" itself to this document. So be sure to open a file first. It can be a project or a family.

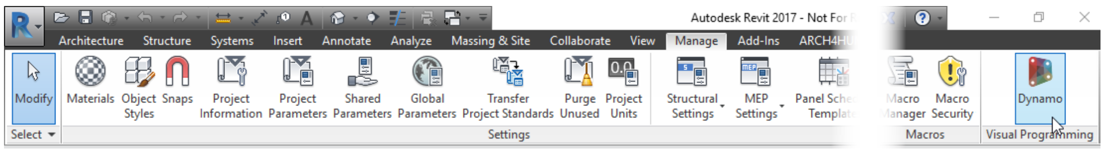


Figure 1

Working with two screens is recommended. If you don't have two, you will want to position Revit so you can see the model behind the Dynamo window.

If you want to create a new Dynamo file (called a "graph"), then click the New button on the welcome screen, otherwise you can click the Open button (see Figure 2).

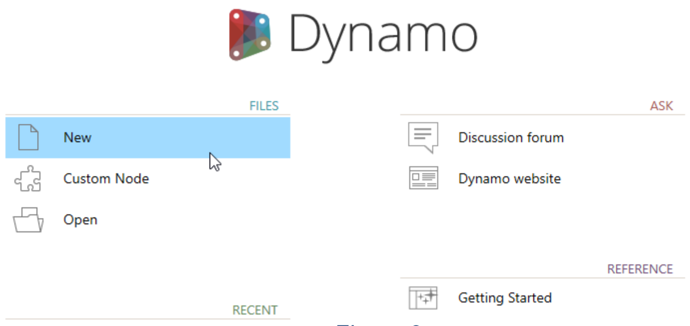


Figure 2

The Dynamo interface will load with menus across the top, the library on the left and the main graph editing window filling the remainder of the screen. Some navigation tools will appear in the upper-right. At the bottom of the screen is the execution options button (see Figure 3).

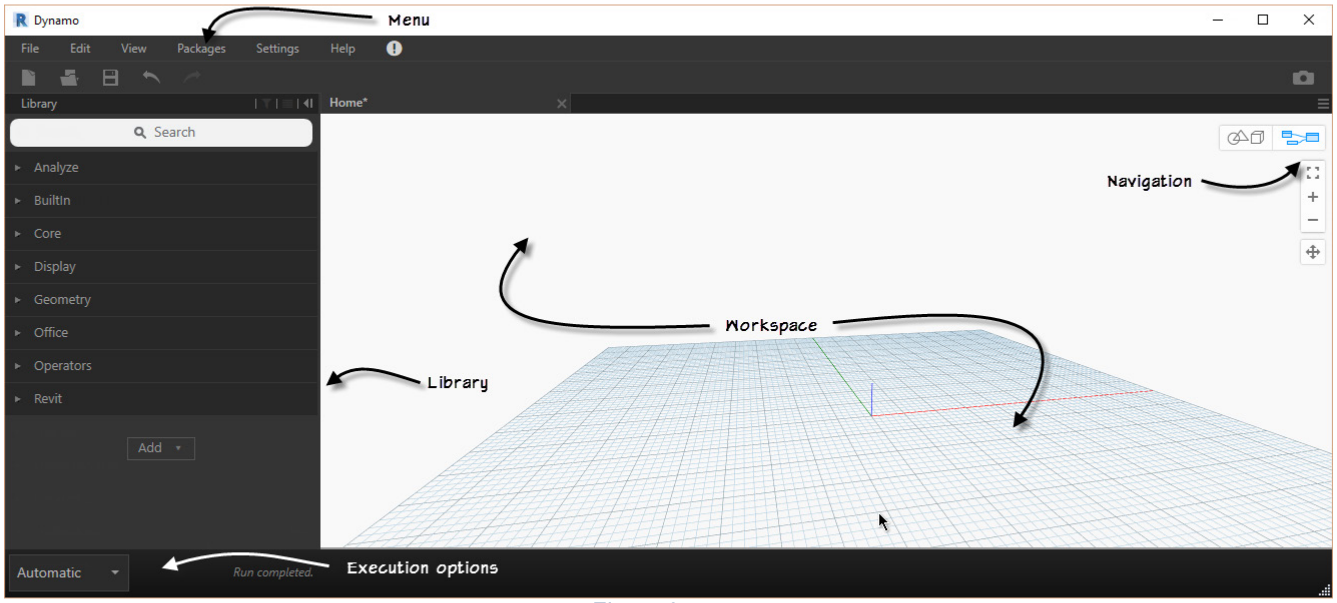


Figure 3

Your library may not match the figure. Dynamo is extensible and many users of the community make their own custom nodes and make them available in "packages" to other users. Any installed packages will appear in your library panel intermingled with the default ones. If you hover over a library category, it will indicate if it is a package by showing the letters: "PKG". The Add button at the base of the library can be used to add more packages to your install as can the Package menu on the menu bar.

Nodes and wires

Creating a Dynamo script (or graph) uses "Nodes" and "Wires." Nodes are prebuilt blocks of code that perform a single discreet action or function. Wires are used to connect nodes together and build the "flow" of the graph moving data from left to right and from node to node (see Figure 4).

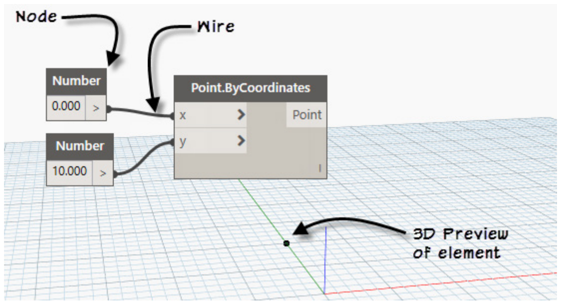


Figure 4

To place a node, simply locate it in the library and click on its name (see the left side of Figure 5). The node will appear in the canvas. You can move it around by dragging it by the titlebar. To add a wire, click on one of the "ports" on the node. Ports appear on the left and right sides of nodes. Data in a Dynamo graph flows from left to right. The left side contains the "inputs" and the right side has the "outputs."

To wire up your nodes, simple click on the port of one node, a wire will extend out of the port as you move your mouse. Click on another port to finish the wire and connect the two ports (see the right side of Figure 5).

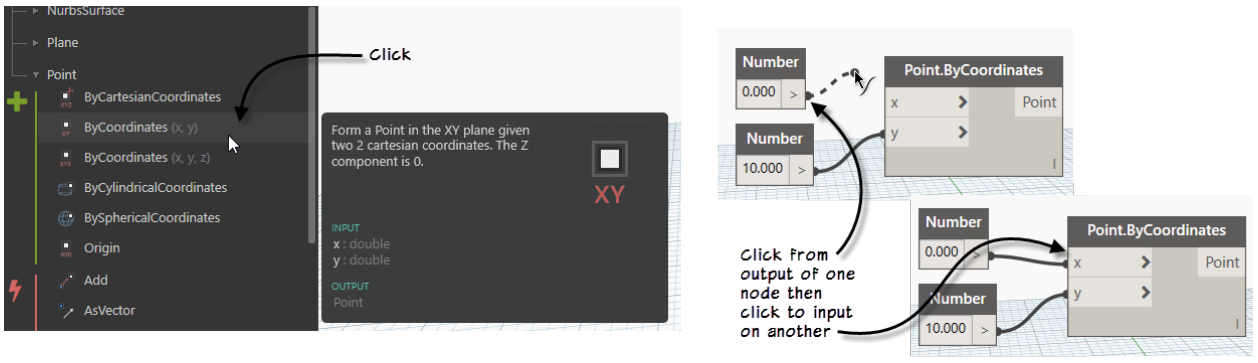


Figure 5

Inputs can only have one wire. But multiple wires can be connected to outputs allowing output values to feed into several other locations of the graph.

Finding Nodes

You can browse the library by clicking on the category headings to see what is stored within them. But Dynamo contains LOTS of nodes. So browsing this way can be time consuming. So an alternative is to search for nodes. There is a Search field at the top of the library and you can also right-click in the canvas to get a search field on the context menu (see Figure 6).

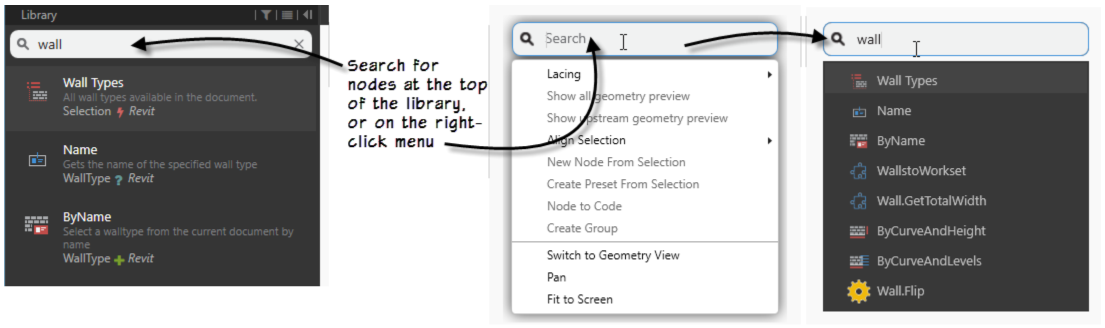

Library
wall
Wall Types
All wall types available in the document.
Selection Revit
Name
Gets the name of the specified wall type
WallType Revit
ByName
Select a walltype from the current document by name
WallType Revit
Search for nodes at the top of the library, or on the right-click menu
Search
Lacing
Show all geometry preview
Show upstream geometry preview
Align Selection
New Node From Selection
Create Preset From Selection
Node to Code
Create Group
Switch to Geometry View
Pan
Fit to Screen
wall
Wall Types
Name
ByName
WallstoWorkset
Wall.GetTotalWidth
ByCurveAndHeight
ByCurveAndLevels
Wall.Flip

Figure 6

However, the trouble with searching if you are a beginner is knowing what to search for…

So I do recommend that you take some time initially to browse the library and get familiar with the included nodes and overall library structure. In the graphs that follow, I indicate where each node is located in the library for your convenience.

Hello World

Once you are familiar with the overall interface, you will want to create your first graph. Programmers always like to show the “Hello World” example as an “ice-breaker.” In other words, something really simple to get quick results.

Simple Text

On the library, click the *Core* branch and then click the *Input* branch. This branch contains several types of input nodes. These are nodes that you use to feed information to your graph. Click the ***String*** node to add it to the canvas (see Figure 7).

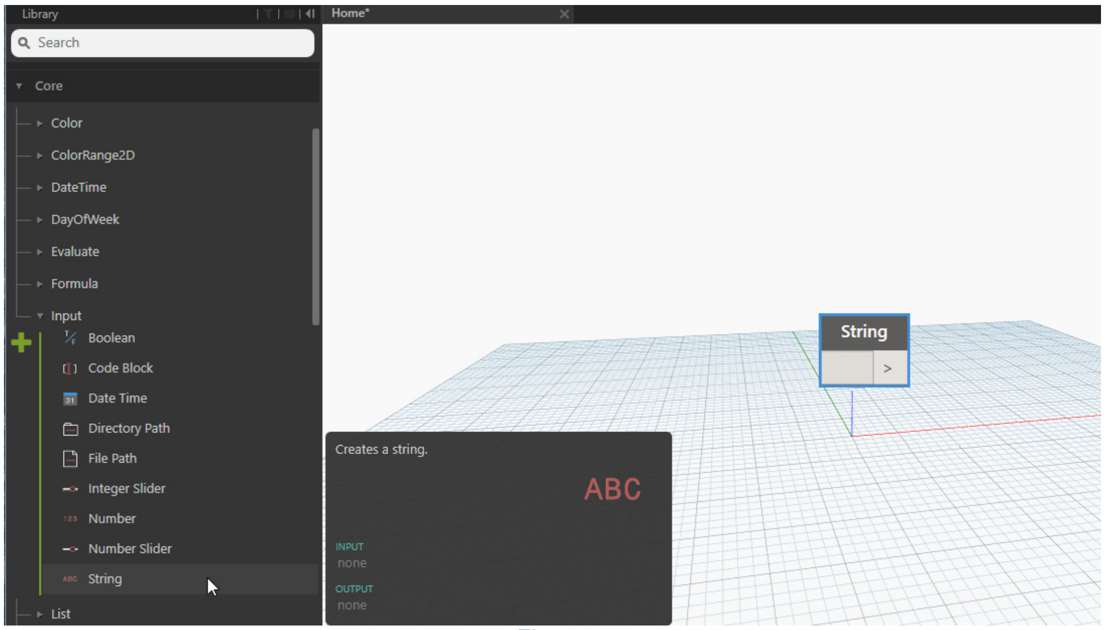


Figure 7

Within a ***String*** node you can input any text you like. Programmers like to refer to text as "strings." So you can type in anything you want into a ***String*** node. And even if you type in numbers, the graph will interpret them as text only. (We'll see numerical input below).

In the ***String*** node, type: **Hello World**. To finish, click away from the node, don't press ENTER. If you press ENTER, it will stay in the node and wrap to the next line.

Now let's grab a "***Watch***" node. ***Watch*** nodes are useful to "report" the output at points along the graph. To find it in the library, expand the *Core* branch and then the *View* branch. Click on the ***Watch*** node to add one. Drag it to the right of the ***String*** node and then wire the output of the ***String*** to the input of the ***Watch*** (see Figure 8).

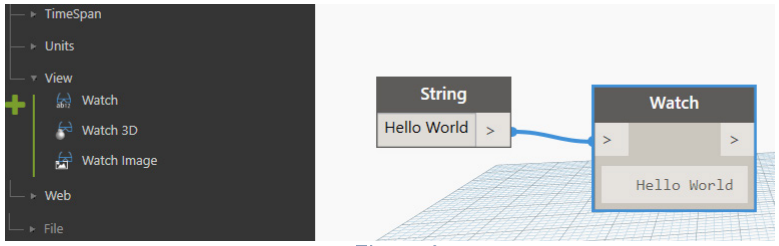


Figure 8

Very exciting! Well, that is a complete graph, just not very useful or exciting. Let's vary it a bit. Add another ***String*** node. Type "Hello" in the first one and "World" in the second. The Watch will still be wired to the original node and will now only report "Hello." To put the two together, remember that we cannot put two outputs into a single input. If you try to wire "World" to the Watch, it will replace the wire from "Hello." So instead, we need another node to combine them first.

Combining Values

So how do we combine them? Well there are lots of ways. Here's a simple one.

On the Operators branch of the library, click the ***+*** node. This has two inputs: ***x*** and ***y***. These can be anything (kind of like algebra class…) Wire "Hello" into ***x*** and "World" into ***y***. Then wire the output of ***+*** to the input of the ***Watch*** node (see Figure 9).

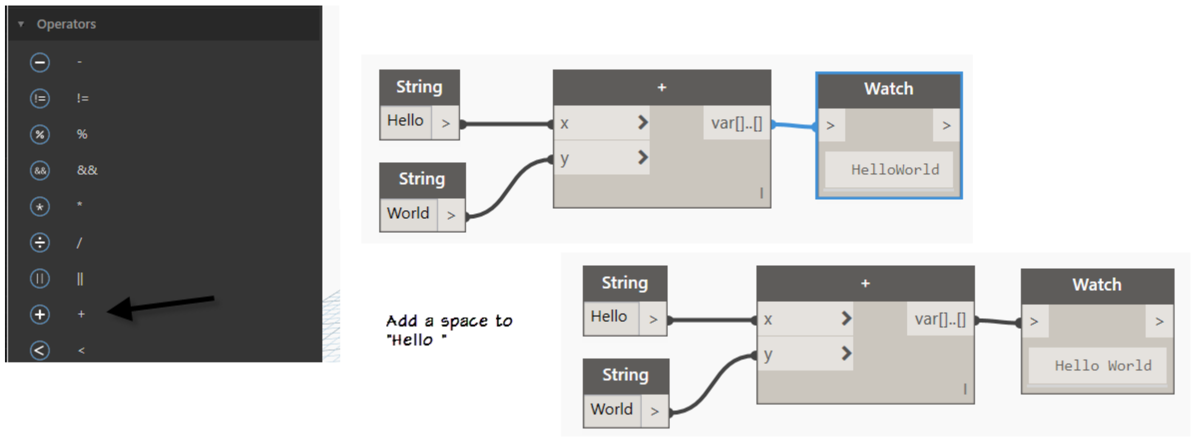


Figure 9

Notice that it is quite literal and will report "HelloWorld" as the result. You can edit the first ***String*** node and add a space at the end of "Hello" to fix that. The graph will update immediately. Again, this is not too exciting, but even this simple example shows how data flows through the graph. Let's take it a little further. Since we have a **+** node, what about some numerical input?

SAMPLE FILE: You can open a file completed to this point named: ***01_Hello World_A.dyn***.

Numbers

In the library, on the *Core* > *Input* branch, click on the ***Number*** node. Wire the ***Number*** node to the ***y*** input of the **+** node. Note the result in the ***Watch***. In this case, Dynamo will happily combine text with numbers, but it will keep the result as text. But if you create a second ***Number*** node and wire it in, it will do the math instead (see Figure 10).

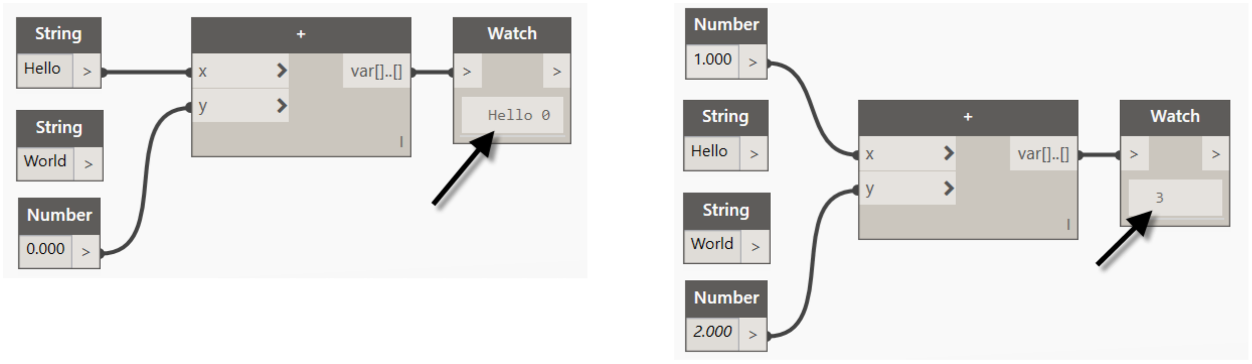


Figure 10

SAMPLE FILE: You can open a file completed to this point named: ***01_Hello World_B.dyn***.

Making Points

Using Dynamo to add two numbers may not be faster than your calculator, but there is plenty more that you can do with numbers. The "hello world" of making geometry would be making points. So let's look at how you can take some numbers and feed them into the inputs for making points. The *Geometry* > *Point* branch has a few options for making points (see Figure 11).

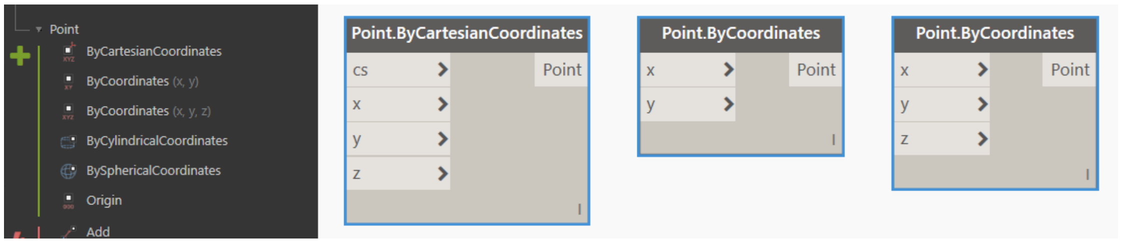
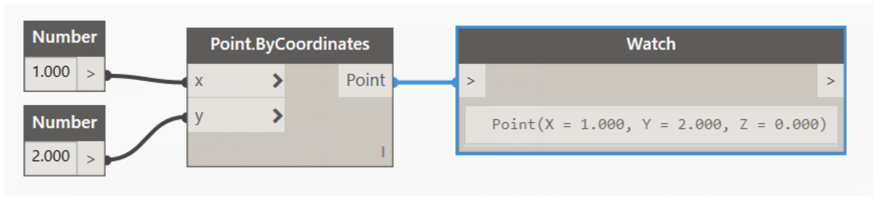


Figure 11

The main difference is in the inputs required. Let's look at the ***Point.ByCoordinates***. It is the simplest one and only needs an ***x*** and ***y*** inputs. If you hover your mouse over an input, it will typically tell you what it expects and if there is a default value. In this case, simply placing this node will add a point to the canvas because the default value of both inputs is zero. So you get a point at 0,0. However, if you wire the two ***Number*** nodes into the two point inputs, and then change their values, the point will move accordingly (see Figure 12).



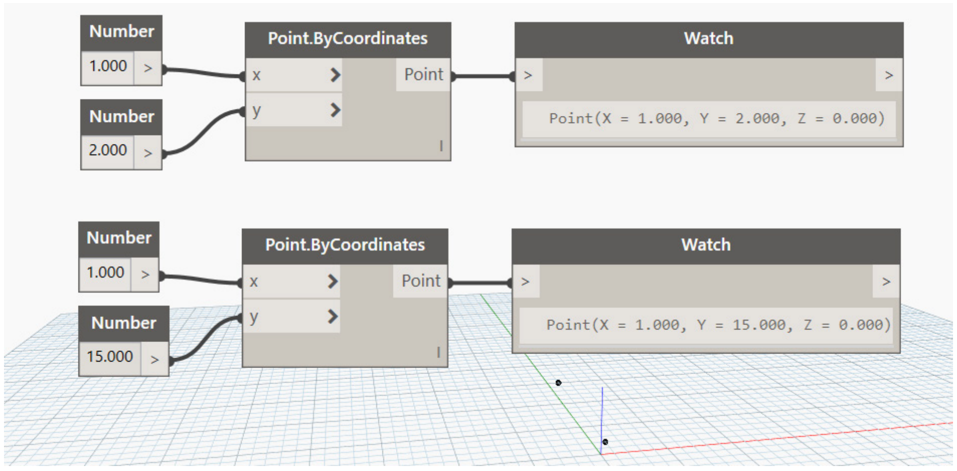
```
Point(X = 1.000, Y = 2.000, Z = 0.000)
```

Figure 12

SAMPLE FILE: You can open a file completed to this point named: ***01_Hello World_C.dyn***.

Making a Line

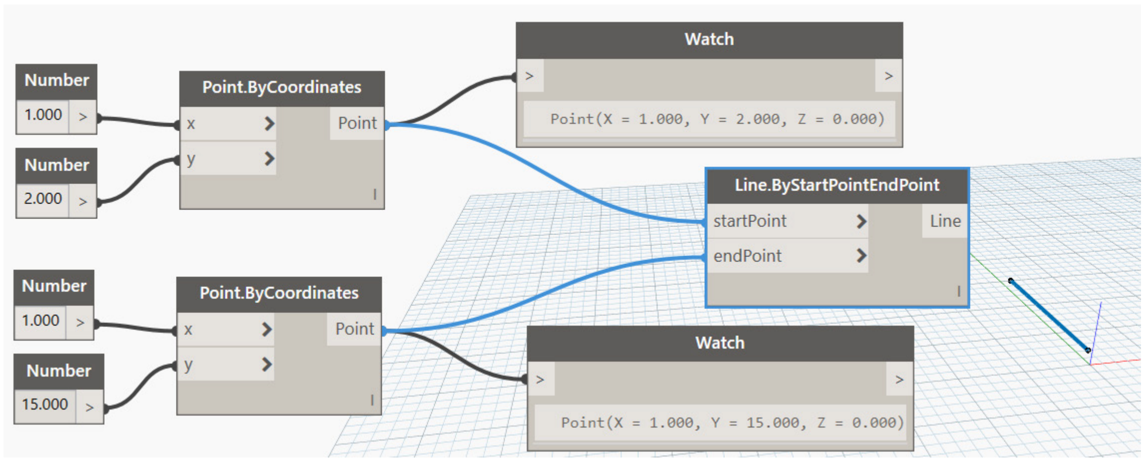
When you want to reuse parts of your graph, you can copy and paste. Simple drag a window around all three nodes (four if you have a ***Watch***), and then from the Edit menu, choose: **Copy** or press CTRL + C. Then from the edit menu, choose: **Paste**, or press CTRL + V. With the copies still selected, drag them to position them in a convenient location. Since we copied a point, you now have two points in the same spot. Change the number values of the copied point to move it (see Figure 13).



```
Point(X = 1.000, Y = 2.000, Z = 0.000)
Point(X = 1.000, Y = 15.000, Z = 0.000)
```

Figure 13

So what to do with two points? How about make a line! In the library, on the *Geometry* > *Line* branch, you will find the ***ByStartPointEndPoint*** node. Add that to the canvas and wire it up (see Figure 14).



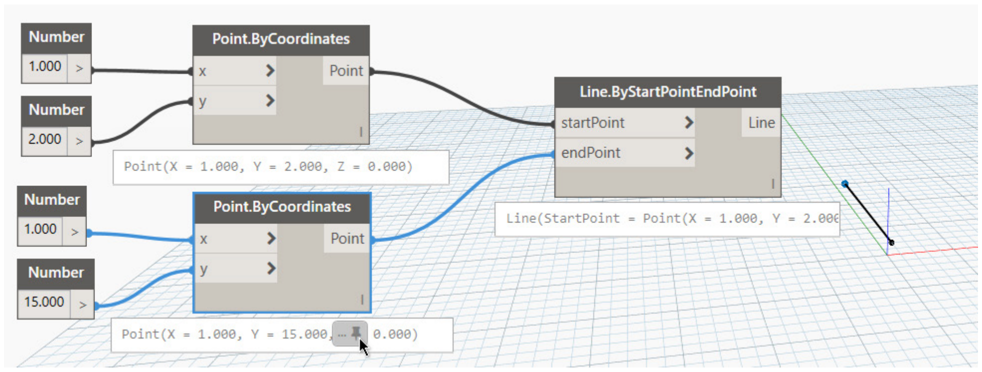
```
Point(X = 1.000, Y = 2.000, Z = 0.000)
Point(X = 1.000, Y = 15.000, Z = 0.000)
```

Figure 14

To Watch or not to Watch…

The ***Watch*** nodes are not necessary here. I like to include them as I am working so that I get feedback as I go. In this case however, you see the points in the 3D canvas. So the ***Watch*** nodes really don't add anything to the graph. You will also notice that ***Watch*** nodes have outputs. You can wire from those or go back to the original node and wire from their output. Notice that here, I have done the latter. This makes it easier to remove the ***Watch*** nodes later without forcing you to re-wire anything.

There is an alternative to Watch nodes. You can instead receive feedback directly from the node itself. When you hover your mouse over a node, it will show a little pop-up (called a "preview bubble") with the output of that node. There is a small pushpin icon that you can click to keep the preview bubble expanded even as you move your mouse away (see Figure 15).



```
Point(X = 1.000, Y = 2.000, Z = 0.000)
Line(StartPoint = Point(X = 1.000, Y = 2.00
Point(X = 1.000, Y = 15.000, ... 0.000)
```

Figure 15

If you use the preview bubbles, you can eliminate the ***Watch*** nodes. Or you can use both. It is up to you.

SAMPLE FILE: You can open a file completed to this point named: ***01_Hello World_D.dyn***.

Draw a Wall

Once you have a line, you can use it to make a Revit wall. As you add nodes to the graph, think about what you want to create, add the nodes and then look to see what inputs are required. There are two nodes available for adding walls. Let's use the ***Wall.ByCurveAndLevels*** node. This is found in the *Revit* branch of the library under the: *Elements* > *Wall* branch.

This node has four inputs: ***c*** stands for "curve." To make a wall, we need a path for it follow. In programmer speak this is called a "curve." This is "curve" in the math class sense of the word. So our line counts as a "curve." As does anything with two endpoints; either a straight line or a curvy line and Dynamo still thinks of it as a curve. We also need two levels to set the height and a wall type.

Starting with the curve, we can wire the output of our Line node above to the ***c*** input. For the others, from the *Revit* > *Selection* branch, add: two ***Levels*** nodes and one ***Wall Types***. Each of these has a drop-down list from which you can make a selection. From the first ***Levels*** node, choose: **Level 1** and wire it to the ***startLevel*** port. Choose: **Level 2** from the next one and wire it to: ***endLevel*** and then choose any wall type and wire it to the ***wallType*** port (see Figure 16).

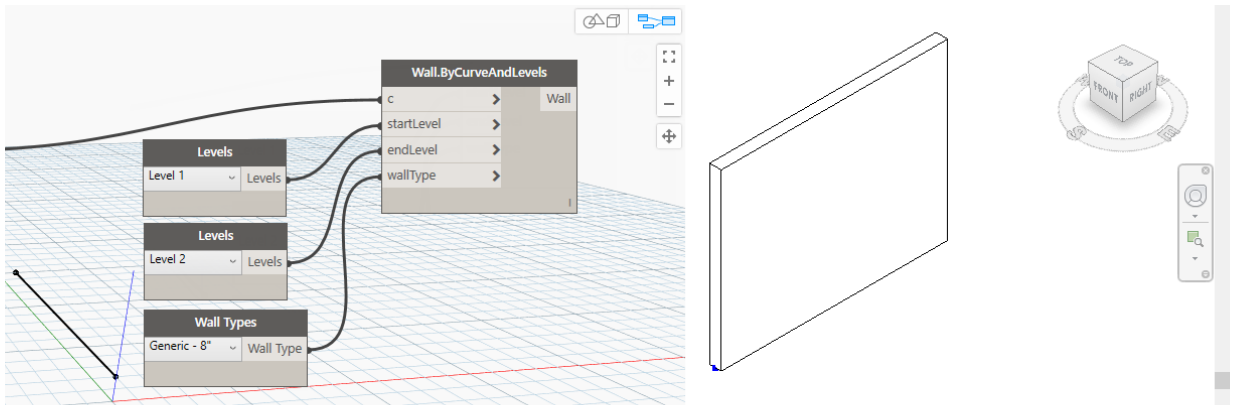


Figure 16

Types of Geometry

Notice that in Dynamo, we still only see the line. To see the wall, you have to look at Revit. A 3D view shows it well. (Again you might have to shuffle your windows around onscreen to see everything). There is a difference between "Dynamo geometry" and "Revit geometry." Dynamo geometry only appears in the Dynamo environment and is more abstract. You can use Dynamo geometry to create Revit geometry (as we have done here) and vice-versa. But you will not automatically get both. If you want to see a representation of the wall in Dynamo, browse to: *Revit* > *Elements* > *Element* and use the ***Geometry*** node. Wire the output of the ***Wall*** node into this node (see Figure 17).

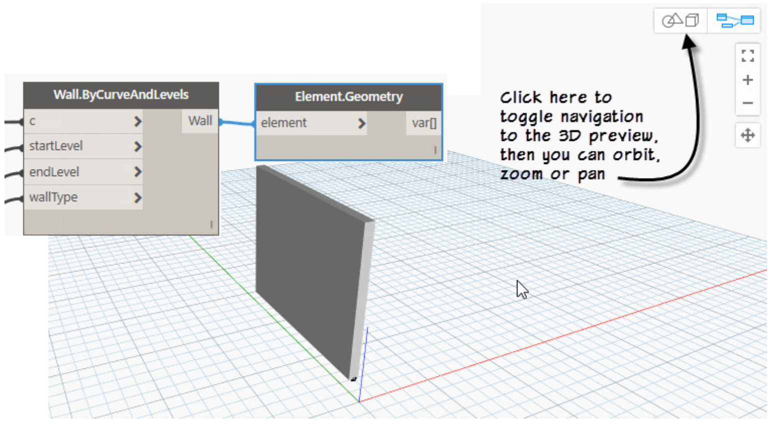

Wall.ByCurveAndLevels
c
startLevel
endLevel
wallType
Wall
Element.Geometry
element
var[]
Click here to toggle navigation to the 3D preview, then you can orbit, zoom or pan

Figure 17

If you want to orbit, pan or zoom the 3D preview in Dynamo, use the small toggle icons at the top right to switch to navigation in the 3D view. Then switch back to the graph when you are done.

SAMPLE FILE: You can open a file completed to this point named: ***01_Hello World_E.dyn***.

Writing Code

All of the previous examples can be considered "Hello World" examples in some form or another. They are very basic, introduce you to the interface of Dynamo and allow you to see immediate results. When you are ready to begin actually using Dynamo to do something practical, you will naturally be building graphs that are more complex. In my experience, this is usually where training sessions like this one dive into the deep end of the pool. However, my goal is to stay in the shallow end for the entire session!

All I will say about the "deep end" is that the possibilities are truly endless. That is because let's make no mistake about it, Dynamo IS **programming**. To be precise, it is "visual programming." This simply means that the Dynamo environment is designed to shield you from as much of the underlying code as possible. So we have the lovely nodes, prebaked with useful code that do the heavy lifting for us. Mostly.

You drag and drop nodes and wire them up. In a nutshell, that's visual programming. However, it is not as simple as all that most of the time. First, even when using prebuilt nodes, you still have to understand programming and think like a programmer. This is important to get the logic right. And, even though we have this library of nodes, what you will see very soon, (if you have not already seen it) is that many, if not most, Dynamo graphs and Dynamo programmers do use code. This code is placed in ***Code Block*** nodes.

At least that is what happens most of the time. But the premise of this session is that you *can* do many useful things in Dynamo *without* having to use any code. That means that you can build a perfectly functional graph, that performs a useful procedure without the need for Code Blocks. So does this mean that I think that Code Blocks are bad? Or that they are not useful? Certainly not. I think they are incredibly useful. Just not so much for beginners. I think it is *rarely* a good idea for beginners to concern themselves with Code Blocks (even if they can save time). I believe that the goal initially should be learning how to work in Dynamo first; before worrying about how to build graphs more quickly or efficiently. "Crawl before you walk or run" so to speak.

So now that you at least understand at a conceptual level what a Code Block is, you don't have to give them any more thought for now, because there won't be any further mention of them here.

Execution

At the bottom of the Dynamo screen, you have a pop-up button that controls how the graph will execute. New graphs default to "Automatic." This means that as soon as you wire up a node, it will run the graph and perform its function. In smaller graphs without much happening, this can be a nice way to make the experience very interactive. However, as your graphs get more complex, you might want to set the execution to "Manual" instead. This make a "Run" button appear. Now the graph will only execute only when you press the Run button (see Figure 18).

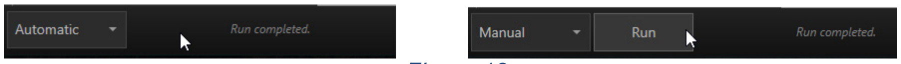


Figure 18

We also have the option to "Freeze" individual nodes to control which parts of the graph execute. This is a great way to execute just a portion of your workflow to ensure that things are working the way that you like before moving on downstream. To freeze a node, right-click it. All nodes connected to it downstream will also freeze (see Figure 19).

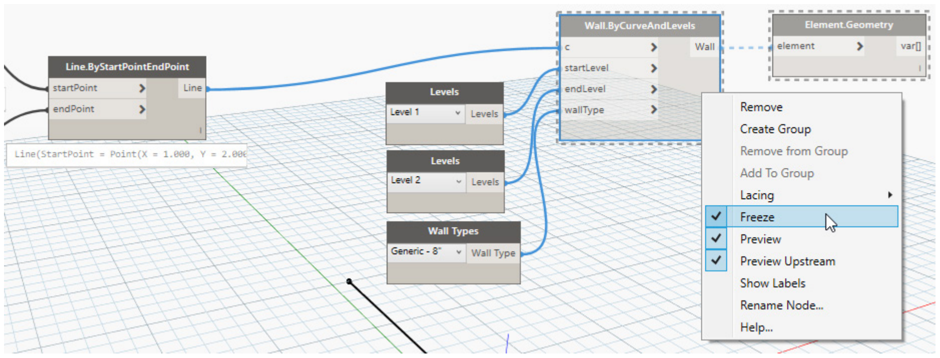
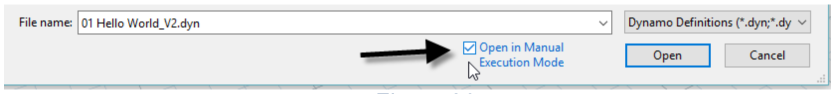


Figure 19

Finally, if you save a graph in automatic mode, you can still open it in manual mode. To do so, be sure to use the Open command (File menu, or on the start screen) and browse to the file. In the "Open" dialog, there will be a checkbox available at the bottom of the window to open the graph in "Manual Execution Mode" (see Figure 20).


File name: 01 Hello World_V2.dyn
Dynamo Definitions (*.dyn;*.dy
Open in Manual Execution Mode
Open
Cancel
Figure 20

In general, it is often desirable to open Dynamo files this way. This allows you to check the graph, ensure it is correct and optionally freeze certain parts of the workflow before execution.

Placing Individual Revit Families

So now that we have gotten some of the basics under our belt, what practical things can we do with Dynamo? A very common task to perform with Dynamo is placing elements in your Revit model. There are nearly limitless approaches to the task, and much of the specifics will depend on the precise goals and expected outcomes. But there will be some common threads. Typically, you will use the selection nodes to choose which Revit item you want to place. Then you will often need to indicate where in the model to place the elements. And in many cases you will want to manipulate the elements during placement as well. In the examples that follow we will showcase a few workflows to get you started with thinking about how to place elements in your Revit projects with Dynamo.

Placing a Single Family

Let's say that you wanted to place a collection of families along a path. This is easy to do directly in Revit if the path is straight or follows an arc; in those situations, you can use the Array command. But not so if it is irregular like a spline or if you have more than one path. In this example, we'll look at a graph that allows you to draw a spline in Revit, select it in Dynamo and then insert a variable quantity of elements along that selected path. I'll use trees here, but you can use this graph to place any non-hosted component family.

Create a spline path in Revit

Launch Revit, start a new project using the default template and then create a model line. Use the spline shape and draw a curvy path (see Figure 21). Save the project. The default template has an RPC tree family pre-loaded. If the template you are using does not, just make sure that you have a family loaded that you want to repeat along the path. It should be a non-hosted family. Wall-based, or other hosted families will not work in this example.

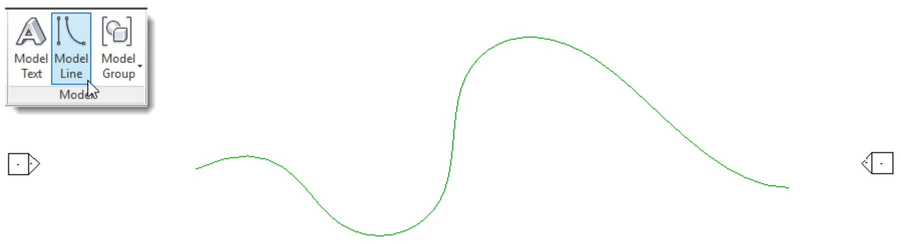


Figure 21

Launch Dynamo next and then click the New button on the welcome page. Add the following nodes to your canvas:

Library Location	Node
Core > Input	Number
Core > Input	Number Slider
Revit > Selection	Select Model Element
Revit > Selection	Family Types
Revit > Elements > Element	Curves
Revit > Elements > FamilyInstance	ByPoint
Geometry > Curve	PointAtParameter

You can manually browse to the location indicated and click the node to add it to the canvas, or you can use the Search field instead and type in the node name to find them. Position the nodes and wire them as indicated in Figure 22.

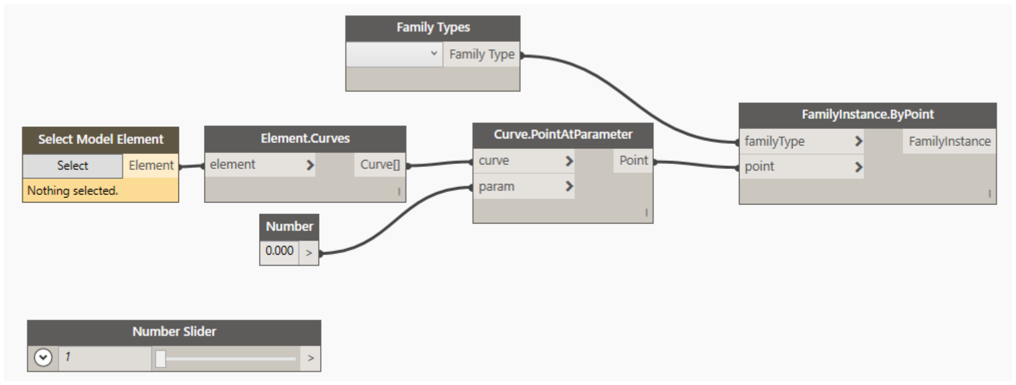


Figure 22

Sample File: You can open a starter Revit file for this example named: ***02_Place Families_!Start.rvt*** and a starter Dynamo file named: ***02_Place Families_A.dyn***

Errors in Nodes

Notice that the ***Select Model Element*** node is yellow. This indicates that it is currently in an error state. When you have not fed the proper information into a node and Dynamo is therefore unable to process it, it will display the node this way to alert you. Here the problem is simple; we have not selected the spline path yet. The Select button on the node is used for this purpose. Click it and then in the Revit window, click on the spline element you created above. Assuming that you have the execution mode (noted above) set to: Automatic, it will process immediately and result in the ***FamilyInstanstance.ByPoint*** node going into an error state. This time there is a small indicator above the node that you can highlight to get more information. If you do this, you see that the message says "cannot be null." This is programmer speak for "empty." We have not chosen a family from the drop-down on the ***Family Types*** node yet. So it does not know which family to place (see Figure 23).

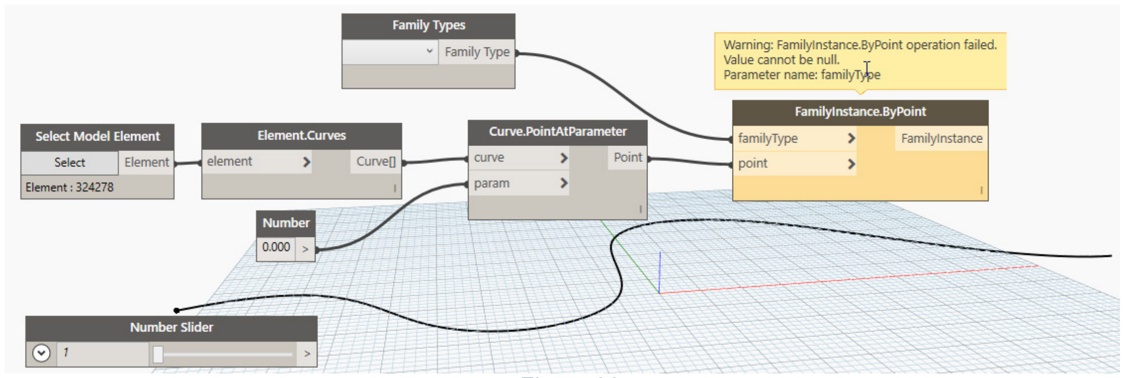

Warning: FamilyInstance.ByPoint operation failed.
Value cannot be null.
Parameter name: familyType

Figure 23

Select a family from the drop-down on the ***Family Types*** node to clear the error and place an instance of the family in the Revit canvas. I chose an RPC tree family (see Figure 24), but feel free to choose another model component family if you like.

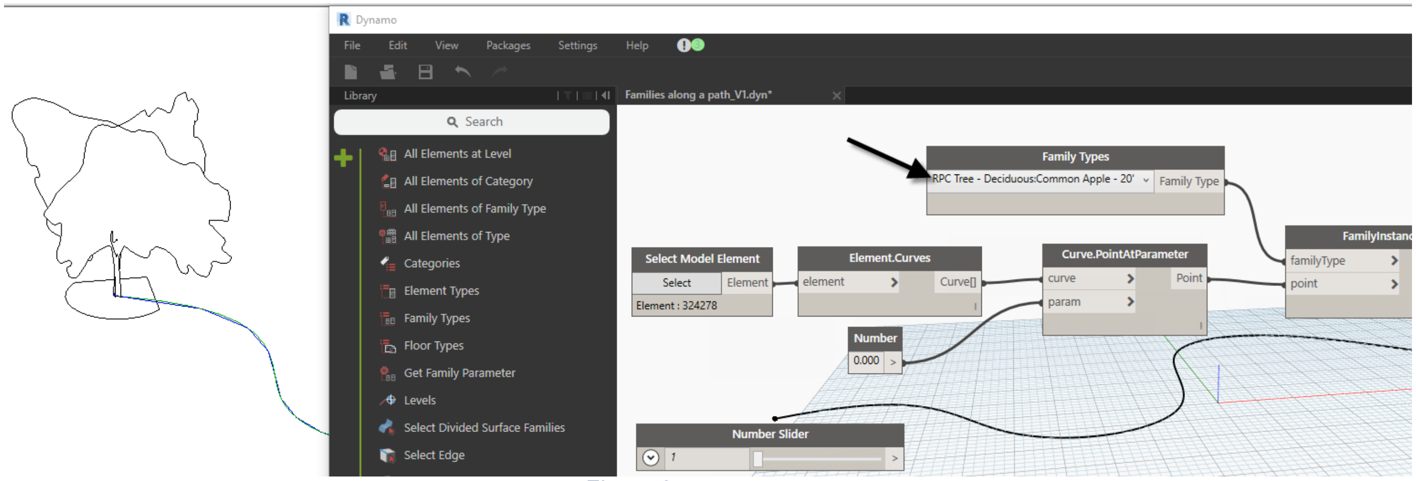


Figure 24

With the graph wired this way, we get one tree at the start of the spline. Also as we noted above, the tree will appear in Revit, but not in the Dynamo canvas unless you add an ***Element.Geometry*** node to the graph. (You are welcome to do this if you like).

SAMPLE FILE: You can open a file completed to this point named: ***02_Place Families_B.dyn***.

Adjust the Graph and the Resulting Revit Model

So how did our tree know to be placed at the end of the spline? And how did it know which end? The key is the ***`param`*** input of the ***Curve.PointAtParameter*** node. Right now, we are feeding it a single number. You can input any number you want here within the allowable range. What is the allowable range? In the case of the "AtParameter" nodes, the "parameter" is a value in the range between zero and one. So a value of zero in the ***Number*** node (like we have here) puts it at one endpoint, while **1** would put it at the other endpoint. If you want the tree at the midpoint, you can type in: **.5**. Use: **.75** to put it three quarters the way along the curve, etc. Go ahead and try some other inputs.

Building a Range of Numbers

But our goal was to have multiple trees spaced evenly along the path. To do this, you need to feed in more than one value in the ***param*** port. There are many ways you can do this in Dynamo. Let's do a very simple range of numbers. In the library, on the *Core* > *List* branch, add a ***Range*** node to the canvas. You have three inputs here: ***start***, ***end*** and ***step***. Since our ***param*** input needs a range from zero to one, we will input those values into the ***Range*** node. Then we can step by any fractional amount we want. For example, if you start at zero, end at one and step by .5, you get three items in your range. Step by .25, and you will get five, etc. To input these values, we can use ***Number*** nodes or the ***Number Slider*** we added above. If you hover over each input, a tooltip will tell you the default value (if there is one). Doing this we see that the ***start*** input already defaults to zero, so we really only need to change the ***end*** input. Rewire the graph to incorporate the ***Range*** node as shown in Figure 25. Be sure to change the value of the ***Number*** node to: **1**.

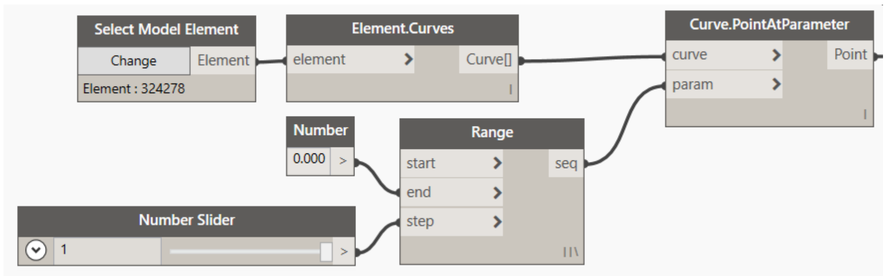


Figure 25

The ***Number Slider*** is nice because you can drag the slider and have the graph update in real-time. However, we need to adjust the settings of the slider to make it work for the range we require. Click the small chevron icon on the left of the slider to reveal its settings. As we noted, we want the Min to be: 0 and the Max to be: 1. For the Step, try a value of: **0.1**. and then close the controls by clicking the chevron again (see Figure 26).

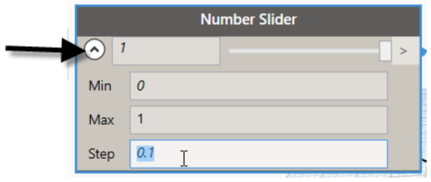


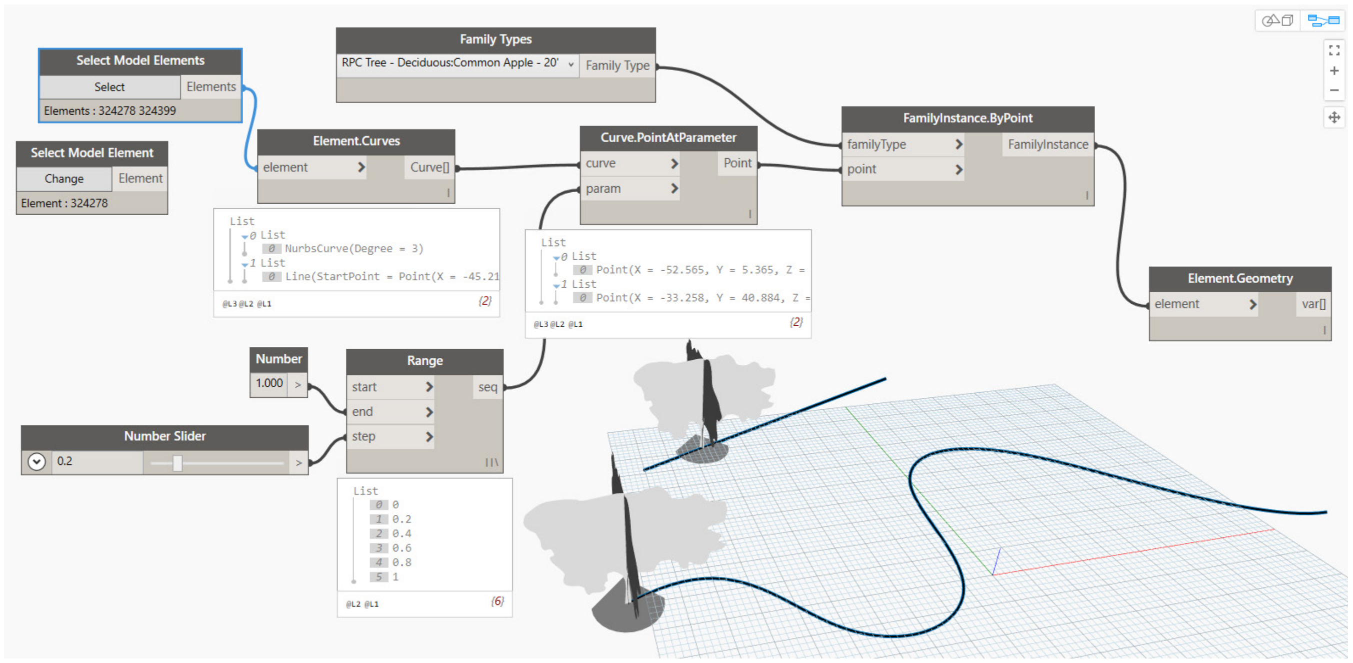
Figure 26

SAMPLE FILE: You can open a file completed to this point named: ***02_Place Families_C.dyn***.

Understanding Lacing

Drag the slider down to about **.1** or **.2**. Unfortunately, it will appear as if nothing is happening. This is where we need to understand the structure of the program we are building here a little better and how the data flows through it. You can add some ***Watch*** nodes, or simply pin open the preview bubbles that appear when you highlight a node. For the ***Element.Curves*** node, we have one item coming out of it. For the ***Range*** node we have a list of items. The ***Curve.PointAtParameter*** node is matching the *one* curve to the *one* list. The list in-turn is giving us its first item (item [0] in this case, because as you will also note, Dynamo uses "zero-based" numbering. Meaning that lists start at index zero, rather than index one). This is why it appears to not be working correctly, even though in reality it is working perfectly.

Now perhaps that is exactly what you want. Perhaps not. Either way we can control what we get for outputs using a concept called: “lacing.” Lacing is Dynamo’s way of matching the values on two or more lists to one another. The default lacing for the ***Curve.PointAtParameter*** node is “Shortest.” Shortest lacing will give you the fewest number of pairings. So in this case, a list of one item matched to a list of six yields one paring, and the simplest of the possible pairings, first item to first item (item [0] in each case). If we fed two curves into the **`curve`** input and ran the graph again, we would still get a single tree on each curve. However, the tree on the second curve would be placed at location number two (index [1]) from the second list (see Figure 27).



```
List
 0 List
   0 NurbsCurve(Degree = 3)
 1 List
   0 Line(StartPoint = Point(X = -45.21
@L3 @L2 @L1                        {2}
```

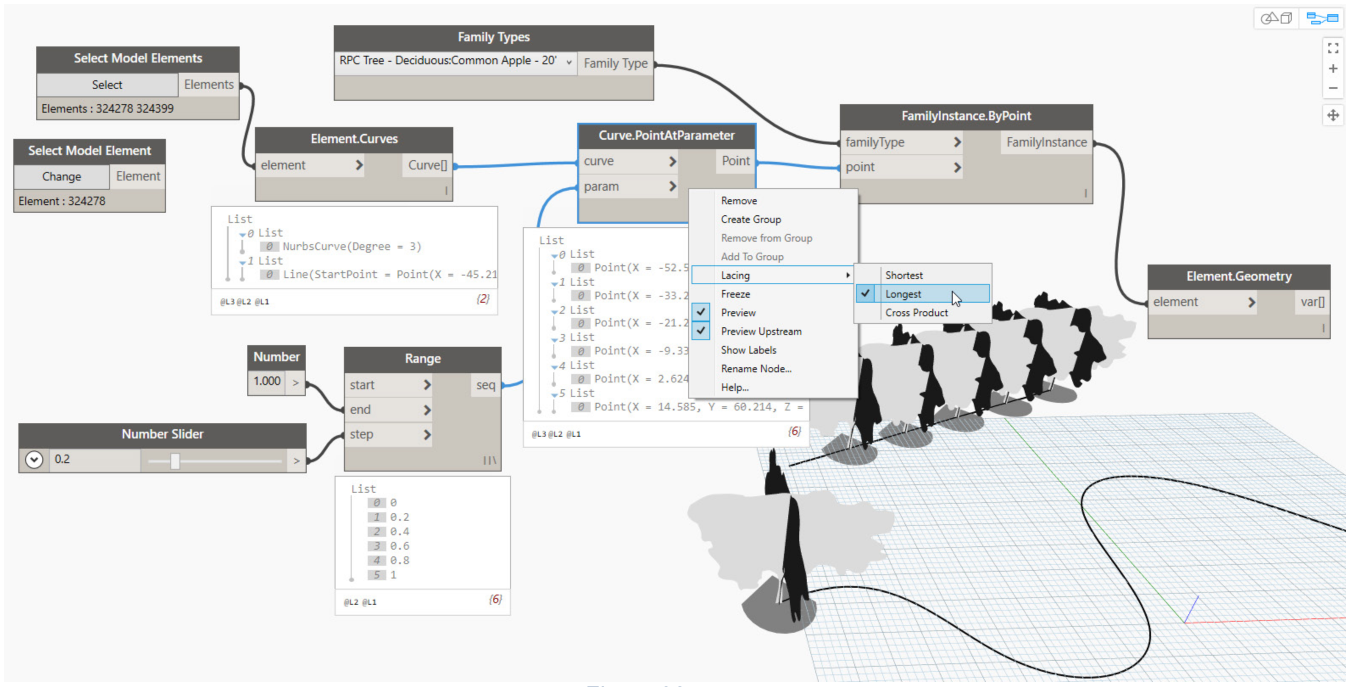
```
List
 0 List
   0 Point(X = -52.565, Y = 5.365, Z =
 1 List
   0 Point(X = -33.258, Y = 40.884, Z =
@L3 @L2 @L1                        {2}
```

```
List
   0 0
   1 0.2
   2 0.4
   3 0.6
   4 0.8
   5 1
@L2 @L1                            {6}
```

Figure 27

> Note that in the figure, I have switched out the ***Select Model Element*** node with a ***Select Model Elements*** (plural) node. ***Select Model Element*** lets you select only one element in the Revit model, while ***Select Model Elements*** allows a selection of two or more elements.

There are two other lacing options: Longest and Cross Product. Right-click on a node to change the setting. With longest, the paring process will be the same as shortest for the first items, but when the shorter list is exhausted, the final item on the shorter list will be repeated to ensure a number of pairings equal to the longer list. This does not always give the desired result (see Figure 28).



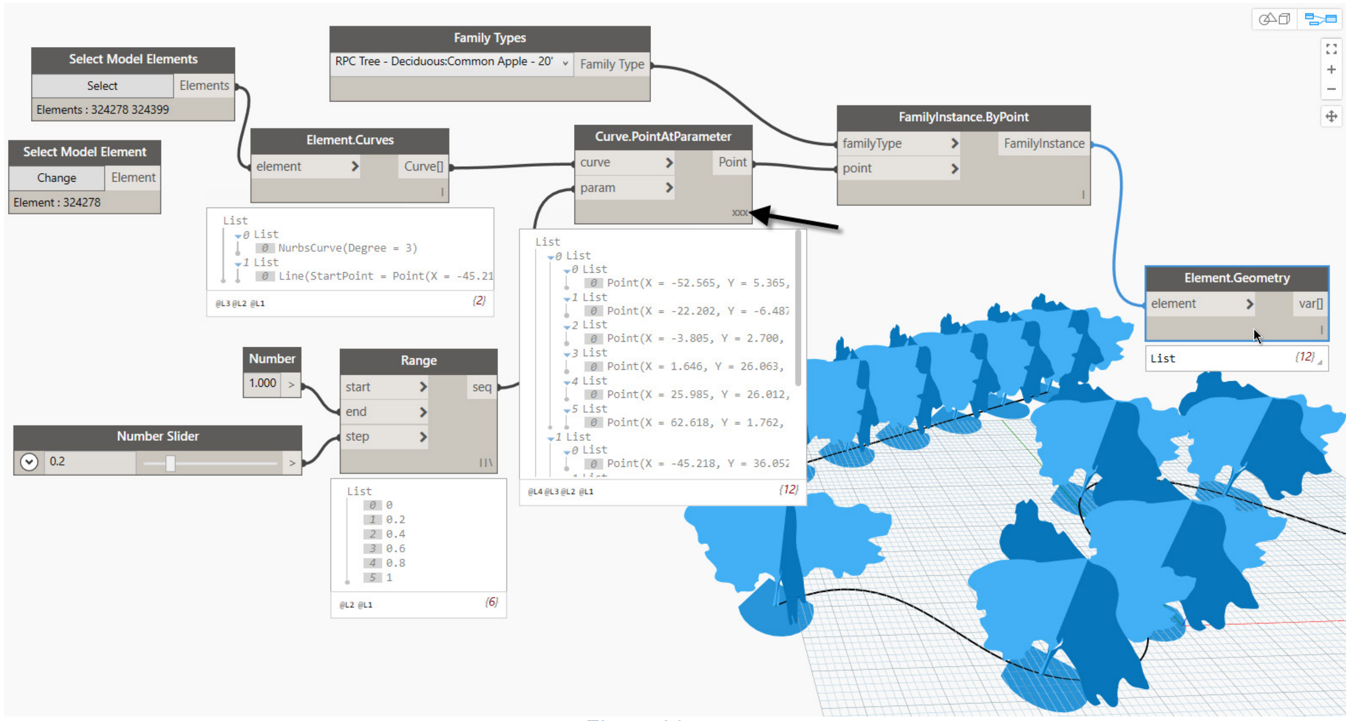
```
List
 0 List
   0 NurbsCurve(Degree = 3)
 1 List
   0 Line(StartPoint = Point(X = -45.21
@L3 @L2 @L1                          {2}
```

```
List
 0 List
   0 Point(X = -52.5
 1 List
   0 Point(X = -33.2
 2 List
   0 Point(X = -21.2
 3 List
   0 Point(X = -9.33
 4 List
   0 Point(X = 2.624
 5 List
   0 Point(X = 14.585, Y = 60.214, Z =
@L3 @L2 @L1                          {6}
```

```
List
 0 0
 1 0.2
 2 0.4
 3 0.6
 4 0.8
 5 1
@L2 @L1                              {6}
```

Figure 28

The final option: Cross Product, matches *all* possibilities. So you can end up with many pairings! In this case, if you want to add trees to all locations on both paths, then Cross Product would do the trick (see Figure 29).



```
List
 0 List
   0 NurbsCurve(Degree = 3)
 1 List
   0 Line(StartPoint = Point(X = -45.21
@L3 @L2 @L1                          {2}
```

```
List
 0 List
   0 List
     0 Point(X = -52.565, Y = 5.365,
   1 List
     0 Point(X = -22.202, Y = -6.487
   2 List
     0 Point(X = -3.805, Y = 2.700,
   3 List
     0 Point(X = 1.646, Y = 26.063,
   4 List
     0 Point(X = 25.985, Y = 26.012,
   5 List
     0 Point(X = 62.618, Y = 1.762,
 1 List
   0 List
     0 Point(X = -45.218, Y = 36.052
@L4 @L3 @L2 @L1                      {12}
```

```
List
 0 0
 1 0.2
 2 0.4
 3 0.6
 4 0.8
 5 1
@L2 @L1                              {6}
```

```
List                                 {12}
```

Figure 29

You may also want to take notice of the structure of the list that is generated by the ***Curve.PointAtParameter*** node in each case. The list structure with lacing set to: shortest is a list of lists. The parent list contains two sub-lists. Each of those lists contain a single point. With lacing at longest, we also get a list of lists. But this time there are six lists each with one point. When we go to cross product, we now have 3-level nested list. The top level is two lists that each contain six lists. Those six lists contain a single point each.

If you go back to the simpler graph with only the spline path selected, then you can get to the final result with either longest or cross product lacing. And in either case, as you drag the slider, it will now change the step value interactively within the limits set; in other words, you will see the quantity of trees reflect the change as you drag the slider. You can also play with the limits on the slider to vary the resultant quantities.

SAMPLE FILE: You can open a file completed to this point named: ***02_Place Families_D.dyn***.

Placing Multiple Families

The previous example placed one or more instances of the same family and type. You may also wish to place more than one family. One of the places where Dynamo really excels is in performing repetitive tasks. In this next example let's assume you wanted to create a single project file that would serve as a library or "warehouse" file. Users can then open the project file, locate the item they want and more importantly see an instance of each element already inserted onscreen in the file. Then they can simply select the one they need and copy and paste it to their project. Many firms build these so called warehouse files. But without a tool like Dynamo, it can be quite tedious to create one. In the first example, we'll create a simple wall type warehouse using out-of-the-box wall types. After that, we'll create a second warehouse using out-of-the-box casework families.

There will be similarities in each graph, but some significant differences as well. This is because walls are system families while casework are component (loadable) families. You are likely already familiar with some of the differences between system and non-system families. Well, they differ under the hood in the API as well. Dynamo is really like our bridge to the API, and while visual programming does shield us from much of the API issues and complexities, it does not conceal all of them. So keep in mind that Dynamo can only perform tasks that are possible through the Revit API. It just provides a more accessible way to do so that is easier to learn for many users.

Prepare a Project File

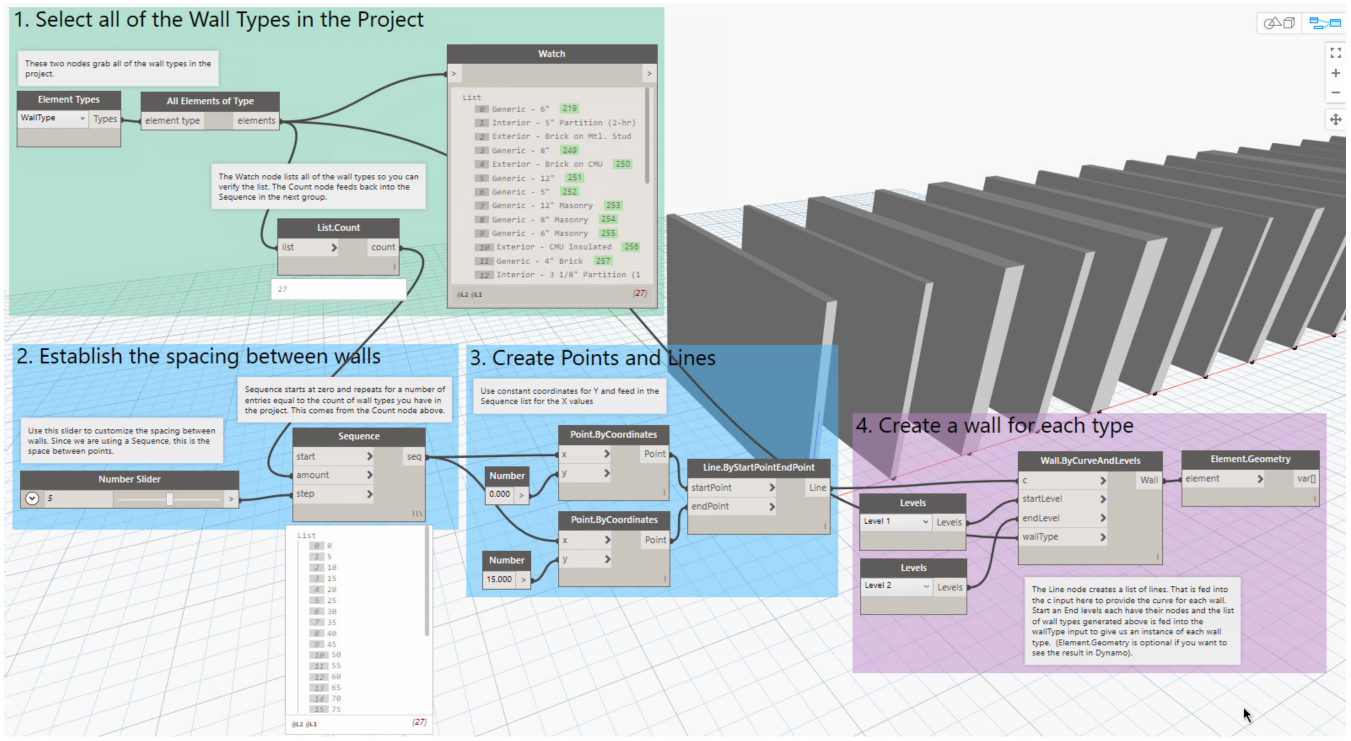
To get started you can simply create a new project file from the default template and save it as: *Wall Warehouse.* You can use any of the default template files. I used the default Architectural template installed with the US Imperial install of Revit for this example.

Repurpose an Old Graph

If you followed along with the "Hello World" examples above, then we will actually be able to reuse much of the graph that we built there. Our wall warehouse will need to make points by coordinates, draw lines and then place walls on these "curves." So if you still have that graph, the easiest thing to do is save it as a new name. I begin many of my Dynamo graphs this way. It saves time and allows you to maintain consistency. I do also re-build them scratch frequently as well, as there is much that can be learned and reinforced by building a new graph for a familiar solution. So either approach is perfectly fine.

Creating a Wall Warehouse

The graph is not too complicated. We need to get a list of all of the wall types in the project, create an equal number of lines (curves) for the placement of each one, and then feed this list of wall types into the node that creates the walls. Rather than explain each step of placing and wiring each node, I will instead show you the final graph (see Figure 30), and then explain each of its pieces.


1. Select all of the Wall Types in the Project

These two nodes grab all of the wall types in the project.

The Watch node lists all of the wall types so you can verify the list. The Count node feeds back into the Sequence in the next group.

2. Establish the spacing between walls

Sequence starts at zero and repeats for a number of entries equal to the count of wall types you have in the project. This comes from the Count node above.

Use this slider to customize the spacing between walls. Since we are using a Sequence, this is the space between points.

3. Create Points and Lines

Use constant coordinates for Y and feed in the Sequence list for the X values

4. Create a wall for each type

The Line node creates a list of lines. That is fed into the c input here to provide the curve for each wall. Start an End levels each have their nodes and the list of wall types generated above is fed into the wallType input to give us an instance of each wall type. (Element.Geometry is optional if you want to see the result in Dynamo).

Figure 30

Sample File: You can open a starter Revit file for this example named: ***03_Wall Warehouse_!Start.rvt*** open the Dynamo file named: ***03_Wall Warehouse.dyn***

Documenting your Graph

The first thing you will notice about this graph is that it has notes, descriptions and colored groups. These tools allow the author of a graph to provide documentation directly within the graph. Documenting your graphs is **highly** recommended. It is not important if you use groups, notes or both. But do make sure that you use at least one of them and make comments about what you did in the graph. This helps both your recipients (to understand how the graph functions) and yourself (when you open the graph later and try to remember what you did).

To create a group, select one or more nodes and then press CTRL + G. Double-click the group to rename it. The name can be a full description if you like, or just a few words. Right-click a group to customize its color and font size (see the left side of Figure 31).

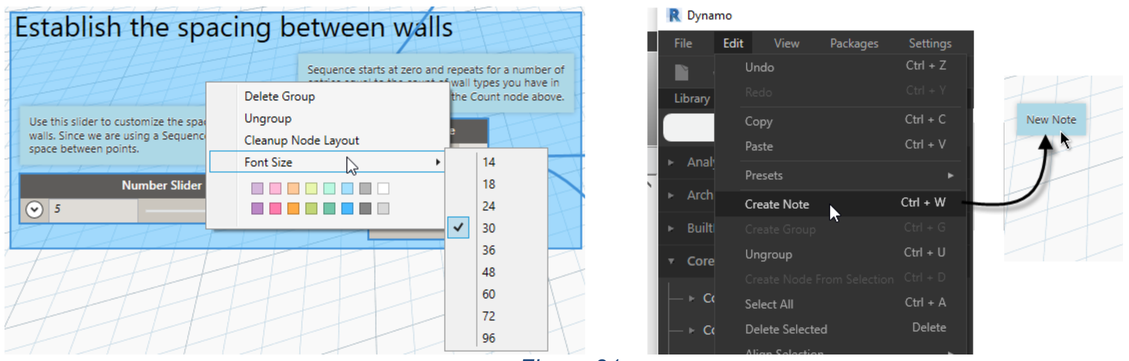


Figure 31

You can also create a Group from the Edit menu. Use the Edit menu to add notes as well. Or press CTRL + W (see the right side of Figure 31). To customize a note, double-click it. You cannot change the color or size of the note. So if you want to control those things, use a group instead.

Now let's take a look at each group in the graph. Refer back to Figure 30 for the following topics. Each topic will list the nodes used at the end with their locations in the library, but you can also simply search for them instead.

Make a List of All Wall Types

Group number 1 wires an ***Element Types*** node into an ***All Elements of Type*** node. The drop-down list on the first node lists all element types in Revit. Choose: **WallType** to get a list of all wall types in the current project. This is reflected in the ***Watch*** node. The ***List.Count*** node shows that this particular project includes 27 wall types. But the nice thing about this is, if you add or delete types, the graph (and the count) will update.

Library Location	**Node**
Core > List	Count
Core > View	Watch
Revit > Selection	Element Types
Revit > Selection	All Elements of Type

Establish the Spacing Between Walls

Group 2 has only two nodes. Here we are using a ***Number Slider*** to interactively set the spacing between the placed walls. This is accomplished by creating a sequence of numbers with a ***Sequence*** node. Its ***start*** input defaults to zero. So we do not need to feed in anything here. The ***amount*** input is how many items you want in the sequence. (These can be numbers or letters incidentally, but we need numbers in this case). So here we feed in the quantity of wall types derived from the ***Count*** node above. For the ***step*** value, we use the slider to make it interactive. You can adjust the settings of the slider to make it snap to more reasonable settings than the default. I used a maximum value of: **10** with a step of: **.5**. So with the value of: 5 shown in the figure, we get a sequence of 27 numbers starting at: 0 and ending at: 130 incrementing by 5 each time. Try other values if you like.

Create the Curves

You recall from above that Dynamo thinks of any linear shape as a curve. It can be a straight line, an arc or freeform spline. These are all curves. Revit however, only allows walls to follow straight line or circular arc paths. So we must always be sure to know any limitations in Revit and ensure that our graph is built with these in mind. So if you fed an ellipse or spline path for example into the Wall node later, it would fail.

In group 3 we are creating two sets of points that will be used to define a series of lines. This part of the graph illustrates an important concept in Dynamo: Most inputs can take either single values or lists! (We saw this in the tree example too, but it is worth highlighting this important fact). If you feed in an individual value, you get a single output. But if you feed in a list, you get a list of outputs! Very cool!

So what do we need? Well we have 27 wall types. So we want 27 pairs of X, Y points, 27 lines from the points and ultimately 27 walls based on those lines. How do we achieve this? We simply make sure that we feed in a list to at least one of the inputs. In our case, we only want the X values to vary. We will keep the Y values constant. This will draw our lines and walls along the X axis (horizontally).

We need two ***Point.ByCoordinates*** nodes. There are two to choose from, one has ***x*** and ***y*** inputs the other also has ***z***. You can use either one. Just leave ***z*** empty and it will default to zero and you get the same result. Since we don't want to vary the `y` inputs, we can use two ***Number*** nodes for those inputs and just type in the values we want. Any numbers will work here, but choose a value that sets the length of the walls to a reasonable size.

The `x` port is where we feed in our lists. They will both use the same list: our output from the ***Sequence*** node above. Recall that this gave us a list of 27 numbers spaced evenly (by the slider). These will now be used as our `x` values and more importantly we will end up with 27 sets of points as a result.

To complete this group, feed the two ***Point*** node outputs into a ***Line.ByStartPointEndPoint*** node and we will end up with 27 lines marching off to the right.

Library Location	**Node**
Core > Input	Number
Geometry > Point	ByCoordinates
Geometry > Line	ByStartPointEndPoint

Create Wall Geometry

Our final group, group 4 creates the walls. This group mimics what we started with from the "Hello World" example above. We have a ***Wall.ByCurveAndLevels*** node. It has four inputs. If you started with the old file, you already have the ***Levels*** nodes inserted and wired up. The `c` input receives the output from the ***Line*** node. This will feed in the 27 lines (curves) to create 27 walls. For the `wallType` input, feed in the list of wall types captured in the first group. That's it! You should get 27 walls onscreen in Revit. If you want to see them in Dynamo as well, add the optional ***Element.Geometry*** node to create the representation in the Dynamo canvas. But this node is not required.

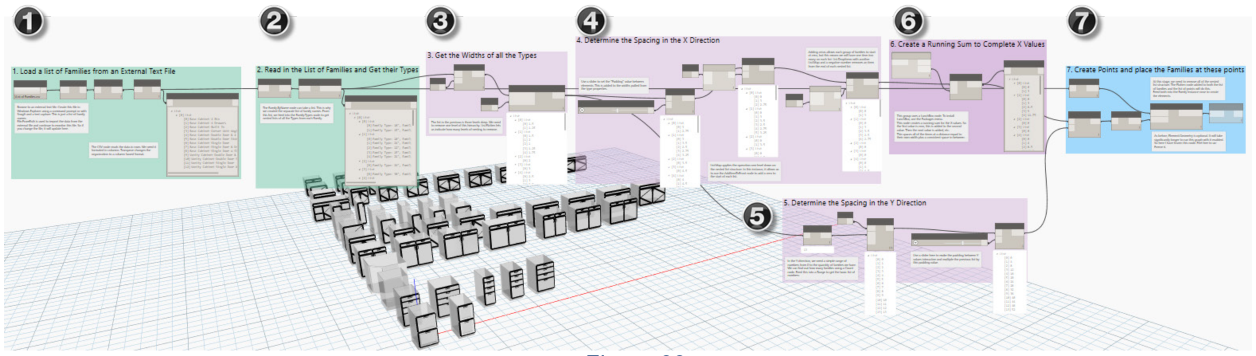
Library Location	**Node**
Revit > Selection	Levels
Revit > Elements > Element	Geometry
Revit > Elements > Wall	ByCurveAndLevels

Creating a Casework Warehouse

As noted above, the procedure for system families differs a bit from component (loadable) families. This is true in the Revit interface and certainly in the API and by extension in Dynamo. For one, system families are already built-in to all Revit projects. Component families must be loaded. So if you want to create a library file of families in a component category such as casework, you will need to ensure that you have some loaded. While there are ways to load from external files directly in Dynamo, in this workflow, we will start with a file that has some casework pre-loaded and focus our graph on placement of the families in the project. So before you begin, from the Insert tab, load a bunch of casework families. You do not need to place any of them in the model. That is what we will use Dynamo for. Just load them into the project and save it. For my example, I am loading all of the families from the out-of-the-box library that are contained in the *Casework\Base Cabinets* folder. I chose these because they are free-standing and do not require wall hosts.

SAMPLE FILE: You can open a starter Revit file named: ***04_Casework Warehouse_!Start.rvt***
and a starter Dynamo file named: ***04_Casework Warehouse_A.dyn***
and the CSV file: ***List of Families.csv***

As you can see, this graph is a bit more complex than the previous one. It still takes a list of types and computes a series of X and Y coordinates for placement, but his graph has two new features not covered in the previous ones. First, to get the list of families, we are reading a text file from disk. And when processing the coordinates, we will also use a custom node from a downloadable "Package." A Package is like a plug-in for Dynamo. Dynamo has a very active user community and many community members have extended the functionality of Dynamo by making Packages available. Once you install a Package, its nodes work exactly like the out-of-the-box ones, so there is no reason to shy away from them. Here is an overall look at the whole graph. In the topics that follow, we'll explore each numbered group (see Figure 32).



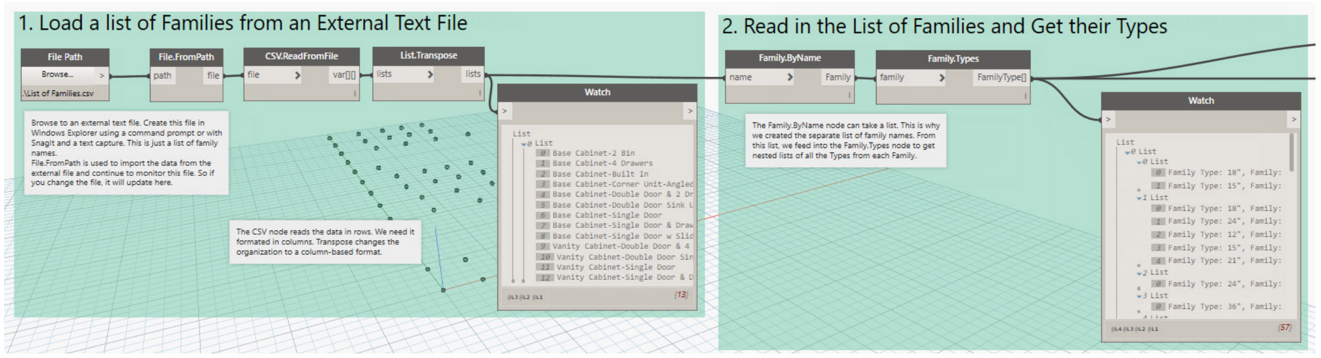
1
2
3
4
5
6
7
1. Load a list of Families from an External Text File
2. Read in the List of Families and Get their Types
3. Get the Widths of all the Types
4. Determine the Spacing in the X Direction
5. Determine the Spacing in the Y Direction
6. Create a Running Sum to Complete X Values
7. Create Points and place the Families at these points

Figure 32

Loading Information from an External File

In the first group, I am loading an external text file. This is a quick way to get a list of all the families in the project and use it to get their types. Later we will see that there is a node to query all of the types from a list of families, but there is not a node to get a list of all the families loaded in the project. There might be external Packages out there with such a node, and you are welcome to explore. For now, we'll save further discussion of Packages for the example showcased below. In the meantime, using an external file to get a list of families is quick, easy and effective.

You can read an external CSV formatted text file or an Excel file. The process and nodes required are similar for each. Since I am doing just a simple list here, I went with CSV for this example. To create the list, you can of course type it manually in: Notepad, but it is quicker to use SnagIt (or similar) and do a text capture or use a command prompt and the DIR command to export a list of families from a folder in Windows Explorer. I will leave the specific choice of process to you. Once you have the file, you can Browse to it with a ***File Path*** node (see Figure 33).



Browse to an external text file. Create this file in Windows Explorer using a command prompt or with SnagIt and a text capture. This is just a list of family names.
File.FromPath is used to import the data from the external file and continue to monitor this file. So if you change the file, it will update here.

The CSV node reads the data in rows. We need it formated in columns. Transpose changes the organization to a column-based format.

```
List
 ▾0 List
    0  Base Cabinet-2 Bin
    1  Base Cabinet-4 Drawers
    2  Base Cabinet-Built In
    3  Base Cabinet-Corner Unit-Angled
    4  Base Cabinet-Double Door & 2 Dr
    5  Base Cabinet-Double Door Sink U
    6  Base Cabinet-Single Door
    7  Base Cabinet-Single Door & Draw
    8  Base Cabinet-Single Door w Slid
    9  Vanity Cabinet-Double Door & 4
    10 Vanity Cabinet-Double Door Sin
    11 Vanity Cabinet-Single Door
    12 Vanity Cabinet-Single Door & D
@L3 @L2 @L1                        {13}
```

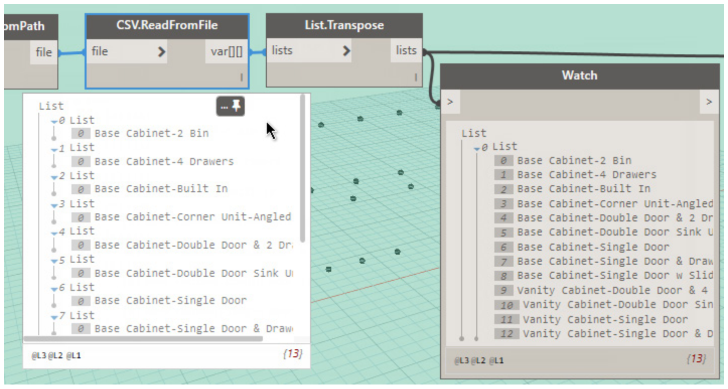
The Family.ByName node can take a list. This is why we created the separate list of family names. From this list, we feed into the Family.Types node to get nested lists of all the Types from each Family.

```
List
 ▾0 List
   ▾0 List
      0  Family Type: 18", Family:
      1  Family Type: 15", Family:
   ▾1 List
      0  Family Type: 18", Family:
      1  Family Type: 24", Family:
      2  Family Type: 12", Family:
      3  Family Type: 15", Family:
      4  Family Type: 21", Family:
   ▾2 List
      0  Family Type: 24", Family:
   ▾3 List
      0  Family Type: 36", Family:
@L4 @L3 @L2 @L1                    {57}
```

Figure 33

File Path points to the file on disk. But to read it into Dynamo and access the data it contains requires two nodes: ***File.FromPath*** and ***CSV.ReadFromFile***.

When you read a file from CSV (or from Excel) it will create a list of lists. Each sub-list will contain one row of data from the comma-separated file in its own list. This will be the case even if there is only one piece of information per row like we have here (see the preview bubble on the left side of Figure 34).



```
List
 0 List
    0 Base Cabinet-2 Bin
 1 List
    0 Base Cabinet-4 Drawers
 2 List
    0 Base Cabinet-Built In
 3 List
    0 Base Cabinet-Corner Unit-Angled
 4 List
    0 Base Cabinet-Double Door & 2 Dr
 5 List
    0 Base Cabinet-Double Door Sink U
 6 List
    0 Base Cabinet-Single Door
 7 List
    0 Base Cabinet-Single Door & Draw
@L3 @L2 @L1                      {13}
```

```
List
 0 List
    0 Base Cabinet-2 Bin
    1 Base Cabinet-4 Drawers
    2 Base Cabinet-Built In
    3 Base Cabinet-Corner Unit-Angled
    4 Base Cabinet-Double Door & 2 Dr
    5 Base Cabinet-Double Door Sink U
    6 Base Cabinet-Single Door
    7 Base Cabinet-Single Door & Draw
    8 Base Cabinet-Single Door w Slid
    9 Vanity Cabinet-Double Door & 4
    10 Vanity Cabinet-Double Door Sin
    11 Vanity Cabinet-Single Door
    12 Vanity Cabinet-Single Door & D
@L3 @L2 @L1                      {13}
```

Figure 34

That data structure might be what you want, but in many cases you would rather have a list organized by column instead. To do this, we need to transpose it (see the ***Watch*** node on the right side of Figure 34). Transpose simply reverses the data structure to organize by columns instead of rows or vice-versa.

Once we have read our file and transposed its data, we can feed that into the next node in group 2. Here we have two nodes: ***Family.ByName*** which takes a name or list of names and ***Family.Types*** which reports all of the types within each family coming in. So this gives us a complete list of the all the types from all of the casework families on our list. The structure of the list is a three-tiered nested list.

Library Location	**Node**
Core > Input	File Path
Core > File	File.FromPath
Core > File > CSV	ReadFromFile
Core > List	Transpose
Revit > Elements > Family	ByName
Revit > Elements > Family	Types

An Alternative to Reading an External File

You may be wondering if there is an alternative to creating a list of families externally to the graph and reading it in. Well, it is possible to use a ***List.Create*** node and build a custom list. You use the small + icon on the node to add inputs. The trouble is, as you can see in Figure 35, you would have to add many items to your list and manually choose each family type from the drop-down. So this is quite tedious and I therefore believe creating and then reading the CSV file is much better choice.

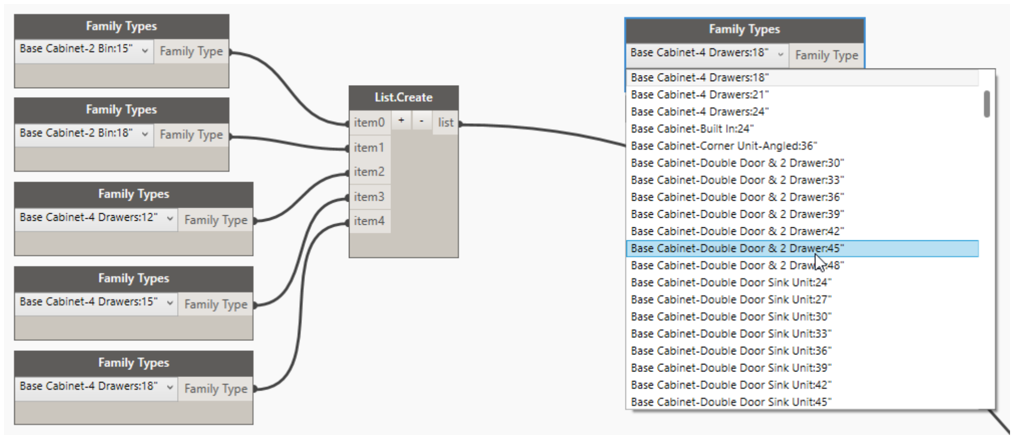
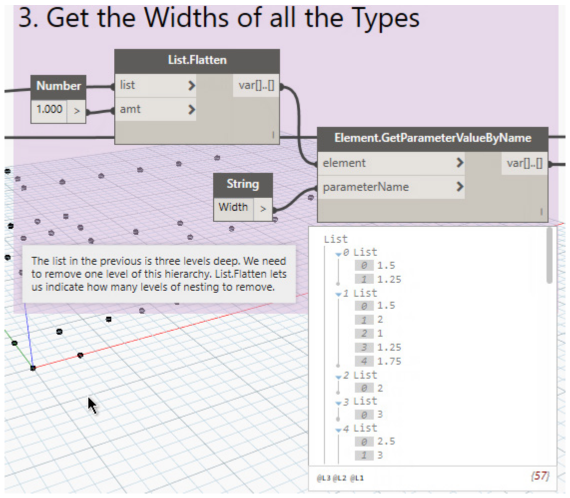

Family Types
Base Cabinet-2 Bin:15"
Family Type
Base Cabinet-2 Bin:18"
Base Cabinet-4 Drawers:12"
Base Cabinet-4 Drawers:15"
Base Cabinet-4 Drawers:18"
List.Create
item0
item1
item2
item3
item4
list
Base Cabinet-4 Drawers:18"
Base Cabinet-4 Drawers:21"
Base Cabinet-4 Drawers:24"
Base Cabinet-Built In:24"
Base Cabinet-Corner Unit-Angled:36"
Base Cabinet-Double Door & 2 Drawer:30"
Base Cabinet-Double Door & 2 Drawer:33"
Base Cabinet-Double Door & 2 Drawer:36"
Base Cabinet-Double Door & 2 Drawer:39"
Base Cabinet-Double Door & 2 Drawer:42"
Base Cabinet-Double Door & 2 Drawer:45"
Base Cabinet-Double Door & 2 Drawer:48"
Base Cabinet-Double Door Sink Unit:24"
Base Cabinet-Double Door Sink Unit:27"
Base Cabinet-Double Door Sink Unit:30"
Base Cabinet-Double Door Sink Unit:33"
Base Cabinet-Double Door Sink Unit:36"
Base Cabinet-Double Door Sink Unit:39"
Base Cabinet-Double Door Sink Unit:42"
Base Cabinet-Double Door Sink Unit:45"

Figure 35

SAMPLE FILE: You can open this Dynamo file named: ***04_Casework Warehouse_B.dyn***
*This graph also showcases the older style usage of **List.Map** to apply functions to nested lists.*

Getting the Widths of Family Types

In group 3 we are getting the widths from the type properties. As noted in the previous topic, the list currently has a three-level hierarchy. For now, we want to drop that to two levels: a parent list containing lists for each family. The elements on the sub-lists will be the values for the widths of each type. To get those, we can use ***GetParameterValueByName***. This node gets the value of any parameter from any element or type in your model. In this case, we are asking the types what their respective width values are (see Figure 36).


3. Get the Widths of all the Types
List.Flatten
list
amt
var[]..[]
Number
1.000
Element.GetParameterValueByName
element
parameterName
String
Width
The list in the previous is three levels deep. We need to remove one level of this hierarchy. List.Flatten lets us indicate how many levels of nesting to remove.

```
List
 0 List
   0 1.5
   1 1.25
 1 List
   0 1.5
   1 2
   2 1
   3 1.25
   4 1.75
 2 List
   0 2
 3 List
   0 3
 4 List
   0 2.5
   1 3
@L3 @L2 @L1                    {57}
```

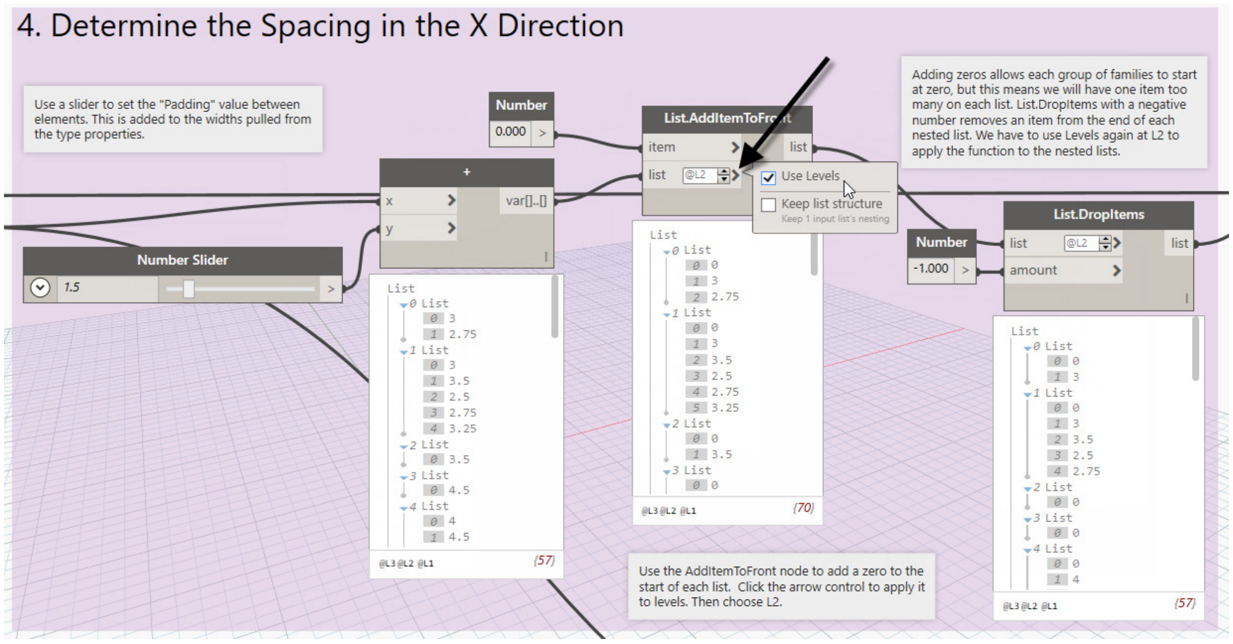
Figure 36

Library Location	Node
Core > Input	Number
Core > Input	String
Core > List	Flatten

Revit > Elements > Element	GetParameterValueByName

Determine the Spacing of Elements

To determine the spacing of elements we will start with the X direction. The list we just generated in the previous group is how wide each family type is. To this, we can add a constant value to maintain a consistent amount of space between each item. If you look at group 4, this is done with the first two nodes. A slider is used here to make it easier to change the spacing interactively (see Figure 37).


4. Determine the Spacing in the X Direction

Use a slider to set the "Padding" value between elements. This is added to the widths pulled from the type properties.

Adding zeros allows each group of families to start at zero, but this means we will have one item too many on each list. List.DropItems with a negative number removes an item from the end of each nested list. We have to use Levels again at L2 to apply the function to the nested lists.

Use the AddItemToFront node to add a zero to the start of each list. Click the arrow control to apply it to levels. Then choose L2.

```
List
 0 List
   0 3
   1 2.75
 1 List
   0 3
   1 3.5
   2 2.5
   3 2.75
   4 3.25
 2 List
   0 3.5
 3 List
   0 4.5
 4 List
   0 4
   1 4.5
@L3 @L2 @L1                {57}
```

```
List
 0 List
   0 0
   1 3
   2 2.75
 1 List
   0 0
   1 3
   2 3.5
   3 2.5
   4 2.75
   5 3.25
 2 List
   0 0
   1 3.5
 3 List
   0 0
@L3 @L2 @L1                {70}
```

```
List
 0 List
   0 0
   1 3
 1 List
   0 0
   1 3
   2 3.5
   3 2.5
   4 2.75
 2 List
   0 0
 3 List
   0 0
 4 List
   0 0
   1 4
@L3 @L2 @L1                {57}
```

Figure 37

This gives us the width plus spacing. But we need to start the first item in each list at zero. This is accomplished with the ***List.AddItemToFront*** node. However, if we use it directly, it will add the item to the main list. We want to add zero to *each* sub-list. This is accomplished by applying the effect with "Levels." You can click the small little triangle icon on the input, and then check the "Use Levels" checkbox. It will default to @L2 which means apply the function to the level 2 list. This is what we want here. If you need it to apply to a different level, click the small spinner icons to choose a different level. (In older versions of Dynamo, you would need to use ***List.Map*** to achieve similar functionality).

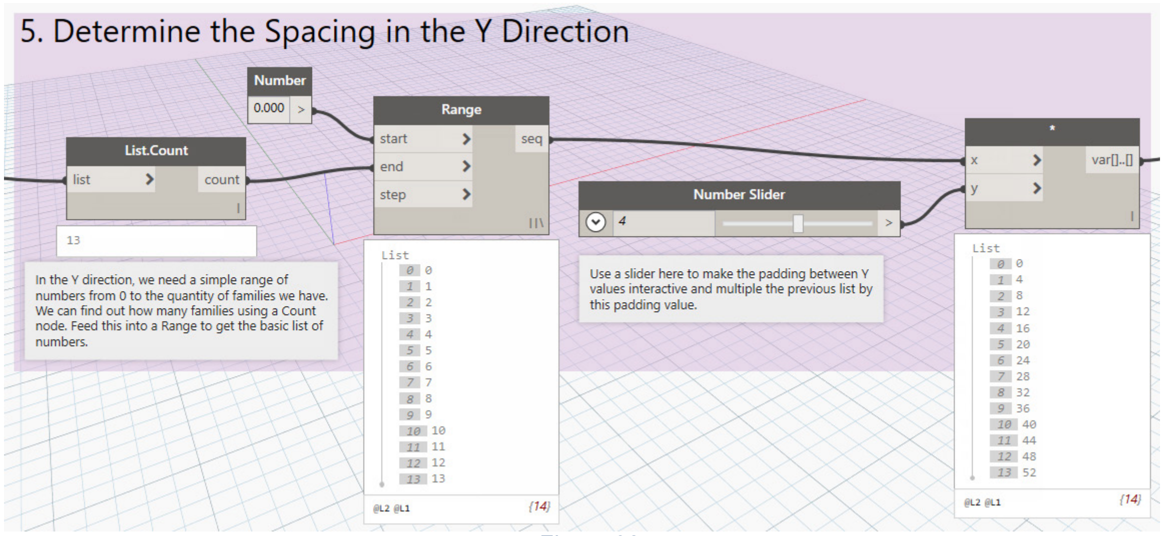
Following this node, we now have too many items on each list. So now we will use a ***List.DropItems*** node to remove the last item from each nested list. Check "use Levels" on this one as well to apply the function to the nested list. The amount input on ***List.DropItems*** takes either positive or negative numbers. Positive numbers drop items from the start of the list, while negative numbers drop items at the end of the list. So here we are using negative one to remove the last item on each list.

This gives us the distances we need to determine the X spacing, but they are not the actual coordinates yet. We will explore how to get there in group 6 below. Meanwhile, let's take a moment to build the spacing in the Y direction.

Library Location	**Node**
Core > Input	Number Slider

Library Location	Node
Core > Input	Number
Operators	+
Core > List	AddItemToFront
Core > List	DropItems

Working in parallel, we have the nodes that determine the Y spacing. If you return to the start of the graph and do another ***GetParameterValueByName*** for the: Depth, we find that since these are casework elements, almost all of them use the same depth for each type. The only exception is the corner cabinet which is a little larger. Therefore, I have decided that it will be simpler to use a consistent value for the Y direction. Furthermore, we can use a slider to change the value and then apply it directly to the Y coordinates using simple multiplication instead of nested lists.



In the Y direction, we need a simple range of numbers from 0 to the quantity of families we have. We can find out how many families using a Count node. Feed this into a Range to get the basic list of numbers.

Use a slider here to make the padding between Y values interactive and multiple the previous list by this padding value.

```
List
0 0
1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 9
10 10
11 11
12 12
13 13
@L2 @L1 {14}
```

```
List
0 0
1 4
2 8
3 12
4 16
5 20
6 24
7 28
8 32
9 36
10 40
11 44
12 48
13 52
@L2 @L1 {14}
```

Figure 38

Start by building a Range (see Figure 38). It starts at zero and the end receives the output from the ***Count*** of original type list. Now recall that this is a nested list containing lists of families that in turn list out all of the types. If we count this list, we get the quantity of parent lists (the number of families, which is what we want here). If you wanted the count of the number of types, you would use the ***Count*** node with a ***List.Map*** instead. We can leave the step alone since it defaults to 1 which is what we need here.

Feed this range of values into a multiplication node and multiply it by the slider. If you want to ensure that there is always enough room for each family, set the minimum value of the slider to something like: **4**. This will ensure that it is a little larger than the largest depth of the families we are using. This gives us results that are usable directly as our Y coordinates. So we will feed them into the ***y*** port of our ***Point.ByCoordinates*** node below. But as noted above, we still need to do a little more work on our X values.

Library Location	Node
Core > Input	Number Slider
Core > Input	Number

Library Location	Node
Operators	*
Core > List	Range
Core > List	Count

Using a Package Node

For the X direction we have a choice. The simplest way to do it would be to do it exactly like we did with Y values. To do this, we would choose a minimum spacing value that was wider than the largest element's width plus a little more to provide some space in-between. This would ensure that there was enough room for each element, but some would have less space between them than others, but the center-to-center distances would always be equal. The other option is the one I have opted for here. I would prefer that the space between elements always be equal, therefore the center-to-center spacing will vary with the widths of each element type. This means that we cannot use simple multiplication like we did with the Y values. Instead, we have to do a running addition of the values computed in group 4 above. Consider list [1] as an example. The first element will be placed at: 0. The next one is at: 0 + 3, the next one is the sum of the first three values: 0 + 3 + 3.5, or 6.5 and so on. I have had some success with this using a ***List.Scan*** node for this is other graphs. I decided to show a different approach here. I have turned to a node from the LunchBox Package called: ***LunchBox Mass Addition***.

To locate a Package, open the Packages menu and choose: **Search for a Package** (see the left side of Figure 39). In the "Online Package Search" dialog that appears, type: **lunchbox** into the Search field. When LunchBox for Dynamo appears, click the arrow icon on the left to download and install it (see the middle of Figure 39). Click OK in any messages that appear to confirm download and installation. (LunchBox will alert you that it has "dependencies." It is safe to click OK here and dismiss that warning). Once installation is complete, you will see a new branch for LunchBox in your library panel. If you hover over the name, the letters PKG will appear to the right of the name. This indicates that it is a Package (see the right side of Figure 39).

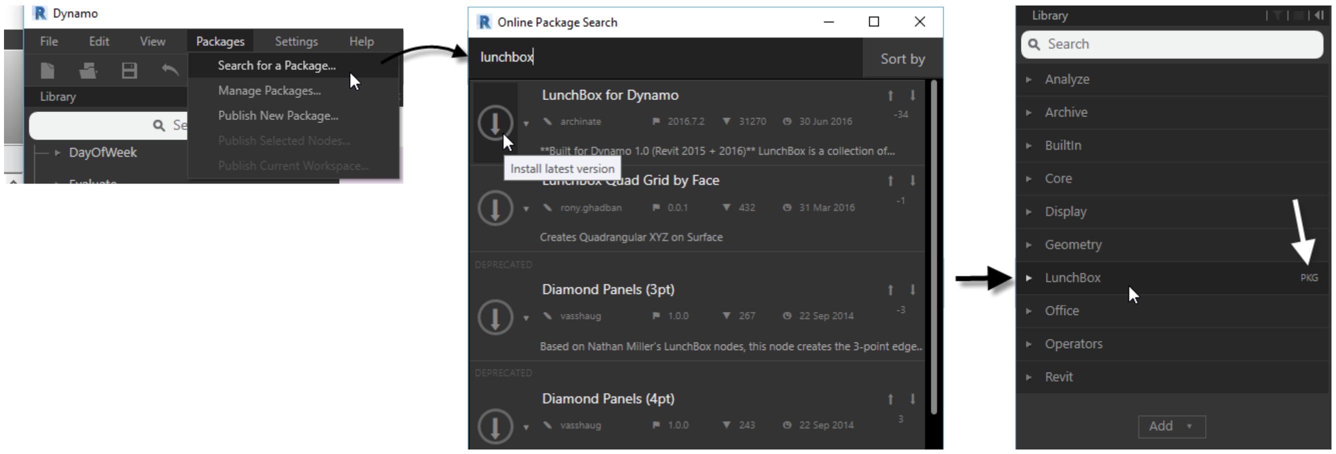
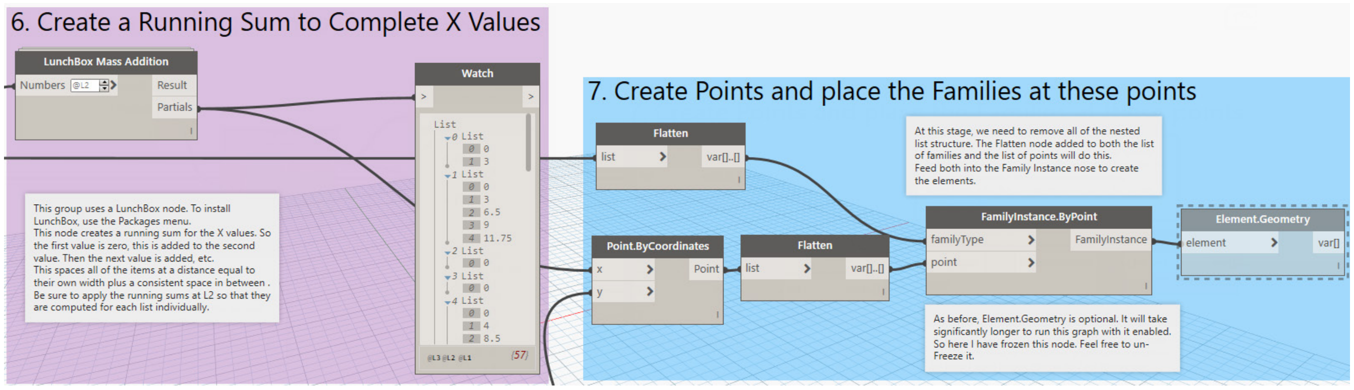


Figure 39

There are hundreds of Packages available that perform all sorts of useful functions. Feel free to explore and install others if you wish. Keep in mind that like any community driven initiative, the quality and utility of Packages will vary. I tend to only install a Package if it has a node that fulfills a certain task I am trying to solve in my graph. If you are concerned about installing Packages, just take a few moments to do a Google search on the Package you are considering. The Dynamo community is very active and you will likely find many posts about the Package you are considering with users giving you the straight talk on the best ones available out there. And of course you can always uninstall ones you no longer find useful.

Using LunchBox to Create a Running Sum

Now that we have the LunchBox Package installed, we can use its nodes just like any other. In this case we need ***LunchBox Mass Addition***. We want it to perform its function on the nested list, so we will check the “Use Levels” option again. A ***Watch*** node will reveal that it has correctly given us a running sum of the values for our X coordinates (see the left side of Figure 40).



This group uses a LunchBox node. To install LunchBox, use the Packages menu.
This node creates a running sum for the X values. So the first value is zero, this is added to the second value. Then the next value is added, etc.
This spaces all of the items at a distance equal to their own width plus a consistent space in between . Be sure to apply the running sums at L2 so that they are computed for each list individually.

At this stage, we need to remove all of the nested list structure. The Flatten node added to both the list of families and the list of points will do this.
Feed both into the Family Instance nose to create the elements.

As before, Element.Geometry is optional. It will take significantly longer to run this graph with it enabled. So here I have frozen this node. Feel free to un-Freeze it.

Figure 40

Creating Points and Placing Family Instances

Group 7 completes the graph and places our family instances. To do this, we need to go all the way back to the list of types generated in group 2. We want to place one of each of the types on the that list. To do that, we have to take our lists of X and Y values and create points from them. A ***Point.ByCoordinates*** node will be used for this. As we noted above, you can use the one that asks for only ***x*** and ***y*** or the one that wants ***x***, ***y*** and ***z***. Just leave ***z*** blank to place them all at the default of zero. Feed the results from the ***List.Map*** in group 6 into ***x*** and the results from the multiplication node in group 5 into ***y***. Both of these are hierarchical lists and more importantly, their respective structures match, so we get a nice grid of points in the quantities required (see Figure 41).

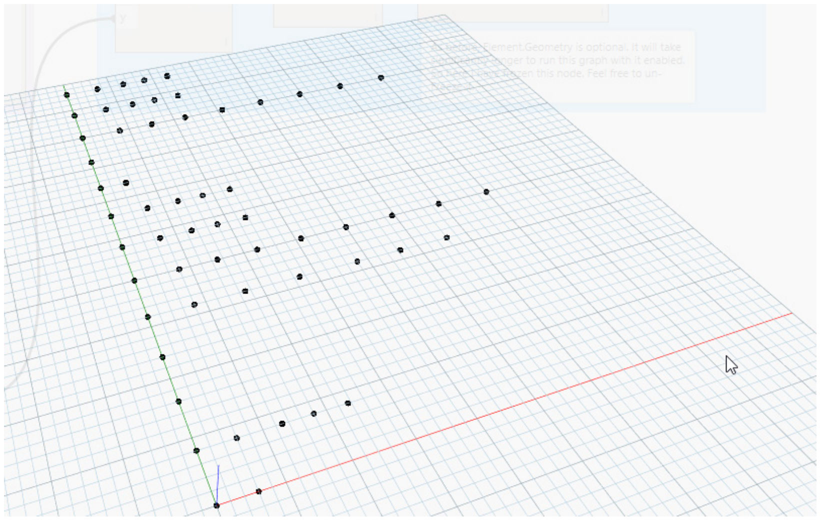


Figure 41

But now that we have this grid of points, the hierarchy is no longer required. And in fact, if we keep it, we will not get families placed properly. So we need to flatten both the list of points coming out of the point node *and* the list of types coming out of the ***Family.Types*** node back in group 2.

There are two flatten nodes in the out-of-the-box library. One is on the *Core* > *List* branch and includes the **`amt`** input so that you can tell it how many levels of lists to flatten. There is also a simple ***Flatten*** node located in the: *Builtin* branch of the library. This one will flatten the entire list regardless of its structure. This is the one we will use here. (However, if you check "Use Levels" there really is not much difference between these two nodes anymore). Add two of them and flatten the output from the ***Family.Types*** node and the output of the ***Point.ByCoordinates*** node. Finally feed these flattened outputs into the ***FamilyInstance.ByPoint*** node to create the families in Revit.

Library Location	Node
LunchBox > Math > Operators	LunchBox Mass Addition
Builtin	Flatten
Geometry > Point	ByCoordinates
Revit > Elements > FamilyInstance	ByPoint

Once again, the ***Element.Geometry*** node is optional but it is not recommended in this case. The reason is that it will add *significantly* to the amount of time it takes to process the graph. So leave it out and use the Revit window to see the results.

So now you have three different approaches to placing Revit families. If you plan to use Dynamo with Revit, there is a good chance that you will need to place elements at some point, so techniques from one or more of those examples should prove helpful. But these examples are by no means exhaustive. There are many other ways you can place Revit elements and interact with those that are already in your model. In the next topic, we will explore a little bit of both.

Processing Data

The goal of the final example involves a curtain wall façade and using Dynamo to help us place many custom shaped curtain panels. The façade has an irregular shape along the edges as it climbs the height of the building. To get the custom curtain wall shape, I used Edit Profile. The curtain panel being used in the design is a custom curtain panel family. The family has a lower horizontal spandrel, a glazing area and then another horizontal band across the top with a slab cover. Instead of using Revit mullions, the mullions are modeled directly in the panel family and wrap around the edges as well as horizontally dividing the three zones of the panel design (see the left side of Figure 42).

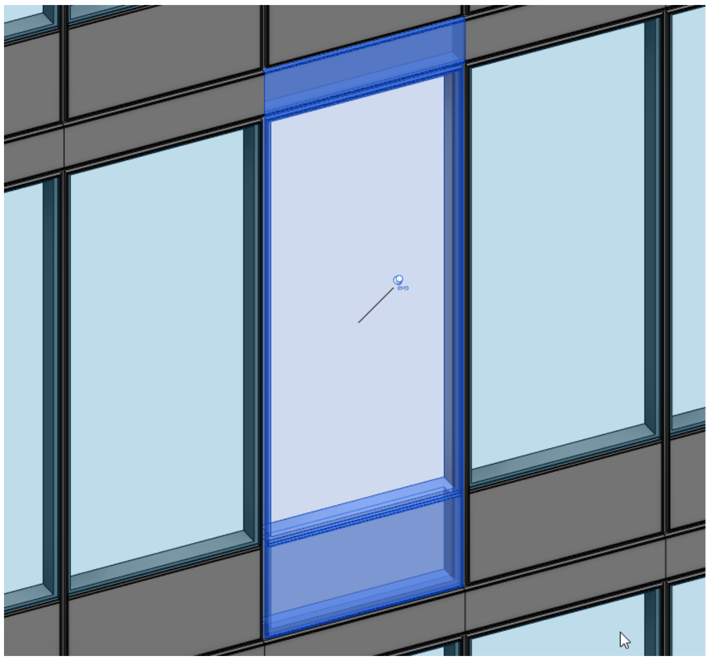
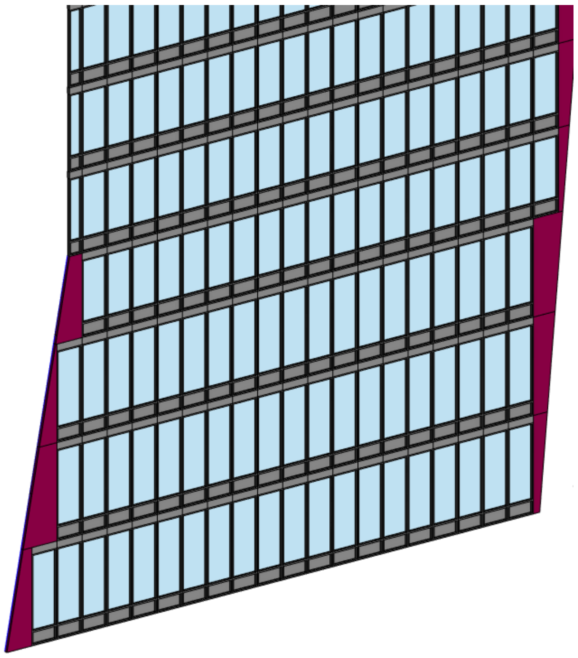



Figure 42

If you have ever used a custom panel in your curtain wall designs, you know that a significant limitation exists; they must always be rectangular. So the challenge here is how to deal with the non-rectangular edges of the façade. When you use Edit Profile on a curtain wall, you typically end up with non-rectangular edge panels. Revit will generate an error for these panels and then replace them with system panels. To make them stand out better, I selected all instances of these system panels and made a new type that is shaded red (see the right side of Figure 42).

The problem with System Panels is that while they can be any shape, they are limited to simple extrusions. So you cannot add any of the intermediate geometry for horizontal mullions, slab covers or spandrels. However, you *can* build such things with an Adaptive Component family. And adaptive components can be any shape you like. The exact process I followed to build the adaptive version of this panel could fill its own class, so I will not be going into the specifics here. To summarize: it is a four-point adaptive component (that can be a non-rectangular shape) and mimics the same look as main panel with its spandrels, slab cover and mullions. These are placed with similar proportions and parameters to match the original. When you place this component, the lower spandrel and top spandrel will flex with the panel but stay parallel to the top and bottom edges.

So the focus of this exercise will be to use Dynamo to select all of the edge panels, extract their corners and then use those points to add the custom four-point adaptive family instances to the model in each location required.

Troubleshooting

So now that we know the challenge and goal of the next exercise, I want to address one other issue before diving in to it. As you begin to learn Dynamo, you will try things that work and many times you will try things that don't work. But even when building a graph that fails to achieve the overall goal, you can still learn quite a bit from the process. In building the adaptive component curtain panel exercise, I ran into some snags along the way (which is completely normal) and to help me figure them out, I used a combination of "old school" sketching (on paper - see Figure 43), "phone a friend" (thank you Zach and Dynamo forum) and more Dynamo or course!

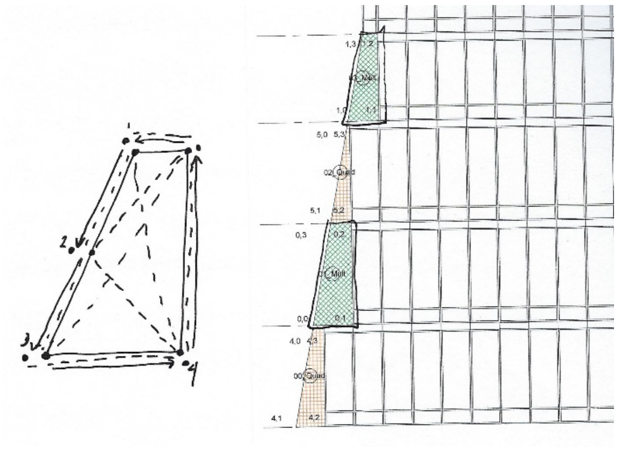


Figure 43

As I worked through it, I thought that one of the "troubleshooting" graphs I created while building the solution was actually educational in itself. So I decided to include that one here as a preliminary to the curtain panel edges graph that we have just outlined. If you would rather skip right to the curtain panel example, you can skip down to the "Placing Adaptive Components" heading below.

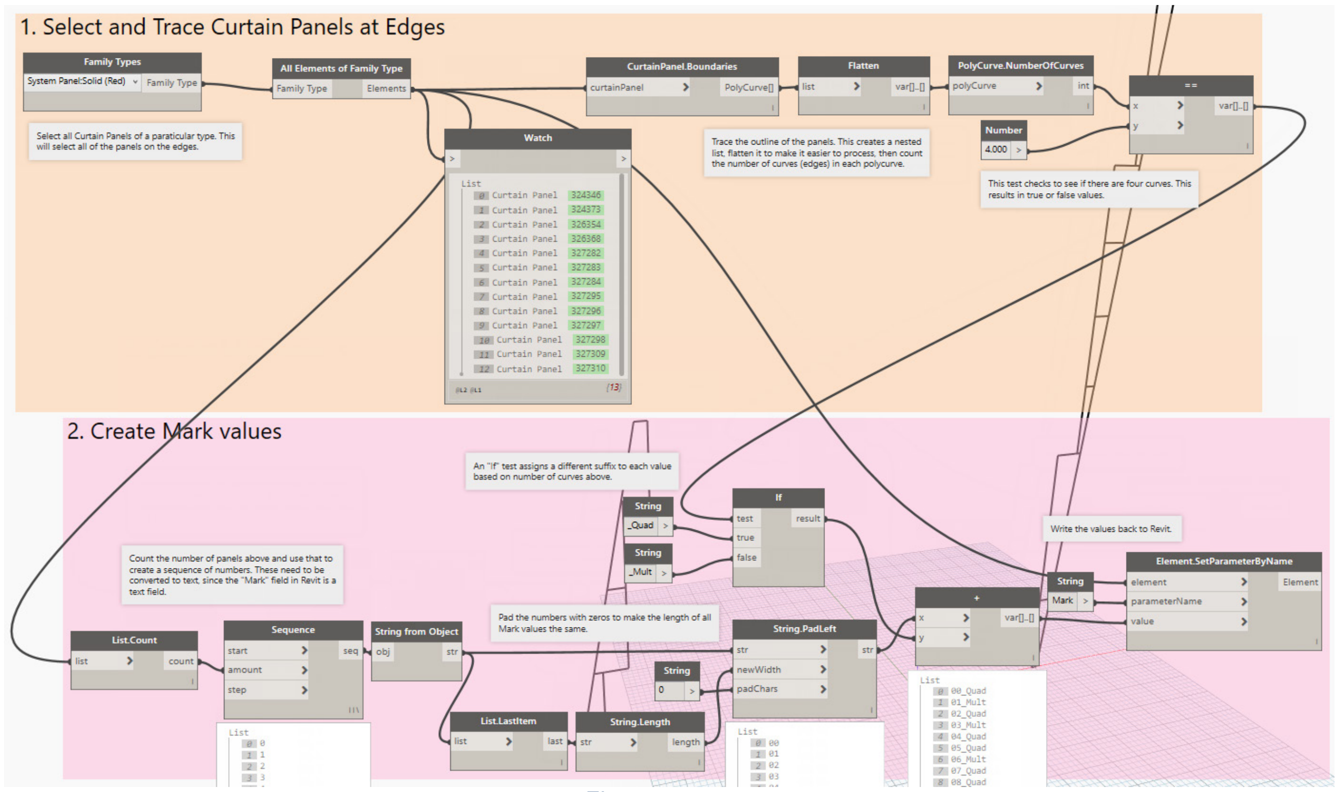
Numbering Elements

While the ultimate goal in this exercise is to add the adaptive components for the edge panels, let's start with the "troubleshooting" graph I noted above. While working out this exercise, I was having trouble determining if the points were being calculated correctly and also having trouble getting the adaptive components placed. To help me troubleshoot this, I found it useful to identify each edge panel in the model uniquely. The easiest way to do this was to assign each one a unique value in their Mark field. Furthermore, one of the Dynamo nodes we will be using will trace the shape of each edge panel. In some cases, this yields 4 points (which we want) while in other cases it yields a different quantity (usually 6, which we don't want). So in addition to being able to assign a unique value to each panel, I wanted to easily point out which were four points and which were more.

SAMPLE FILE: You can open a starter Revit file named: ***05_Curtain Wall Facade_!Start.rvt***
open the Dynamo file named: ***05_Curtain Wall Façade_A.dyn***

Select Curtain Panels and Process them

The first part of the graph uses a ***Family Types*** node and an ***All Elements of Family Type*** to select all of the curtain panels on the edge. In the initial state of the file, this is: System Panel: Solid (Red). Next we have a ***CurtainPanel.Boundaries*** node. This node traces the outline of the curtain panel with a polycurve. This will create a nested list of lists. So the next node flattens the list and then using a ***PolyCurve.NumberOfCurves***, we find out how many curves are contained in each polycurve. The final node in group 1 is an "equal to" node. This node asks if input ***x*** is equal to input ***y***. It outputs a list of true or false values (see Figure 44).



Select all Curtain Panels of a paraticular type. This will select all of the panels on the edges.

Trace the outline of the panels. This creates a nested list, flatten it to make it easier to process, then count the number of curves (edges) in each polycurve.

This test checks to see if there are four curves. This results in true or false values.

An "If" test assigns a different suffix to each value based on number of curves above.

Count the number of panels above and use that to create a sequence of numbers. These need to be converted to text, since the "Mark" field in Revit is a text field.

Pad the numbers with zeros to make the length of all Mark values the same.

Write the values back to Revit.

```
List
  0 Curtain Panel 324346
  1 Curtain Panel 324373
  2 Curtain Panel 326354
  3 Curtain Panel 326368
  4 Curtain Panel 327282
  5 Curtain Panel 327283
  6 Curtain Panel 327284
  7 Curtain Panel 327295
  8 Curtain Panel 327296
  9 Curtain Panel 327297
  10 Curtain Panel 327298
  11 Curtain Panel 327309
  12 Curtain Panel 327310
@L2 @L1                  {13}
```

```
List
  0 0
  1 1
  2 2
  3 3
```

```
List
  0 00
  1 01
  2 02
  3 03
```

```
List
  0 00_Quad
  1 01_Mult
  2 02_Quad
  3 03_Mult
  4 04_Quad
  5 05_Quad
  6 06_Mult
  7 07_Quad
  8 08_Quad
```

Figure 44

Library Location	Node
BuiltIn	Flatten
Core > Input	Number
Geometry > Polycurve	NumberOfCurves
Operators	==
Operators	+
Revit > Selection	Family Types
Revit > Selection	All Elements of Type
Revit > Elements > Curtain Panel	Boundaries

Build a Mark value from a Number Sequence and Conditional Suffixes

In group 2 at the bottom of the figure, we are creating the desired mark values. We start with a ***Sequence*** node. Its **`start`** input defaults to 0. This is fine for our purposes, so no need for an input there. The **`amount`** input is for how many items you want in the sequence. In this case, a ***List.Count*** from the panel selection above will give us the correct value and will adjust automatically if the number of panels changes as you re-run the graph. The output here will be numerical. In any kind of programming, including Dynamo, Data types are very important. If you have even gotten an "Insistent Units" message while building content in the family editor, then you know what I am talking about.

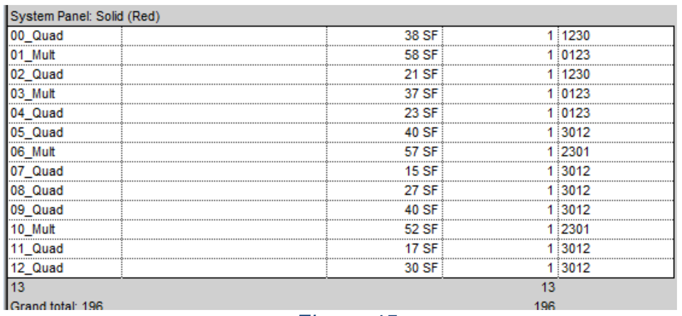
If you haven't, just know that data types must match and if they don't you have to convert them. So since the "Mark" field that we will be writing this data to is a text field in Revit, we will make sure to convert our group of numbers here to text (string) values in Dynamo. The ***String from Object*** node will do this conversion for us.

The next group of nodes will "pad" the length of the numbers to make them consistent. This is certainly not required, but I think in many cases, it is preferable to have the length of each string consistent. (If you don't mind your single digit values being shorter than your double-digit ones, you can skip these nodes). Let's look at what they do.

The ***List.LastItem*** node grabs the last item on the sequence list and using the ***String.Length*** node, we find out how many characters it is. This is similar in concept to using the ***List.Count*** above. If you edit your model and the quantity of panels increases, these nodes will update to report current values. The ***String.PadLeft*** value takes this number in its **`newWidth`** input. For **`padChars`**, input a zero, but make sure to place it in a **String** node, *not* a **Number** node so that we avoid conversion issues again. Finally feed in the sequence list for the **`str`** input.

Directly above these nodes in group 2 we have an ***If*** node and its inputs. The ***If*** node checks for a condition. If the value is true, it passes the value from the **`true`** input, otherwise it passes the value from the **`false`** input. Here we are checking the results from the **==** node above. This will add the suffix: "_Quad" to the four-point panels and the suffix "_Mult" to the rest. Finally, we use a **+** node to concatenate the padded numbers with these suffixes to give us the completed Mark values.

To write the values back to Revit, all you need is an ***Element.SetParameterByName*** node. Feed in the name of the parameter, "Mark" in this case, into the **`parameterName`** input and the list of concatenated values from the **+** node for the **`value`** input. For the **`element`** input, we feed the original list from the ***All Elements of Type*** node above (see the bottom right of Figure 44). I have included a schedule in the sample file to quickly check the results after running the graph (see Figure 45).



System Panel: Solid (Red)				
00_Quad		38 SF	1	1230
01_Mult		58 SF	1	0123
02_Quad		21 SF	1	1230
03_Mult		37 SF	1	0123
04_Quad		23 SF	1	0123
05_Quad		40 SF	1	3012
06_Mult		57 SF	1	2301
07_Quad		15 SF	1	3012
08_Quad		27 SF	1	3012
09_Quad		40 SF	1	3012
10_Mult		52 SF	1	2301
11_Quad		17 SF	1	3012
12_Quad		30 SF	1	3012
13			13	
Grand total: 196			196	

Figure 45

Library Location	**Node**
BuiltIn	Flatten
Core > Input	Number
Core > Input	String
Core > List	Count
Core > List	Sequence
Core > List	LastItem
Core > String	String from Object

Library Location	Node
Core > String	Length
Core > String	PadLeft
Core > Logic	If
Geometry > Polycurve	NumberOfCurves
Operators	==
Operators	+
Revit > Selection	Family Types
Revit > Selection	All Elements of Type
Revit > Elements > Curtain Panel	Boundaries
Revit > Elements > Element	SetParameterByName

But what does numbering have to do with placing curtain panels?

Ultimately I included this graph here because it is a useful strategy that you can use for any kind of element in Revit that does not auto-number. You might vary the specific nodes you use and how you construct the specific Mark values, but the essential concepts and approach will still apply. I should note however, that even though this was not a very complex graph, it still might seem a bit complicated just to create a series of numbers. And you may be wondering what it has to do with placing irregular curtain panel edges. Well as to the second point, it does not relate directly. But keep in mind that the datasets here are kept small on purpose. So we only have about a dozen edge panels in our example. But in a real project, you might have hundreds. So by numbering them and then using filters and schedules to help you locate specific instances in the model, this can be very beneficial during any troubleshooting you might undertake. As to the seeming complexity of the graph, keep in mind that each node does *one* very specific task. And building a sequence of Mark values may seem like an easy task (conceptually), but as you can see (and as is typical with programming) there are actually quite a few things you have to decide and then do: Numbers or letters? Pad the values or use them as-is? Add a conditional prefix based on the element or just number them sequentially? Use a delimiter between the parts of the mark value, or not? Etc. Once you have decided on the format, you then have to provide (programmatic) instructions to achieve the desired result. This can take many nodes…

The right tool for the right job

Having said that, Dynamo is *not* the only way to do this work. Sometimes it is easy to get tunnel vision. (If all you have is a hammer; every problem looks like a nail…) Another alternative to the approach shown here is to export your schedule to Excel. In Excel, it is very easy to build a sequence of numbers or letters and using some very simple formulas, you can even add prefixes and suffixes. So, you can alternatively export from Revit, open in Excel* and build the Mark values and then use Dynamo to re-import the modified data from Excel. And of course there are third-party plug-ins to Revit that renumber elements with no Dynamo or Excel required. So there are many ways to tackle this problem. But we're interested in Dynamo here. So naturally, I presented a Dynamo solution!

**Note, if you do want to try an Excel export, in an earlier exercise, we looked at reading from a CSV file. The process would be nearly identical to import from an Excel file. If you have access to Lynda.com, I do an example of this in the Revit: Create Signage Plans course in Chapter 5.*

Placing Adaptive Components

Once I had the panels numbered I used that information and some filters, tags and text on the *South* elevation to help me figure out why the graph that I really wanted to run was not working. Turns out the problem was part Dynamo and part Revit… perfect!

SAMPLE FILE: Continue in the same Revit file named: ***05_Curtain Wall Facade_!Start.rvt***
open the Dynamo file named: ***05_Curtain Wall Façade_B.dyn***

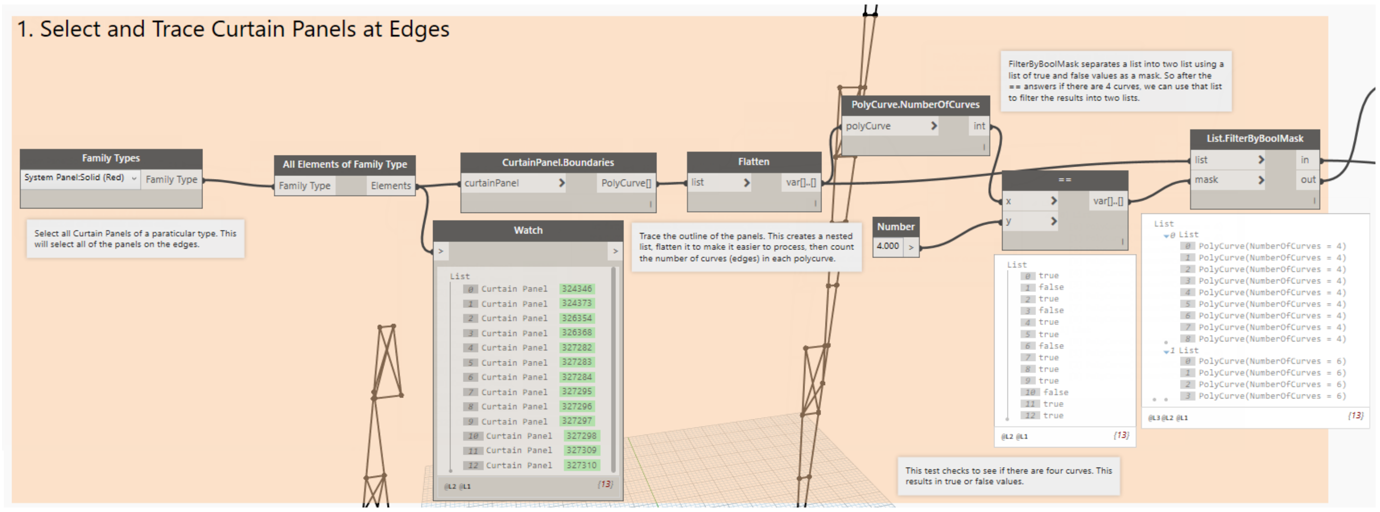
So let's start with how adaptive components work. An adaptive component is a family with special "super powers." Among other things, it can be helpful to think of it as a family that can have more than one insertion point. These are called "Placement Points" and during placement, you will click to place each placement point of the family at some location in the project. Furthermore, if the adaptive component is built with this in mind (which is kind of the point of them) then the shape of the family will "adapt" to the placement points. So in our case, we have several shapes on the perimeter of our curtain wall that are not rectangular. However, the designer ensured that they are all four-point polygons. Or at least that is one of the things we want Dynamo to check for us. So we will re-use the first few nodes of the previous graph and then branch it at the point where we determine if there are four curves or more.

The number of points is important. If you try to place a four-point adaptive component but feed it three points or five points, it will fail. But there is another important issue as well. The points have to be placed in a logical and consistent order. For example, always clockwise or always counter-clockwise. But typically not "crisscross." One of the things that my analysis (including the previous example) and troubleshooting revealed is that the polycurves generated by Dynamo (which are based on the underlying Revit geometry) did not always start at the same point. This means that sometimes they would try to place the adaptive component rotated or upside-down. But at least they were always going in the same direction (counter-clockwise in this case), so we will not have to correct that!

Finally, I also discovered that some of what I had to solve was back in Revit. Adaptive components can be quite fussy. So they have to be built quite carefully. Again, this paper will focus on the Dynamo part of the solution, but keep in mind that if you want Dynamo to be successful in placing adaptive components, they must be built carefully and thoroughly tested. One thing that proved quite bizarre, was that my component worked perfectly and flexed as expected when I placed it in Revit manually, but Dynamo was unable to place it. Ultimately, it seemed to stem from the template that the family was based on originally. To verify this, I built a new parent adaptive component family based on the: *Generic Model Adaptive.rft* template. This file, unlike the: *Curtain Panel Pattern Based.rft* template that I used originally to create my panel family has no adaptive points in it to start. You have to add them manually. So perhaps there is something about the built-in adaptive points in the curtain panel template that differs from the generic model one. I am not sure. But I added four adaptive points in the generic template, made sure they were numbered in the correct order and then nested in my curtain panel and it now works great in Dynamo. Very strange… You will also see a few of the "testing" panels I made in the starter file.

Tracing the Curtain Panels

Most of group 1 in this graph is the same as group 1 in the previous graph. We are selecting the irregular shaped panels that use the curtain panel type called: Red. We trace these with a polycurve and then check the number of curves generated. Curtain panels that span more than one grid bay and other custom shapes will have more than 4 curves. The new node in this group (not used above) is: ***List.FilterByBoolMask***. This node separates a list into two lists based on some condition. In this case, the **==** node generates the mask. A "mask" is just a list of true and false values that are used to build the two filtered lists (see Figure 46).



Select all Curtain Panels of a paraticular type. This will select all of the panels on the edges.

Trace the outline of the panels. This creates a nested list, flatten it to make it easier to process, then count the number of curves (edges) in each polycurve.

FilterByBoolMask separates a list into two list using a list of true and false values as a mask. So after the == answers if there are 4 curves, we can use that list to filter the results into two lists.

This test checks to see if there are four curves. This results in true or false values.

```
List
  0 Curtain Panel 324346
  1 Curtain Panel 324373
  2 Curtain Panel 326354
  3 Curtain Panel 326368
  4 Curtain Panel 327282
  5 Curtain Panel 327283
  6 Curtain Panel 327284
  7 Curtain Panel 327295
  8 Curtain Panel 327296
  9 Curtain Panel 327297
  10 Curtain Panel 327298
  11 Curtain Panel 327309
  12 Curtain Panel 327310
@L2 @L1                {13}
```

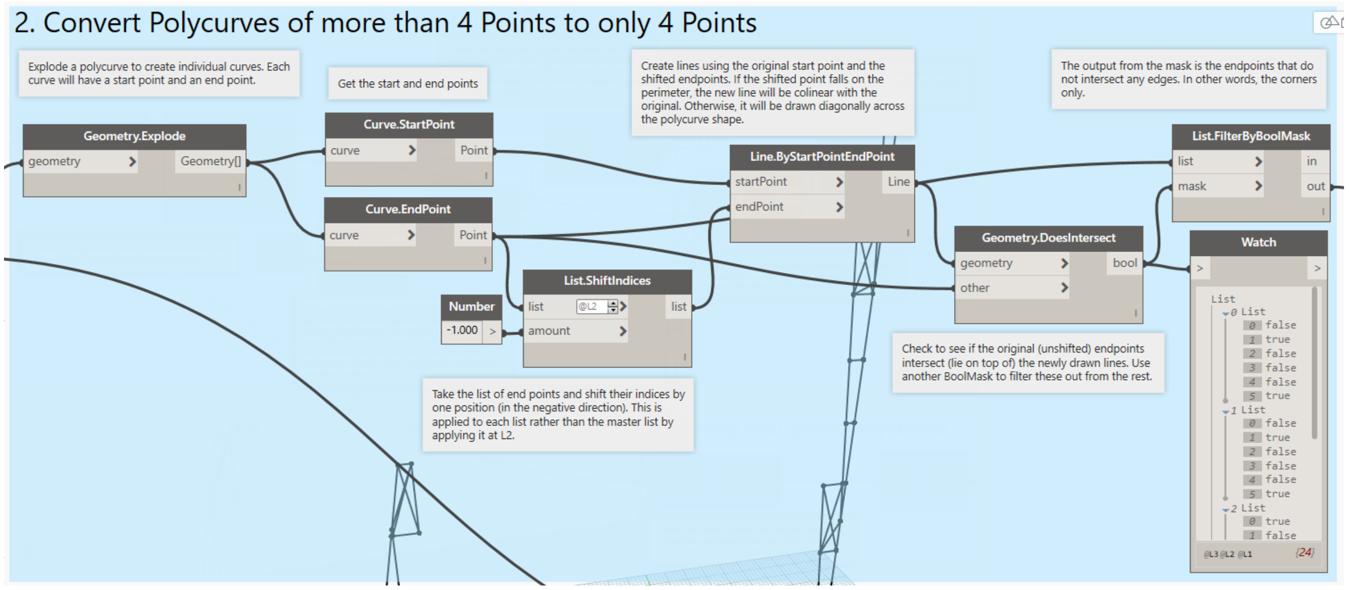
```
List
  0 true
  1 false
  2 true
  3 false
  4 true
  5 true
  6 false
  7 true
  8 true
  9 true
  10 false
  11 true
  12 true
@L2 @L1                {13}
```

```
List
 0 List
    0 PolyCurve(NumberOfCurves = 4)
    1 PolyCurve(NumberOfCurves = 4)
    2 PolyCurve(NumberOfCurves = 4)
    3 PolyCurve(NumberOfCurves = 4)
    4 PolyCurve(NumberOfCurves = 4)
    5 PolyCurve(NumberOfCurves = 4)
    6 PolyCurve(NumberOfCurves = 4)
    7 PolyCurve(NumberOfCurves = 4)
    8 PolyCurve(NumberOfCurves = 4)
 1 List
    0 PolyCurve(NumberOfCurves = 6)
    1 PolyCurve(NumberOfCurves = 6)
    2 PolyCurve(NumberOfCurves = 6)
    3 PolyCurve(NumberOfCurves = 6)
@L3 @L2 @L1                {13}
```

Figure 46

Convert Multi-Point Polycurves to Four Points

From the ***out*** port of the BoolMask, we get the shapes that have more than four points. We want to convert these to only four points so that they will work with our adaptive component family later. (The output from the ***in*** port passes forward to group 3 below). A polycurve is a compound shape made of several curves. (Recall from above that a curve does not always mean "curvy," so while the terminology is "curve" we are really talking about lines in this example). The first step in group 2 is to explode the polycurve into individual curves (lines). Next we pass that list of curves to the ***Curves.StartPoint*** and ***Curves.EndPoint*** nodes. (If you installed the LunchBox package, you can use the ***Curves.EndPoints*** node instead if you prefer). This gives us a list of the start and end points from each curve. Next we use the ***List.ShiftIndices*** node to shift each point by one index. You can control the direction of the shift using a positive or negative number. In this case we are using a negative shift. This means the first item on each list wraps around to the bottom and each subsequent item moves up one on the list. By applying the shift at the L2 level, we ensure the points on each sub list shift, not the overall list (see Figure 47).



Explode a polycurve to create individual curves. Each curve will have a start point and an end point.

Get the start and end points

Create lines using the original start point and the shifted endpoints. If the shifted point falls on the perimeter, the new line will be colinear with the original. Otherwise, it will be drawn diagonally across the polycurve shape.

The output from the mask is the endpoints that do not intersect any edges. In other words, the corners only.

Take the list of end points and shift their indices by one position (in the negative direction). This is applied to each list rather than the master list by applying it at L2.

Check to see if the original (unshifted) endpoints intersect (lie on top of) the newly drawn lines. Use another BoolMask to filter these out from the rest.

```
List
 0 List
    0 false
    1 true
    2 false
    3 false
    4 false
    5 true
 1 List
    0 false
    1 true
    2 false
    3 false
    4 false
    5 true
 2 List
    0 true
    1 false
@L3 @L2 @L1                {24}
```

Figure 47

Next we will draw some lines using the ***Line.ByStartPointEndPoint*** node using the original start point and the shifted endpoints. The first line will be drawn from point 0 to the first shifted point, which is now at point 2. Then we compare this to the original curve (from 0 to 1). If they intersect; we will flag that shifted point and remove it from the list. If they don't we'll keep the point. In the end we will end up with only four points. Another way to think of this, is if the shifted point falls on the perimeter, the new line will be collinear with the original. Otherwise, it will be drawn diagonally across the polycurve shape (see Figure 48).

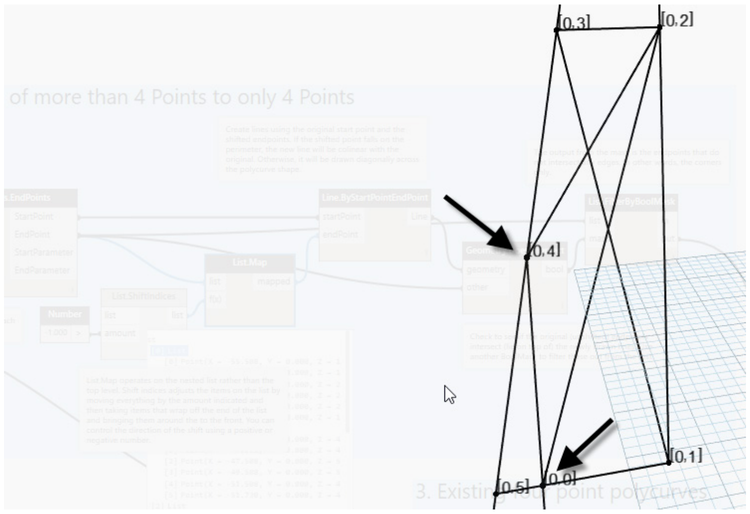

[0.3]
[0.2]
[0.4]
[0.1]
[0.5]
[0.0]
of more than 4 Points to only 4 Points
3. Existing four point polycurves

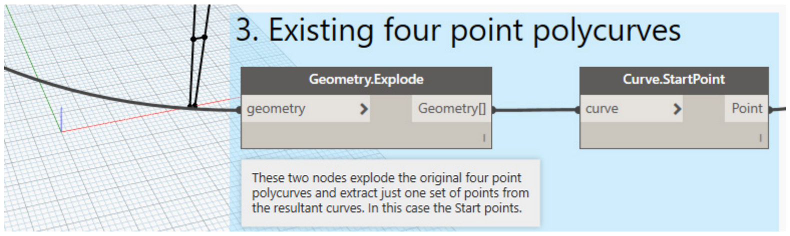
Figure 48

We use ***Geometry.DoesInterset*** to check this and send the output to another BoolMask to filter them out from the rest. The output from the mask is the endpoints that did *not* fall on any edges. In other words, the corners only.

I got help figuring out the logic of this graph from the DynamoBIM forum. I highly recommend that you add this resource to your list of "go to" sites. Here is the conversation:

https://forum.dynamobim.com/t/create-4-point-polycurves-from-list-of-6-points/4831

Going back to the original branched list from the first BoolMask, we have the shapes that were already four points only going into the nodes shown in Figure 49. There are two nodes to explode the original four point polycurves and extract just one set of points from the resultant curves (in this case the Start points).



These two nodes explode the original four point polycurves and extract just one set of points from the resultant curves. In this case the Start points.

Figure 49

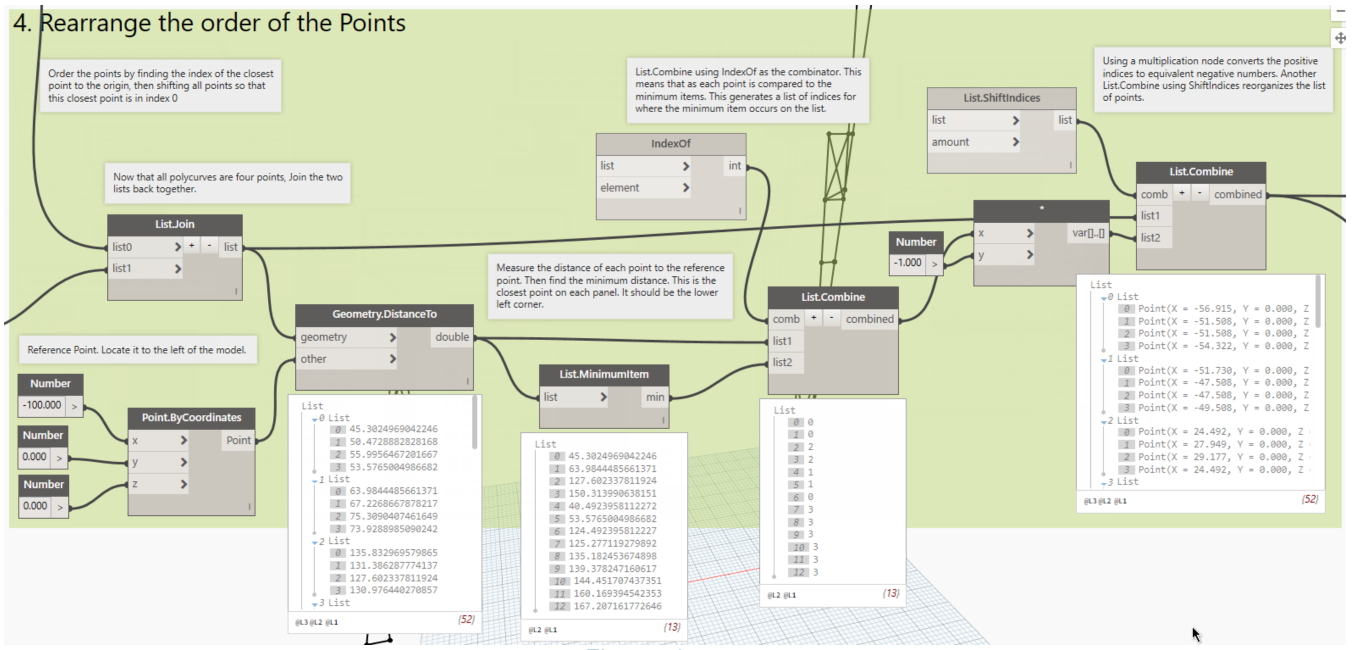
Library Location	Node
Core > List	List.Map
Core > List	ShiftIndices
Core > List	FilterByBoolMask

Library Location	Node
Geometry > Geometry	Explode
Geometry > Geometry	DoesIntersect
Geometry > Line	ByStartPointEndPoint
Geometry > Curve	StartPoint
Geometry > Curve	EndPoint

Shifting Points

In the start of group 4, we pull this list and the list created in group 2 back together into a single list using a ***List.Join*** node. This new list contains collections of four points. These are *almost* ready to use in creating our adaptive components. If you fed the list we have now into the node that places the adaptive components, some of the panels would be created, but several would fail. Of the ones that did not fail, many would be oriented improperly. So first we have to shift some points to ensure that the lists all generate components in the desired orientation.

An adaptive component has one or more adaptive placement points as noted above. These points are numbered in the order in which they will be placed. Currently, there is no consistency in where our collections of points begin and end. Some start bottom, some on top, some left, others right. So in the next group, group 4, we rearrange the points so that all of them begin at the same relative position (see Figure 50).



Order the points by finding the index of the closest point to the origin, then shifting all points so that this closest point is in index 0

Now that all polycurves are four points, Join the two lists back together.

Reference Point. Locate it to the left of the model.

Measure the distance of each point to the reference point. Then find the minimum distance. This is the closest point on each panel. It should be the lower left corner.

List.Combine using IndexOf as the combinator. This means that as each point is compared to the minimum items. This generates a list of indices for where the minimum item occurs on the list.

Using a multiplication node converts the positive indices to equivalent negative numbers. Another List.Combine using ShiftIndices reorganizes the list of points.

```
List
 0 List
   0 45.3024969042246
   1 50.4728882828168
   2 55.9956467201667
   3 53.5765004986682
 1 List
   0 63.9844485661371
   1 67.2268667878217
   2 75.3090407461649
   3 73.9288985090242
 2 List
   0 135.832969579865
   1 131.386287774137
   2 127.602337811924
   3 130.976440270857
 3 List
@L3 @L2 @L1                {52}
```

```
List
  0 45.3024969042246
  1 63.9844485661371
  2 127.602337811924
  3 150.313990638151
  4 40.4923958112272
  5 53.5765004986682
  6 124.492395812227
  7 125.277119279892
  8 135.182453674898
  9 139.37824716061 7
 10 144.451707437351
 11 160.169394542353
 12 167.207161772646
@L2 @L1                {13}
```

```
List
  0 0
  1 0
  2 2
  3 2
  4 1
  5 1
  6 0
  7 3
  8 3
  9 3
 10 3
 11 3
 12 3
@L2 @L1                {13}
```

```
List
 0 List
   0 Point(X = -56.915, Y = 0.000, Z
   1 Point(X = -51.508, Y = 0.000, Z
   2 Point(X = -51.508, Y = 0.000, Z
   3 Point(X = -54.322, Y = 0.000, Z
 1 List
   0 Point(X = -51.730, Y = 0.000, Z
   1 Point(X = -47.508, Y = 0.000, Z
   2 Point(X = -47.508, Y = 0.000, Z
   3 Point(X = -49.508, Y = 0.000, Z
 2 List
   0 Point(X = 24.492, Y = 0.000, Z
   1 Point(X = 27.949, Y = 0.000, Z
   2 Point(X = 29.177, Y = 0.000, Z
   3 Point(X = 24.492, Y = 0.000, Z
 3 List
@L3 @L2 @L1                {52}
```

Figure 50

The newly joined list is fed into a ***Geometry.DistanceTo*** node. This node measures the distance of each point on the list from a single reference point. Using the number inputs, ensure that the reference point is to the left of the curtain wall. This will ensure that the closest point in each grouping of four is the lower-left corner. The ***List.MinimumItem*** node grabs the shortest value from each list of four measurements.

Using ***List.Combine*** with an ***IndexOf*** as the "combinator" gives the relative position of the minimum item from each list. This means that as each point is compared to the minimum item on its list. The result is a list of indices for where the minimum item occurs on each respective list.

Using a multiplication node with a value of -1 converts the positive indices to equivalent negative numbers. Another ***List.Combine*** with a combinator of ***ShiftIndices*** reorganizes each list of points.**

***Thanks to my good friend Zach Kron at Autodesk for assisting me with figuring out the logic in this part of the graph.*

Library Location	**Node**
Core > List	Join
Core > List	List.Combine
Core > List	MinimumItem
Core > List	ShiftIndices
BuiltIn	IndexOf
Geometry > Geometry	DistanceTo
Geometry > Point	ByCoordinates
Operators	*

Adaptive Component Placement and Checking

We now have lists of four points that will work reliably and consistently for each location on the curtain wall. We are therefore ready to add the adaptive components in group 5. This takes just two nodes: ***AdaptiveComponent.ByPoints*** and ***Family Types***. Family Types gives a drop-down list containing all of the loaded family types in the current project. Choose the one you want to add. As noted previously, I have two versions of my panel family. The one called: *_Nested SSG:Standard* will work much better. It is a simple adaptive component family with four placement points and its category changed to Curtain Panels. And most important, the other version of the SSG panel, the fully parametric one, is simply nested in here. Feed the list of corrected points and the selected family type into the ***AdaptiveComponent.ByPoints*** node and run the graph (see Figure 51).

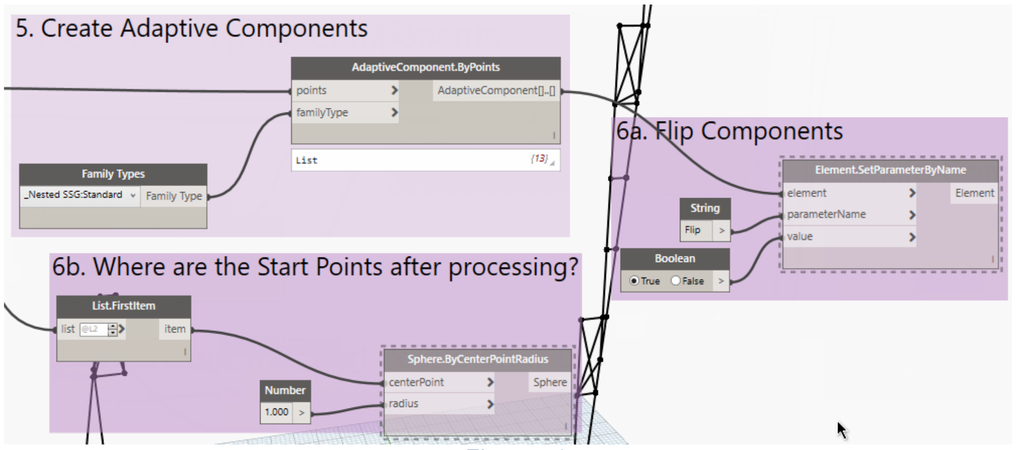


Figure 51

Library Location	Node
Revit > Selection	Family Types
Revit > Elements > Adaptive Component	ByPoints

The figure also shows groups 6a and 6b. Sometimes when placing the adaptive components, they are facing the wrong way. The nodes in this group will flip the components. You can right-click on a node and Freeze it to disable it and anything "downstream" of it. Therefore, simply unfreeze them if needed.

In group 6b, we have a simple check to ensure that all of the points were oriented correctly in group 4. These nodes add a small sphere in the lower left corner. Again, you can freeze these when not needed.

Complete the curtain wall

After successfully running the graph, use your TAB key to select one of the red panels. Right-click it and choose: **Select all instances > Visible in View**. Change this selection to the Empty System Panel. Close Dynamo to see the completed result (see Figure 52). On the left side of the figure, is the completed version of the file shown here. On the right, the west side of the façade has been added. The lower sloping portion uses a roof with a sloped glazing family and the top portion uses another curtain wall. The same Dynamo script was run on that model and it works equally well on sloped glazing as it does on vertical curtain walls! Very exciting!

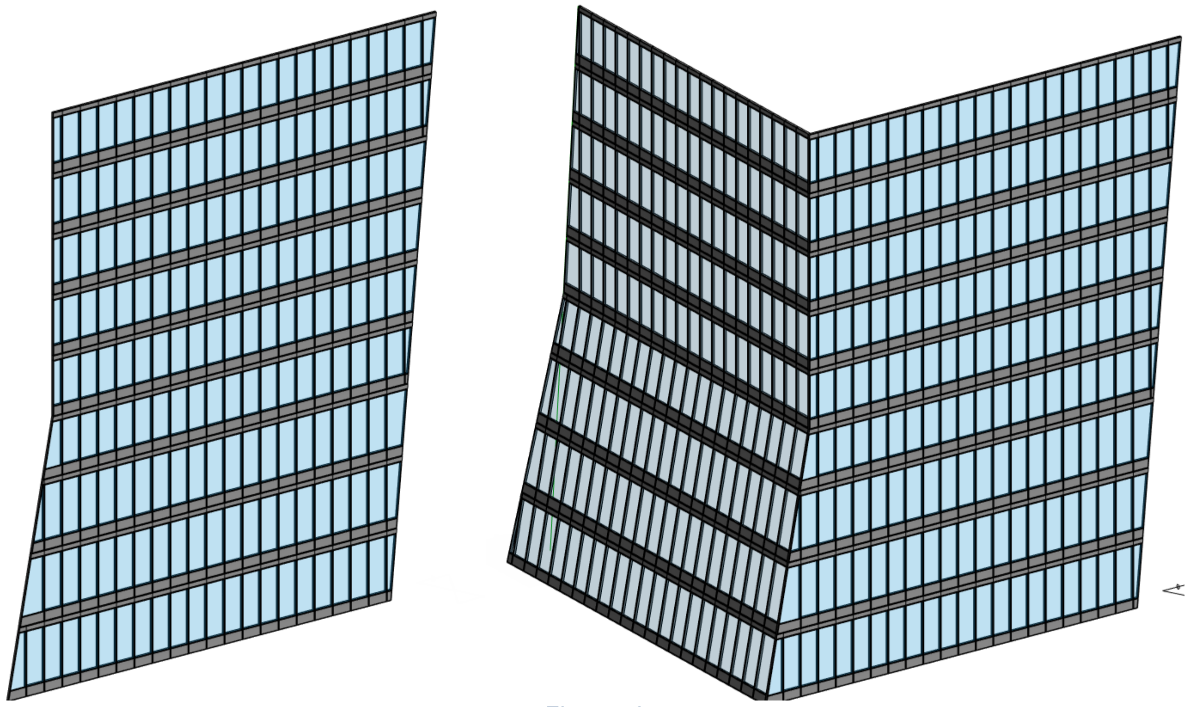


Figure 52

SAMPLE FILE: Alternate file with sloped glazing named: ***06_Curtain Wall Façade w Sloped_!Start.rvt***

Conclusion

That wraps up our quick tour of the essentials of Dynamo. As you can see, Dynamo is quite powerful and offers a great deal of potential. Now that you have the basics well in hand, you might find you are ready to go further. The number one resource for you to explore is the DynamoBIM.org website. There you will find downloads to the latest builds of Dynamo, learning resources (like the Dynamo Primer) and most importantly, the Dynamo forums which are very active with a vibrant community of Dynamo users. You also might want to check out: dynamonodes.com which has some good resources and a number of very simple graphs for you to try out as you are getting acquainted with Dynamo.

After spending some time there and doing the tutorials in the Dynamo Primer, you might even find that you are ready to give some of those Code Blocks a try…

Further Study

You can find more information and tutorials in:

***Renaissance Revit: Creating Classical Architecture with Modern Software*.** This book can be thought of as a "deep dive" into the family editor. It starts with the basics, but gets very advanced as well. The entire book is on family creation using classical architectural examples. Both the traditional and massing family editors are covered.

The Aubin Academy Revit Architecture: 2016 and beyond. Chapter 11 is devoted to the subject of the family editor. (**A PDF update for 2017 is available for download at my website**).

The Aubin Academy Master Series: Revit MEP. Chapters 12 and 13 are devoted to the subject of the family editor.

Other Autodesk University courses: I have taught this family editor lab before in previous years here at AU. I have also taught an advanced follow-up lab. Both class have papers and materials available for download from my website: www.paulaubin.com/au

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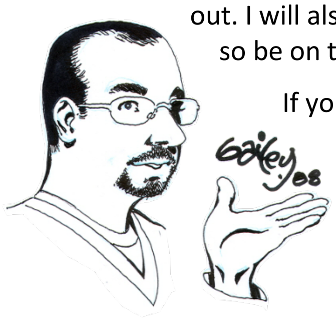
If you prefer video training, I have several Revit video courses at: **www.lynda.com/paulaubin**. Check out: *Revit Essential Training*, *Revit Family Editor*, *Revit Family Curves and Formulas* and *Revit Advanced Modeling*. There is also the excellent: *Dynamo Essential Training* by Ian Siegel. Definitely worth checking out. I will also be recording a Dynamo course to add to the library in the very near future, so be on the lookout for it!



If you have any questions about this session or Revit in general, you can use the contact form at **www.paulaubin.com** to send me an email.

Follow me on Twitter: **@paulfaubin**

Thank you for attending. Please fill out your evaluation.