ParaView Scripting

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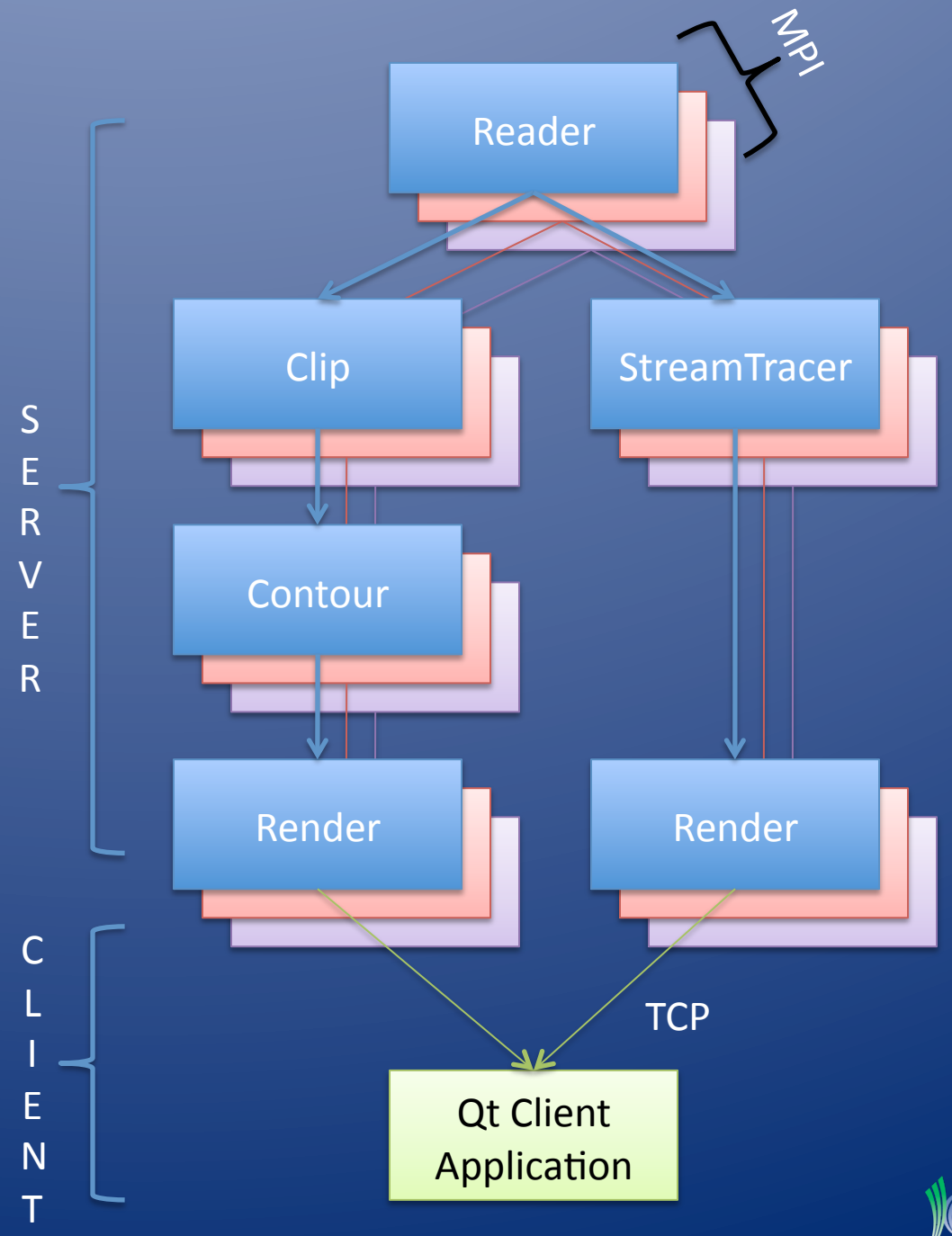
Why?

- Run in Batch mode
  - Set up Vis task on small representative dataset locally
  - Repeat with real data on supercomputer
- Script arbitrary parallel processing tasks
  - Not just visualization
  - A parallel interpreted programming environment
  - Examine, change and act upon individual data values in huge data sets
- To interface to use ParaView with other tools
- Script alongside the GUI

ParaView Architecture

VTK Pipeline,
in parallel,
on remote server(s),

controlled by and feeds into client application.



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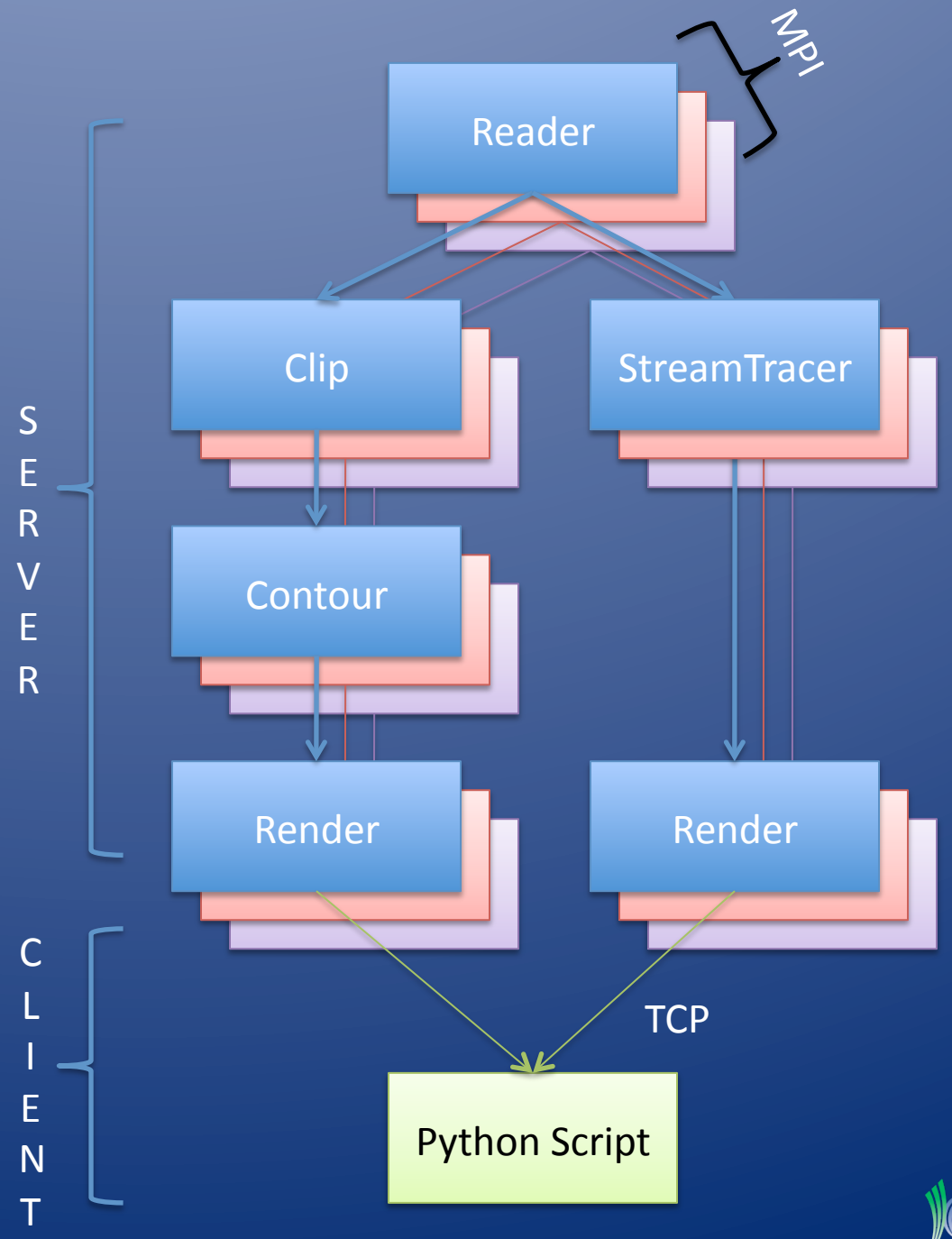
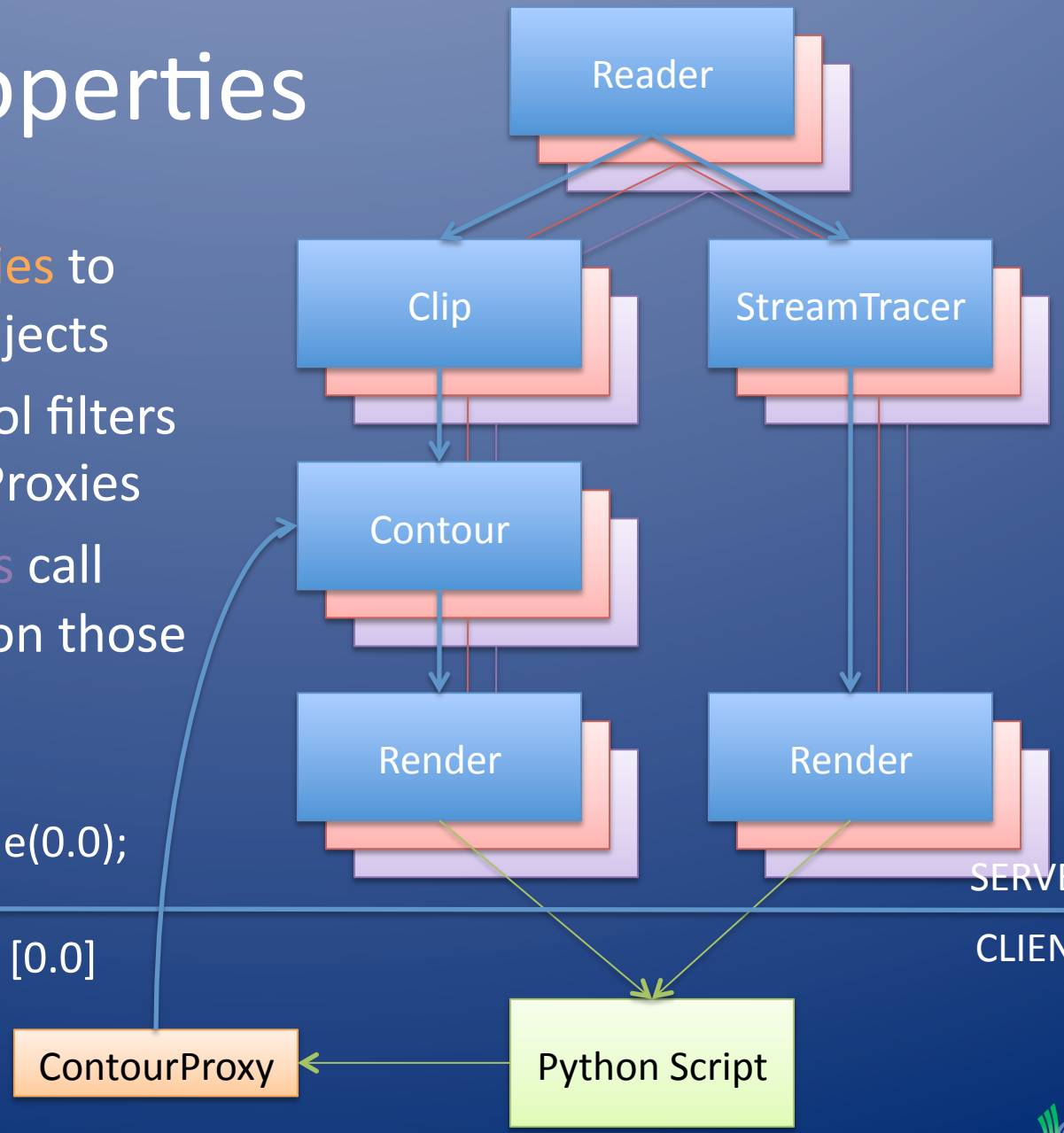


Proxies, Properties

- Client makes Proxies to control remote objects
- Proxies that control filters are called SourceProxies
- Proxies' Properties call specific methods on those objects

vtkContourFilter::SetValue(0.0);

Contour.ContourValues = [0.0]



How it Works

- Python wrapping of VTK
  - All public methods* of concrete classes callable
  - Unfortunately, can only call them on objects that live on client
- Python wrapping of ServerManager (SM)
  - vtkServerManager library is what allows client to control remote vtkSMSourceProxy, vtkSMProperty, etc
  - At this level you can control things on server
- Layered modules on top of wrapping simplify life

  >>> import paraview (deprecated, PV <= 3.2)

  >>> from paraview import servermanager (deprecated, PV <= 3.4)

  >>> from paraview.simple import * (New and Improved! PV >= 3.6)

* That do not take pointer arguments, are not within //BTX … //ETX, and are not in manually excluded files

How to Use it

- Shell within GUI
  - Tools->Python Shell
  - Fixed to same server that GUI is connected to
- Any python interpreter
  - Set PATHS to include ParaView libraries (bin and Utilities/VTKPythonWrapping)
- pvpython
  - python interpreter that comes with ParaView
  - Paths are set automatically
- pvbatch
  - MPI pvpython
  - Made to run on supercomputer
  - Can not interact with it, must give it filename of a script to run
  - Can not change server (no TCP) it actually runs inside the server
- All: Start script with “>>> from paraview.simple import *”

WARNING! None have event loop -> No mouse, just good old command line

Using External Interpreter

- Mac/Linux

```
% set PVBUILD=/Builds/ParaView/devel/build
% export PATH=${PATH}:${PVBUILD}/bin
% export LD_LIBRARY_PATH=${LD_LIBRARY_PATH}:${PVBUILD}/bin
% export PYTHONPATH=${PVBUILD}/bin:
% export PYTHONPATH=${PYTHONPATH}:${PVBUILD}/Utilities/VTKPythonWrapping
```

- Windows

Start->Control Panel->Performance and Maintenance ->
System->Advanced->Environment Variables

Add new user variable	PVBUILD	C:\Builds\ParaView\devel\build
Add/Edit user variable	PATH	%PVBUILD%\Debug\bin
Add/Edit user variable	PYTHONPATH	%PVBUILD%\Debug\bin;
Edit user variable	PYTHONPATH	%PVBUILD%\Utilities\VTKPythonWrapping

Where to Start?

- build a pipeline by creating SourceProxies*
- Use properties to inspect and change the filters settings
- Properties are often assigned at instantiation

```
>>> myCone = Cone()
```

```
>>> print myCone.Center
>>> myCone.Center = [10,10,10]
```

```
>>> aDuplicateCone = Cone(Center=[10,10,10])
```

* SourceProxy – ParaView term for any reader, procedural generator, filter, or writer

Getting Help

- help(paraview.simple)
  lists all functions that paraview.simple gives you including all SourceProxies
- help(Cone)
  gives top level information about Cones (the class)
- help(myCone)
  gives more details (ex properties you can access) when you give it a particular Cone (the object)
- dir(myCone) compact and sometimes more complete alternative
- print(myCone) sometimes gives more details about member values

About Properties

- Properties are python-esque

```
>>> myCone.Center = [0,0,0]
>>> myCone.Center[0] = [1]
>>> myCone.Center[2:3] = [2,3]
```

- VTK and ParaView are lazily evaluated. You don't see results until you tell Pipeline to run

```
>>> myCone.Radius = 2.0
>>> Show(myCone)
>>> Render()
>>> myCone.Radius = 0.1
>>> #!? Why no change?
>>> Render()
```

Building a Pipeline

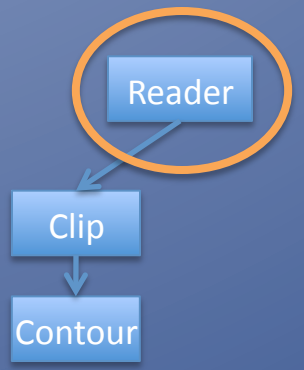
- Like in GUI, build on top of the "Active" source
- Set Properties as you go, like editing Property Tab in GUI's ObjectInspector

```
>>>aReader =
     XMLStructuredGridReader(
      FileName="multicomb_0.vts")

>>> aClip = Clip()
>>> aClip.ClipType.Normal =
     [0,-1,0]

>>> aContour = Contour()
>>> aContour.ContourBy =
     "Density"
>>> aContour.Isosurfaces = [0.5]
```

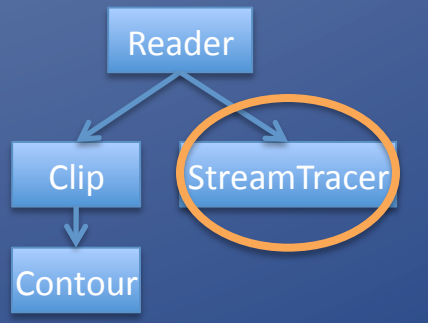
Building a Pipeline

- Branch by changing the active source, like choosing in GUI's PipelineBrowser

```
>>> SetActiveSource(aReader)
```

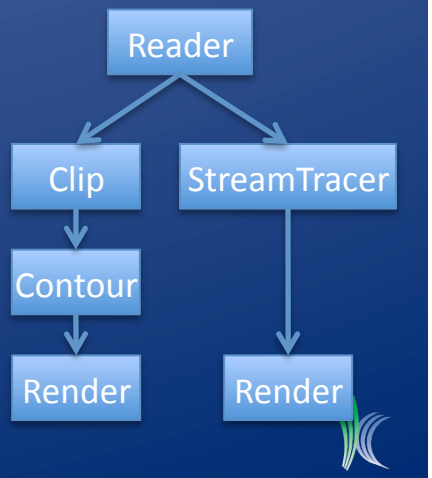



```
>>> aST = StreamTracer()
>>> aST.Vectors = "Momentum"
>>> aST.SeedType.Center = [3,2,28]
>>> aST.SeedType.Radius = 2
>>> aST.SeedType.NumberOfPoints
    = 100
```



- Unlike in GUI, displays are not automatically made or refreshed

```
>>> Show(aContour)
>>> Show(aStreamTracer)
>>> Render()
```



Navigating the Pipeline

- Don't have to use active source to branch, can assign at creation

```
>>> aST = StreamTracer(Input=aReader)
```

- Can change after the fact

```
>>> aST = StreamTracer()
>>> aST.Input = aReader
>>> aST.Input = aClip
```

- Can inspect ActiveSource

```
>>> aSource = GetActiveSource()
```

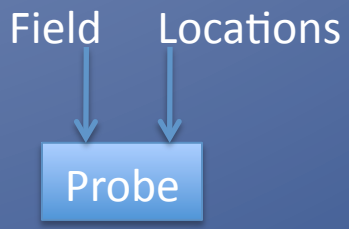
- Can get a hold of all or any particular SourceProxy

```
>>> GetSources()
>>> someSource = FindSource("Contour1")
```

Merging and Multiplicity

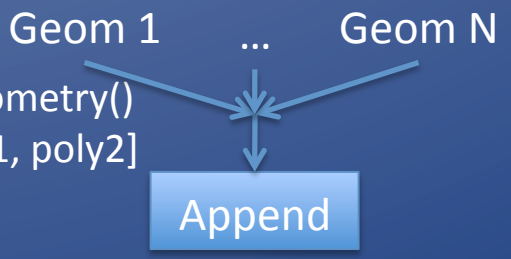
- Some SourceProxies require multiple inputs, usually named “Input” and “Source”, but not always

```
>>> probe = ProbeLocation()
>>> probe.Input = Mandebrot()
>>> probe.ProbeType = Sphere()
```



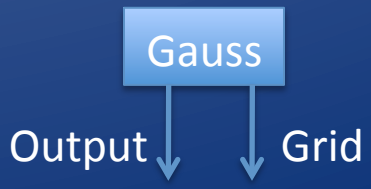
- Some SourceProxies have inputs that are repeatable, use array notation to assign them

```
>>> append = AppendGeometry()
>>> append.Input = [poly1, poly2]
```



- A few SourceProxies produce multiple outputs, use array notation to retrieve them

```
>>> reader =
    GaussianCubeReader(filename=“my.cube”)
>>> shrink=Shrink()
>>> shrink.Input=reader[1]
```



Displaying Results

- Can show output of any SourceProxy
- Parallel Flexible Display Pipeline complexity encapsulated by "Representations" in "Views"

  Representation – visual qualities of an output

  ≈ Mapper + Actor + parallel transport

  Show() returns a Representation

  View - Visual qualities of a window

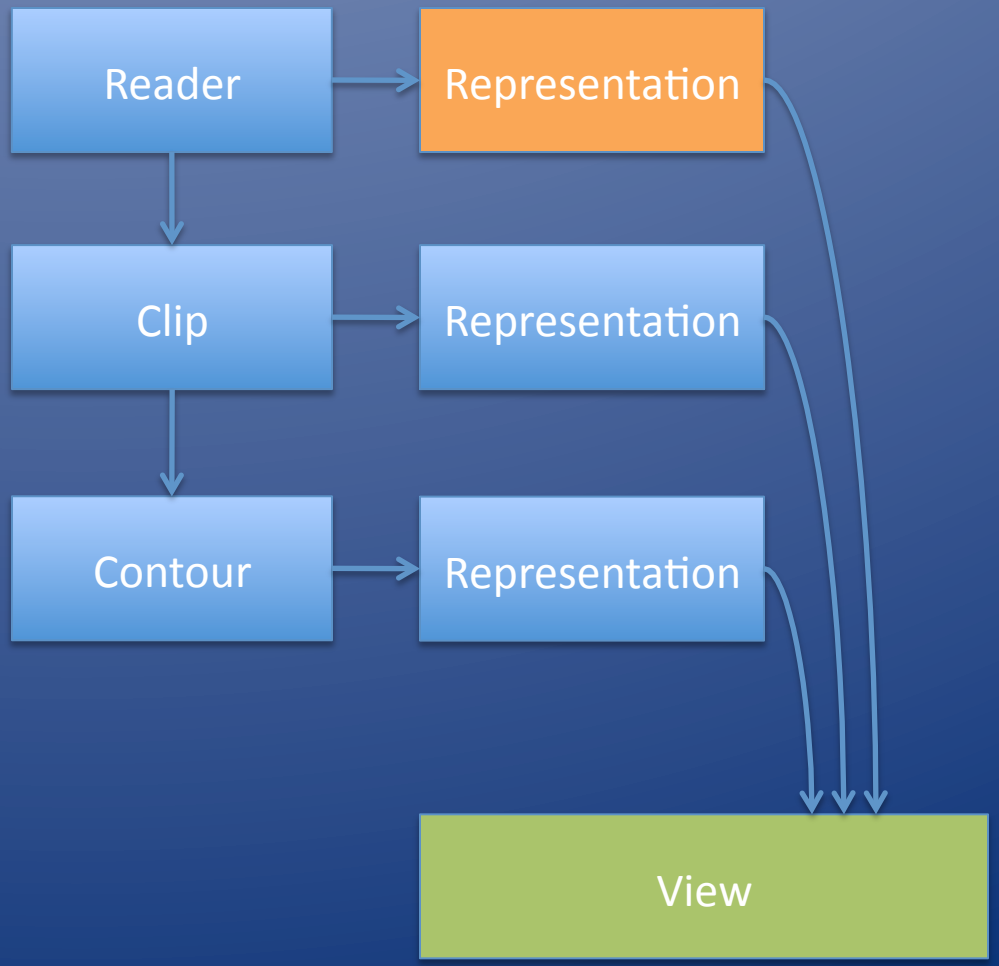
  ≈ Renderer + Camera + Lights + RenderWindow

  Render() returns a View

- To make it easier to build, commands default to working with the

  Active Representation

  Active View



Controlling Display

- Change Properties of View and Representation Proxies to affect display

```
>>> aView = GetActiveView()
>>> help(aView)
>>> aView.Background = [0.0,0.0,0.0]
```

- Don't forget lazy evaluation

```
>>> Render()
```

- Visibility is particularly important, since all pipeline stages can be shown

  Show() and Hide() shortcuts set Visibility property

```
>>> aRep = GetRepresentation()
>>> help(aRep)
>>> aRep.Visibility = 0
>>> aRep.Visibility = 1
```

Controlling Display

- Many methods take ActiveRepresentation and ActiveView as default arguments (very Python-esque)

```
>>> activeSourcesRep = GetDisplayProperties()
>>> clipFiltersRep = GetDisplayProperties(aClip)
>>> clipFiltersRepInMyView =
      GetDisplayProperties(aClip, myView)
```

- But can get hold of and then control any particular View and Representation

```
>>> GetRenderViews()
>>> view0 = GetRenderViews()[0]
>>> allReps = view0.Representations()
>>> rep0_0 = allReps[0]
```

Camera

- RenderViews (not PlotViews etc) have Cameras
- View has properties to manipulate them
- Camera is actually a local VTK object that you can control with standard python wrapped VTK commands

```
>>> view0.CameraPosition = [16,0,51]

>>> cam = view0.GetActiveCamera()
>>> #or usually
>>> cam = GetActiveCamera()

>>> cam.GetPosition()
>>> cam.SetPosition(-16,0,51)
>>> print(cam)
>>> Render()
```

Rendering Modes

- A Representation's *Representation** property controls rendering mode:

Bounding Box
Points
Wireframe
Polygons (surface)
Volume Render
etc

```
>>> aRep = Show(aClip)
>>> aRep.GetProperty("Representation").
        Available
>>> aRep.Representation = 'Outline'
>>> Render()
>>> aRep.Representation = 'Points'
>>> Render()
>>> aRep.Representation = 'Wireframe'
>>> Render()
>>> aRep.Representation = 'Surface With Edges'
>>> Render()
>>> aRep.Representation = 'Surface'
>>> Render()
```

* Yes it is confusing, so top level is often called "DisplayProperty" or "Display Pipeline"

ColorMapping

- Representations have LookupTables that assign colors to values
- MakeBlueToRedLT(min,max) is a convenient way to make one

```
>>> aRep.ColorArrayName = 'Density'
>>> aRep.LookupTable=
    MakeBlueToRedLT(0,1)
>>> Render()
```

- You can design your own if you need to:
  - Pick an array to color with
  - Pick the value ranges
  - Pick the colors

```
>>> aRep.ColorAttributeType='POINT_DATA'
>>> aRep.ColorArrayName="Density"
>>> lut =
    servermanager.rendering.PVLookupTable()
>>> aRep.LookupTable = lut
>>> #                    value,      R,G,B
>>> lut.RGBPoints = [  0.0,        0, 0, 1,
                       0.1,        0.5,0,0.5
                       1.0,        1, 0, 0]
```

Getting information

- ParaView has a client server architecture, and is lazily evaluated (designed for large data)
- You have to ask ParaView politely if you want results back from server (other than display)

- Three ways ways to get quantitative results back
  - Information properties
  - DataInformation
  - Fetch

Information Properties

- Properties
  Most VTK methods on server set parameters
    SetFileName(), SetContours()

```
>>> aReader.FileName = “multicomb_0.vts”
>>> print aReader.FileName
foo.ex2
>>> #does not ask server, just remembers
>>> #what we set
```

- Information Properties
  Some VTK methods return simple results
    GetFileName(), GetNumberOfPoints()

```
>>> aReader.UpdatePropertyInformation()
>>> print aReader.TimestepValues
```

  Information Properties let the client read these results

```
>>> aST2 = StreamTracer(Input=aReader)
>>> aST2.UpdatePipeline()
>>> aST2.UpdatePropertyInformation()
>>> aST2.GetProperty(“NumberOfPoints”)
```

Data Information

- Data Information
  - What GUI shows in Pipeline Browser's Information Tab
  - What GUI uses to assign filter default settings
  - Meta-Information about output of a SourceProxy

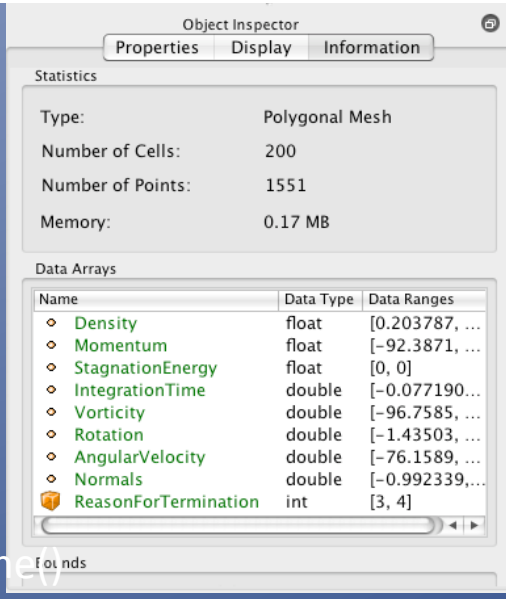
    CLASSNAME,

    MEMORYSIZE,

    EXTENT,

    NUMCELLS, NUMPOINTS,

    ARRAYS, ARRAY NAMES, ARRAY RANGES
  - Can't get individual values out




```
>>> aReader.UpdatePipeline()
>>> aReader.UpdatePipelineInformation()
>>> dInfo = aReader.GetDataInformation()
>>> dInfo.GetDataClassName()
>>> pdInfo = dInfo.GetPointDataArrayInformation()
>>> pdInfo.GetNumberOfArrays()
>>> ai0 = pdinfo,GetArrayInformation(0)
>>> ai0.GetName()
>>> ai0.GetNumberOfComponents()
>>> ai0.GetComponentRange(0)
>>> ai0.GetNumberOfTuples()
```

Fetch

- Copies entire DataSet from server to Client
- Once local, you can manipulate the data with python Wrapped VTK API and access individual data values

```
>>> output = servermanager.Fetch(aClip)
>>> print(output)
```

- Since data is large, don't often want whole data set on client

```
>>> processor1sOutput =
    servermanager.Fetch(aClip,1)
```

- Can also do some simple aggregation of attribute values
  Just specify an aggregator function to apply on the way

```
>>> mm = MinMax()
>>> mm.Operation = "MIN"
>>> minResult = servermanager.Fetch(elev, mm, mm)
>>> a0 = minResult.GetPointData().GetArray(1)
>>> a0.GetName()
>>> a0.GetValue(0)
```

Now that you know…

- Choosing a server

  Disconnect from one server (destroying pipeline there) and connect to another.

  >>> Connect(host, portnum)

  >>> Help(Connect)

- Writers

  Save output of any SourceProxy on server's file system

  >>> writer =XMLUnstructuredGridWriter()

  >>> writer.FileName = "foo.pvtk"

  >>> writer.Input = aClip

  >>> writer.UpdatePipeline()

Features I'm skipping

- Screen Shots

  >>> WriteImage(filename, view==ActiveView, Magnification==0.0)
- Animation

  Create key frames in tracks and automatically animate through them. Like GUI's Animation View

  >>> scene = servermanager.animation.AnimationScene()

  >>> track1 = servermanager.animation.KeyFrameAnimationCue()

  >>> keyframe1 = servermanager.animation.CompositeKeyFrame()

  >>> track1.KeyFrames = [keyframe1, keyframe2]

  >>> scene.Cues = [track1]
- Movies

  Save as series of screenshots or into a movie file*

  >>> AnimateReader(reader, view, "myMovie.png")

*Assuming your ParaView has a codec, otherwise limited to numbered screenshots

Even More Features

- State

  Save state in GUI, load it in python (and vice-versa)

  >>> servermanager.LoadState("myteststate.pvsm")

  >>> SetActiveView(GetRenderView())

  >>> Render()

- Python Programmable Filter

  A white box filter

  Arbitrary scripted parallel processing

  Numerous examples on wiki

Python Programmable Filter

runs inside a filter's RequestData() on server
python wrapped VTK API

Get hold of input and output DataSet(s)
examine geometry, topology and attributes
Do some arbitrary calculation

```
inDS = self.GetInput()
outDS = self.GetOutput()
inPtData = inDS.GetPointData()
outPtData = outDS.GetPointData()
outPtData.ShallowCopy(inPtData)
```

```
inPTArray = inPointData.GetArray("Name")
array = vtk.vtkDoubleArray()
array.SetName("Another Name")
outPtData.AddArray(array)
```

```
>>> pfilter = ProgrammableFilter()
>>> pfilter.Script = """
pdi = self.GetPolyDataInput()
pdo =  self.GetPolyDataOutput()
newPoints = vtk.vtkPoints()
numPoints = pdi.GetNumberOfPoints()
for i in range(0, numPoints):
   coord = pdi.GetPoint(i)
   x, y, z = coord[:3]
   x = x * 1
   y = y * 1
   z = 1 + z*0.3
   newPoints.InsertPoint(i, x, y, z)
pdo.SetPoints(newPoints)
"""
```

Getting More Help

- **Wiki Page**
  - http://www.paraview.org/Wiki/ParaView
- **Source Code Documentation**
  - http://www.paraview.org/ParaQ/Doc/Nightly/html/annotated.html
- **Mailing List**
  - Sign up-> http://public.kitware.com/mailman/listinfo/paraview
  - Search ->http://markmail.org/search/?q=list:paraview
- **Bug Tracker**
  - http://www.paraview.org/Bug/my_view_page.php
  - Project:-> ParaView3