



Next Steps: Houdini Procedural Modeling

M01: Pipes & Hoses

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**SIDE EFFECTS
SOFTWARE**

Prerequisites

If you have not taken Houdini First Steps or have equivalent knowledge
this course is not for you

This course will use VOPs extensively, expressions, and some Python
The focus of this course is to create production ready assets

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Workflow

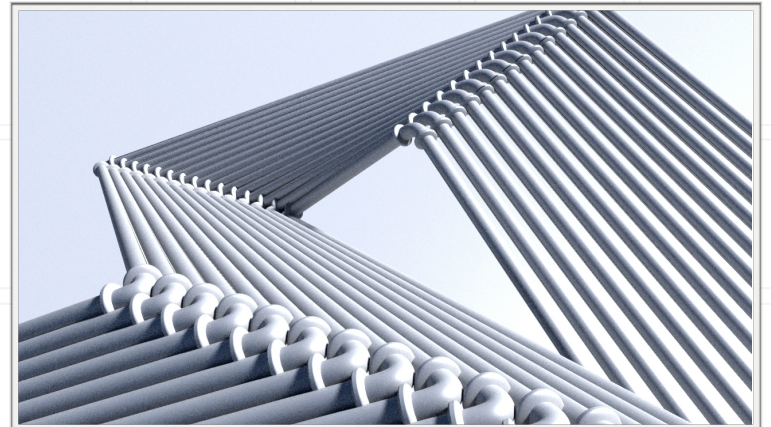
The Networks in this course are too large to build from scratch in one hour. So I will be walking you through the networks. You will have the networks to explore at home on your own time

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Agenda - Pipes

▶ Pipes

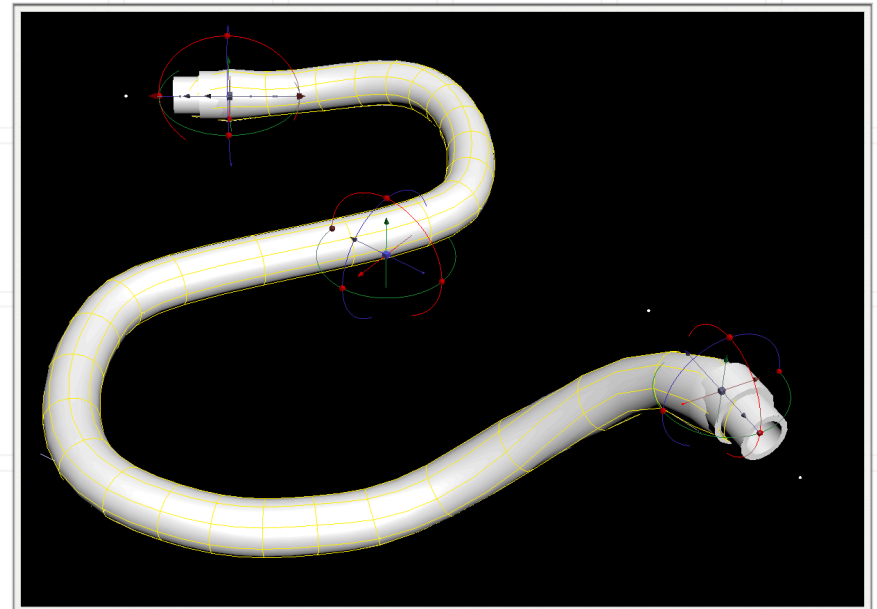
- ▶ Goals
- ▶ What is not Included
- ▶ Included Digital Asset for Download
- ▶ Creating the Backbone Curve
- ▶ Creating Arrays of Curves
- ▶ Converting Curves to Cleaned Up Line Segments
- ▶ Carving Out Pipes and Elbow with the Carve SOP
- ▶ Converting Sharp Corners into Elbows
- ▶ Sweeping Pipes and Elbows
- ▶ Making UVs and Materials
- ▶ Cut_End HDA
- ▶ Flanges



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Agenda - Hose

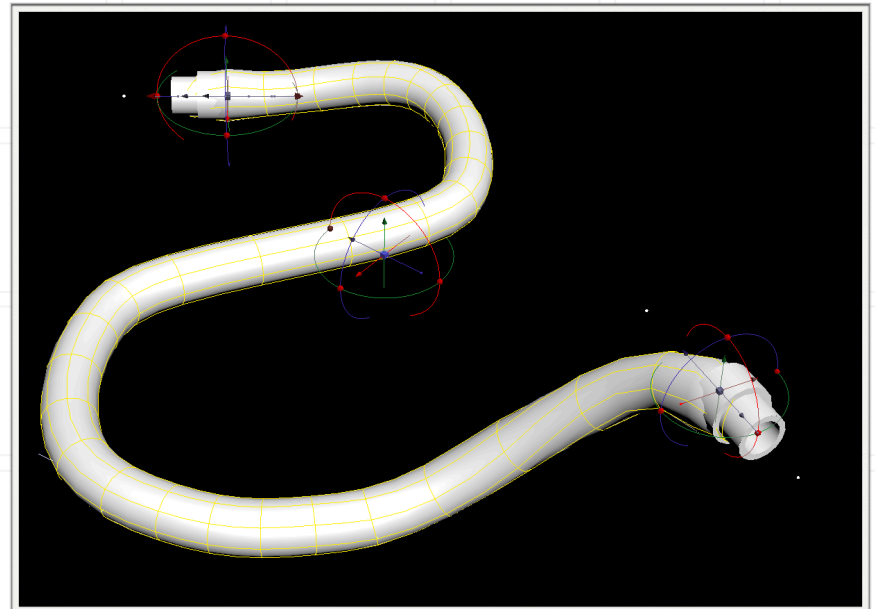
- ▶ Rubber Hose (A Quickie - Bad Start)
- ▶ Requirements for the Digital Asset
- ▶ A Simple “One Off” hose and why it is bad
- ▶ Building the Coupler
- ▶ Cross sections keeping the poles facing up
- ▶ Creating Instances using the Geo Object
- ▶ Creating the Path (Path and Path CVs)
- ▶ Making the Hose and Evaluating its Deficiencies
- ▶ Rubber Hose (A Much More Robust Solution)
- ▶ Adding CVs intelligently
- ▶ Grouping End Points (Point SOP vs VOPs)



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Agenda - Hose (cont.)

- ▶ VOPSOP to push points into Coupler
- ▶ Push points into hose to add tension
- ▶ Scaling the Normals and Offsetting Position
- ▶ Rebuilding the Backbone Curve with new points
- ▶ Smoothing Out the Up Vector
- ▶ Creating the Cross Sections



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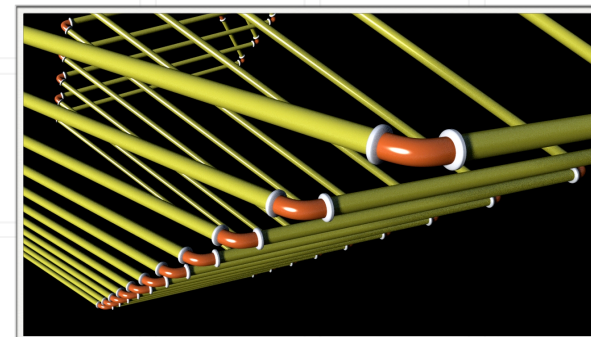
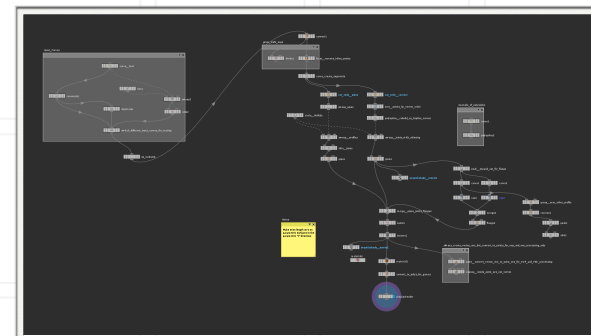


Pipes

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Goals

- ▶ Be able to create a curve and have a pipe with elbow joints and fittings automatically created
- ▶ Allow the curve to be created in Houdini, Adobe Illustrator, or other 3D Application
- ▶ Extrapolate one pipe to an array of pipes either using the duplicate or sweep SOPs



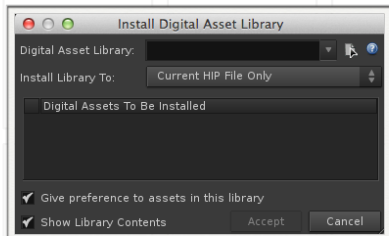
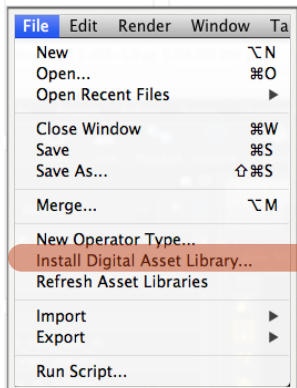
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What is Not Included



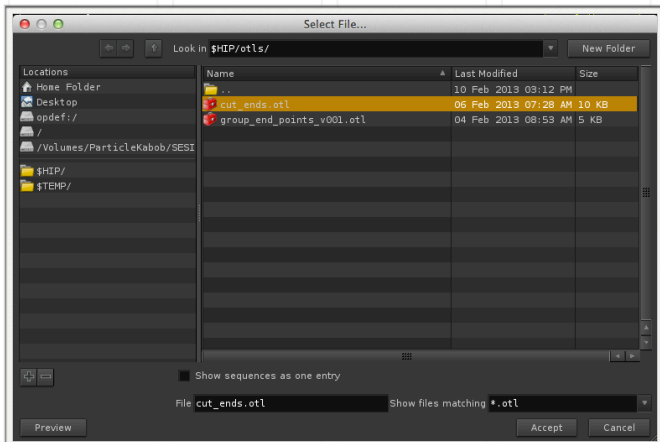
T-Sections and Cross-Sections
Will Not be Discussed in this
Module

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Digital Asset Required for Project

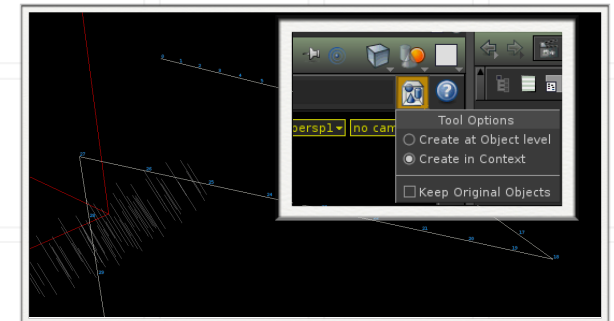
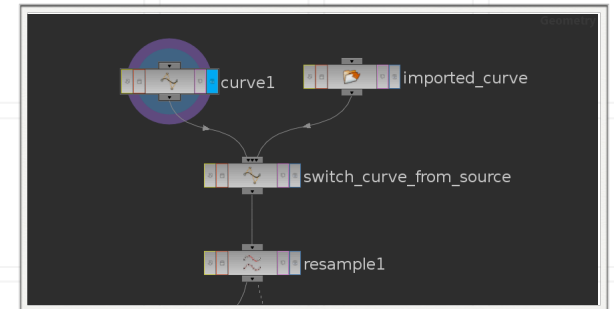
- ▶ In the otls folder you will find an HDA named “cut_ends” - Author of HDA is Jeff Wagner
- ▶ This HDA is required for the project
- ▶ To use “cut_ends” either start the Houdini Session from the project folder that contains the HDA
- ▶ Or use the menu File-->Install Digital Asset Library



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Create the Backbone Curve

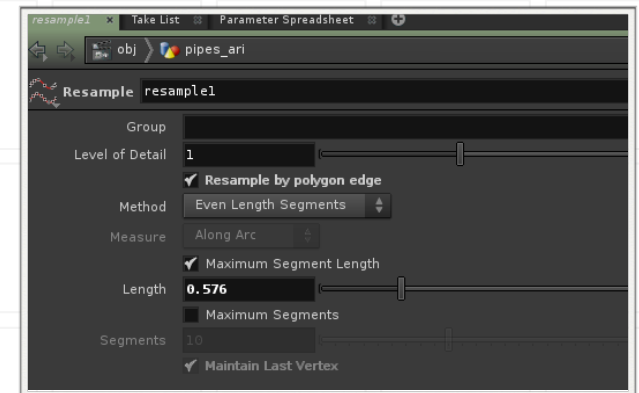
- ▶ In the Scene View create a polygonal curve
 - ▶ Make sure the Tool Options is set to “Create in Context”
- ▶ Append a SWITCH SOP to the Curve and add a FILE SOP as the second input
 - ▶ We do this so we can either use internally built curves or externally built curves from other applications
- ▶ Append a RESAMPLE SOP



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Create the Backbone Curve (cont.)

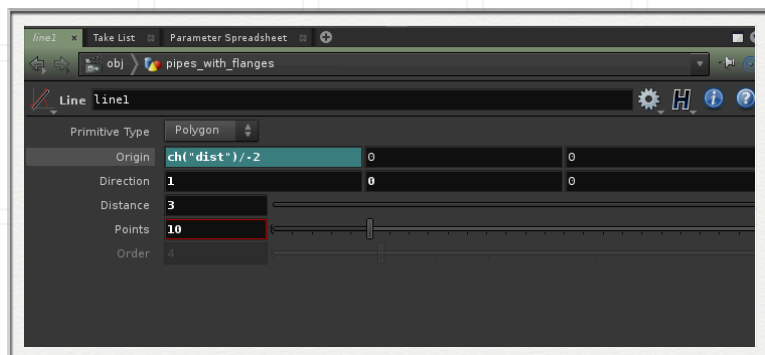
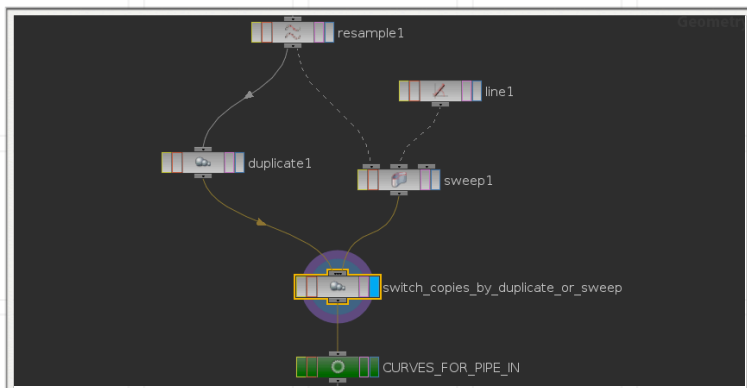
- ▶ On the RESAMPLE SOP make sure to:
 - ▶ Turn on “Resample by polygon edge”
 - ▶ If turned off it will chamfer sharp corners “Try it”
 - ▶ Set Maximum Segment Length to a value that returns several points between line segments



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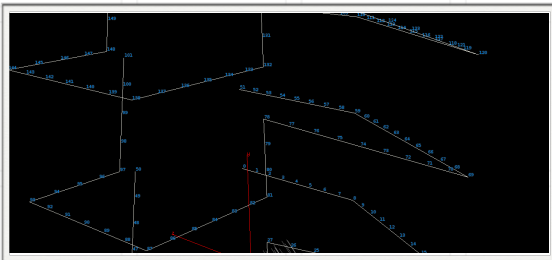
Make Duplicates of the Curve

- ▶ Two ways to duplicate the Curves
 - ▶ Duplicate SOP
 - ▶ Sweep SOP with the input being a LINE SOP with multiple points
 - ▶ On the line SOP use the expression `ch("dist")/-2` in the position x channel to center the line
 - ▶ The number of points on the line will determine the number of copies
 - ▶ The Distance will determine the gap between copies
 - ▶ Append a SWITCH SOP to the duplicate and sweep SOP to determine the method of making copies
 - ▶ Finally add a NULL SOP to state these are the curves to make into pipes

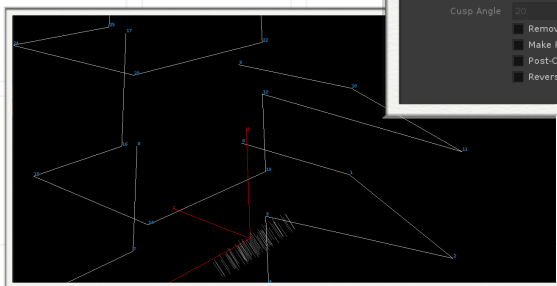
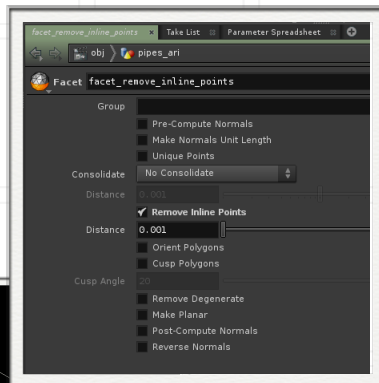
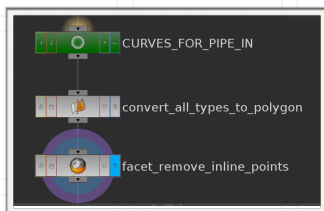


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Creating Line Segments



Before Facet



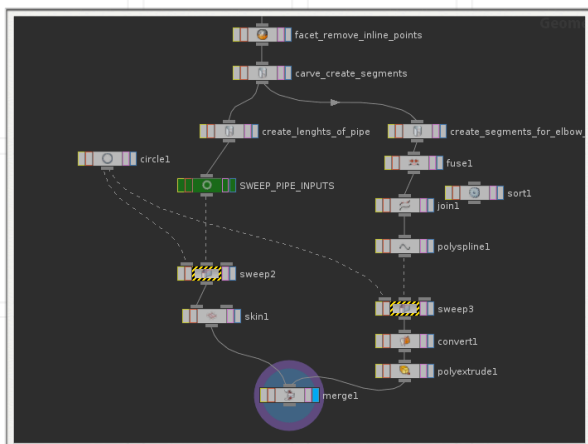
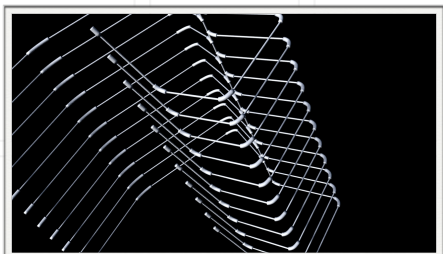
After Facet

- ▶ After the NULL “CURVES_FOR_PIPE_IN” Append a CONVERT SOP
- ▶ Set the Convert to “Polygon”
- ▶ We do this because we do not know what type of curve could be imported from other applications (Polygon, NURB, B-Spline)
- ▶ After the Convert append a FACET SOP
- ▶ Select “Remove Inline Points” and give it a very small distance (0.001)
- ▶ We do this to remove all points between corners of the pipe

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Creating Line Segments (cont.)

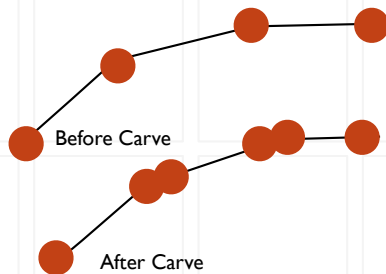
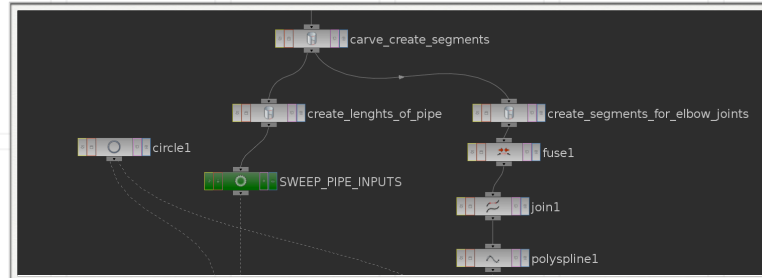
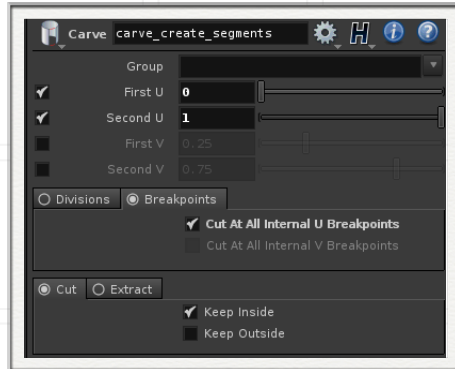
First Method with use no custom Digital Assets...



- ▶ Our first approach will only use SOPs that come with Houdini
- ▶ The problem with this approach as use can see in the middle image on the top right is that each elbow joint has a different length
- ▶ Let us first create this network then we will swap out the custom HDA to solve the problem

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Carving Out Pipes and Elbows



- ▶ Drop down a CARVE SOP. This first carve will disconnect all the line segments into distinct lines
- ▶ In the carve parameters switch to the Breakpoints tab
- ▶ Select “Cut at All Internal U Breakpoints”
- ▶ For the Cut select “Keep Inside”

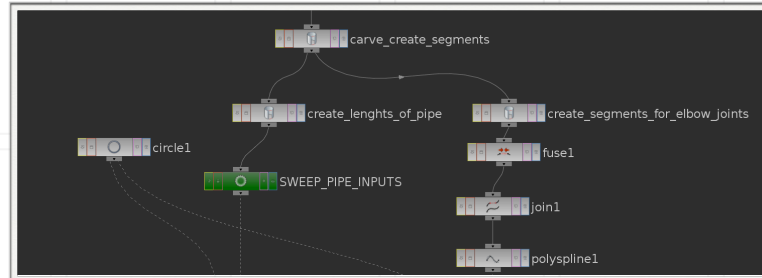
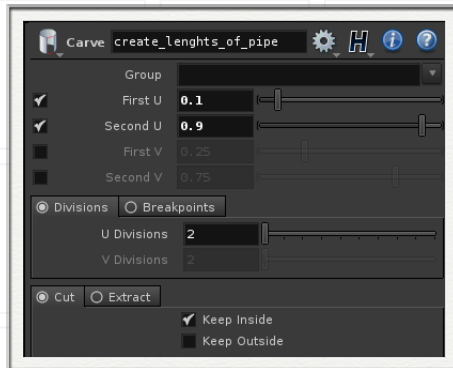
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Carve SOP

- ▶ Slices, cuts or extracts points or cross-sections from a primitive.
- ▶ The Carve op works with any face or surface type, be that polygon, Bezier, or NURBS. It can be used to slice a primitive, cut it into multiple sections, or extract points or cross-sections from it.
- ▶ Like the Project SOP, it also creates profile curves, but they are extracted as iso-parametric (2D) profiles directly from a surface, whereas the Project SOP extracts a 3D curve projected onto a surface.

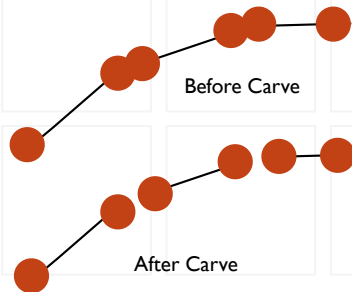
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Carving Out the Pipes



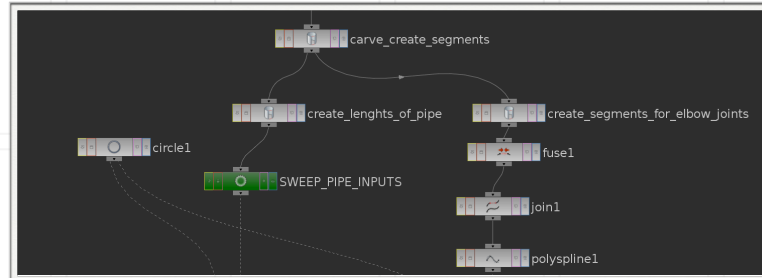
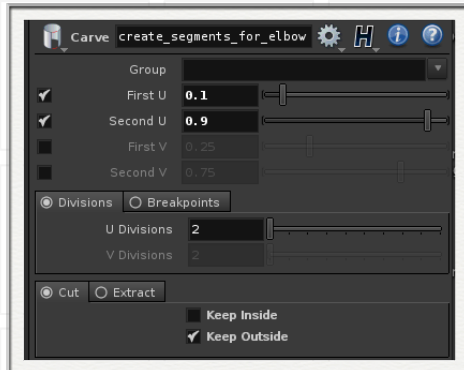
- ▶ Drop down another Carve. This one will be for creating the pipes. We want to shorten each line segment a bit so there will be room for the elbows.

- ▶ Set “First U” to 0.1
- ▶ SET “Second U to 0.9”
- ▶ In the Divisions Tab set U divisions to 2
- ▶ In the Cut Tab set to “Keep Inside”



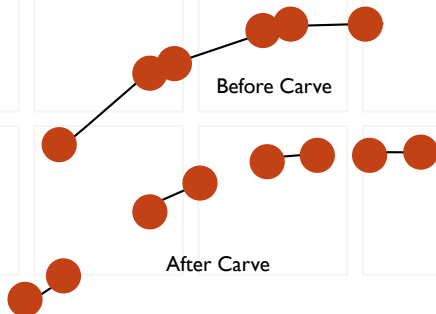
**SIDE EFFECTS
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Carving Out the Elbows



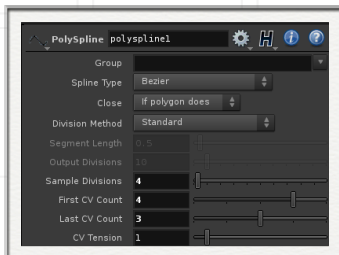
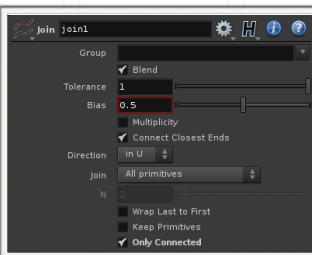
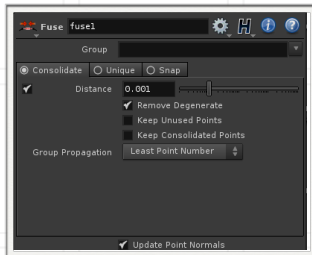
- ▶ After the first carve (making a separate chain) drop down another Carve. This one will be for creating the elbows.

- ▶ Set “First U” to 0.1
- ▶ SET “Second U to 0.9”
- ▶ In the Divisions Tab set U divisions to 2
- ▶ In the Cut Tab set to “**Keep Outside**”



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Smooth Out the Elbows



- ▶ Append a FUSE SOP to the carve to make sure the points are merged. Make the distance is very small (0.001)
- ▶ Append a JOIN SOP
 - ▶ The main parameter for the join is “Only Connected.” See the difference when this is selected and not selected.
- ▶ Append a POLY SPLINE SOP to change the corners from sharp corners to rounded elbows

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Fuse, Join, and PolySpline SOP

▶ Fuse Sop

- ▶ Merges or splits (uniques) points.
- ▶ The Fuse SOP is used to snap points together, make the points unique, or snap points to a 3d grid.

▶ Join SOP

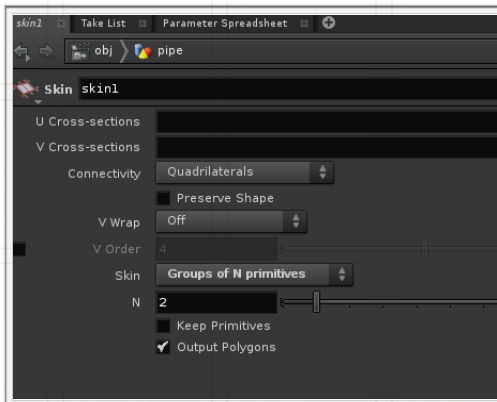
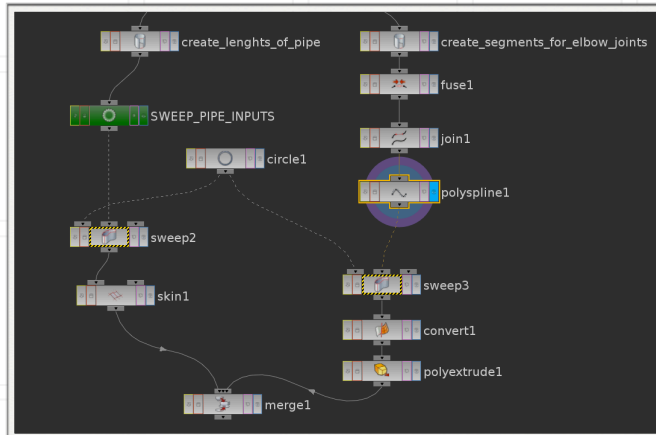
- ▶ The Join op connects a sequence of faces or surfaces into a single primitive that inherits their attributes. Faces of different types can be joined together, and so can surfaces. Mixed face-surface types are not allowed. The surfaces do not have to have the same number of rows or columns in the side being joined. Spline types of different orders and parameterization are all valid inputs. The Join op converts simpler primitives such as polygons into Beziers and NURBS if necessary.

▶ PolySpline SOP

- ▶ The Polyspline op fits a spline curve to a polygon or hull and outputs a polygonal approximation of that spline.
- ▶ The Polyspline op fits a spline curve to a polygon or hull and outputs a polygonal approximation of that spline. You can choose either to create divisions between the original points, or to ignore the position of the original points and divide the shape into segments of equal lengths.

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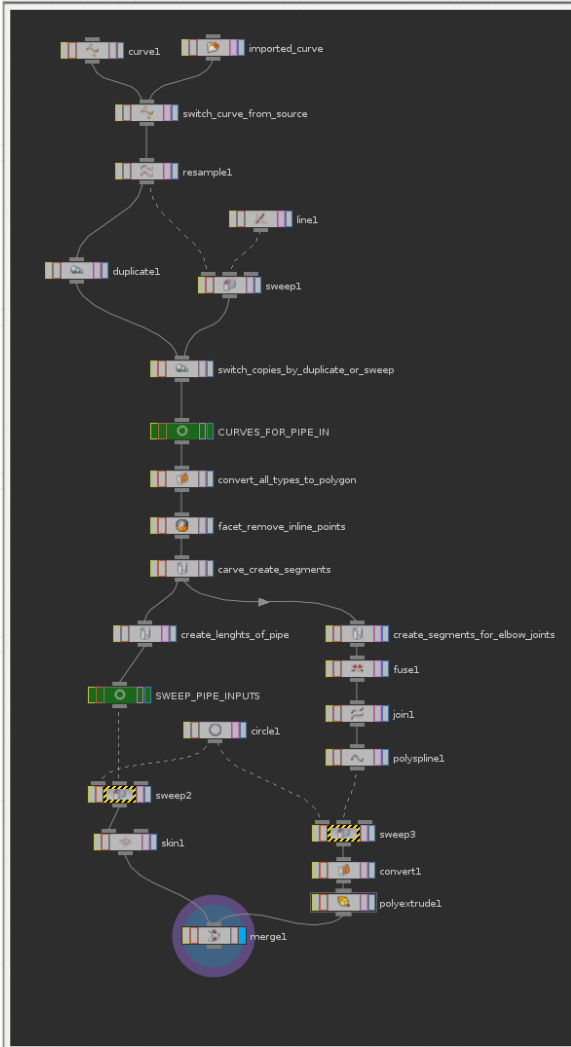
Sweeping the Pipes and Elbows



- ▶ Now it is as simple as creating a NURB circle for the pipes cross section and sweeping then skinning the pipes
- ▶ For the elbows you still sweep the elbows but then take two extra steps
 - ▶ Convert the NURBS to a polygon so you can extrude out the thickness
 - ▶ Polyextrude the thickness
 - ▶ Output front and side
 - ▶ Keep points shared - Use Normals
 - ▶ Merge the pipe and elbow

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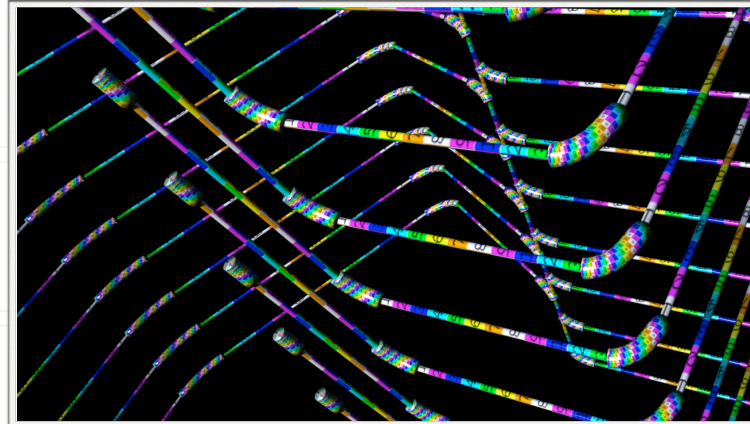
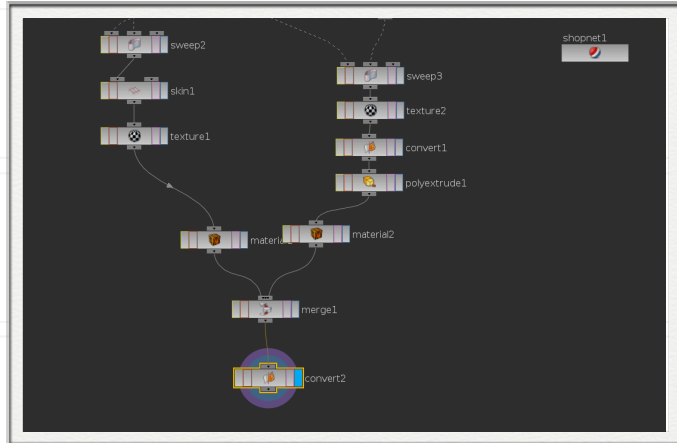
Full Network



- ▶ Additional Things You Can Do
 - ▶ Convert whole network to polygons for games
 - ▶ Add UVs for pipe and elbows

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Adding UVs and Materials



- ▶ We can use to our advantage the ppipes and elbows are at one point NURBS
- ▶ Set UVTexture to “Uniform Spline”
- ▶ Apply to “Vertex Texture”

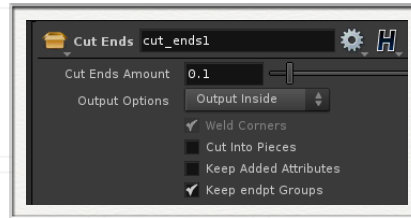
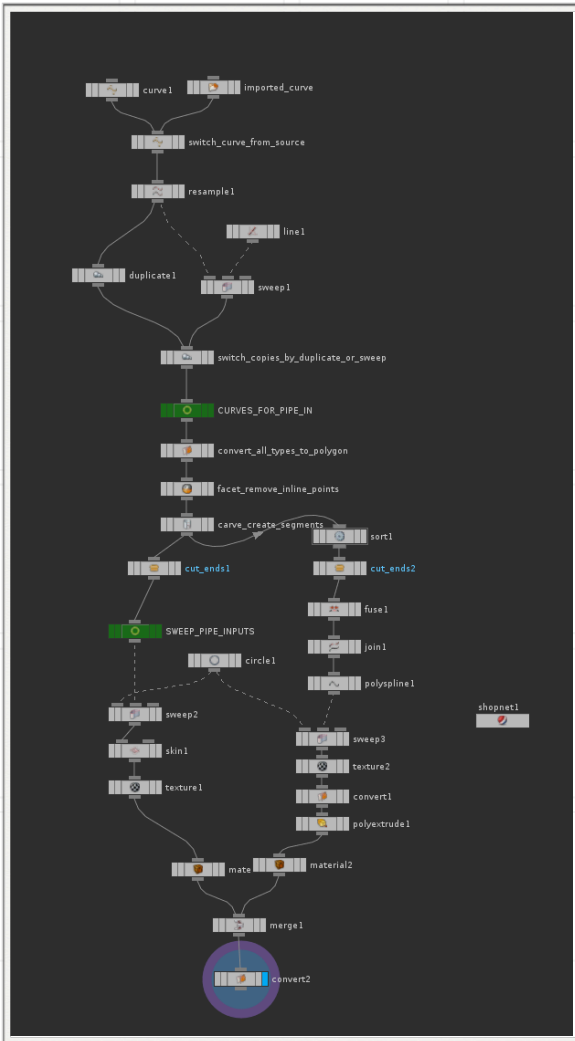
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Fixing the Elbows

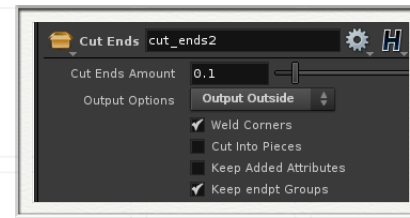
- ▶ Included with the Project Directory in the otls folder is a HDA created by Jeff Wagner named “Cut_Ends”
- ▶ The problem with the Carve SOP is that it cuts using the “s/t” space instead of world space. This causes the difference in gaps
- ▶ Cut_Ends uses world space and therefore fixes the problem

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Full Network with Cut_End HDA



For Pipes

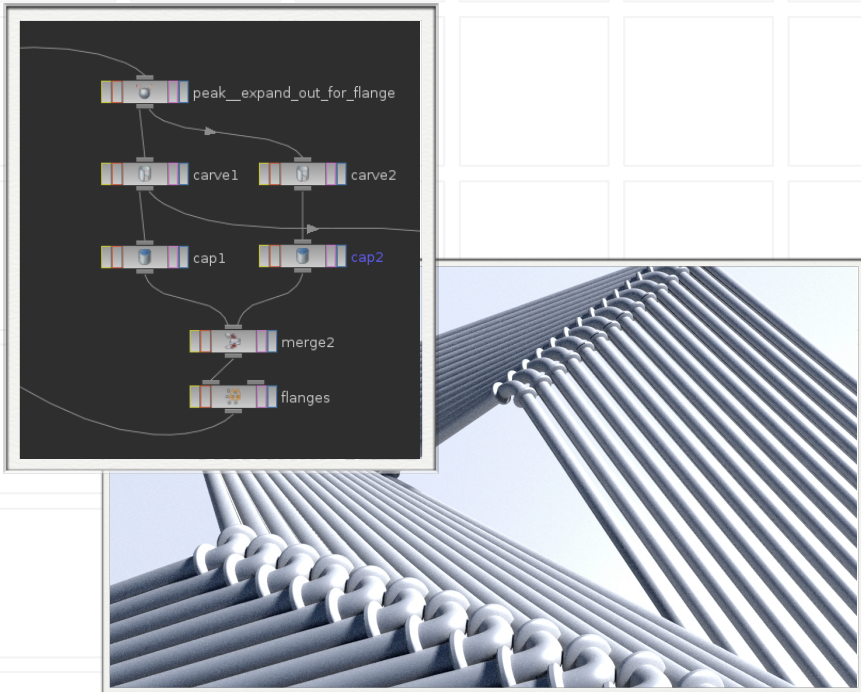


For Elbows

- ▶ For the elbows add a SORT SOP before the CUT_ENDS
- ▶ Sort on Vertex - Just to make sure vertex numbers are in correct order

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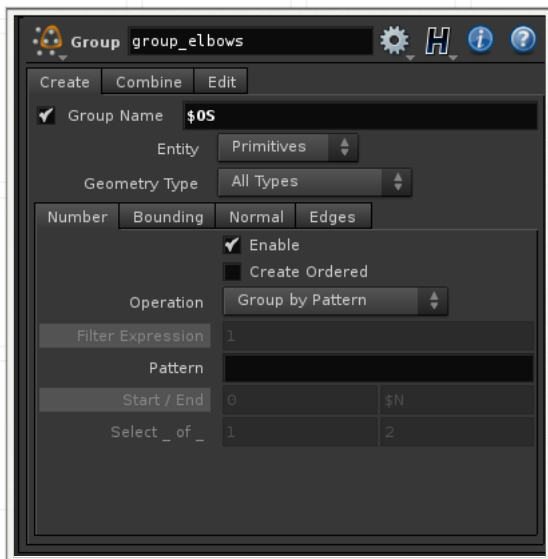
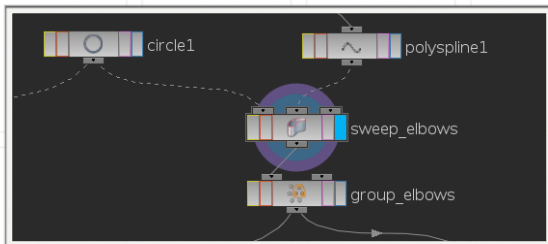
One More Thing ... Let's Add Flanges



- ▶ Now we understand how to make a basic elbow let us go back and create elbows with Flanges
- ▶ We will not convert the elbow this time to a polygon but rather keep everything as NURBs
- ▶ We explore how to use the PEAK SOP

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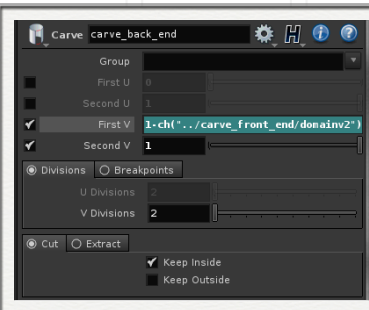
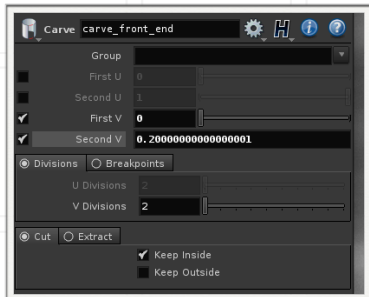
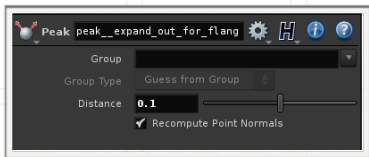
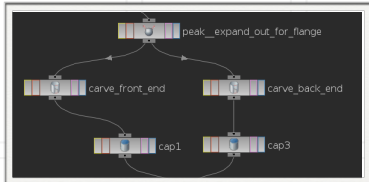
Group the Elbow Primitives



- ▶ Under the sweep for the elbows add a GROUP SOP
 - ▶ This will be used to add Materials later for the elbows

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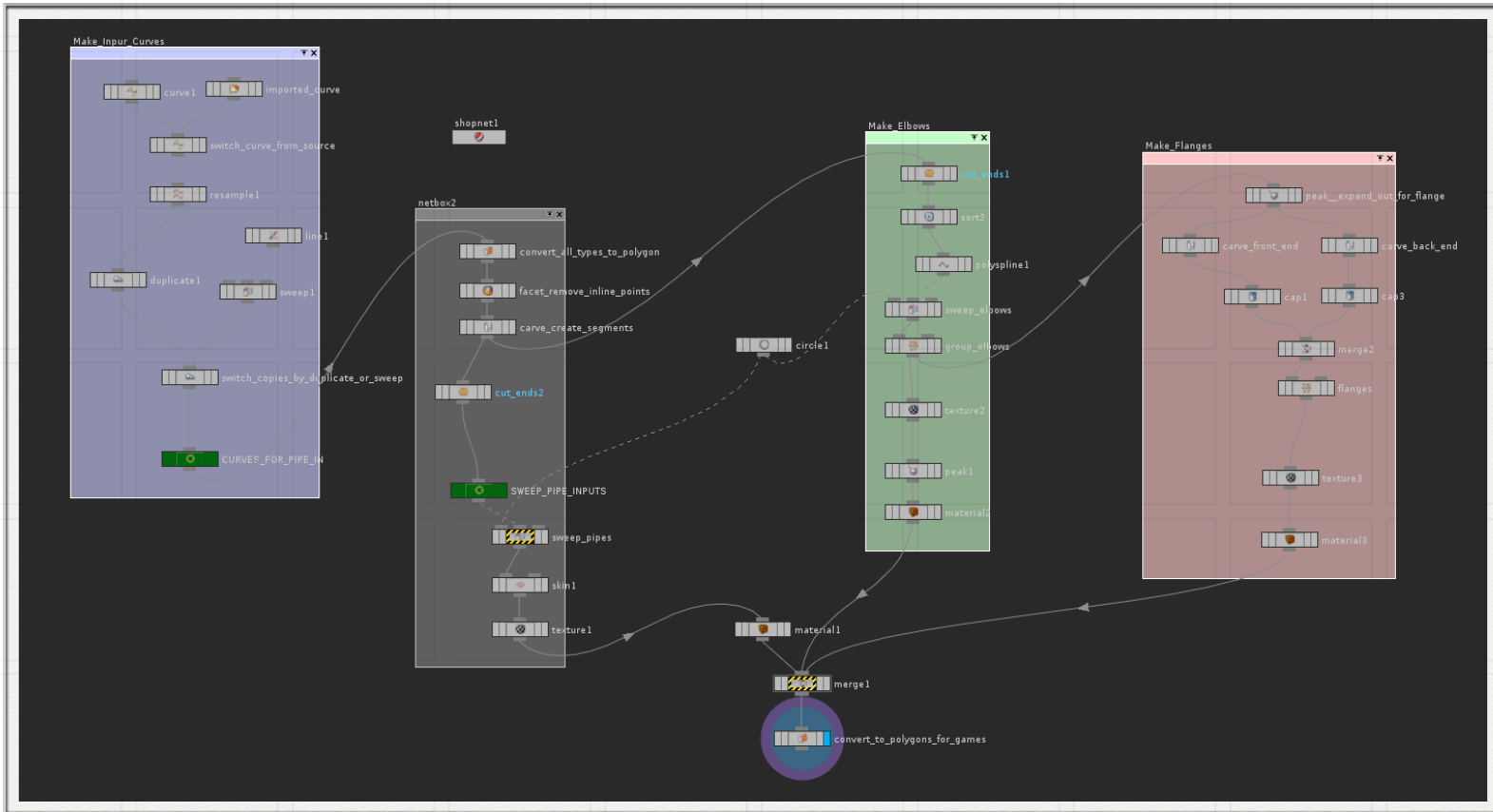
Carve out the Flanges



- ▶ After the Group SOP split off a new branch and append a PEAK SOP.
 - ▶ Set the Distance to 0.1 - This will expand the radius of the pipe to make the flanges. Very much like a polyextrude would do for polygons
- ▶ Now append a CARVE SOP on one branch and another on another branch (see top image)
 - ▶ The first carve will determine the thickness for first flange the other carve the thickness of the second flange
 - ▶ On the second flange we want to make sure the thickness is the same thickness of the first flange. Use the expression
 - ▶ `1 - ch("../carve_front_end/domainv2")`
 - ▶ domainv2 refers to "Second V"

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Final Pipe Network



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Hoses

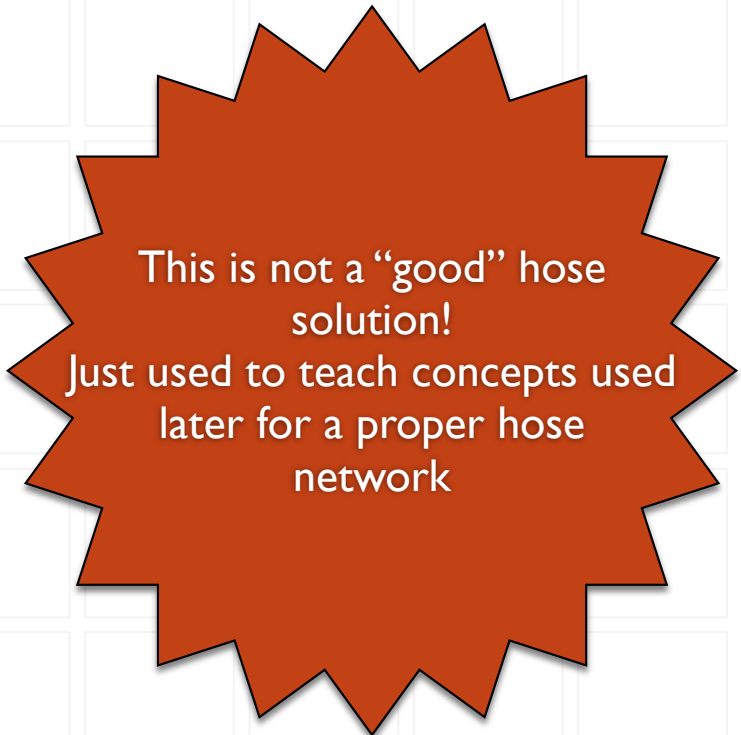
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Goals

- ▶ It is simple to create a hose, but not simple to create a robust hose that will hold up in varying conditions
- ▶ Does the hose stay attached to the couplings?
- ▶ Does the hose work during twisting, turning, and translation?
- ▶ Do the uvs stay put or swim?

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A One Off Hose

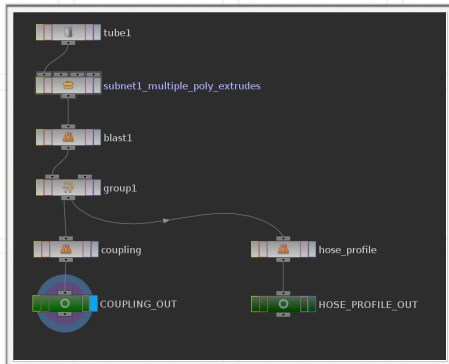
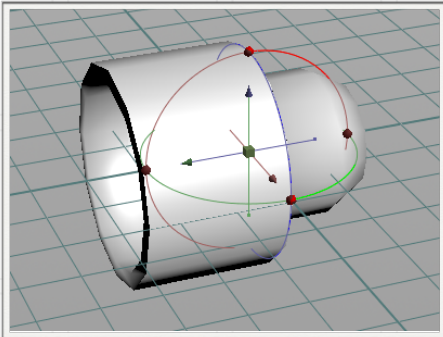


This is not a “good” hose
solution!
Just used to teach concepts used
later for a proper hose
network

- ▶ Two approaches to a simple hose
- ▶ The simplest would be to use a curve and a sweep
- ▶ More robust would be to use a path
- ▶ Let us use a path. While this approach will not be robust it will teach us important techniques to build the robust hose.

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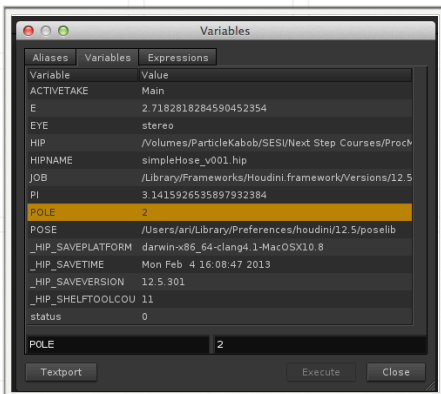
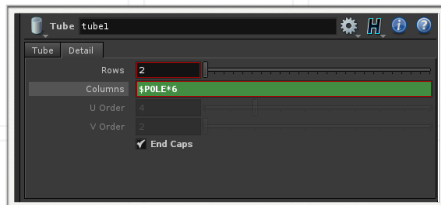
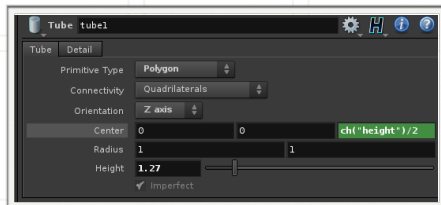
Step One... Build the Master Coupler



- ▶ Built along the z-axis
- ▶ Polygonal
- ▶ Saved the last extrude as the future profile for the hose

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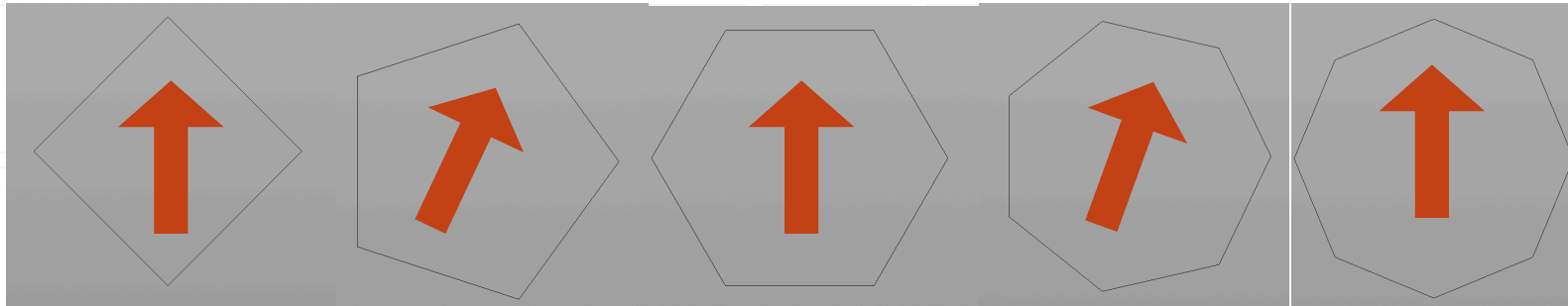
Coupler (cont.)



- ▶ Tube is flush with the +Z axis
- ▶ I Created a Global Variable named “POLE”
- ▶ It purpose is to keep the orientation of the hose

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Coupler (cont.)

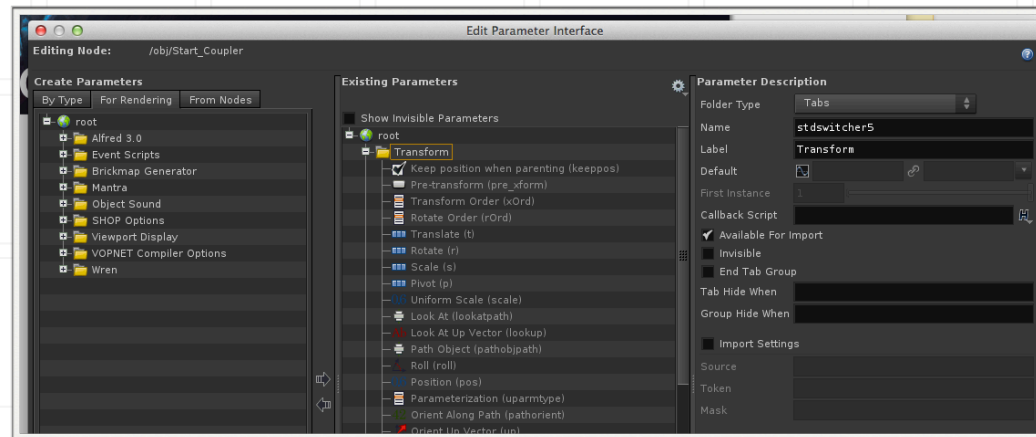


By keeping columns a multiple of 2 you are guaranteed the tube will have its “poles” up.

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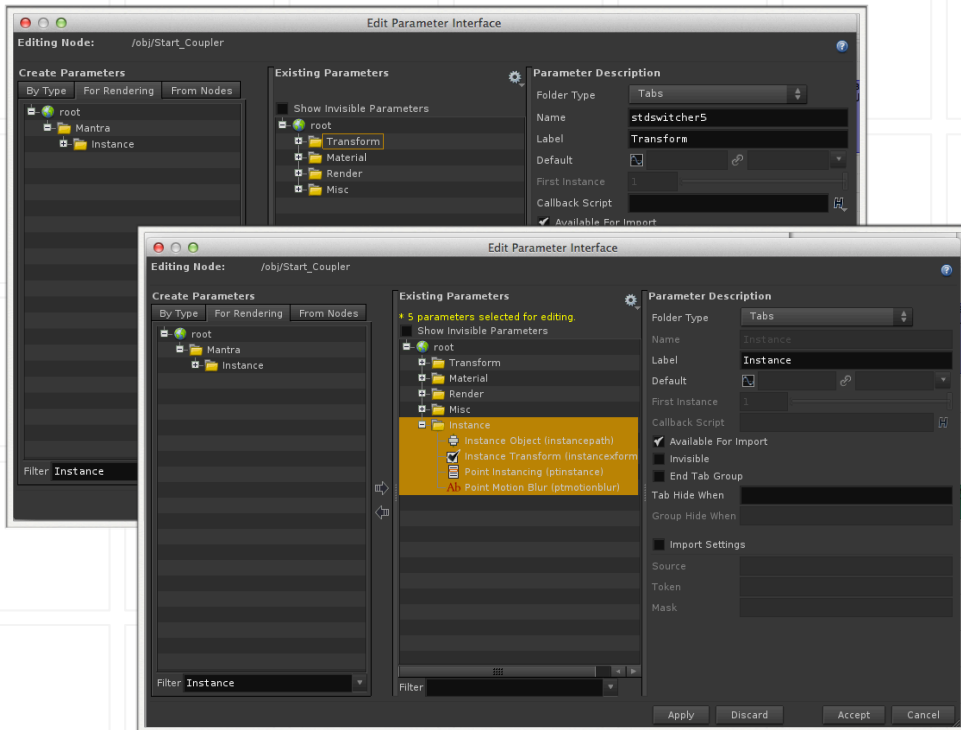
Creating Instances of the Coupler

- ▶ We created the Master, Now let us create the instances
- ▶ One for each end of the hose
- ▶ DO NOT USE THE INSTANCE OBJECT - Instead let us add parameters to the GEO Object
- ▶ Drop down a Geo
- ▶ Open up the parameter interface - Go to “For Rendering” Tab



**SIDE EFFECTS
SOFTWARE**

Coupler Instance (cont.)



- ▶ In the “Filter field of the first column type “Instance”
- ▶ Drag the Instance folder to the root of the second column
- ▶ Click Accept

**SIDE EFFECTS
SOFTWARE**

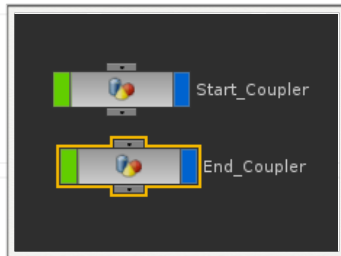
Why Not an Instance Object?



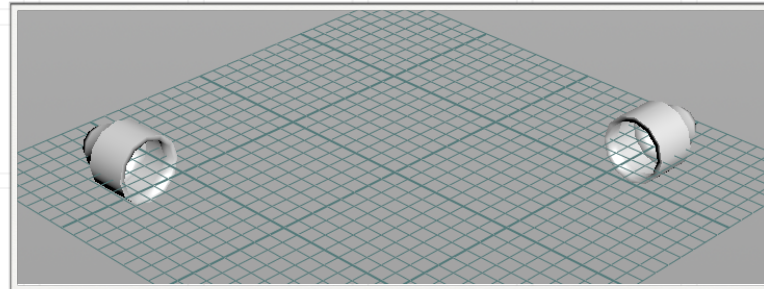
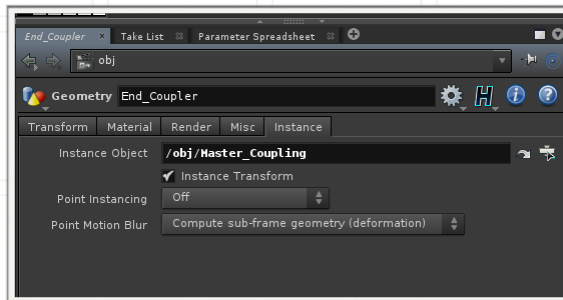
The instance object contains no render tab. By adding the instance controls to a Geometry Object you get instancing plus more control of rendering

**SIDE EFFECTS
SOFTWARE**

Coupler Instance (cont.)

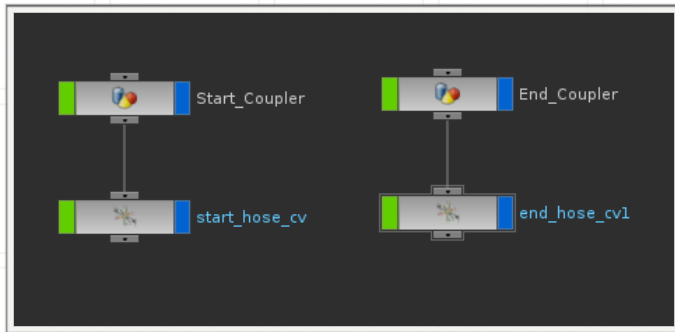


- ▶ Drag the Master Coupler into the Instance Object Parameter of both the Start & End Coupler
- ▶ Now position the two couplers where you want the ends of the hose to be



SIDE EFFECTS
SOFTWARE

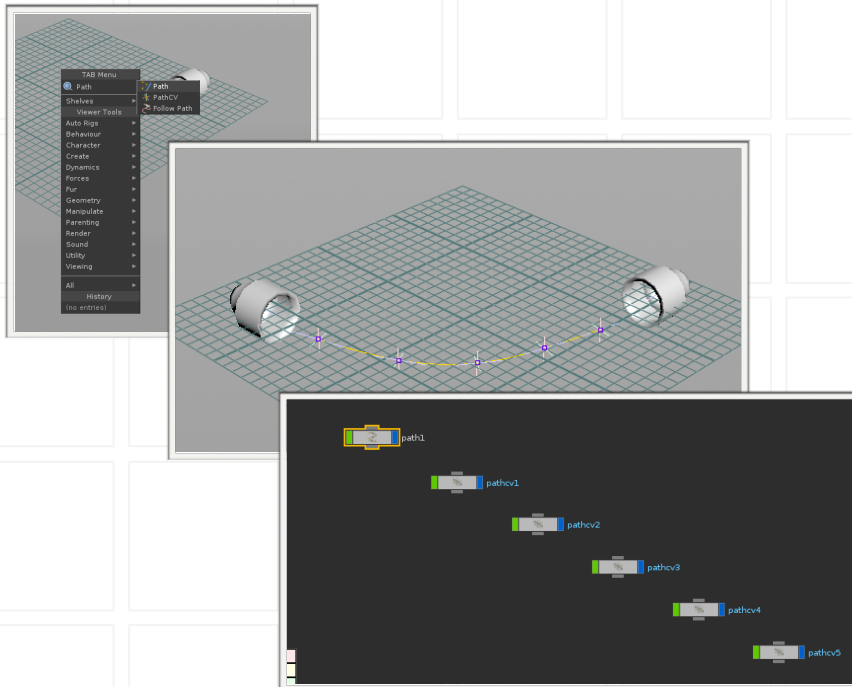
Creating the Path



- ▶ In the network view at the object level
- ▶ Drop down a PATHCV Object
- ▶ Make it a child of the Start_Coupler
- ▶ Rename it “Start_Hose_CV”
- ▶ Repeat for the End_Couple
- ▶ Name it “End_Hose_CV”

We will append these cvs to the path we are about to create

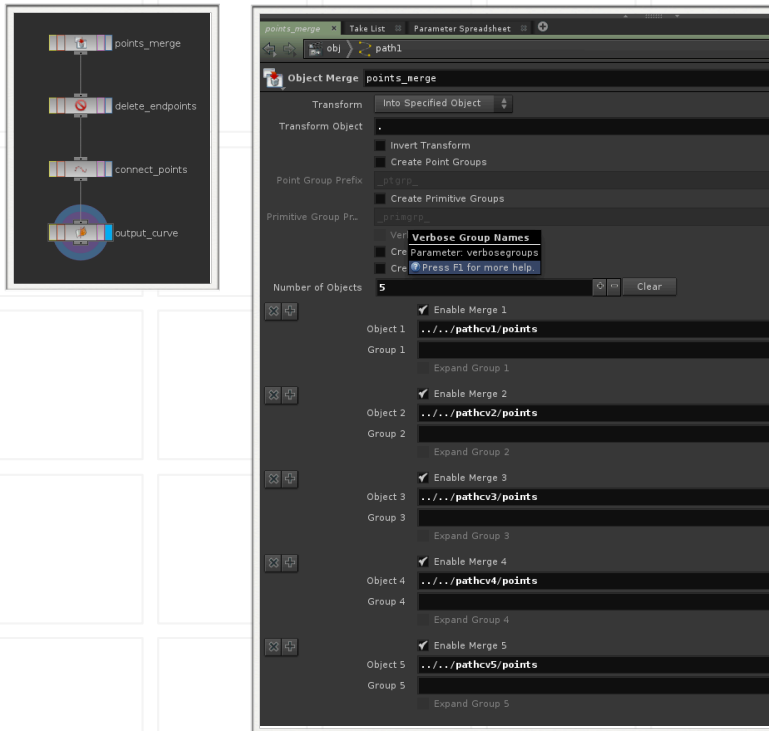
Path (cont.)



- ▶ In the scene view hit the “tab” key and type “path”
- ▶ Select the path object
- ▶ Click in the scene view to draw your path
- ▶ You just created the intermediate points of the path
- ▶ In the network view you will see a “PATH OBJECT” and the associated cvs.

SIDE EFFECTS
SOFTWARE

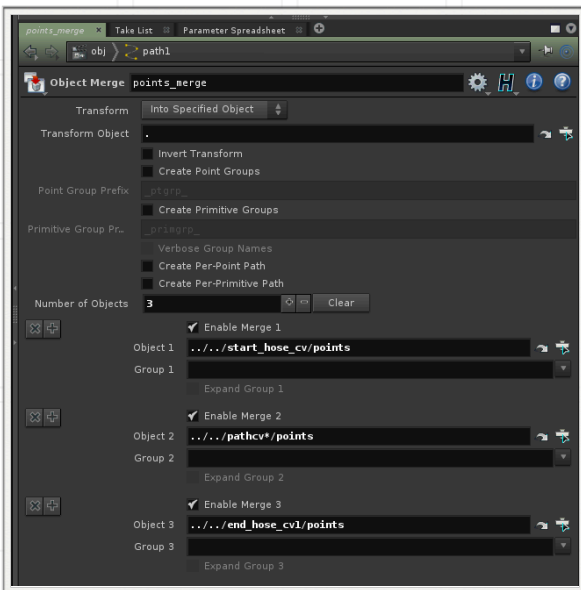
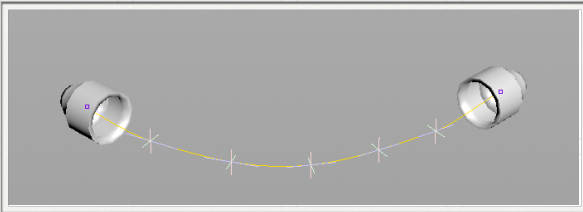
Let's Look Inside the Path Object



- ▶ The parameters of the Object merge contain all the cvs that were created when you created the path in the Scene view
- ▶ We will modify the parameters to use the start_hose_cv and end_hose_cv

SIDE EFFECTS
SOFTWARE

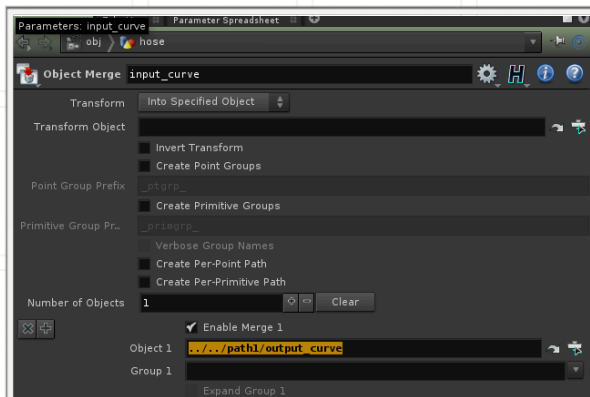
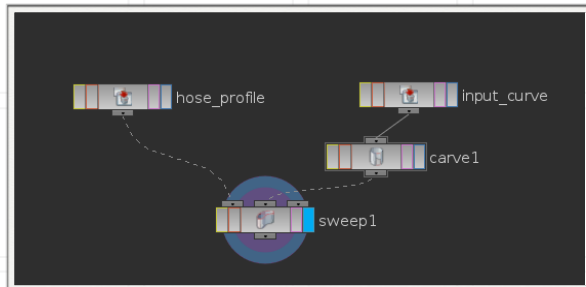
Path (cont.)



- ▶ Change the Object 2 Parameter to:
- ▶ `../../start_hose_cv/points`
- ▶ Now we will use the wild card “*” to tell the Object 2 parameter to read in all the cvs we created when drawing the path
- ▶ `../../pathcv*/points`
- ▶ The Object 3 Parameter will be used for the end point
- ▶ `../../end_hose_cv/points`
- ▶ Finally delete the rest of the Object Parameters

SIDE EFFECTS
SOFTWARE

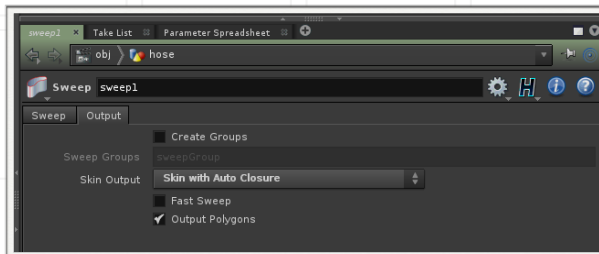
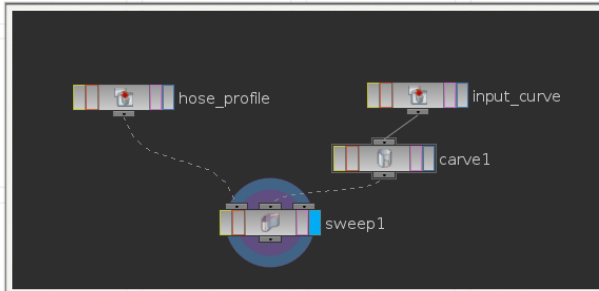
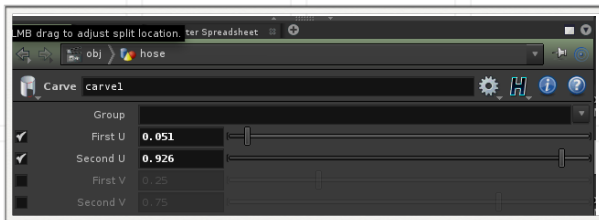
Making the hose



- ▶ At the Object Level drop down a GEOMETRY Obj
- ▶ Rename it “hose”
- ▶ Go inside hose
- ▶ Drop down two OBJECT MERGE SOPs
- ▶ Name one “profile”, the other “input_curve”
- ▶ The hose_profile will point to the Master_Coupler profile
- ▶ ../../Master_Coupling/HOSE_PROFILE_OUT
- ▶ The input_curve will point to
- ▶ ../../path1/output_curve

SIDE EFFECTS
SOFTWARE

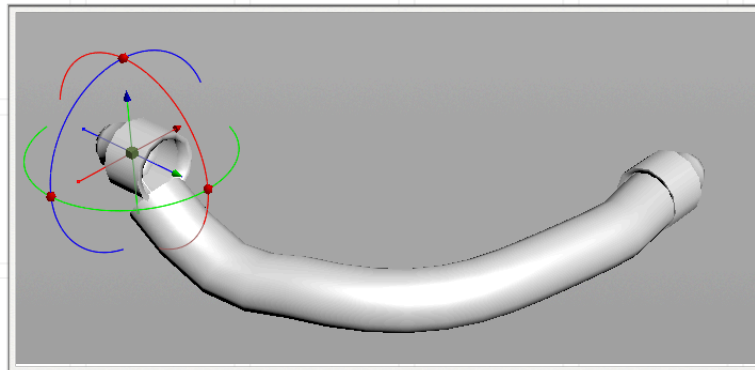
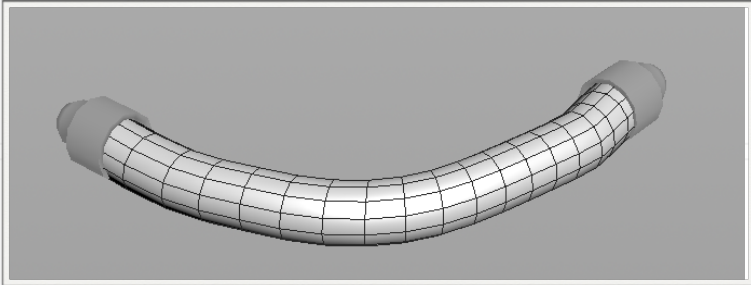
Making the Hose (cont.)



- ▶ The CARVE SOP is to adjust the start and end points
- ▶ Turn on First u and Second u
- ▶ Dial them as needed
- ▶ Attach the hose_profile and carve to a sweep
- ▶ In the Detail Tab of the Sweep turn on
- ▶ Skin with Auto Closure


SIDE EFFECTS
SOFTWARE

Looks like a hose..



**SIDE EFFECTS
SOFTWARE**

We Need...

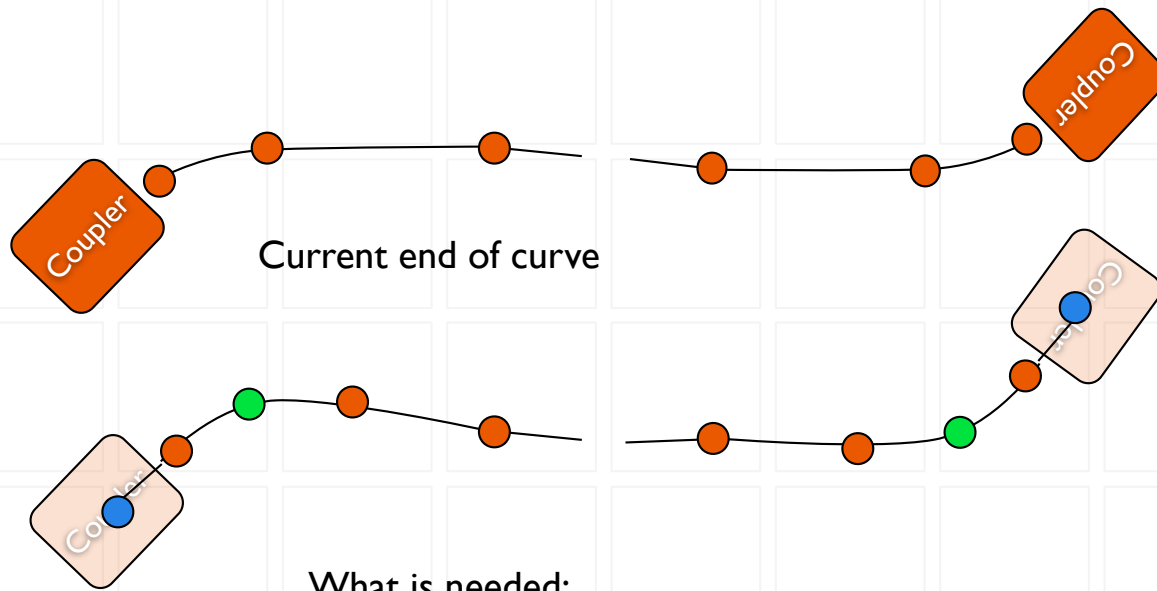


We Need a lot more
sophistication to make a
robust hose

- ▶ A more sophisticated approach to secure the ends of the hose together while the couplings move
- ▶ The hose needs to be stiffer at the coupling insertion points.
- ▶ Need to keep track of up vectors
- ▶ Need offsets to bury hose in coupling

**SIDE EFFECTS
SOFTWARE**

Illustration

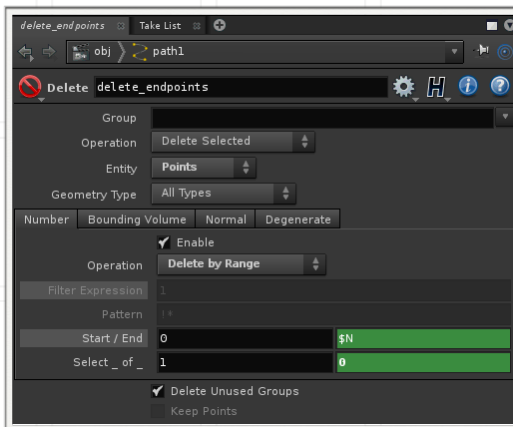
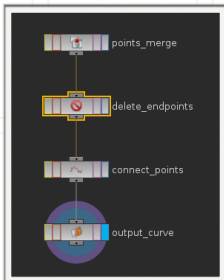


What is needed:

- Extend curve into Coupler for better fit - add cv
- Add cv into curve to increase tension of hose at coupler

SIDE EFFECTS
SOFTWARE

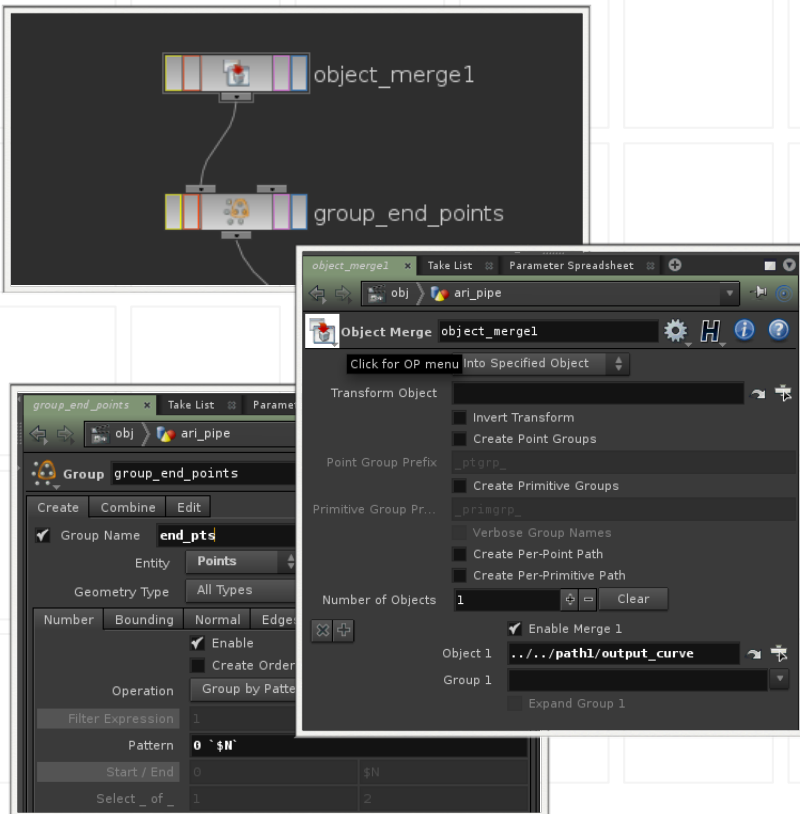
End Points... Three Approaches



- ▶ If you look at the Path Object the Delete SOP has the following pattern
- ▶ We can make a group geometry with a very similar looking pattern...

**SIDE EFFECTS
SOFTWARE**

End Points Created with Group Geometry SOP

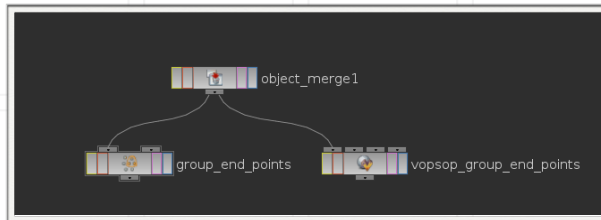


- ▶ Let us create a new GEOMETRY Object to create the more robust pipe
- ▶ Dive inside the Geometry
- ▶ Delete the FILE SOP and put down an OBJECT MERGE SOP
 - ▶ Point the Object Merge to ../path1/output_curve
- ▶ Append a GROUP GEOMETRY SOP
 - ▶ Group Name - end_pts
 - ▶ Entity - Points
 - ▶ Pattern - 0`\$N`

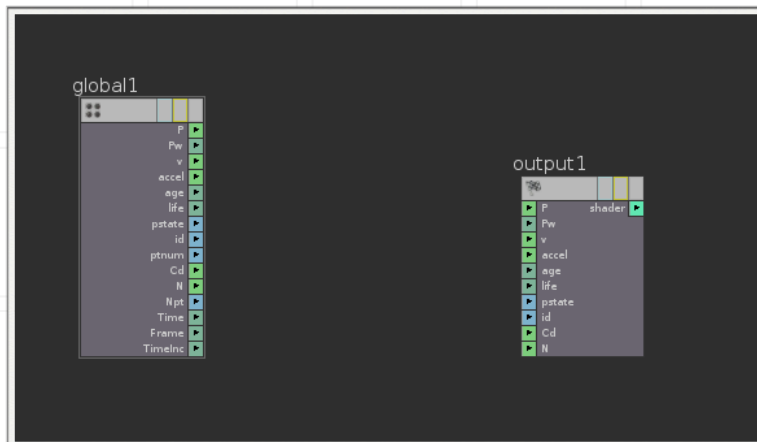
Back ticks are needed to evaluate local variable and not think it is a string

**SIDE EFFECTS
SOFTWARE**

End Points Created with a VOPSOP



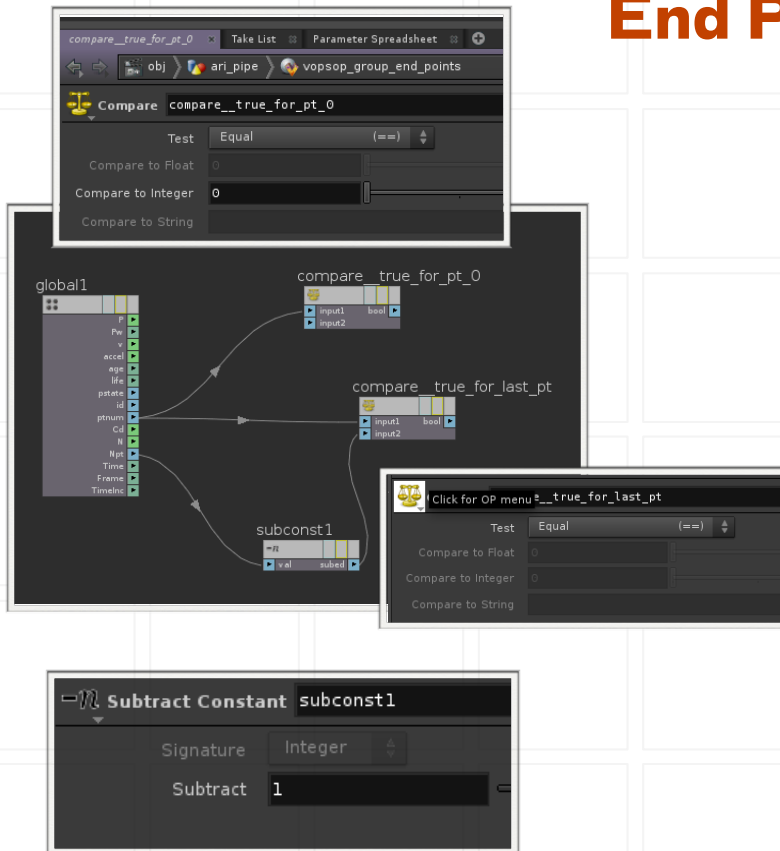
- ▶ Lets create a group called end_pts again but this time with a VOPSOP (either VOPS or Group Geometry are equally good)
- ▶ Append a VOPSOP to the Object Merge on a separate branch from the group geometry
- ▶ Dive into the VOPSOP
- ▶ Initially there are two nodes. Global1 and Output1
 - ▶ The two parameters we are interested in are:
 - ▶ ptnum - The Current Point Number
 - ▶ Npt - The Total Number of Points



**SIDE EFFECTS
SOFTWARE**

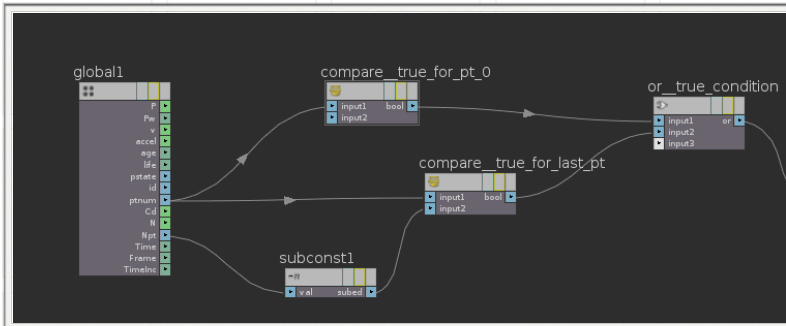
End Points Created with a VOPSOP (cont.)

- ▶ Remember the end goal - we want to group the first and last point
- ▶ The COMPARE VOP lets us compare to a specific number
 - ▶ Drop down a Compare VOP. Wire Input 1 to ptnum
 - ▶ Compare to Integer 0 - this is testing if we have the first point
 - ▶ Drop down another Compare VOP. Wire Input 1 to ptnum
- ▶ This time we want to test for the last number but since point count starts at zero we have to subtract 1 first
 - ▶ Drop down a SUBTRACT CONSTANT VOP - set it to 1
 - ▶ Wire the Subtract Constant to Npt
 - ▶ Wire the Output of Subtract Constant to Input2 of the Compare



SIDE EFFECTS
SOFTWARE

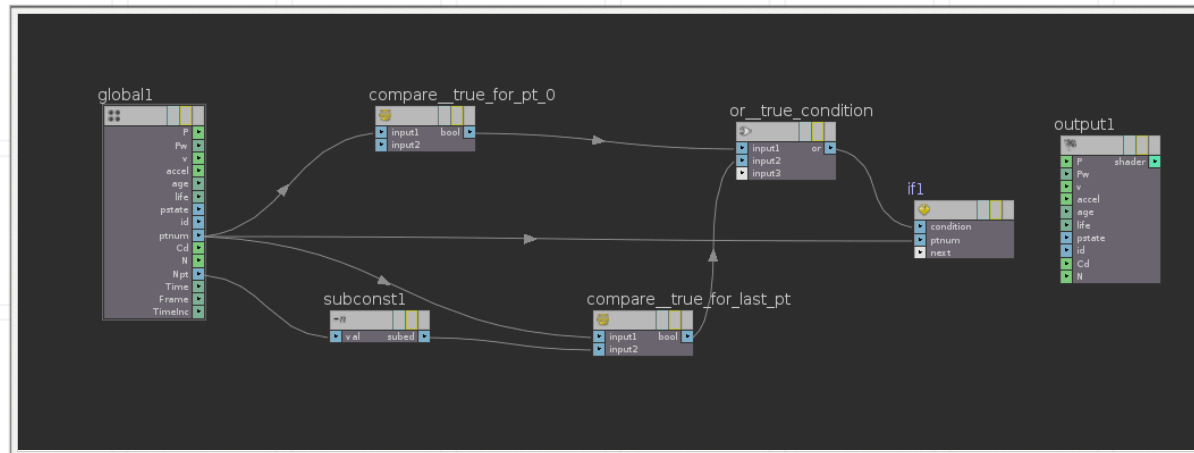
End Points Created with a VOPSOP (cont.)



- ▶ Now Drop down a OR VOP
- ▶ OR tests if either input is true (is the point the first point or last point?)
- ▶ Wire the output of the two compares to the input of the OR

**SIDE EFFECTS
SOFTWARE**

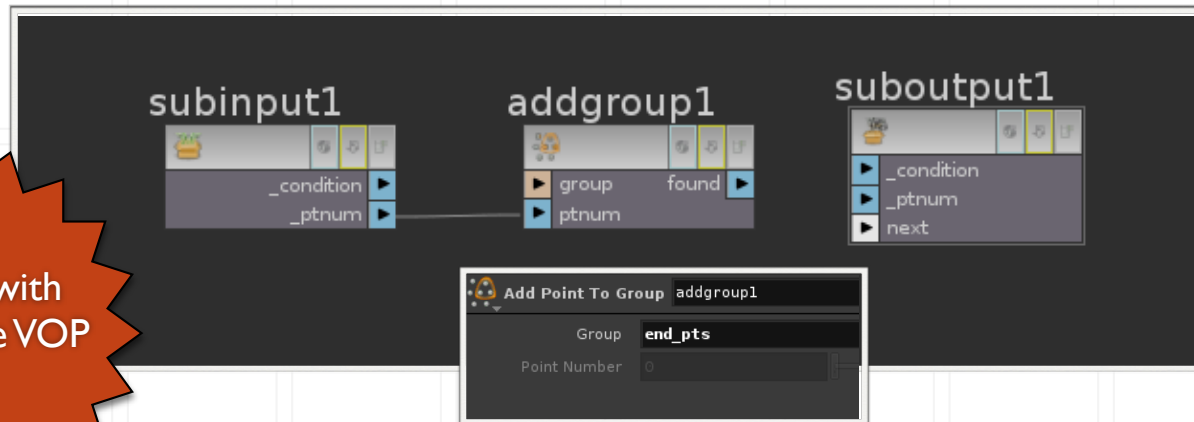
End Points Created with a VOPSOP (cont.)



- ▶ Finally we need to test if we have the first or last point and if so put them in a group called “end_pts”
- ▶ Drop Down an IF VOP
- ▶ Wire the output of the OR to the condition parameter of the IF and ptnum from the Global1 to ptnum of the if1 VOP

**SIDE EFFECTS
SOFTWARE**

End Points Created with a VOPSOP (cont.)



All done with
creating the VOP
SOP

- ▶ Dive inside the IF VOP
- ▶ Add a ADD POINT TO GROUP VOP
- ▶ Wire `_ptnum` to `ptnum` of the Add Point to Group VOP
- ▶ Name the Group - `end_pts`

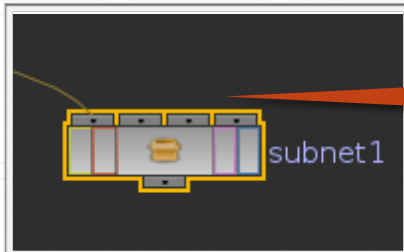
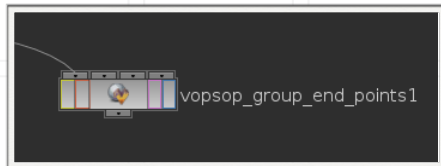
SIDE EFFECTS
SOFTWARE

One Last Thing with the VOPSOP...

Let's make it into a Digital Asset

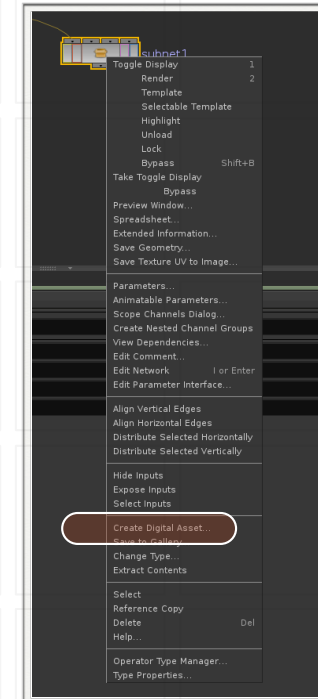


SubNetwork
Button



VOPSOP
Converted
to Subnet

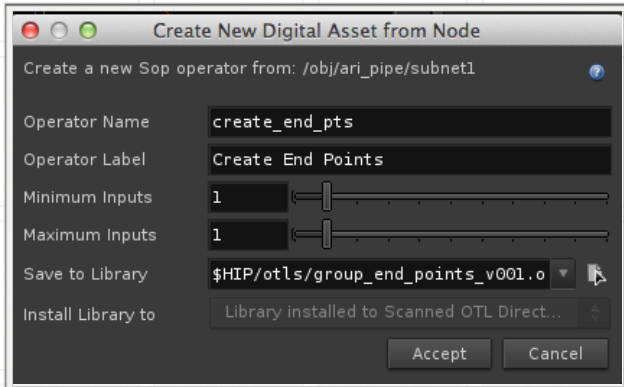
- ▶ By making it into a digital asset you can reuse it on all your projects
- ▶ Select the VOPSOP and make a SubNetwork from it
- ▶ Now right click on subnet and Convert to Digital Asset



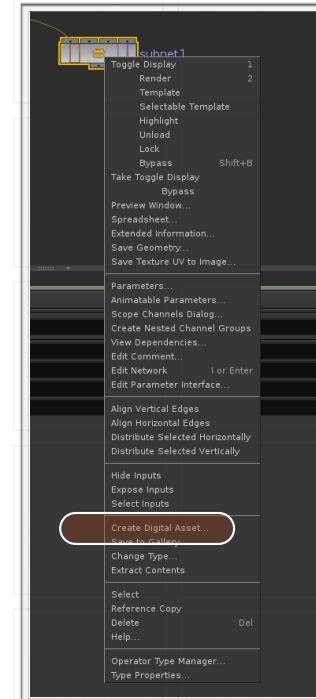
**SIDE EFFECTS
SOFTWARE**

One Last Thing with the VOPSOP...

Let's make it into a Digital Asset



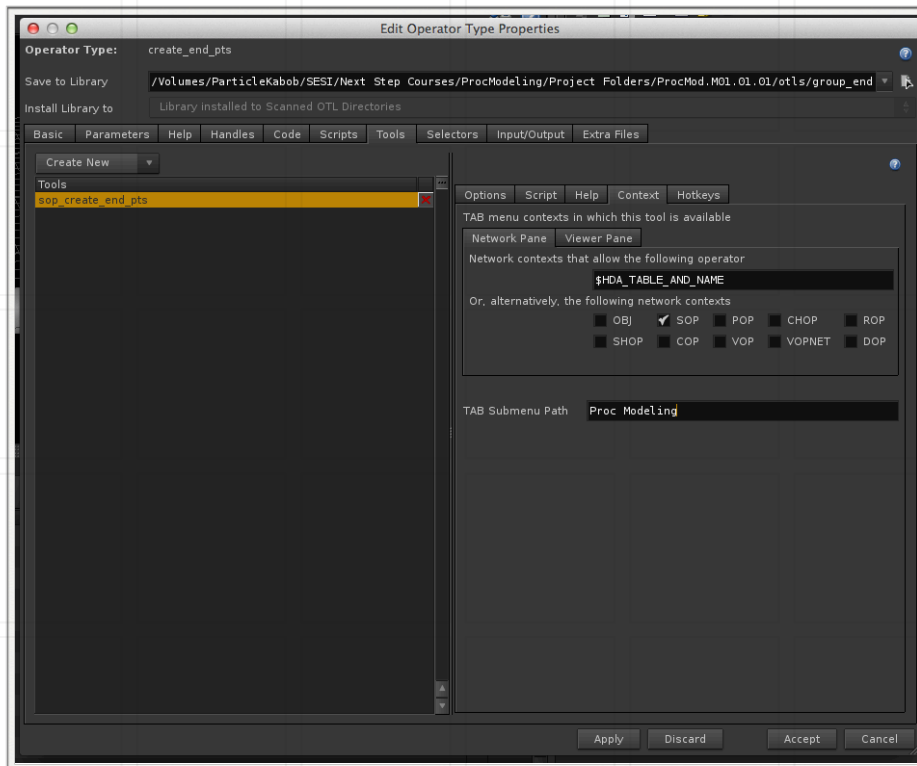
- ▶ After clicking on Create Digital Asset a dialog box will pop up
- ▶ Give it the Name and label in the image on the left
- ▶ Save it to the otls folder in your project folder.
- ▶ Give it the name group_end_points_v001.otl



**SIDE EFFECTS
SOFTWARE**

One Last Thing with the VOPSOP...

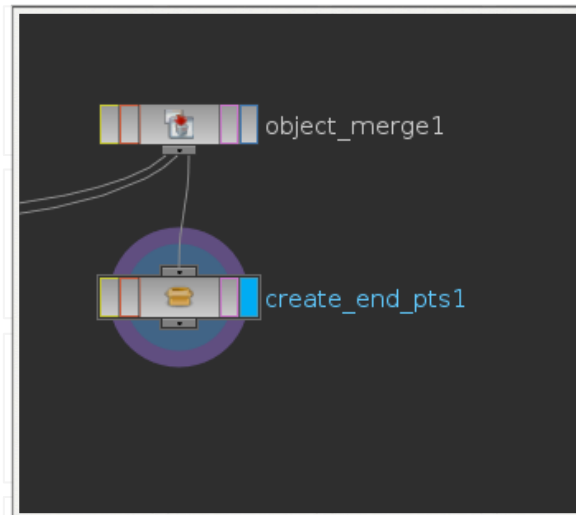
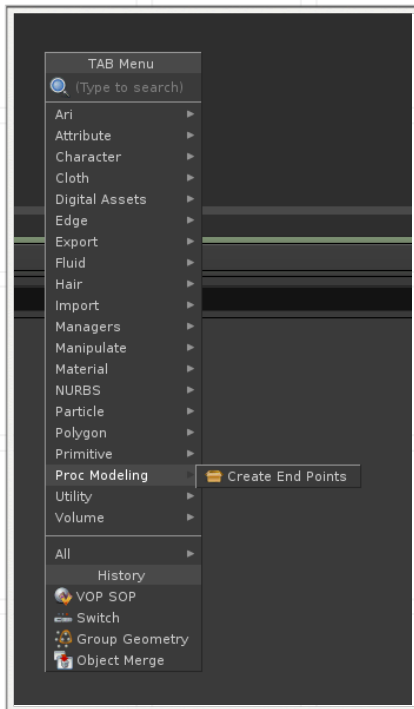
Let's make it into a Digital Asset



- ▶ A Large Dialog Box will appear
- ▶ Go to the Tools Tab
- ▶ We are creating a SOP Digital Asset so select SOP
- ▶ In the Tab Selection Path parameter - Type Proc Modeling
- ▶ Click Accept

**SIDE EFFECTS
SOFTWARE**

Try It Out



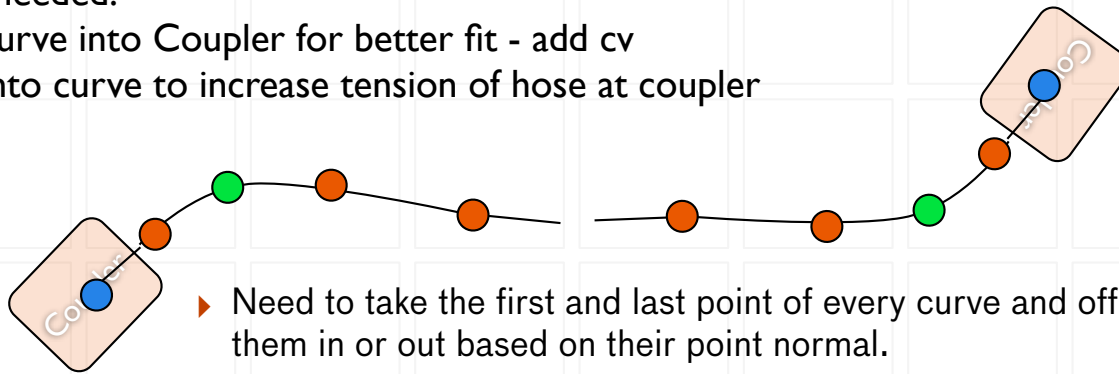
- ▶ Hit the tab key in the Network Pane
- ▶ Go down to Proc Modeling and you will see your Create End Points SOP
- ▶ Click it and append to the Object Merge

**SIDE EFFECTS
SOFTWARE**

Offsetting the End Points into the Couplers

What is needed:

- Extend curve into Coupler for better fit - add cv
- Add cv into curve to increase tension of hose at coupler



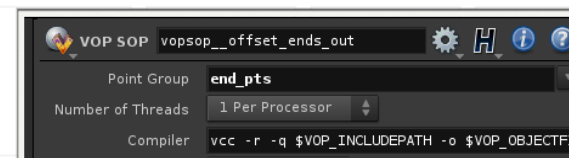
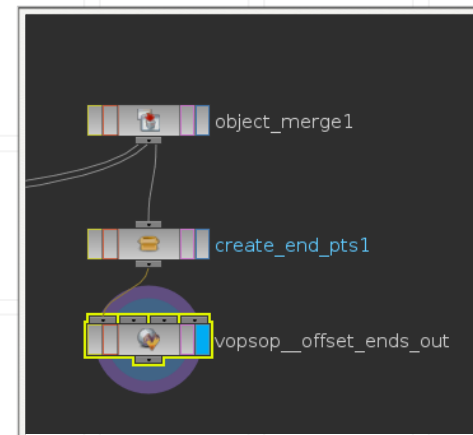
- ▶ Need to take the first and last point of every curve and offset them in or out based on their point normal.
- ▶ We need to flip the normal direction for the first point O so that the ends move in or out together.
- ▶ To offset the P position, simply add the normal vector N to the point position P.
- ▶ Normalize the normal vector N so that the offset is in object space units where 1 = 1 object scene unit.
- ▶ To control the amount of offset, simply scale N.

Steps we need to do to Offset End Points

**SIDE EFFECTS
SOFTWARE**

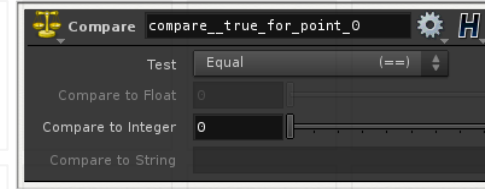
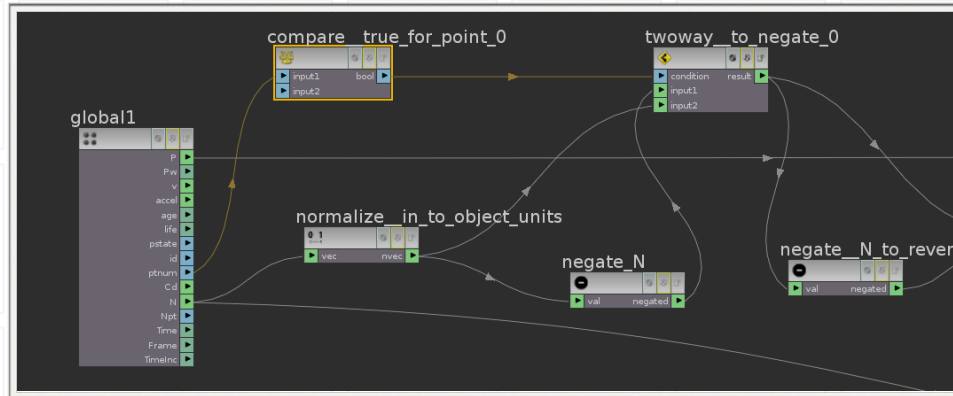
Append a VOPSOP - Pushing End Points into Coupler

- ▶ Append a VOPSOP to the Create End Pts SOP
- ▶ Set the Point Group Parameter - end_pts
- ▶ Dive Into the VOPSOP



**SIDE EFFECTS
SOFTWARE**

Test if First or Last Point and if First Negate Normal

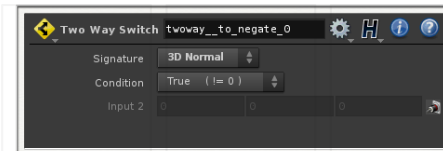
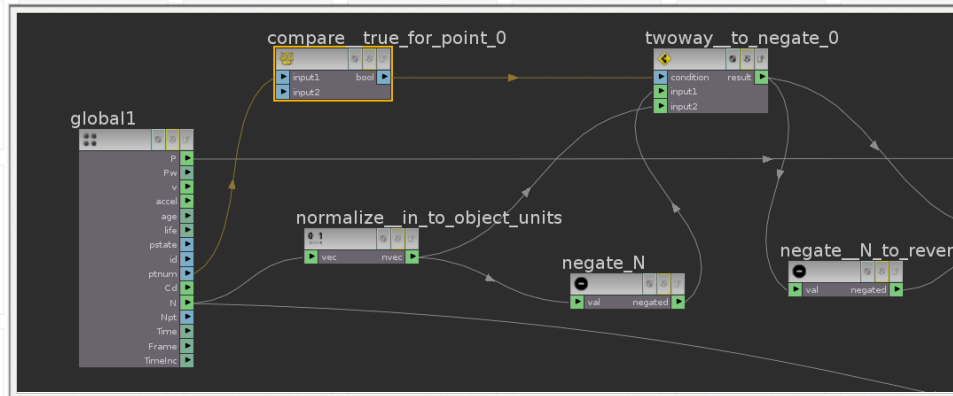


- ▶ Add a COMPARE VOP and attach ptnum to Input1
 - ▶ Test to see if it is point 0
- ▶ Add a TWO WAY SWITCH VOP
 - ▶ Attach the output of the compare to the “condition” of the two switch (the two way switch will flip the normal if it is point 0 and leave the normal alone if it is the end point)
- ▶ Add a NORMALIZE VOP and attach the N input to vec input of the Normalize VOP

Continue on next slide...

**SIDE EFFECTS
SOFTWARE**

Test if First or Last Point and if First Negate Normal

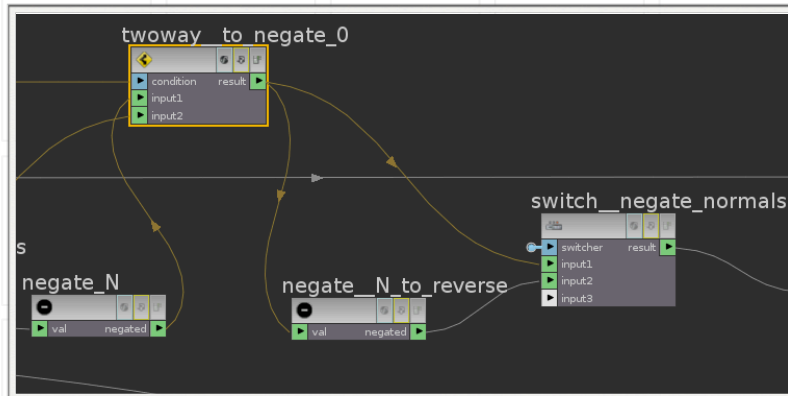


- ▶ We want the Negated Normalized Normal and the Normalized Normal. One for the first point and the other for the last point
- ▶ Drop down a NEGATE VOP - Attach the Normalize VOP to the Negate Input
- ▶ On the Two Way Switch add the output of the Negate to Input1 and the output of the Normalize to Input2

Continue on next slide...

**SIDE EFFECTS
SOFTWARE**

Add a Switch to Control Direction of Normals

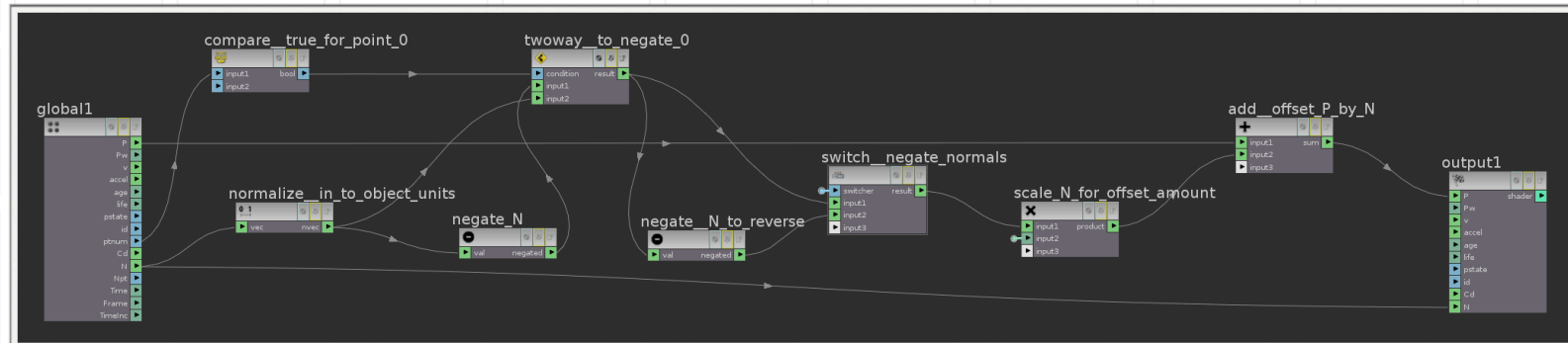


- ▶ Now we are going to add a user controlled parameter to allow the user to switch the direction of the normals just in case
- ▶ Drop down another NEGATE VOP - Attach to the result of the two way switch
- ▶ On the Two Way Switch add the output of the Negate to Input1 and the output of the Normalize to Input2
- ▶ ADD a SWITCH VOP - Promote the switcher parameter
- ▶ Attach the output of the two way switch to Input1 of the switch and attach the output of the negate to Input2

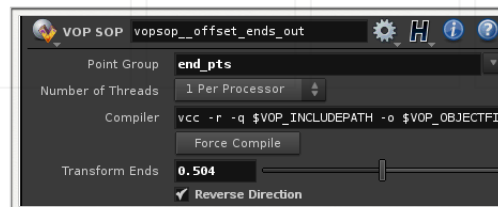
Continue on next slide...

**SIDE EFFECTS
SOFTWARE**

Scale the Normals and Offset the Positions



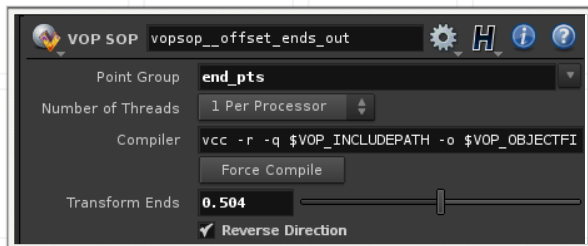
- ▶ All that us now needed is scale the normals to increase the tension of the hose near the coupler ad offset the position of the hose into the coupler.
- ▶ Drop down a MULTIPLY VOP - Input1 is attached to the result of the switch. Input2 is promoted so the user can adjust the tension of the cable
- ▶ Drop down an ADD VOP - This is used offset the hose into the coupler. Take P from the Global Input and connect to Input1. The product of the multiply goes into Input2
- ▶ Finally the sum of the Add goes into P of Output1 and The N of Global1 goes into N of Output1



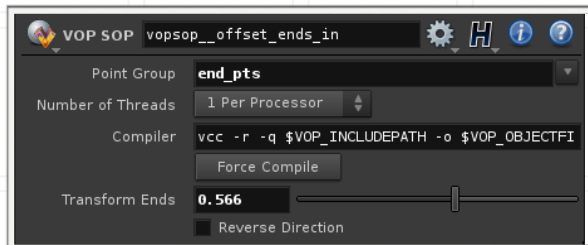
**SIDE EFFECTS
SOFTWARE**

Append a VOPSOP - Pushing End Points into Hose

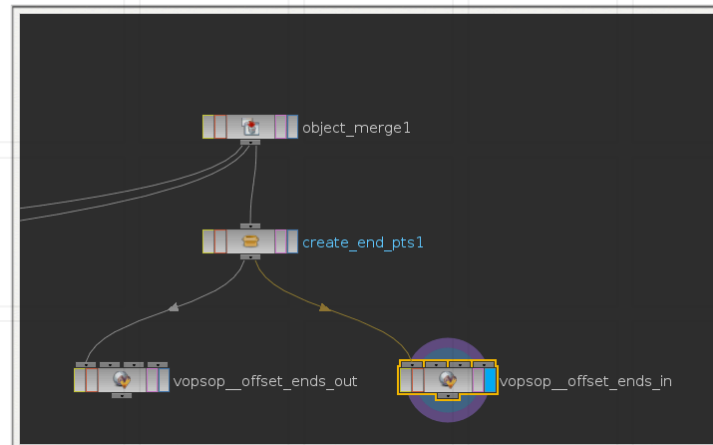
- Copy and Paste the VOP we just created. This time we are going to use it to push the points into the hose



Parameters for Pushing Points out into Coupler

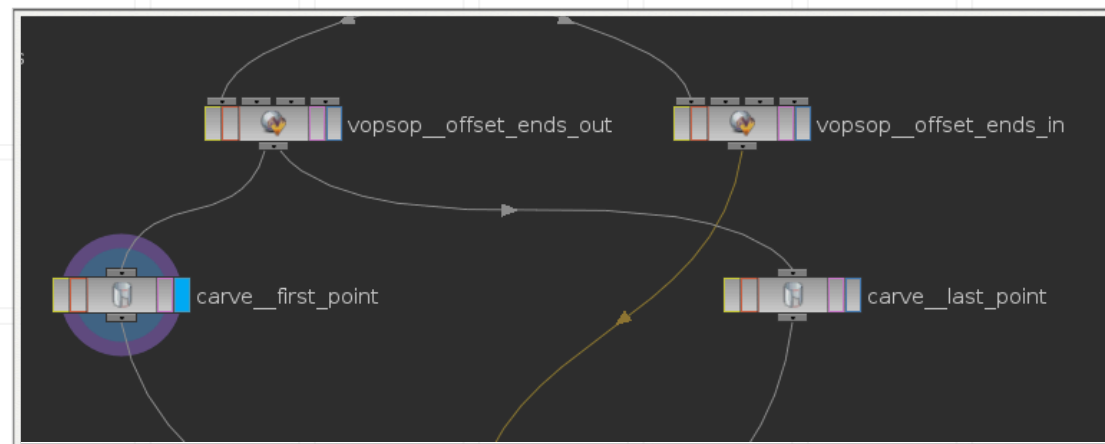
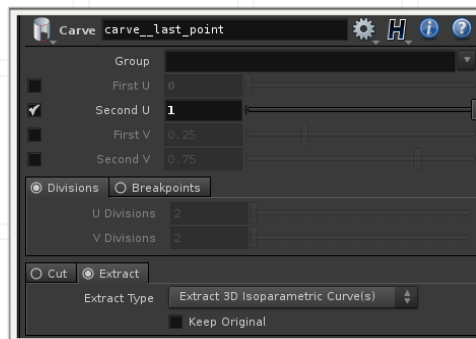
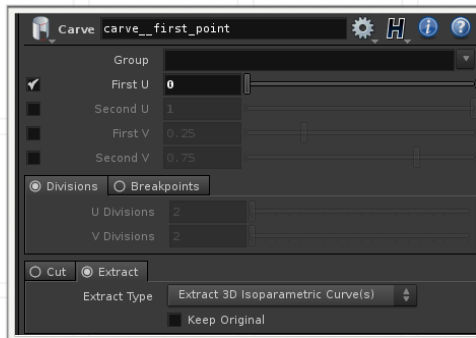


Parameters for Pushing Points into Hose



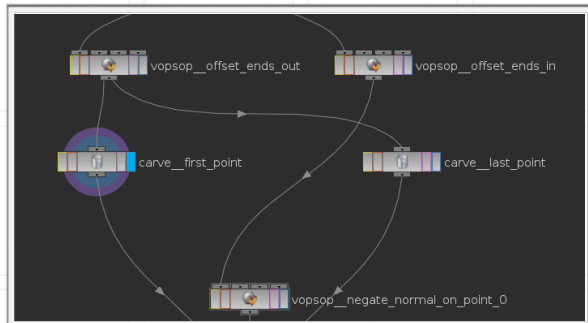
SIDE EFFECTS
SOFTWARE

Carving out the Hose Ends

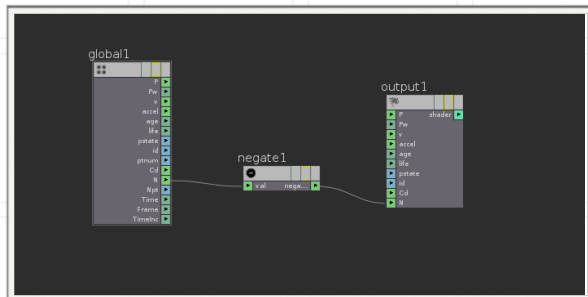


**SIDE EFFECTS
SOFTWARE**

Negating the Normal of the Points in the Hose

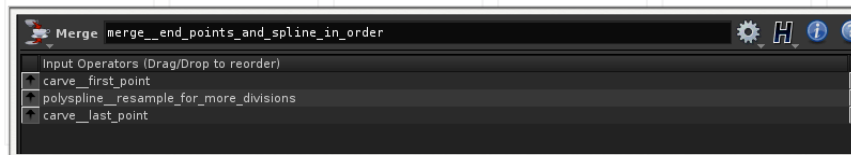
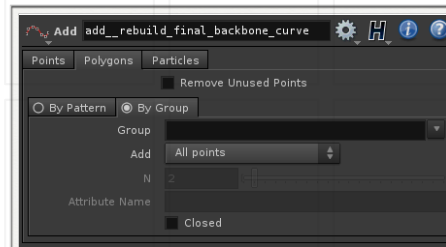
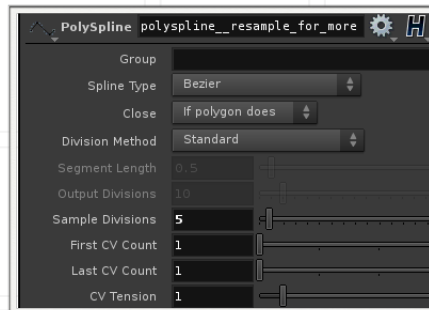
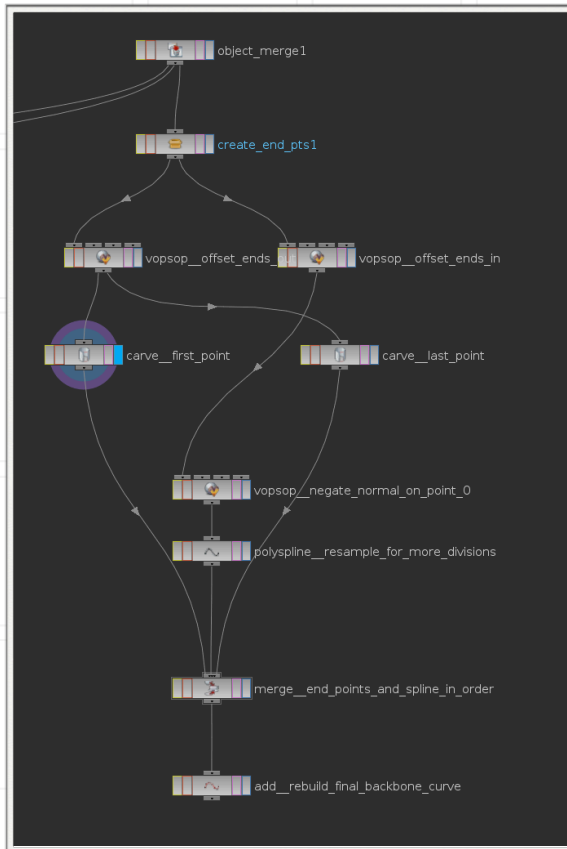


- ▶ Just negating the point normal on Point 0 to face in the right direction for the polyspline.



**SIDE EFFECTS
SOFTWARE**

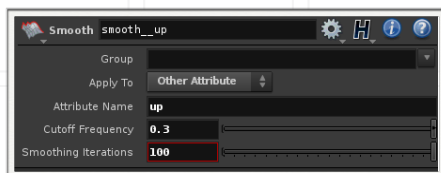
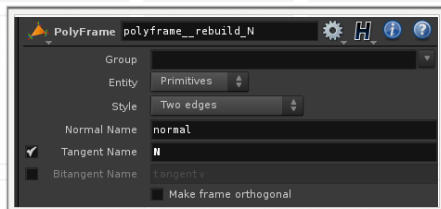
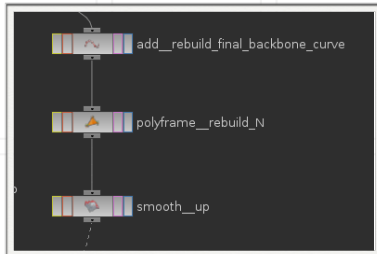
Rebuilding the Curve for the Hose with New Points Added



- ▶ The POLYSPLINE SOP is used to add more points to the curve to smooth it out
- ▶ The ADD SOP takes all the merged points and rebuilds the curve

SIDE EFFECTS
SOFTWARE

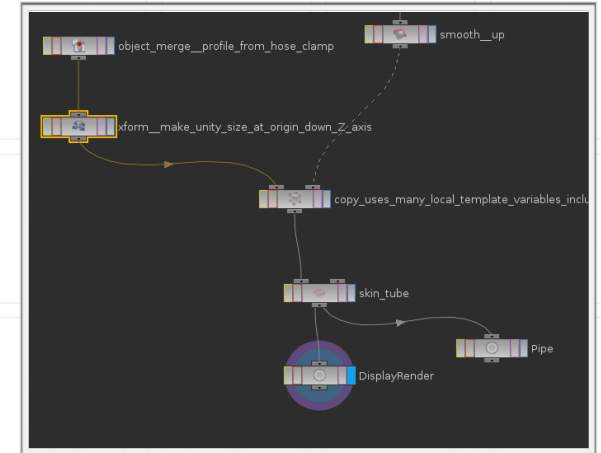
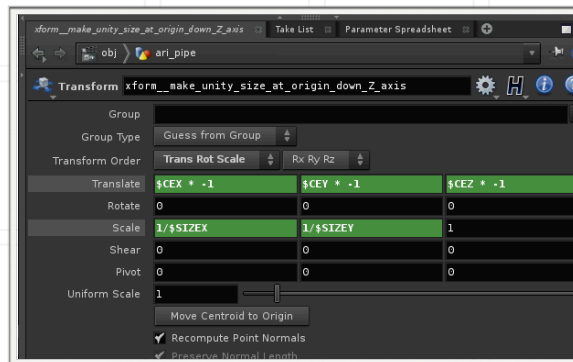
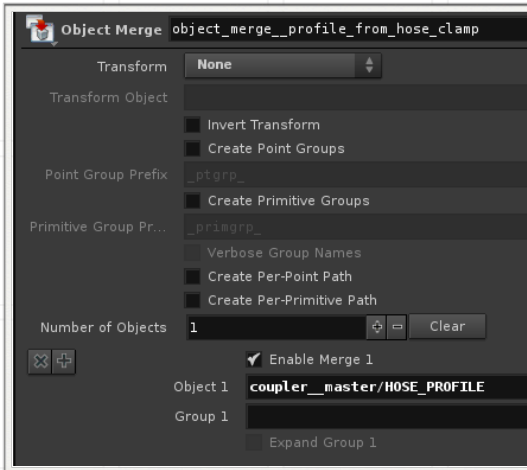
Finishing Off the Curve



- ▶ Drop down a POLYFRAME SOP to rebuild the tangents and Normals
 - ▶ Normal Name - normal
 - ▶ Tangent Name - N
- ▶ Drop down a SMOOTH SOP to smooth the up Vector
 - ▶ Attribute Name - up
 - ▶ Cutoff Frequency 0.3
 - ▶ Smoothing Iterations - 100

**SIDE EFFECTS
SOFTWARE**

Creating the Cross Section



- ▶ Object Merge the Hose Profile we created at the start of the lesson
- ▶ Calculate the centroid for hose placement and scale to whatever is needed
- ▶ Copy the profile to all the points for sweeping
- ▶ Skin the hose and test away

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End MO1

Pipes & Hoses

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