VisMashup: Streamlining the Creation of Custom Visualization Applications*

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University of Utah

joint work with
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James Ahrens - *Los Alamos National Lab*

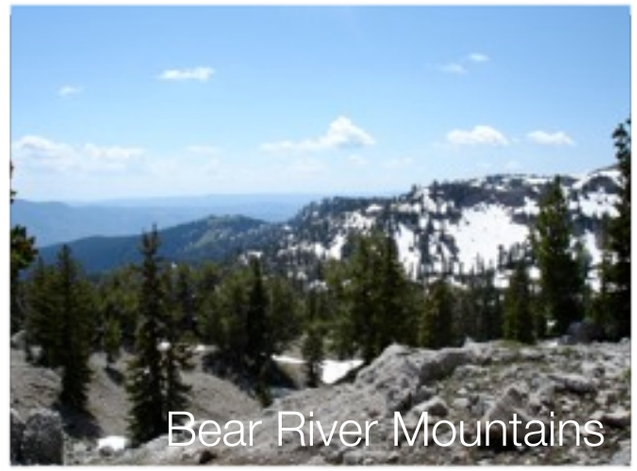
* *Paper submitted to IEEE Vis 2009*

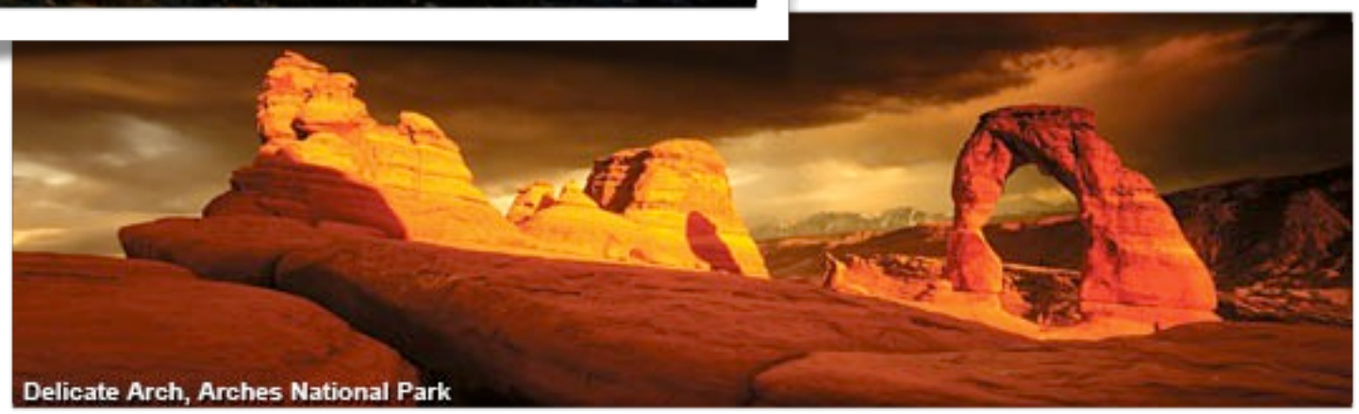
Agenda

- A bit about Utah
- Introduction
- Model
- The VisMashup System
- Case Study: Sharing Astrophysics Analyses
- Limitations
- Conclusions and Future Work

Utah

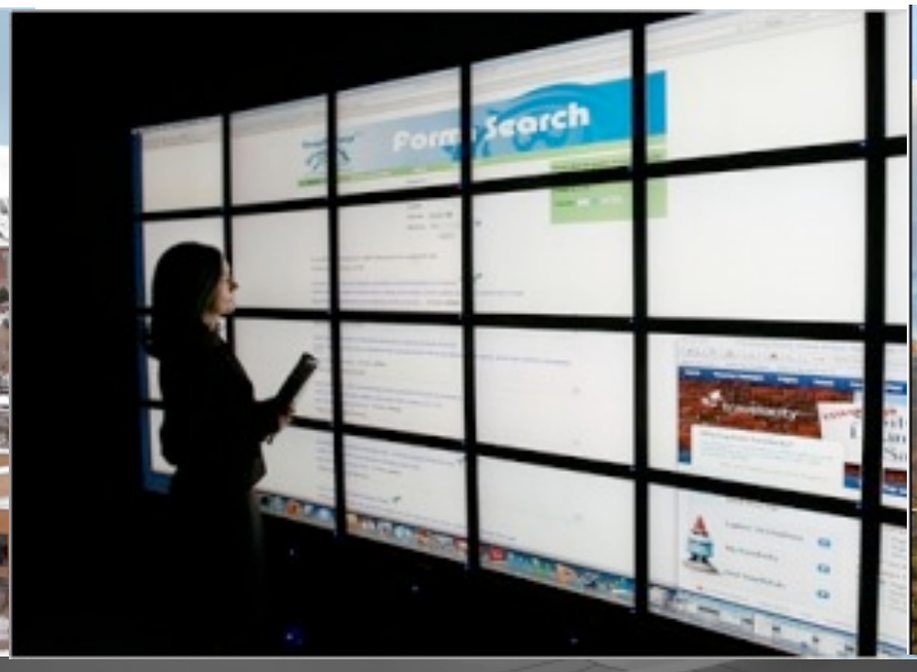
“The Greatest Snow on Earth”

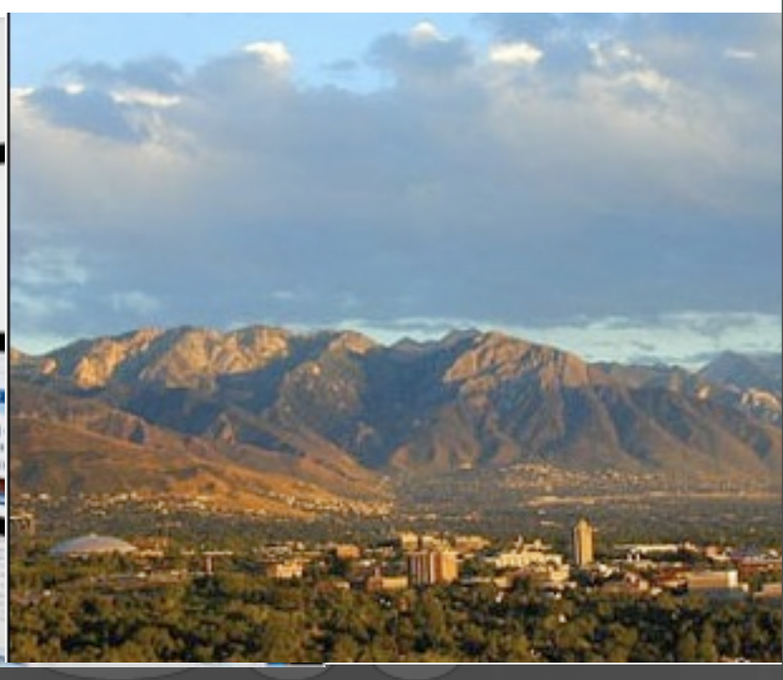




University of Utah

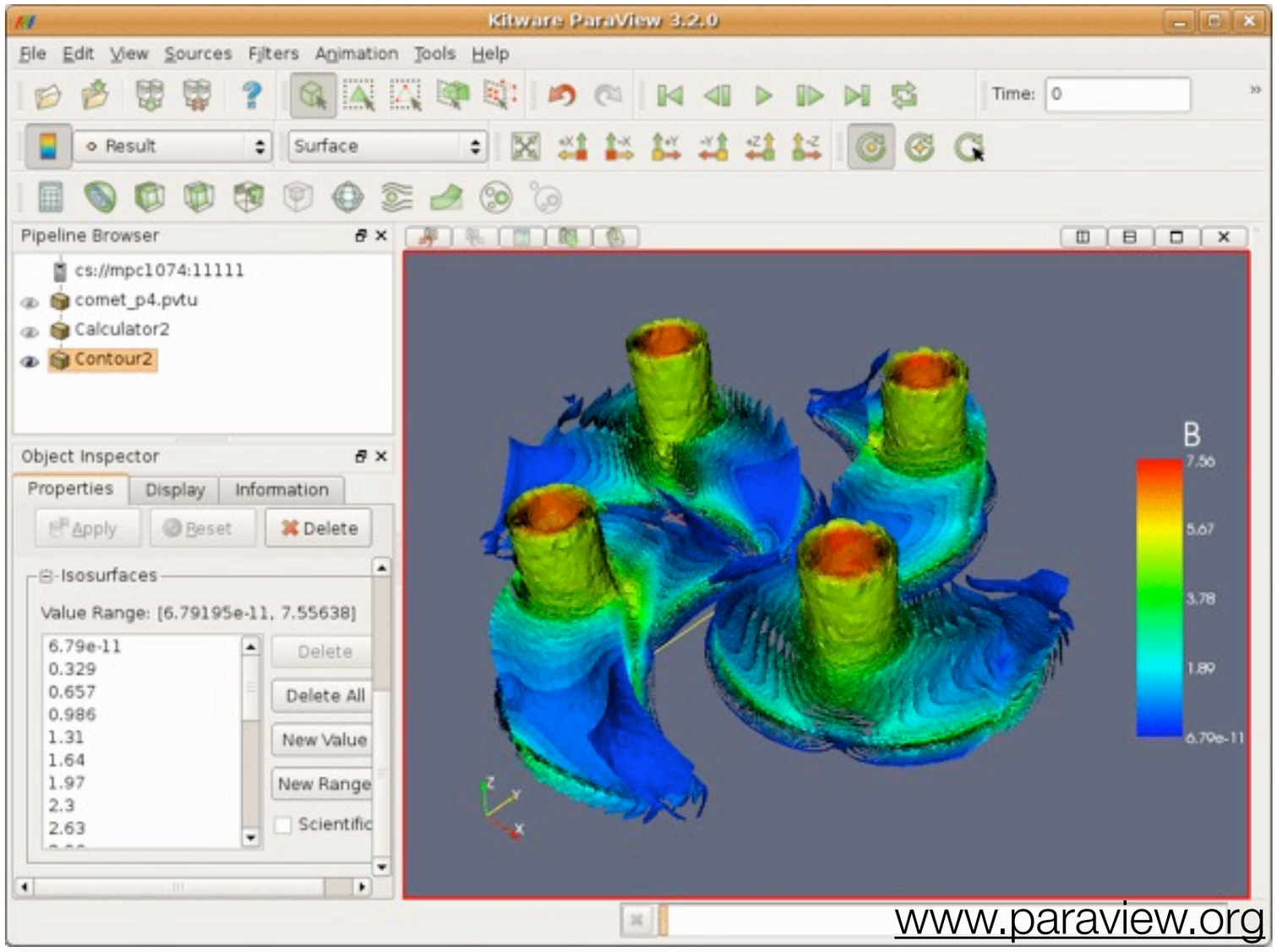
- Scientific Computing and Imaging (SCI) Institute
  - 15 faculty members and more than 100 students and post docs
- VGC Group: 3 post docs, 9 grads and 2 undergrads





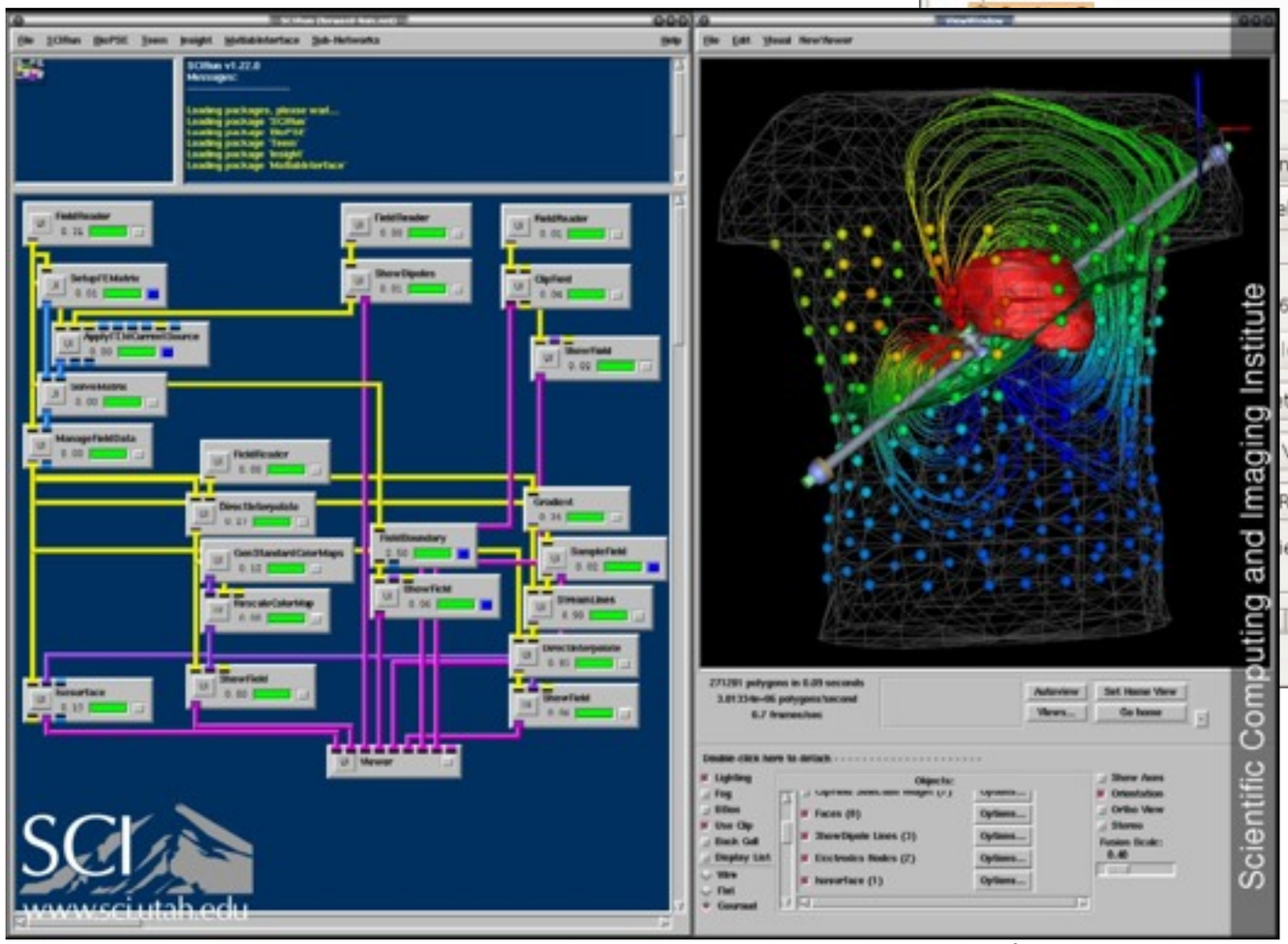
Introduction

Visualization tools

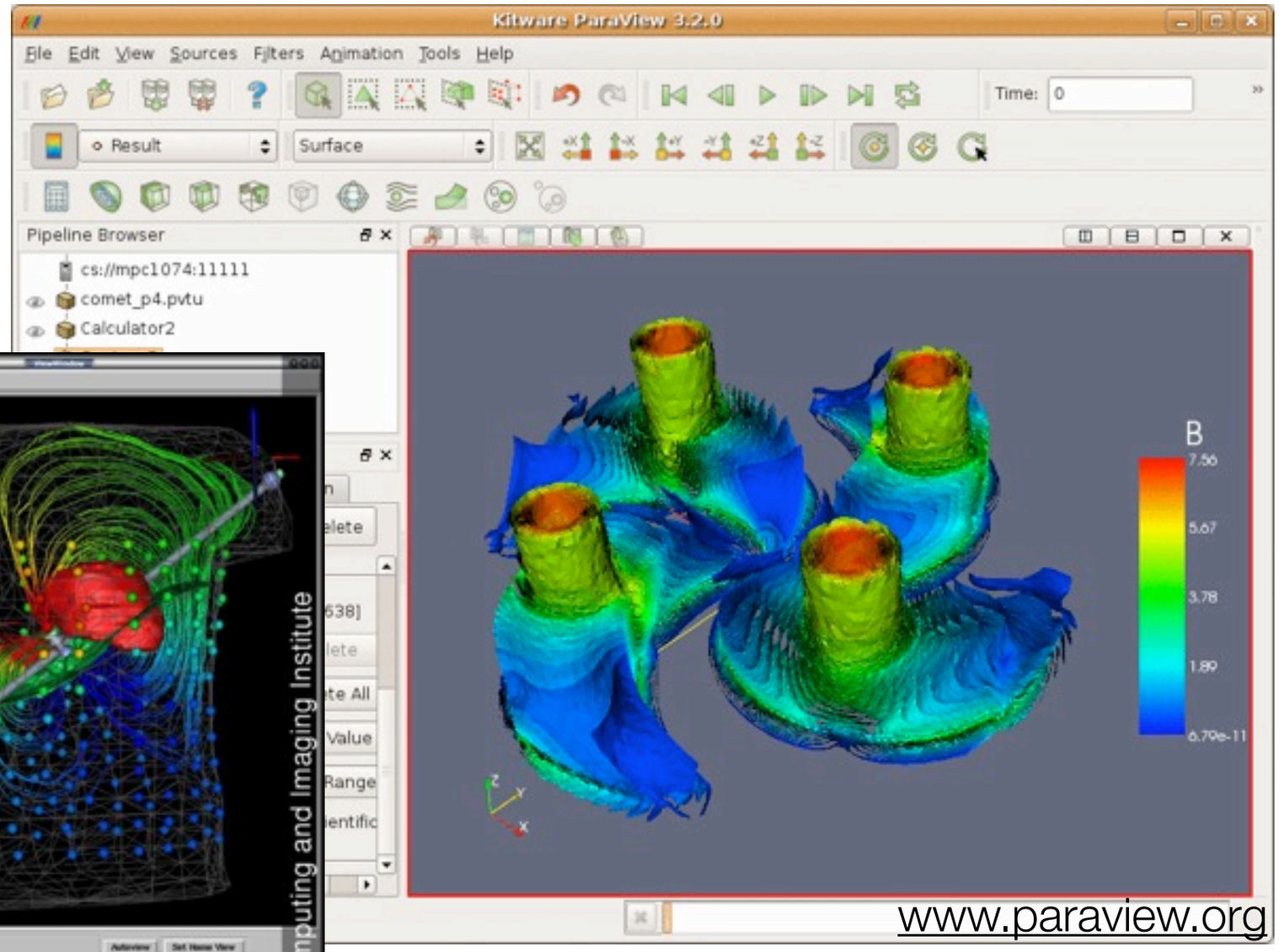


Data exploration through visualization is an effective means to understand and obtain insights from large collections of data

Visualization tools



software.sci.utah.edu/scirun.html



www.paraview.org

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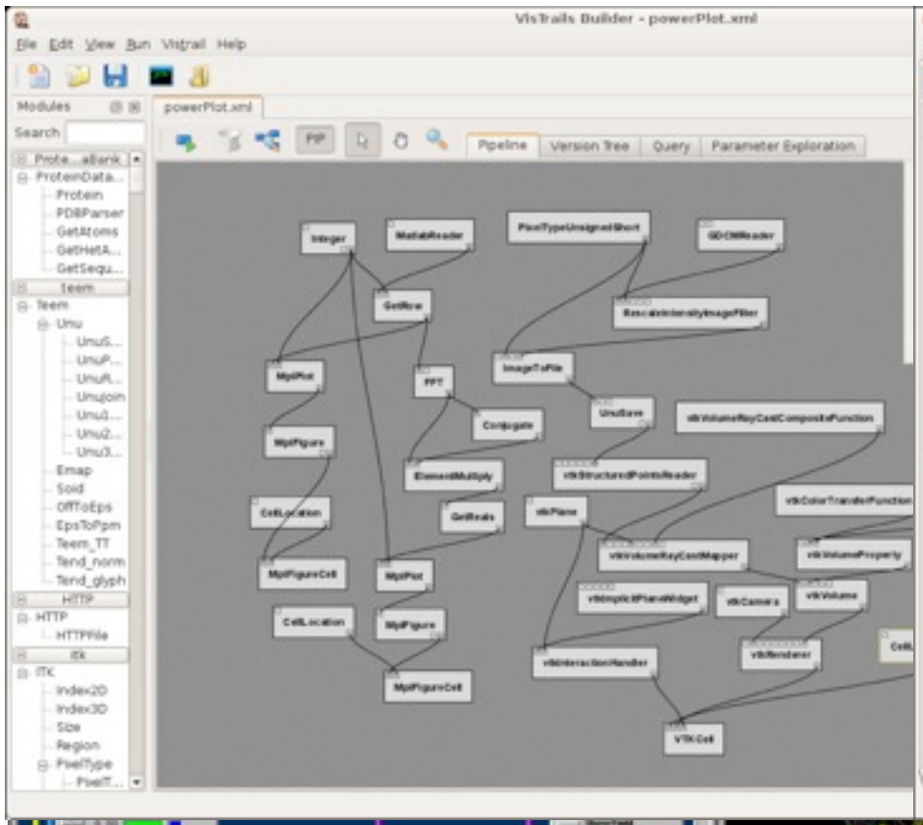
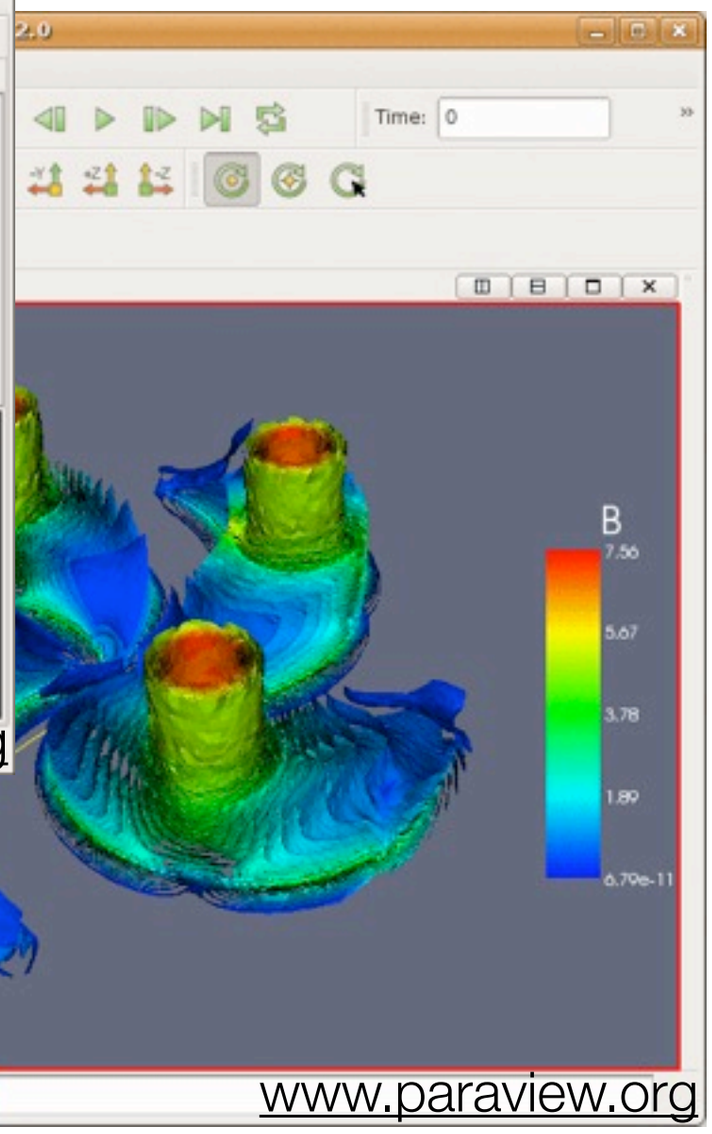
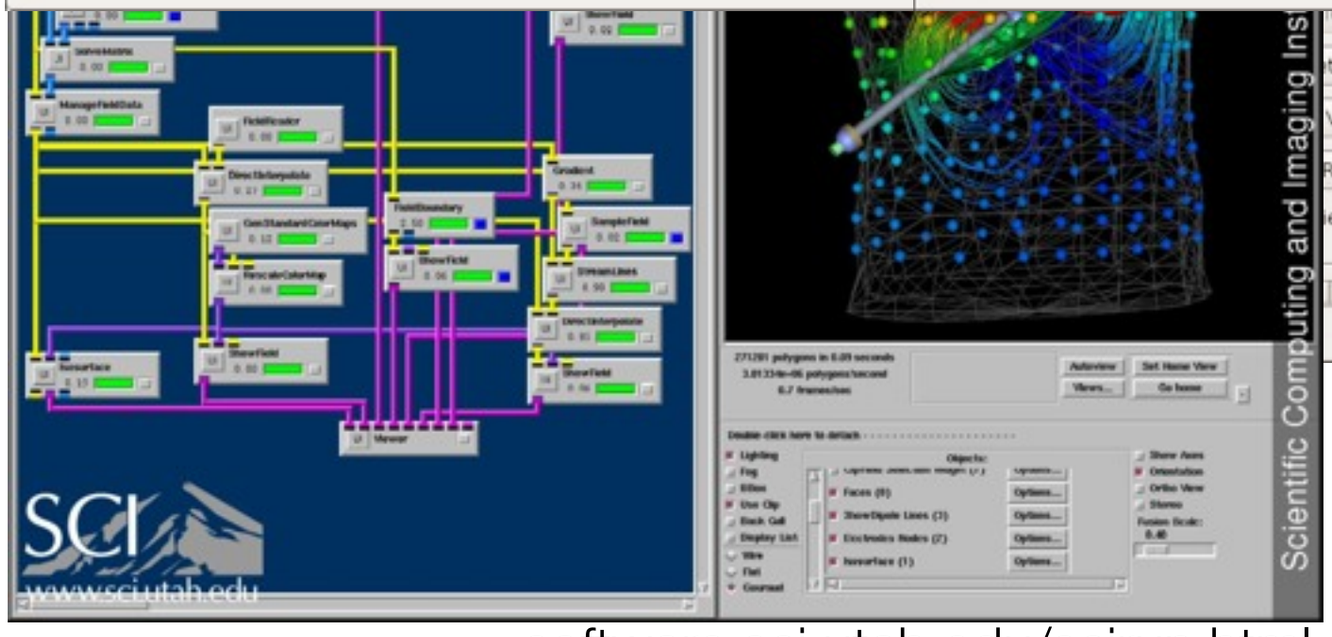
Visualization tools



www.vistrails.org



www.paraview.org



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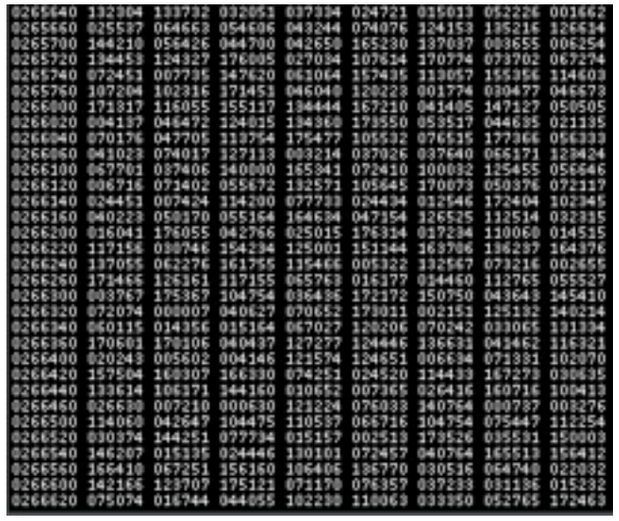
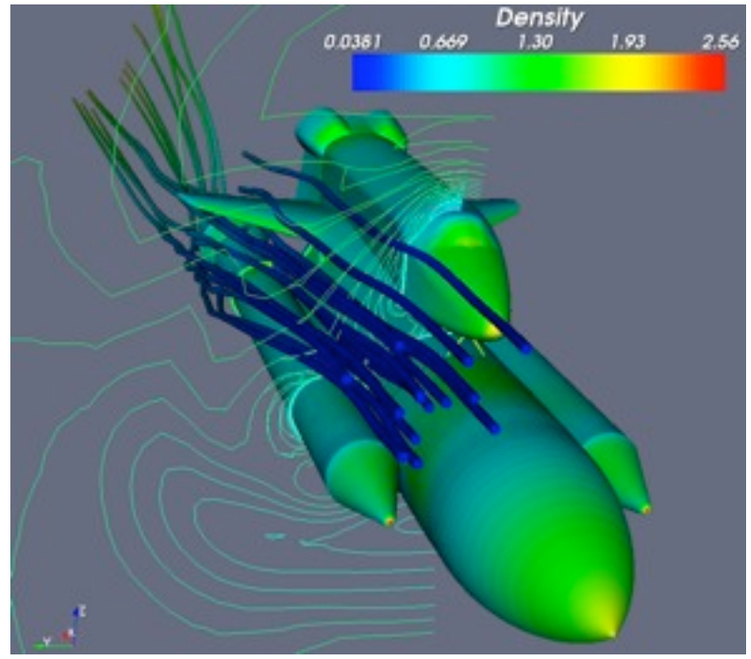
Data exploration through visualization is an effective means to understand and obtain insights from large collections of data

Creating visualizations

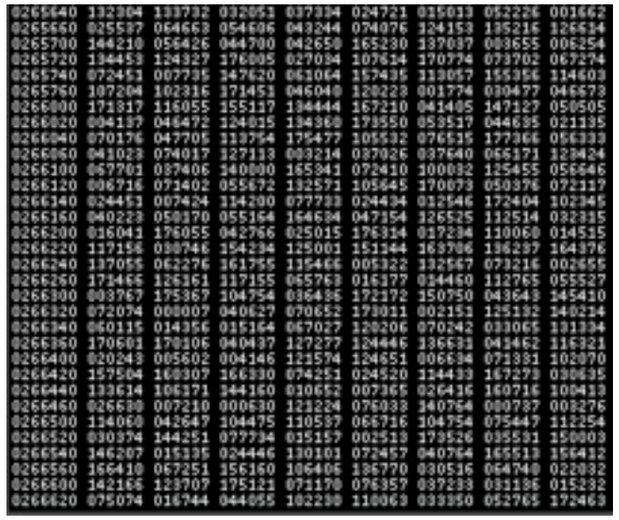


Raw Data

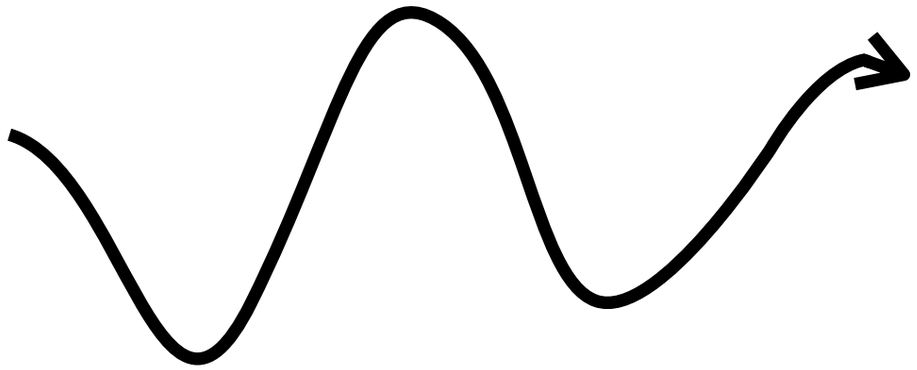


Insightful Visualization

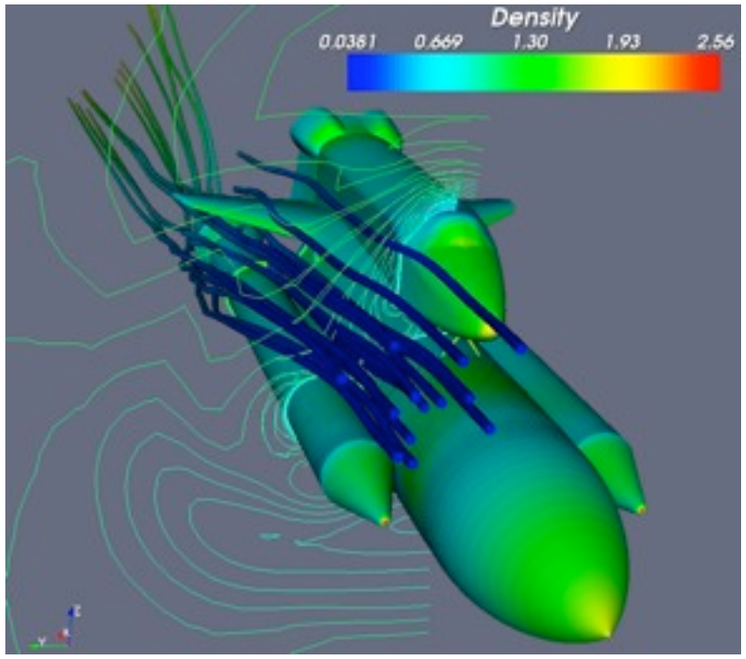
Creating visualizations



laborious



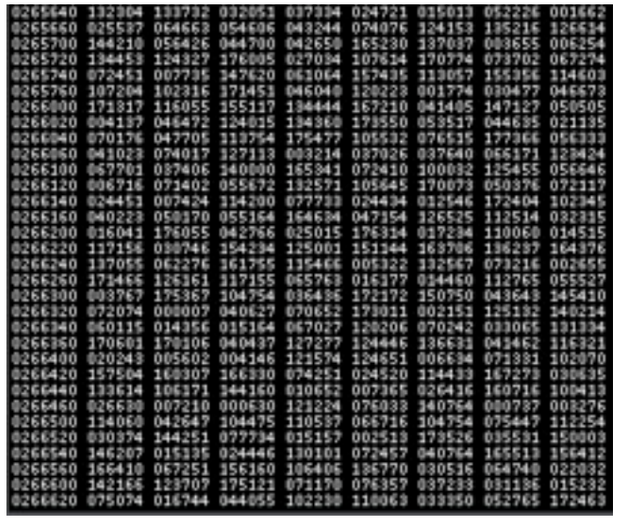
error-prone



Raw Data

Insightful Visualization

Creating visualizations



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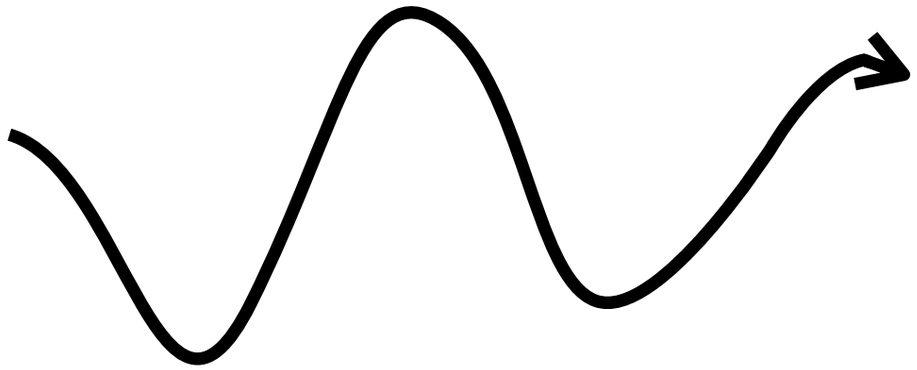

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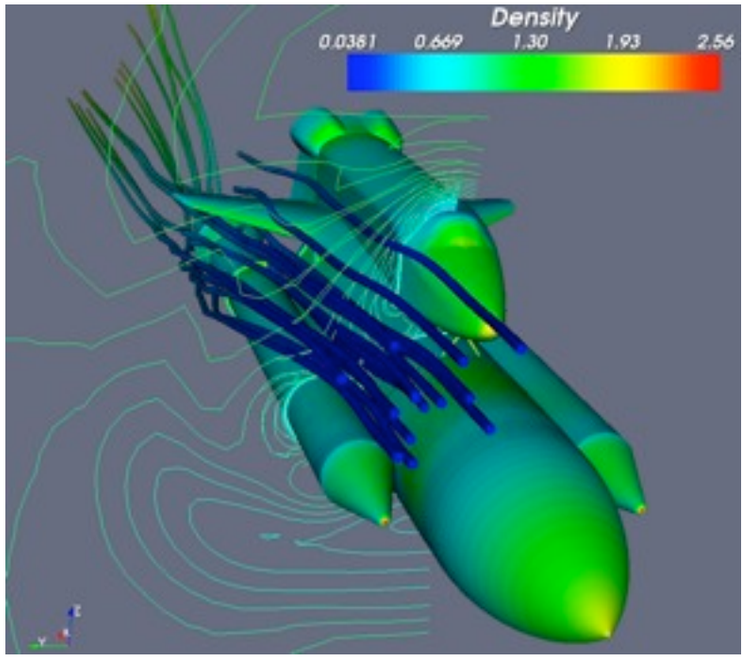


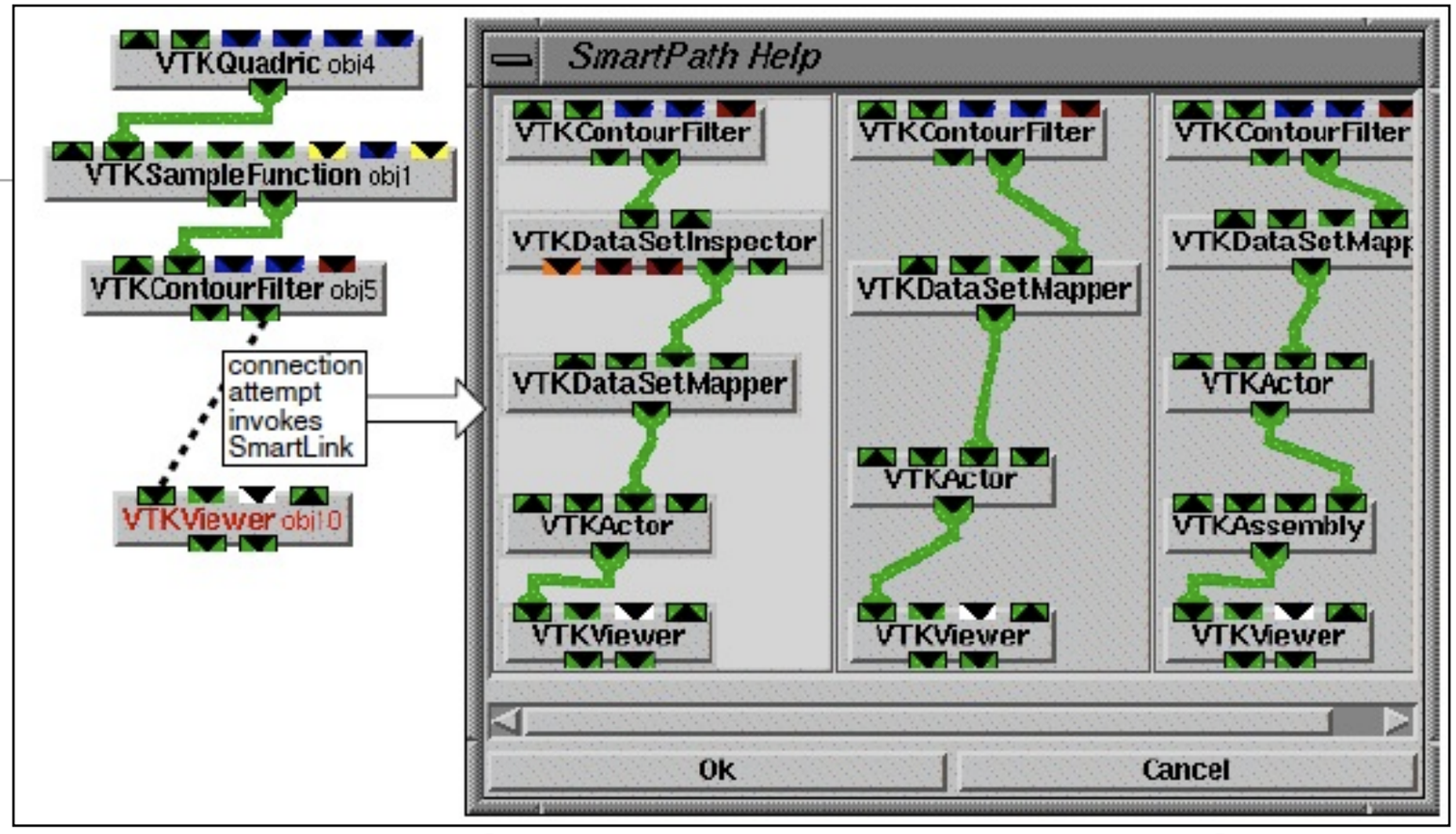
Raw Data

Insightful Visualization

The generation of visualizations is still best carried out by experts!

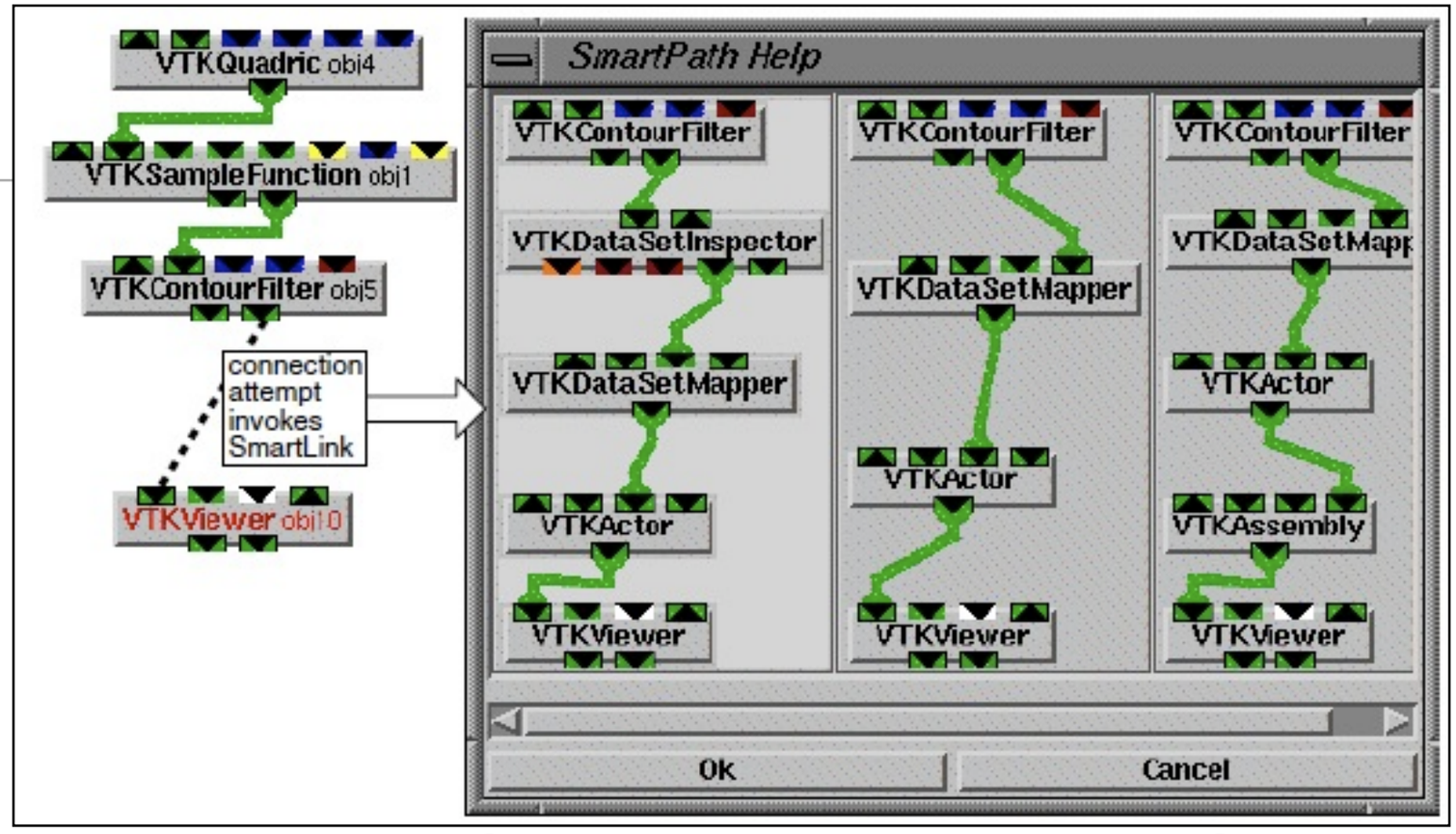
Helping to create visualizations

Helping to create visualizations



SmartLink: Telea & van Wijk, VisSym 1999

Helping to create visualizations



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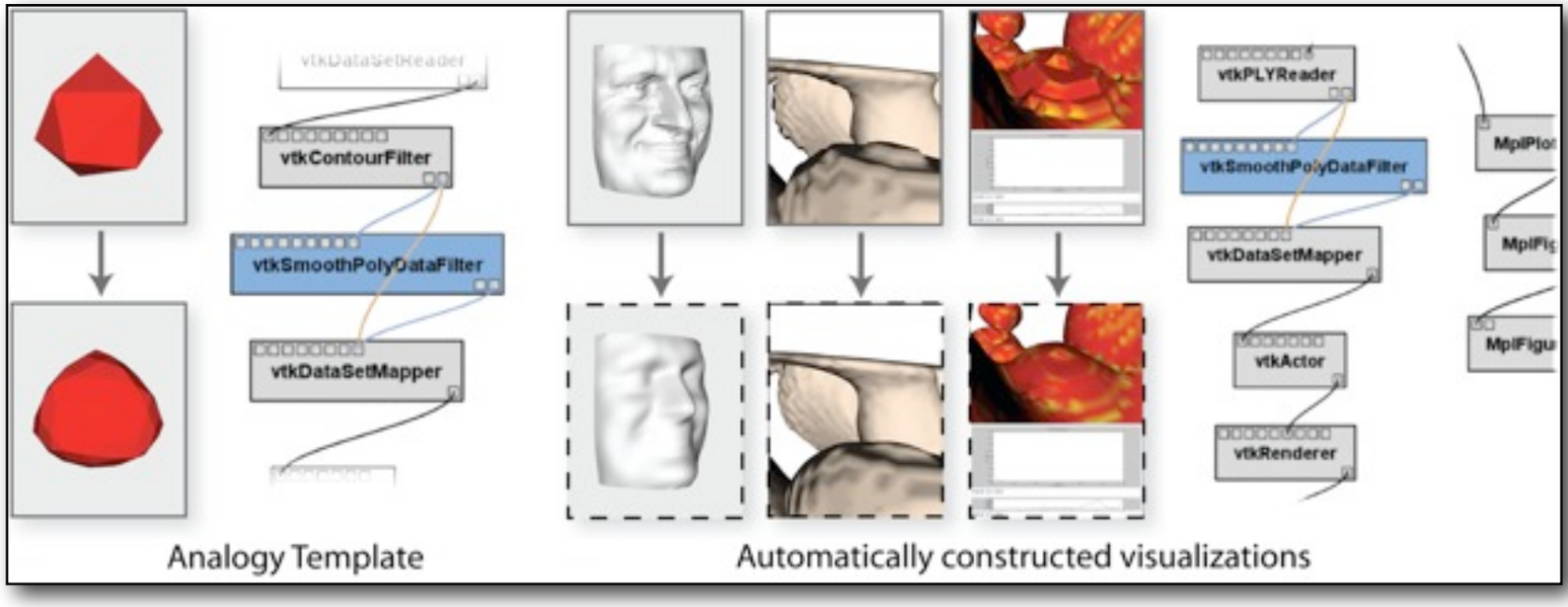
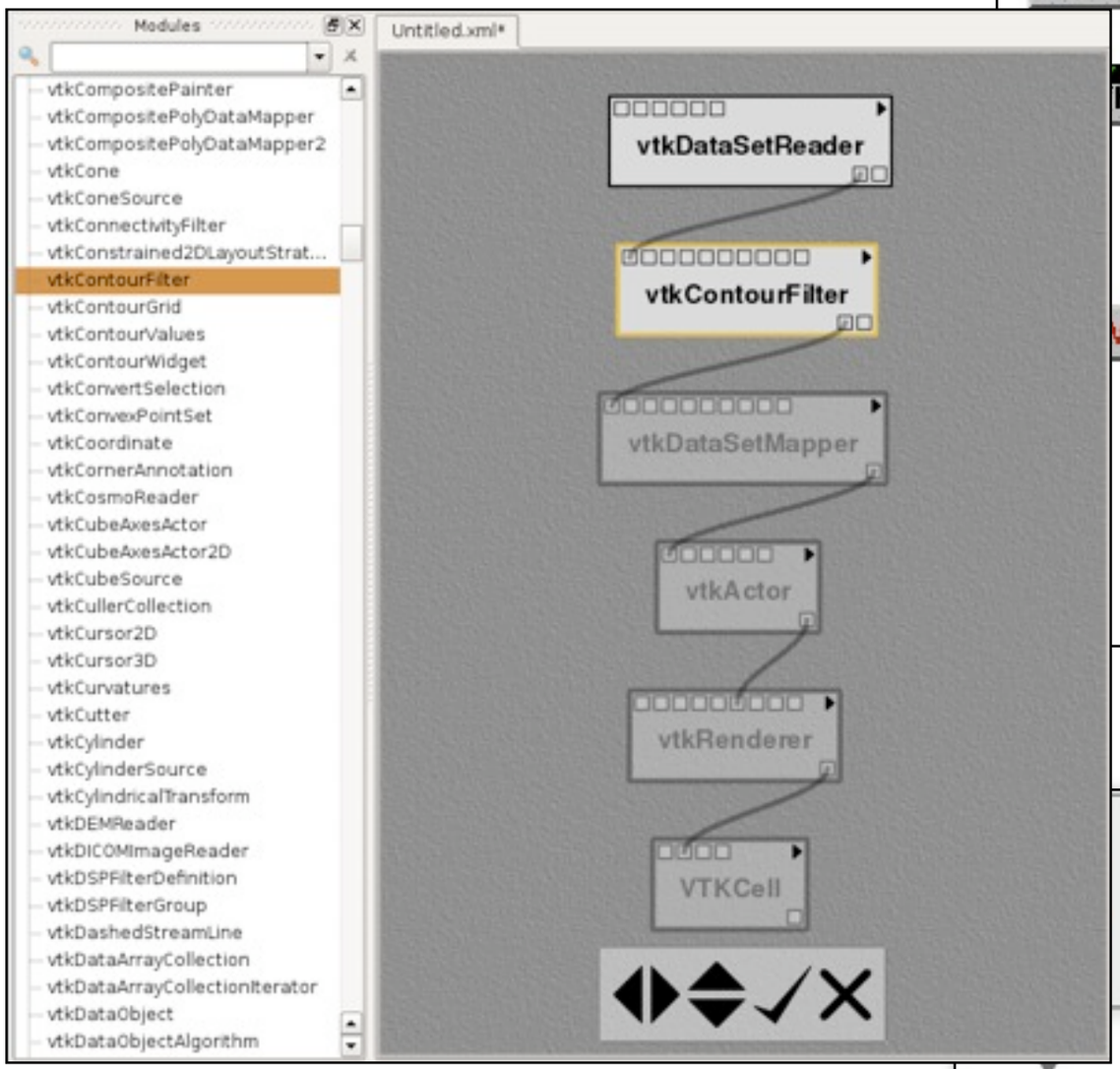
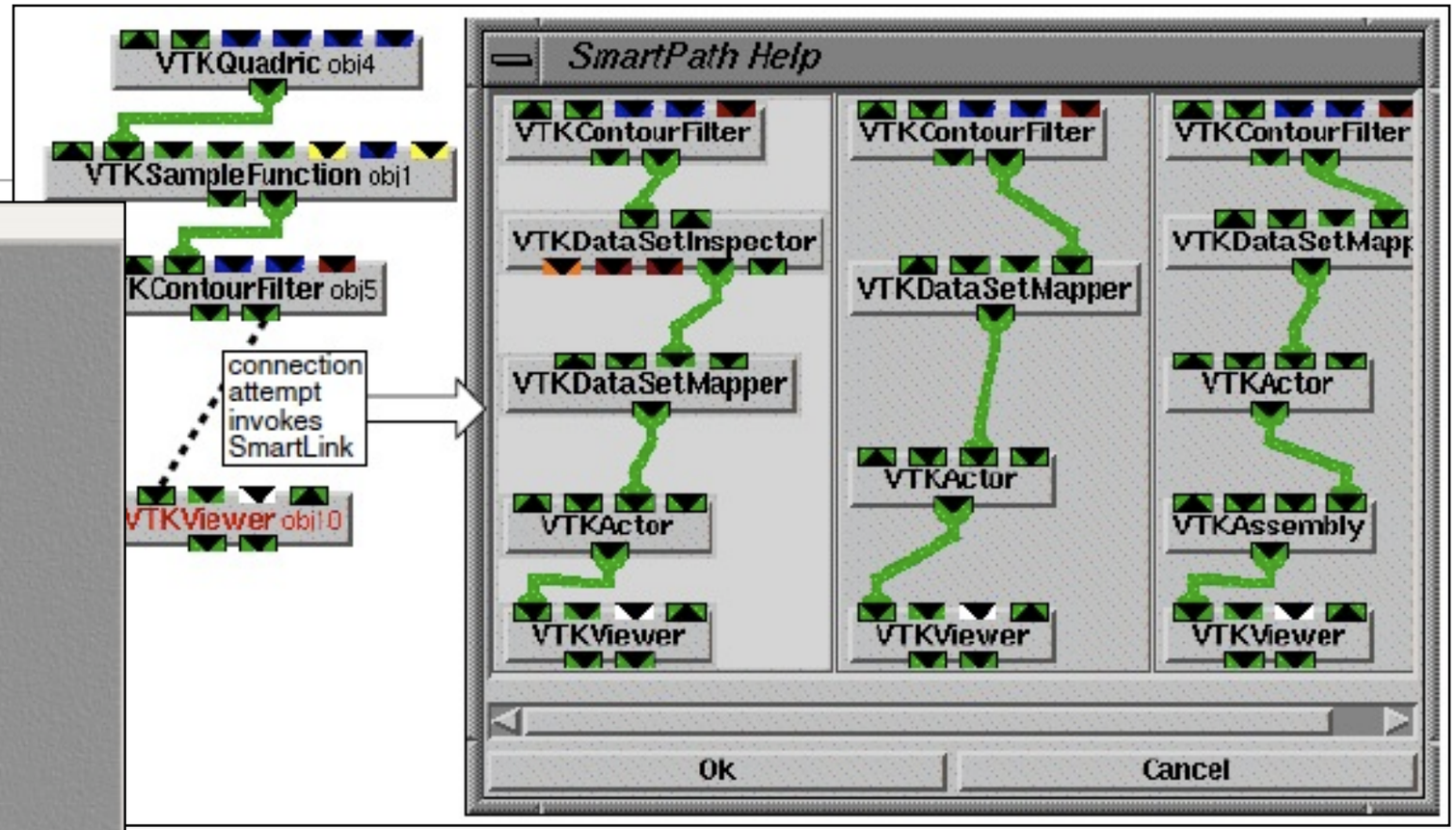


Vis by Analogy: Scheidegger et al., Vis 2007

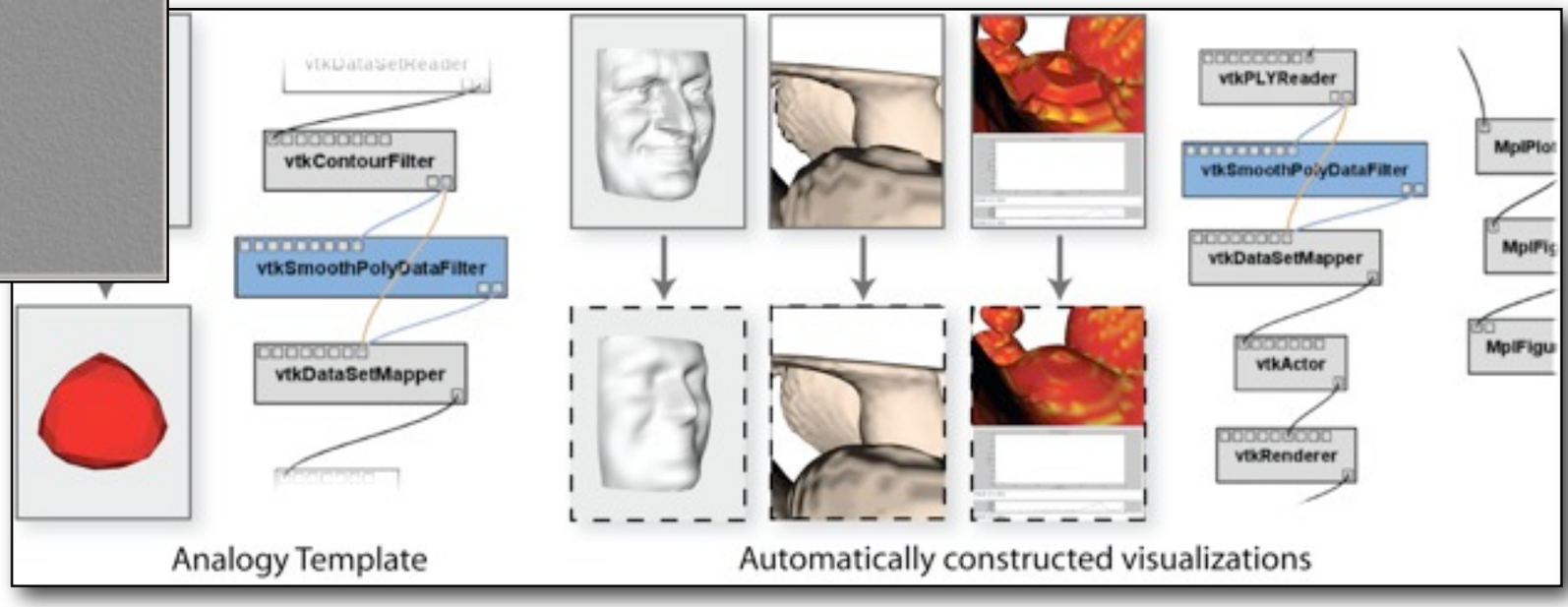
Helping to create visualizations



VisComplete: Koop et al., Vis 2008

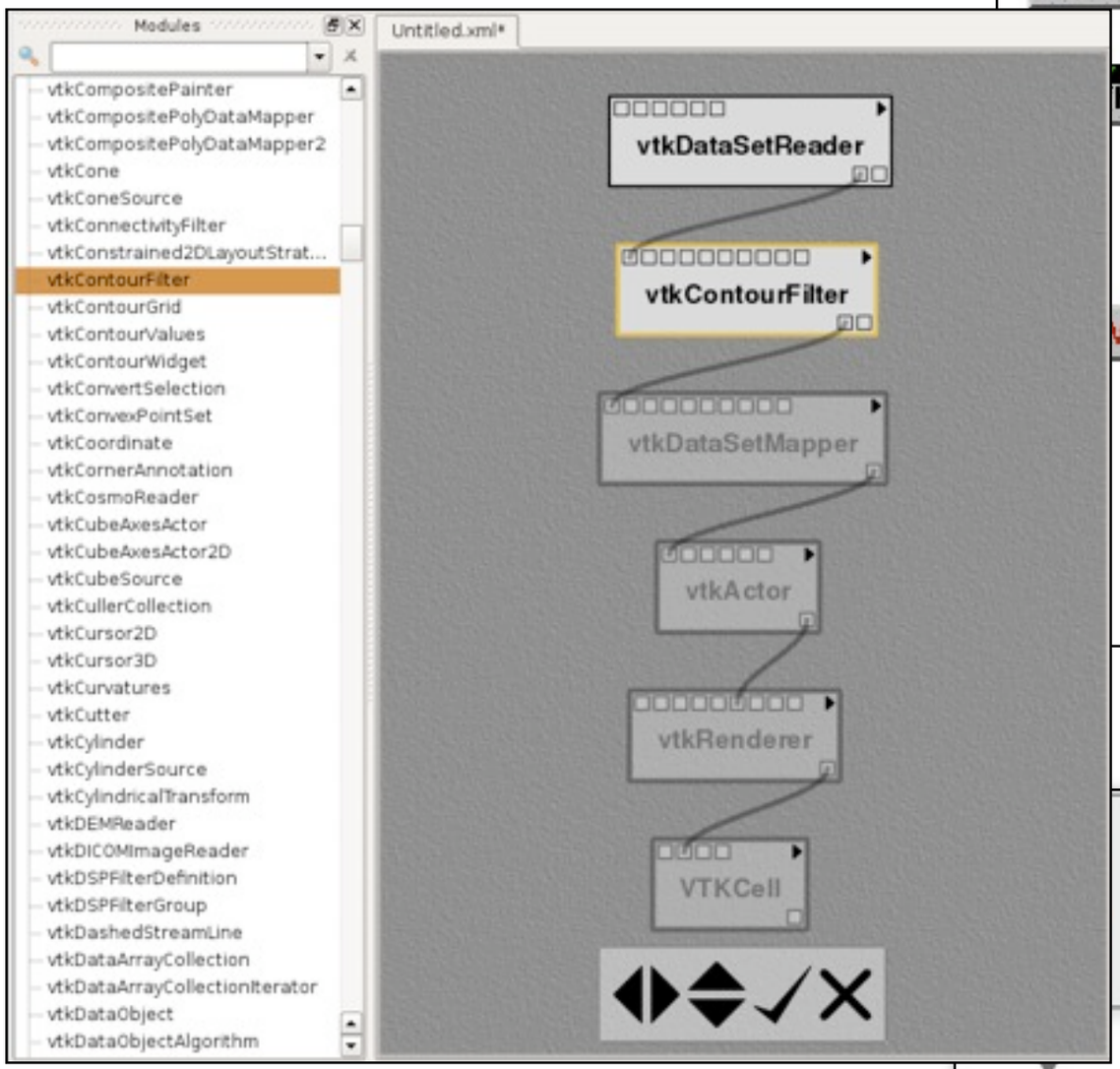


SmartLink: Telea & van Wijk, VisSym 1999



Vis by Analogy: Scheidegger et al., Vis 2007

Helping to create visualizations



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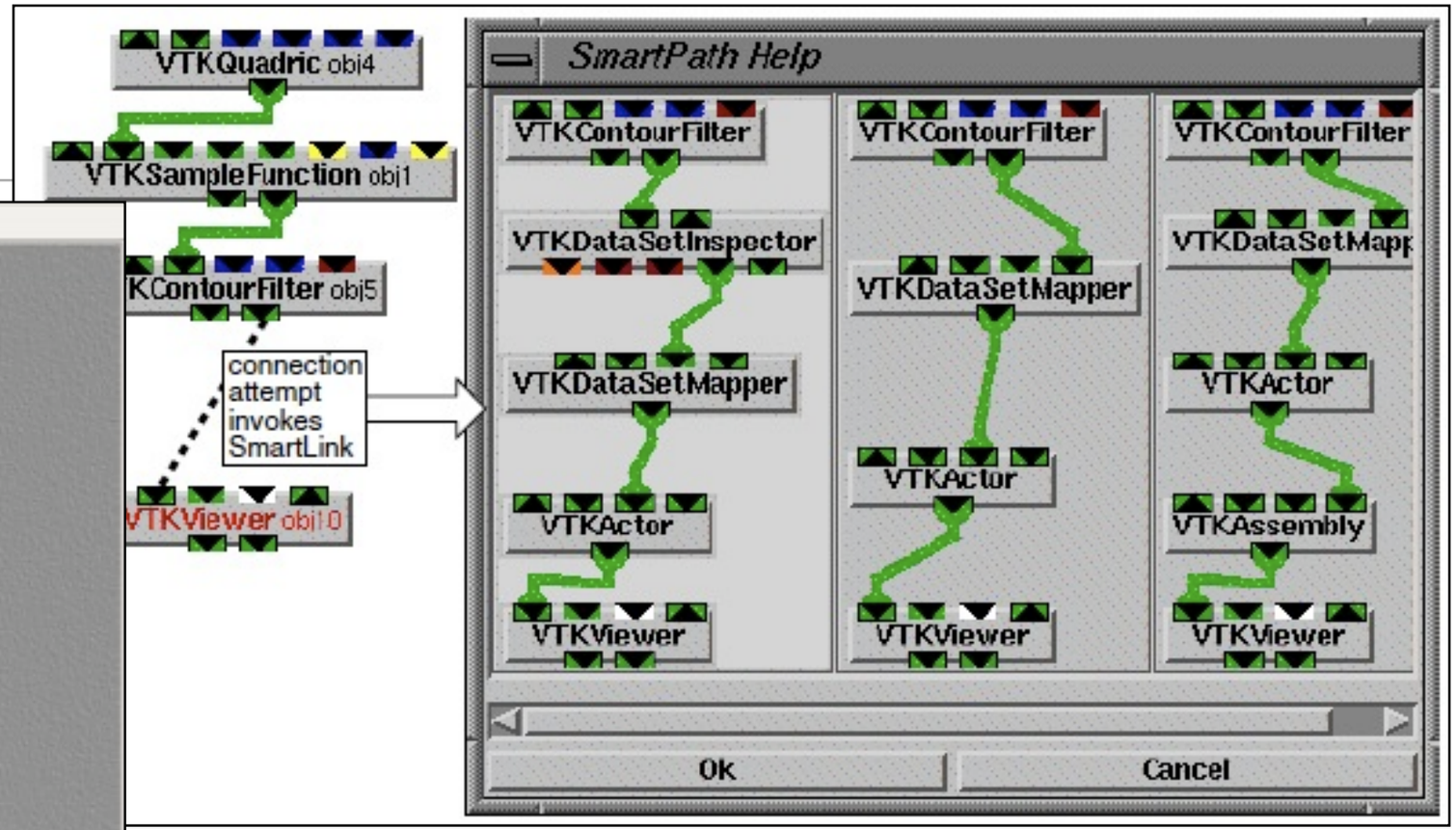
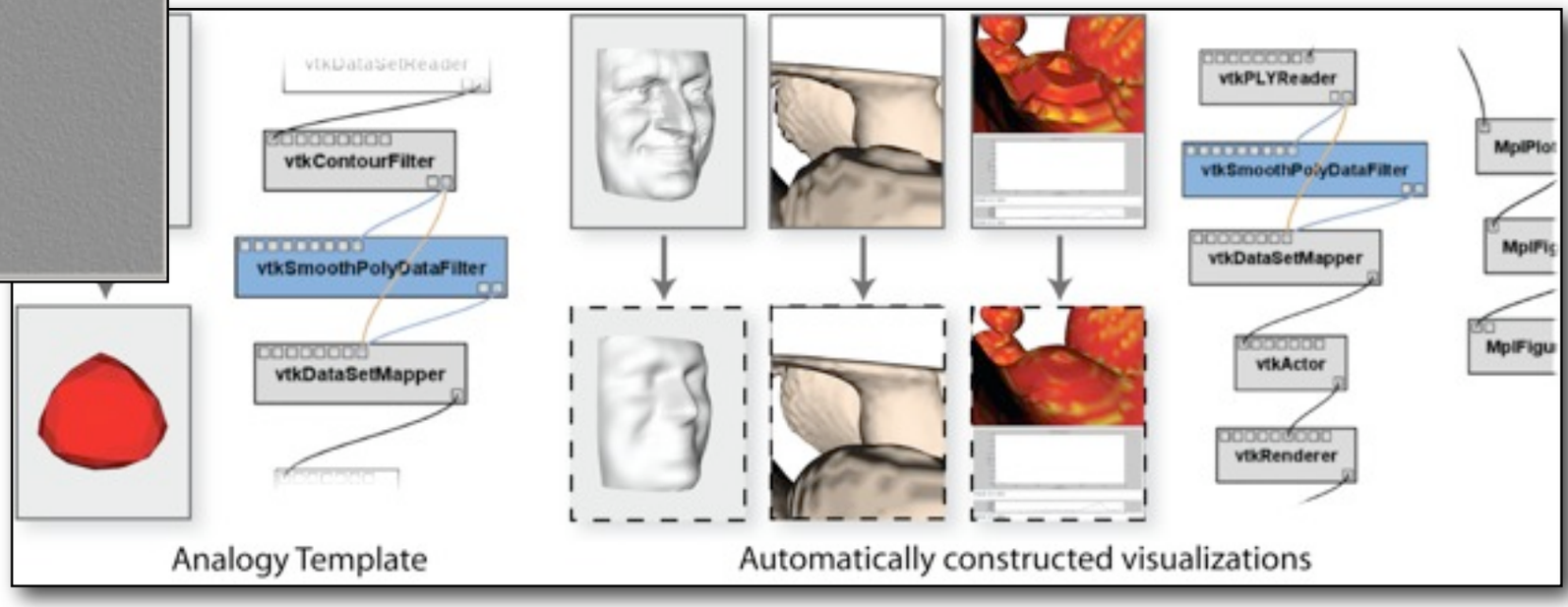


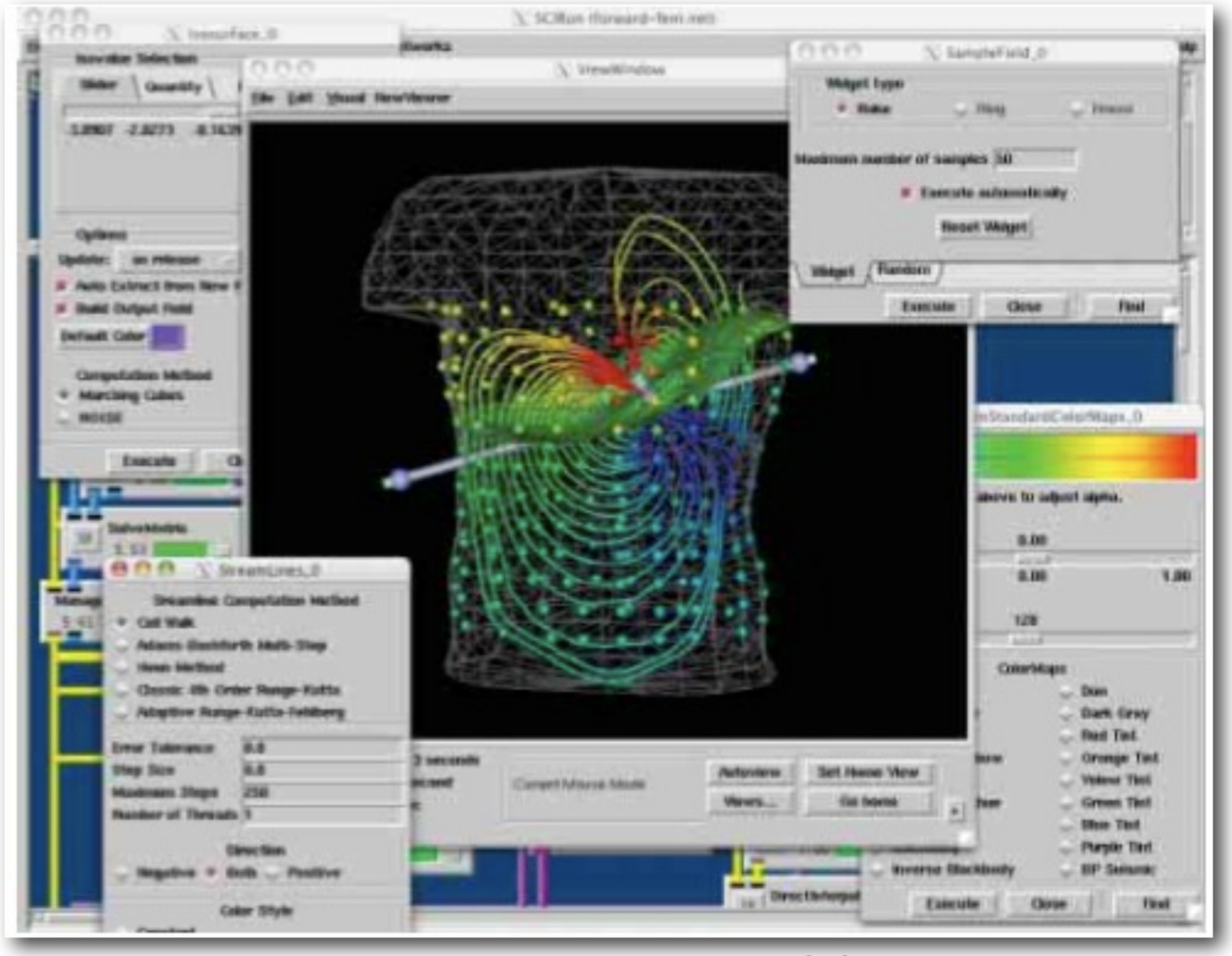
SmartLink: Telea & van Wijk, VisSym 1999

Detailed knowledge of the underlying computational components is still necessary

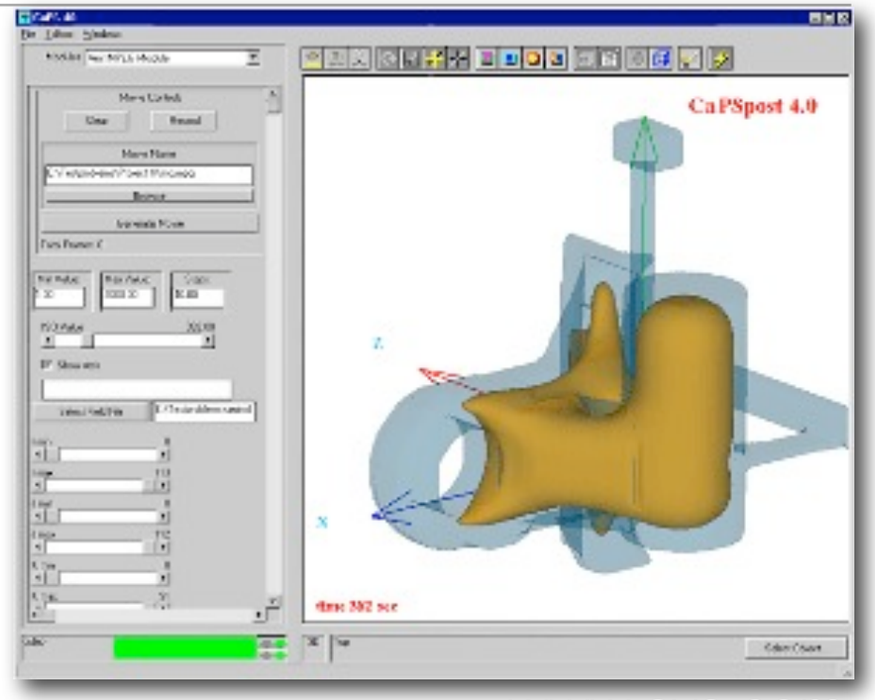


Vis by Analogy: Scheidegger et al., Vis 2007

Helping to create visualizations: Custom Applications

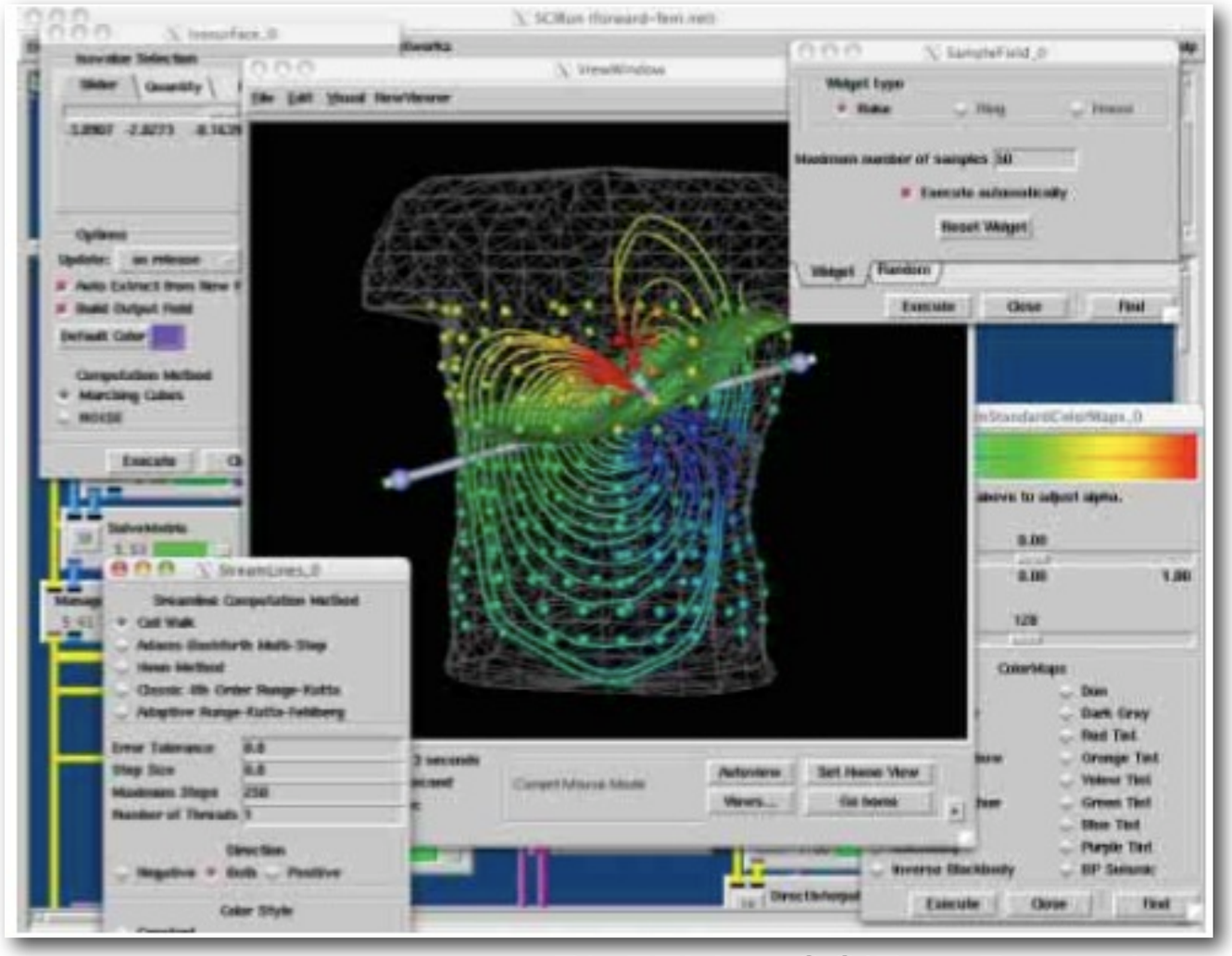


BioFEM: a SCIRun PowerApp



www.avs.com

Helping to create visualizations: Custom Applications



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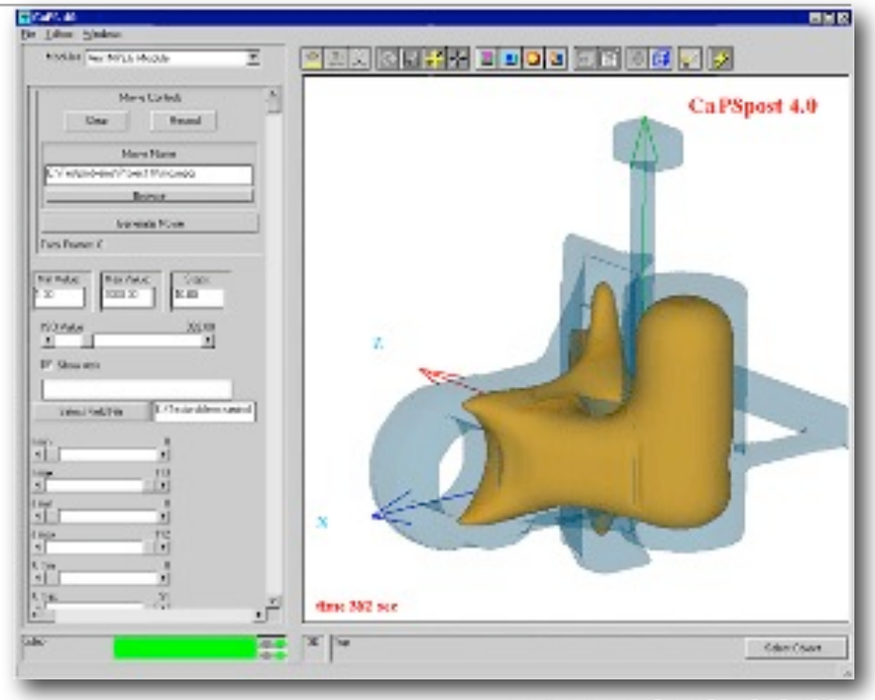
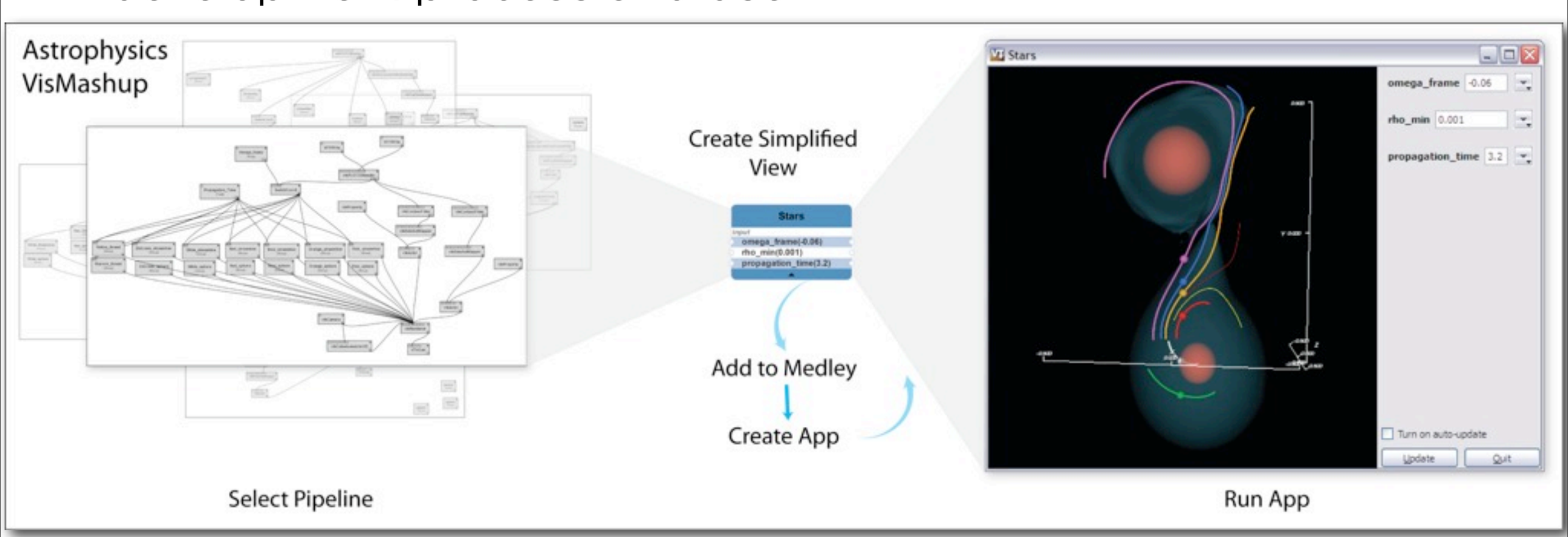


www.avs.com

Applications are costly to develop, manually crafted for a given pipeline

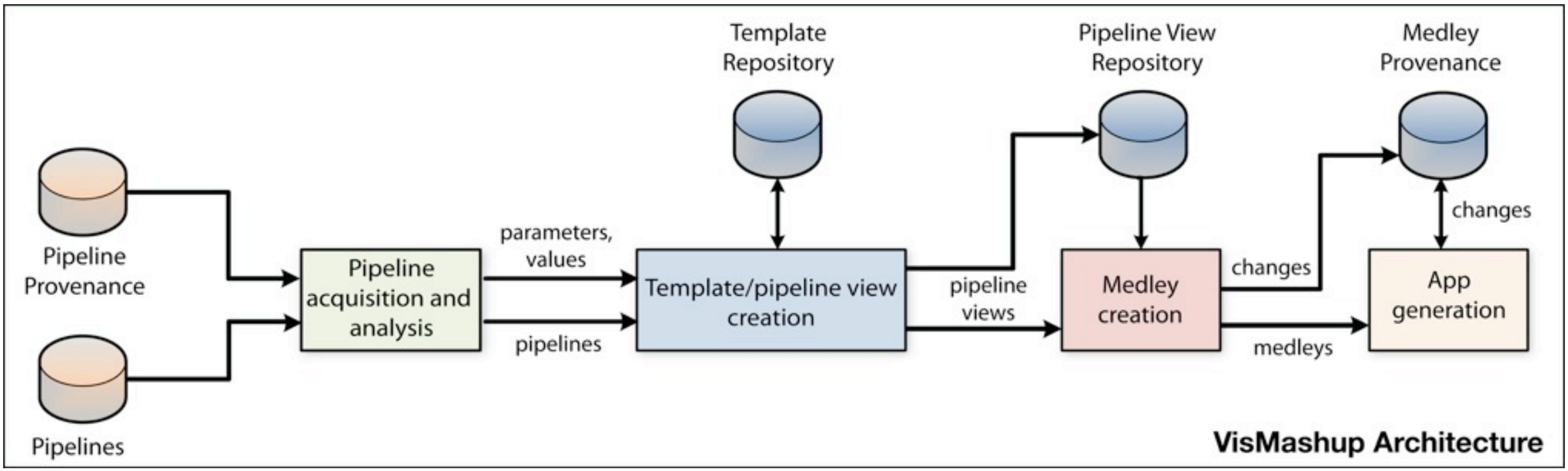
Our Approach: VisMashup

- Simplifies the creation, maintenance and use of customized visualization applications (mashups)
- Uses dataflows as the underlying model
- Keeps detailed provenance information of the application development process and use



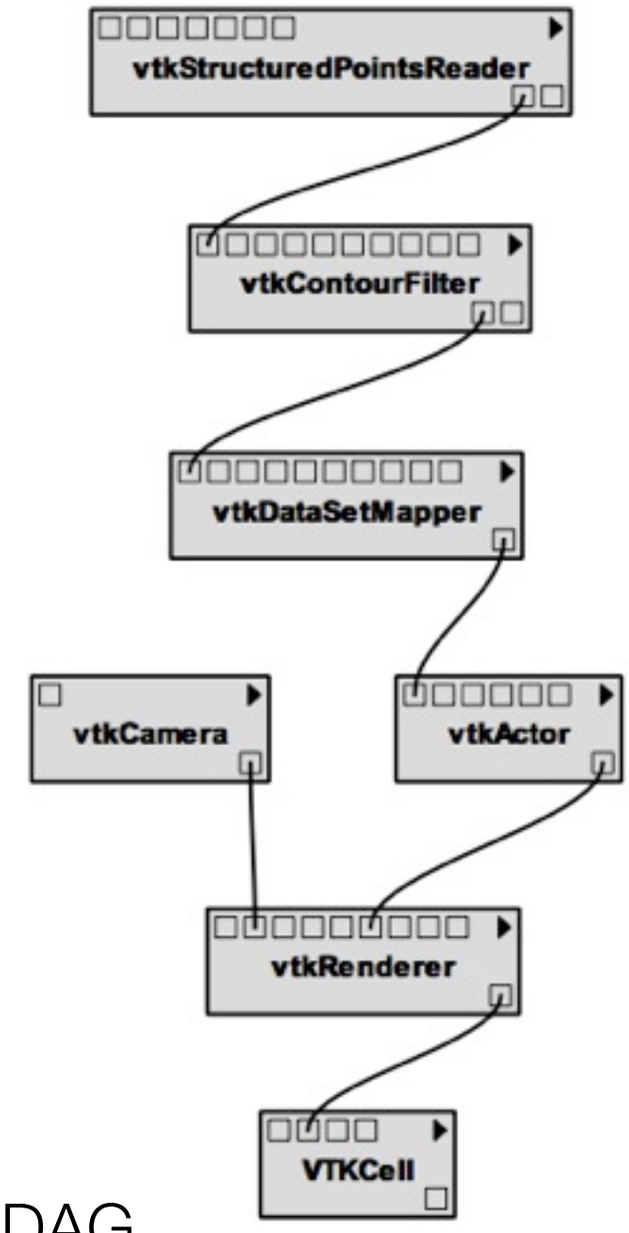
Model

The VisMashup Architecture

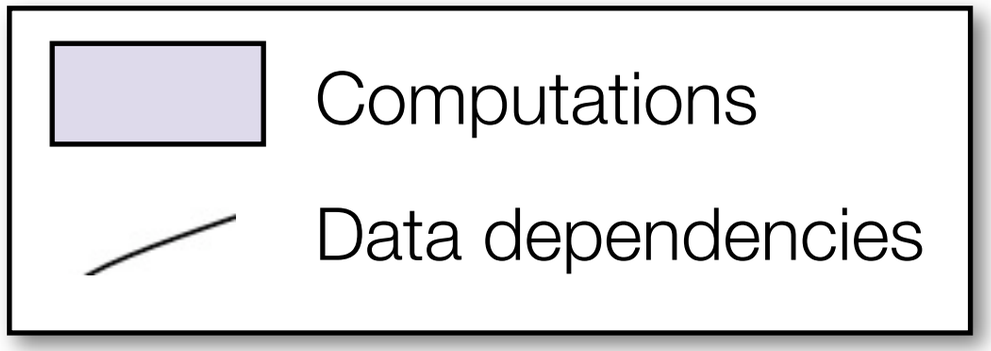


Pipelines

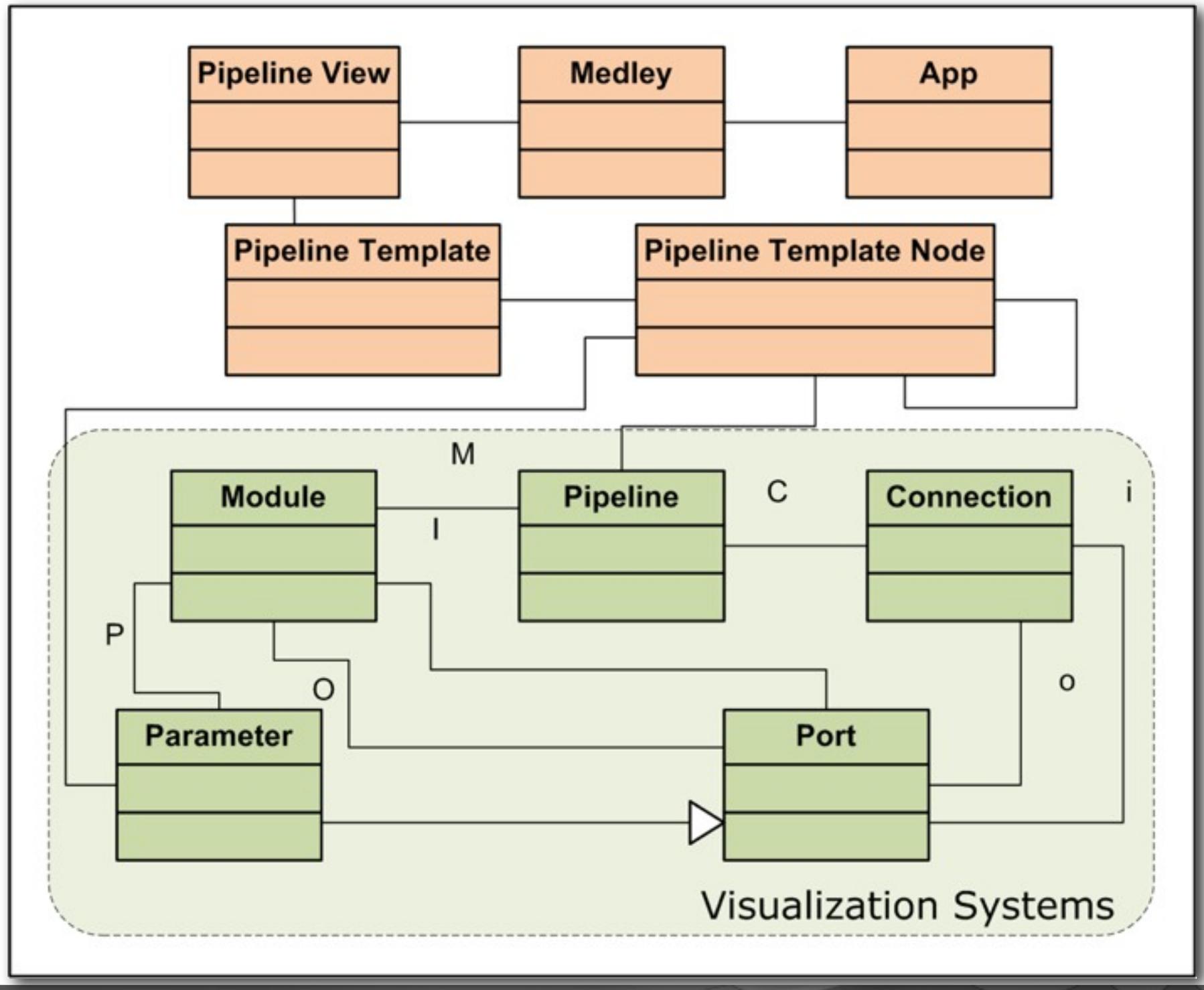
- Dataflow model is used to specify visualization pipelines



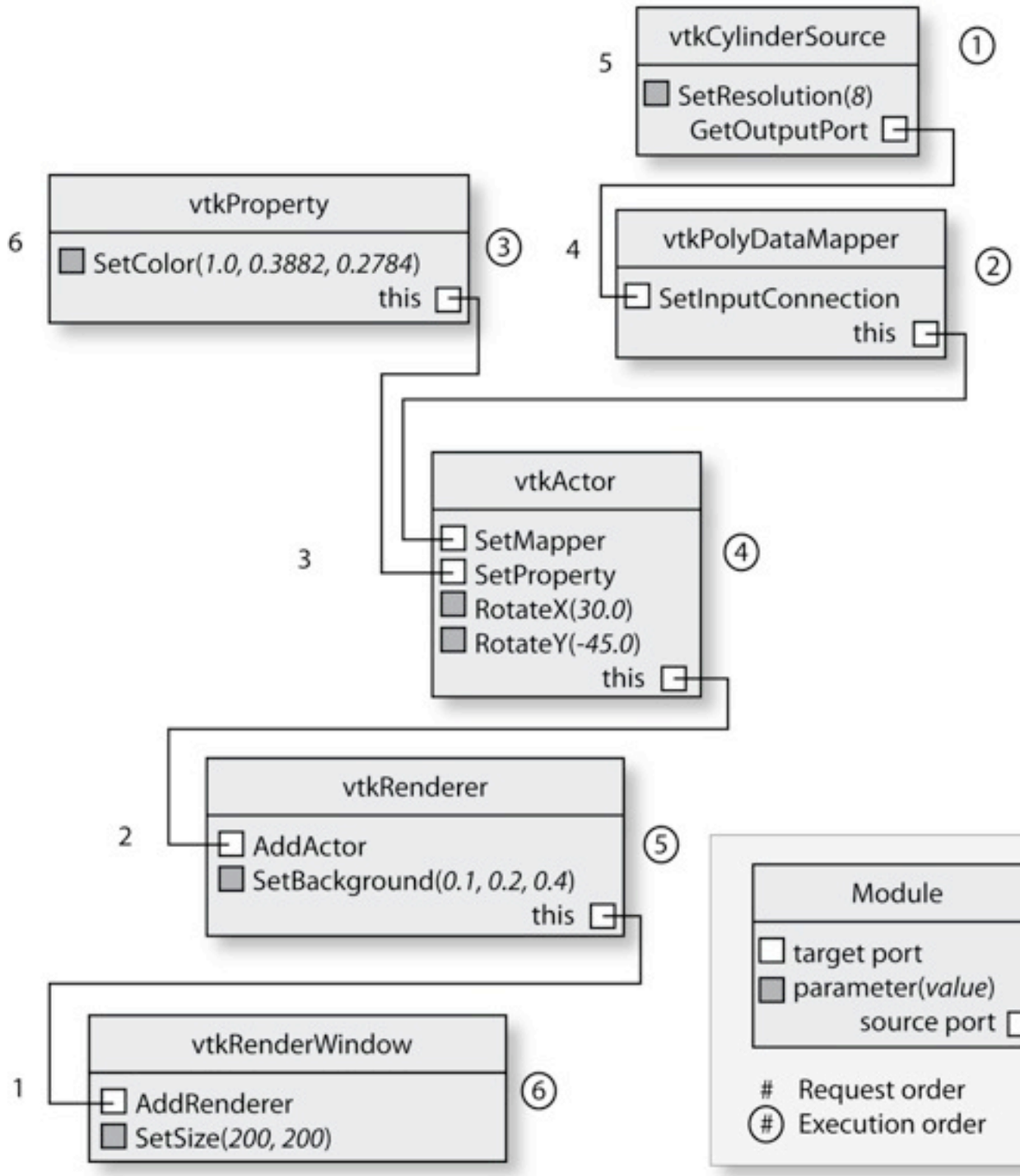
DAG



Main concepts in VisMashup

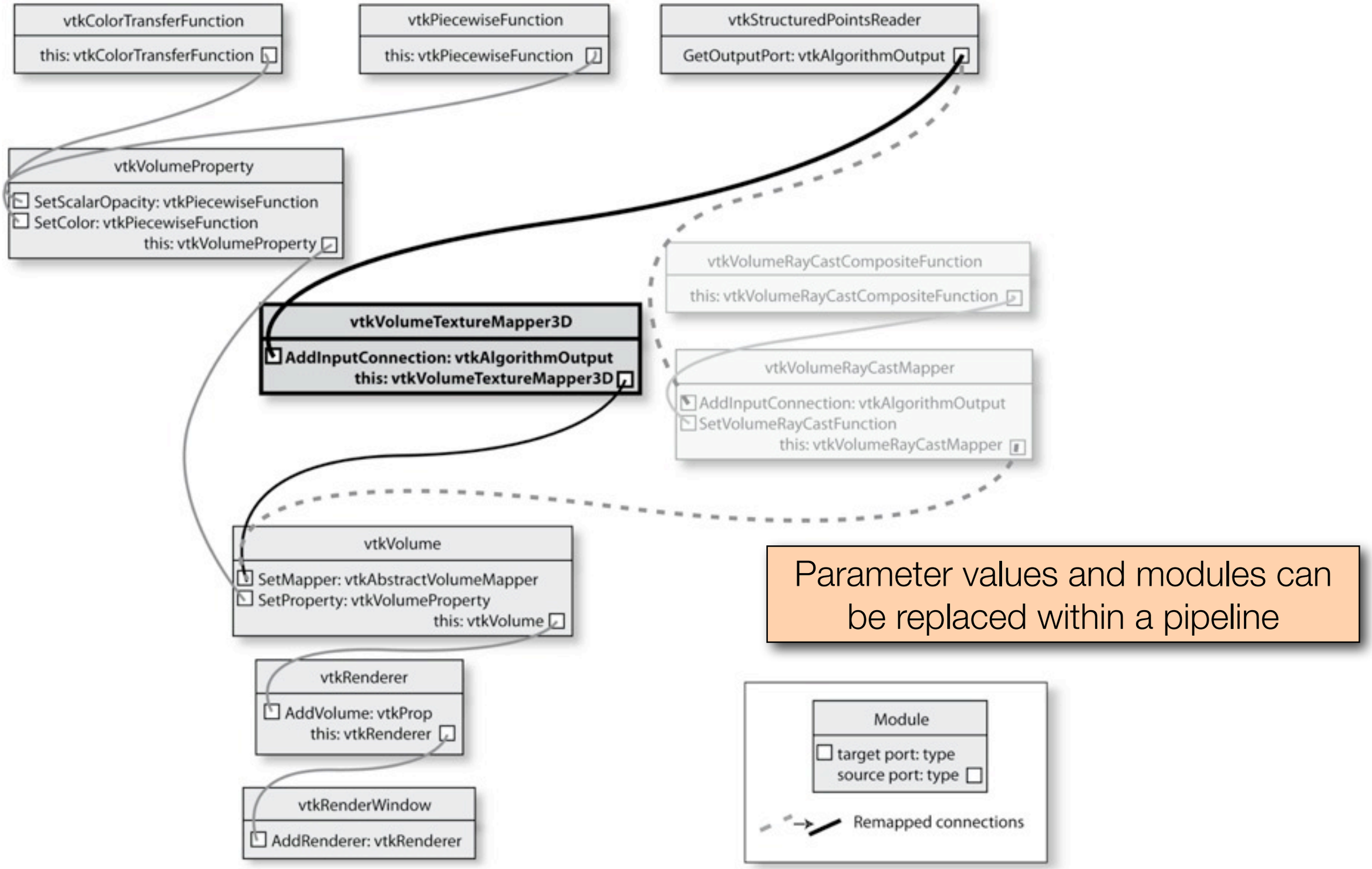


Pipeline Operations: Run



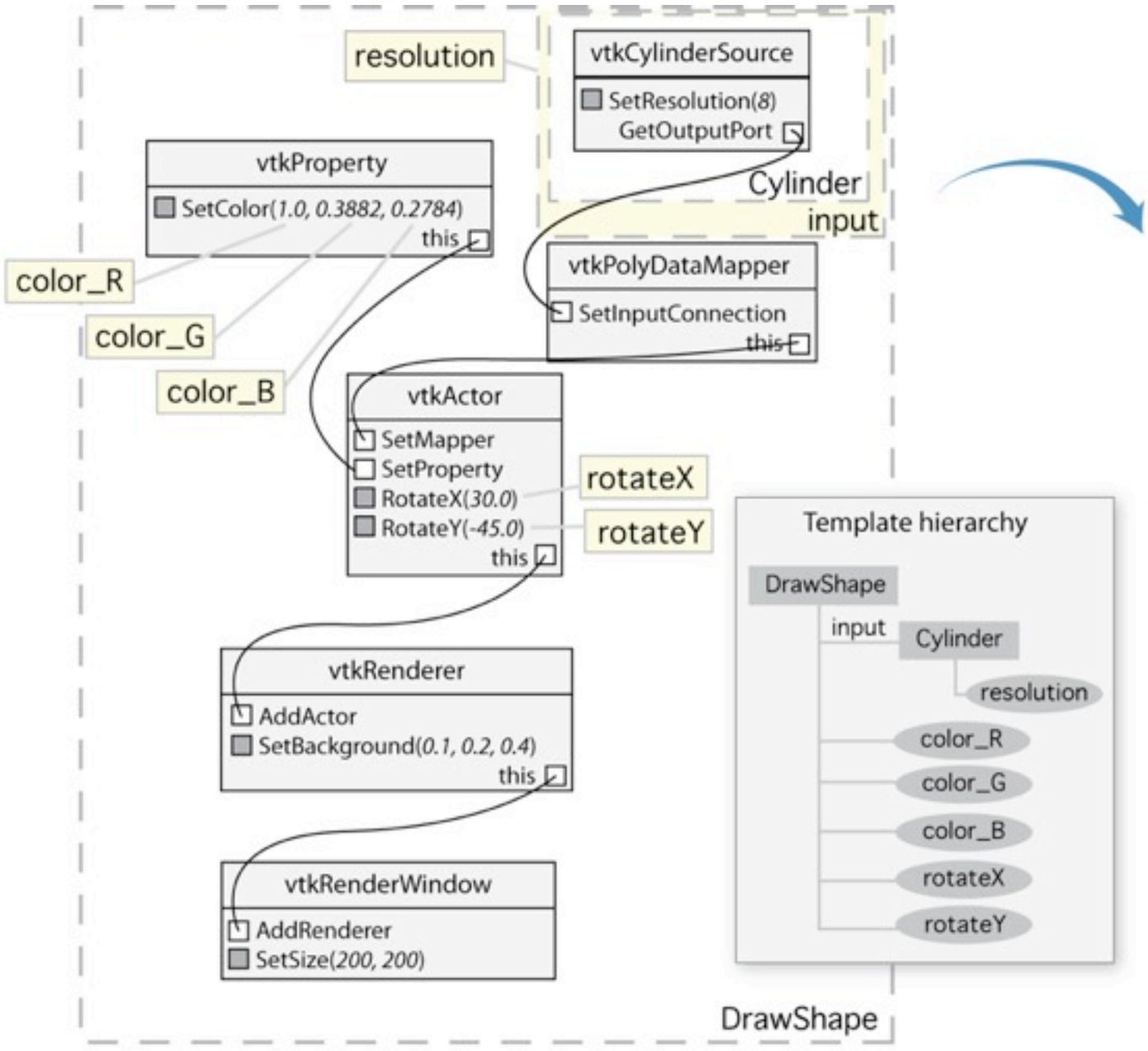
The pipeline is executed in the order determined by the network of modules and connections, in a *demand-driven* fashion

Pipeline Operations: Substitution



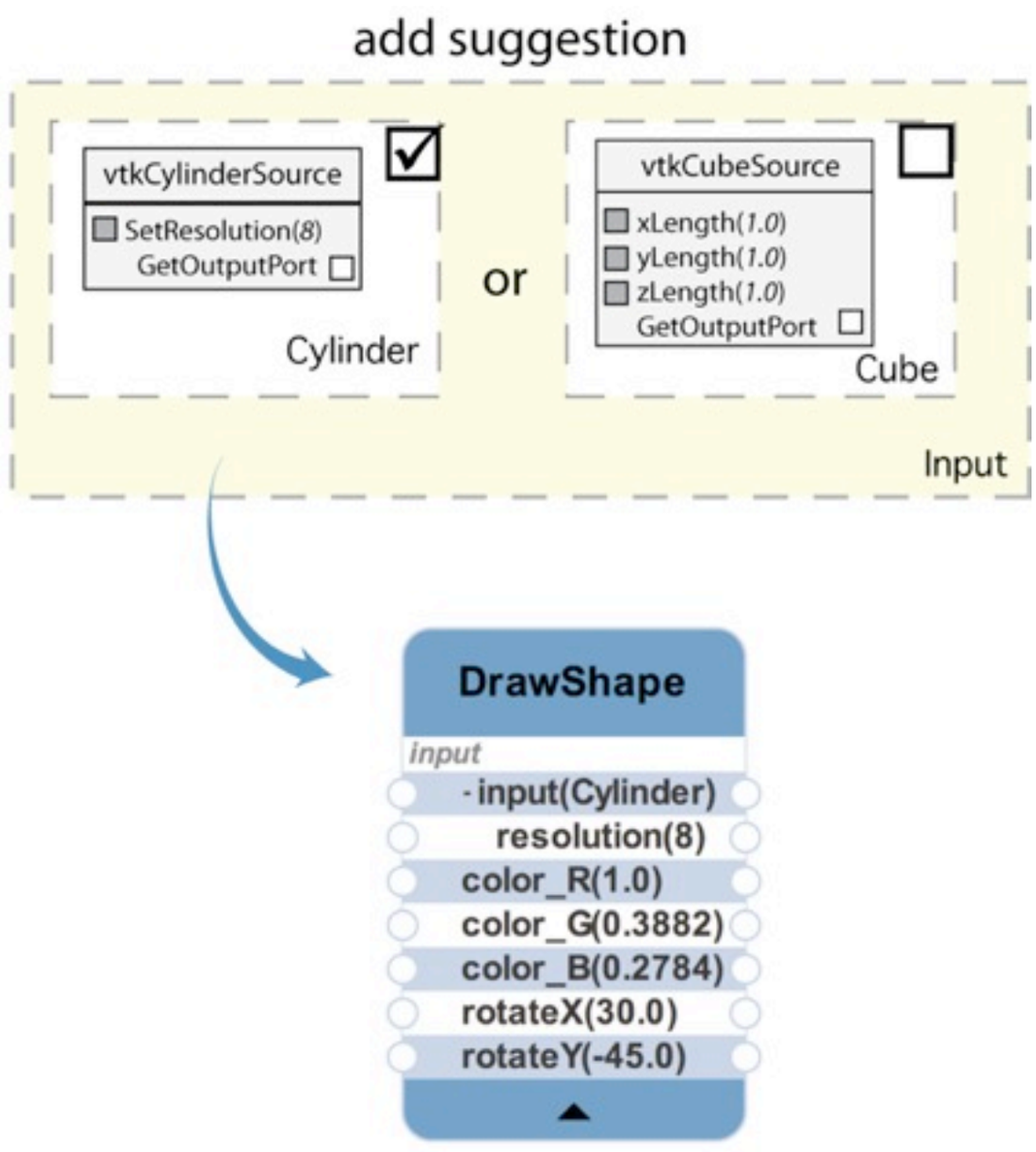
Parameter values and modules can be replaced within a pipeline

Pipeline Templates and Pipeline Views



Pipeline Template

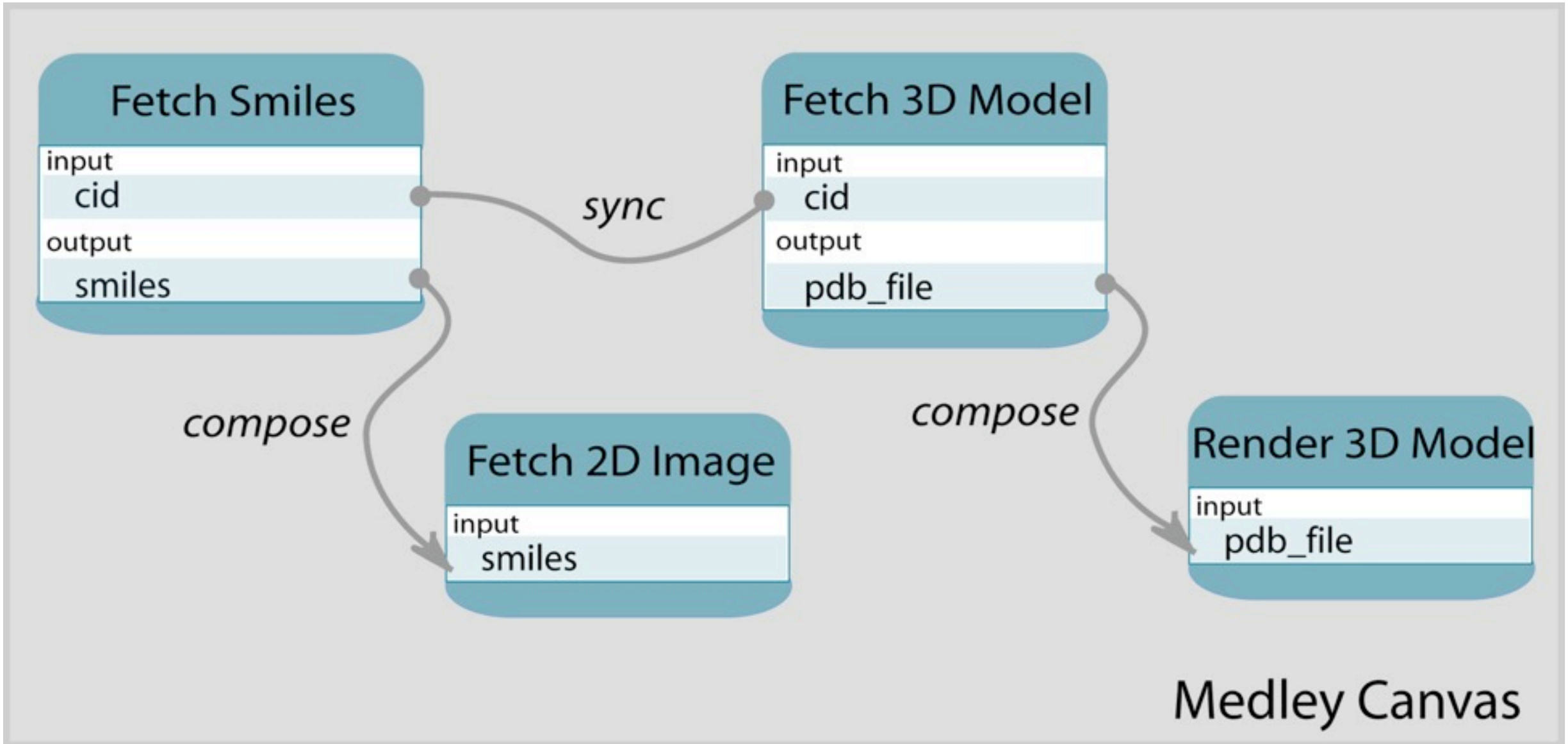
(b)



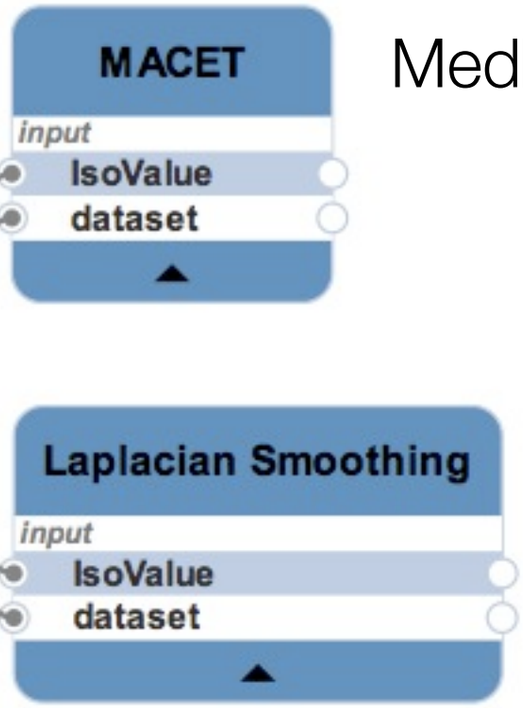
Pipeline View

(c)

Medleys: Collection of pipeline views



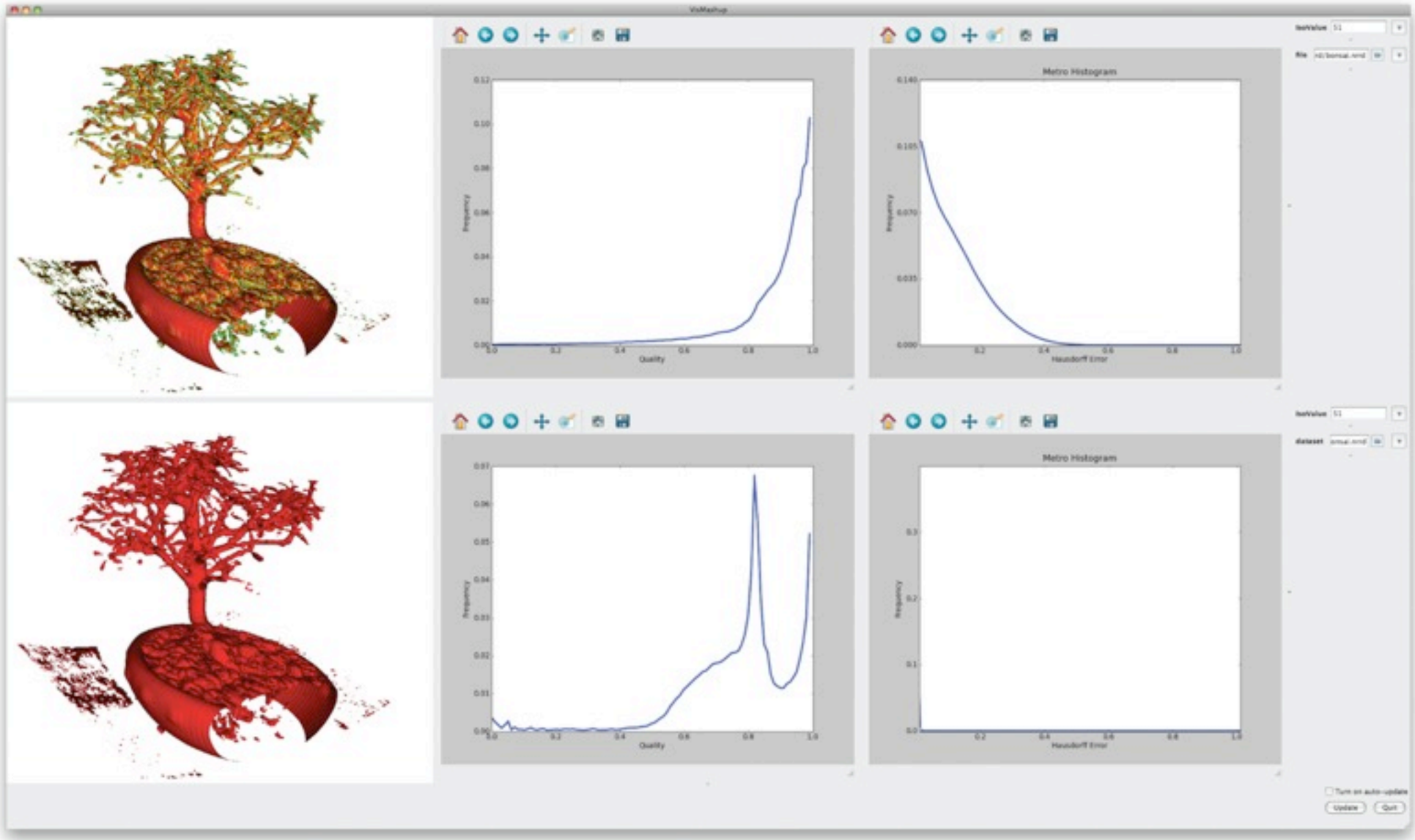
VisMashup



Medley

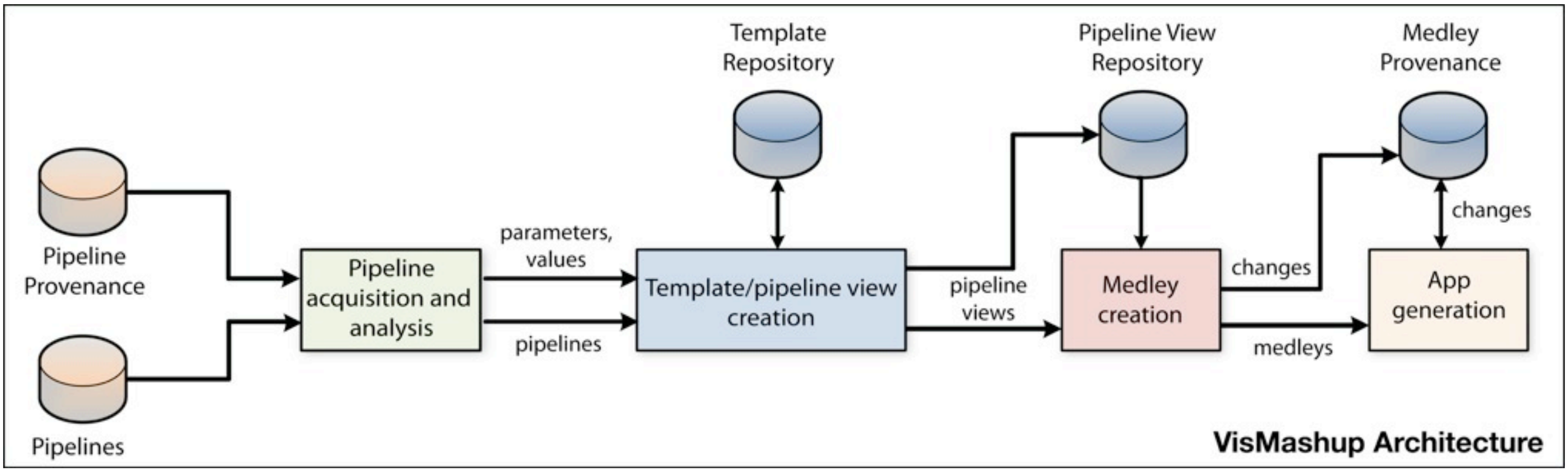
VisMashup

a flexible GUI automatically generated from a medley specification



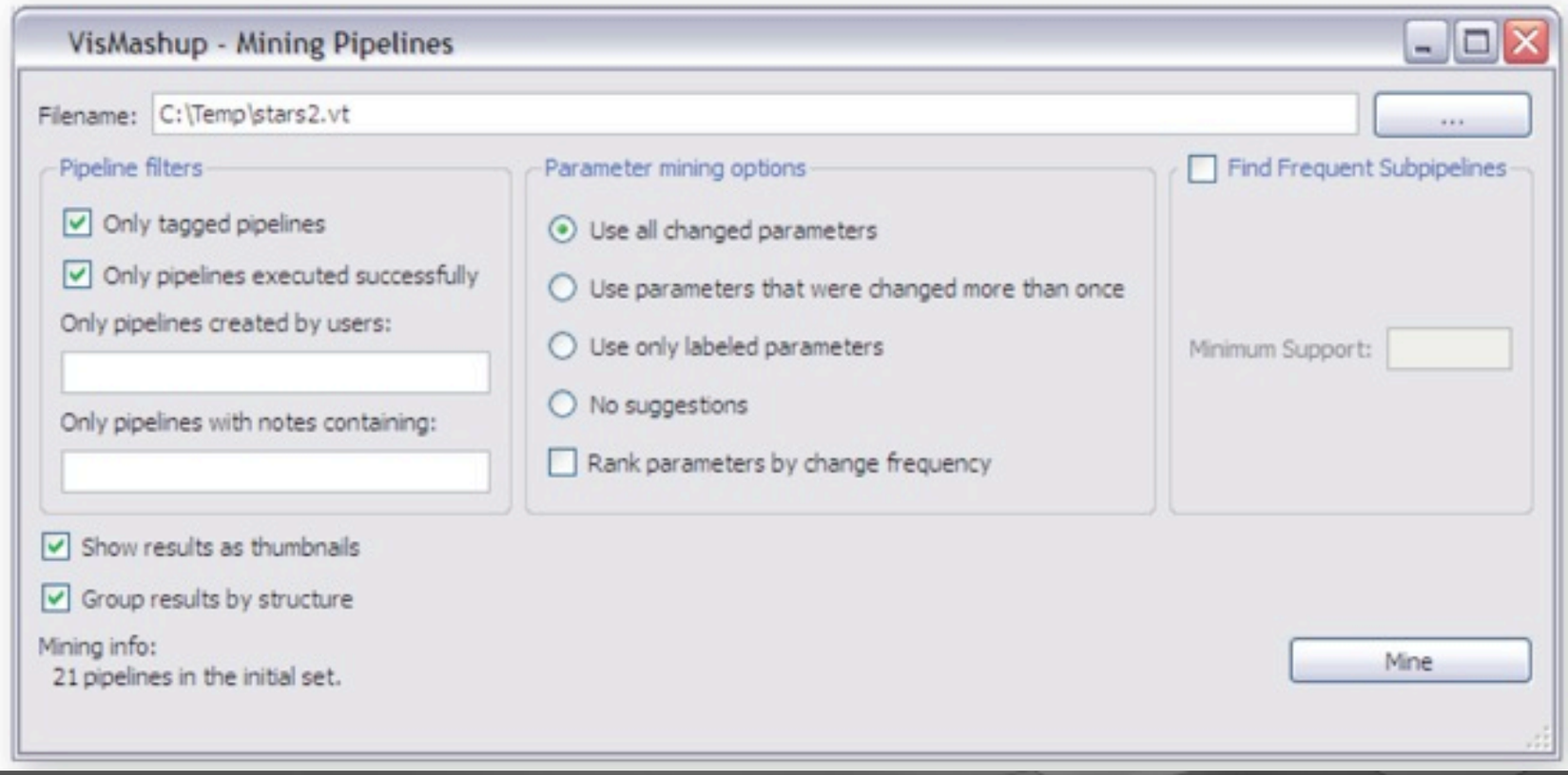
The VisMashup System

The VisMashup Architecture



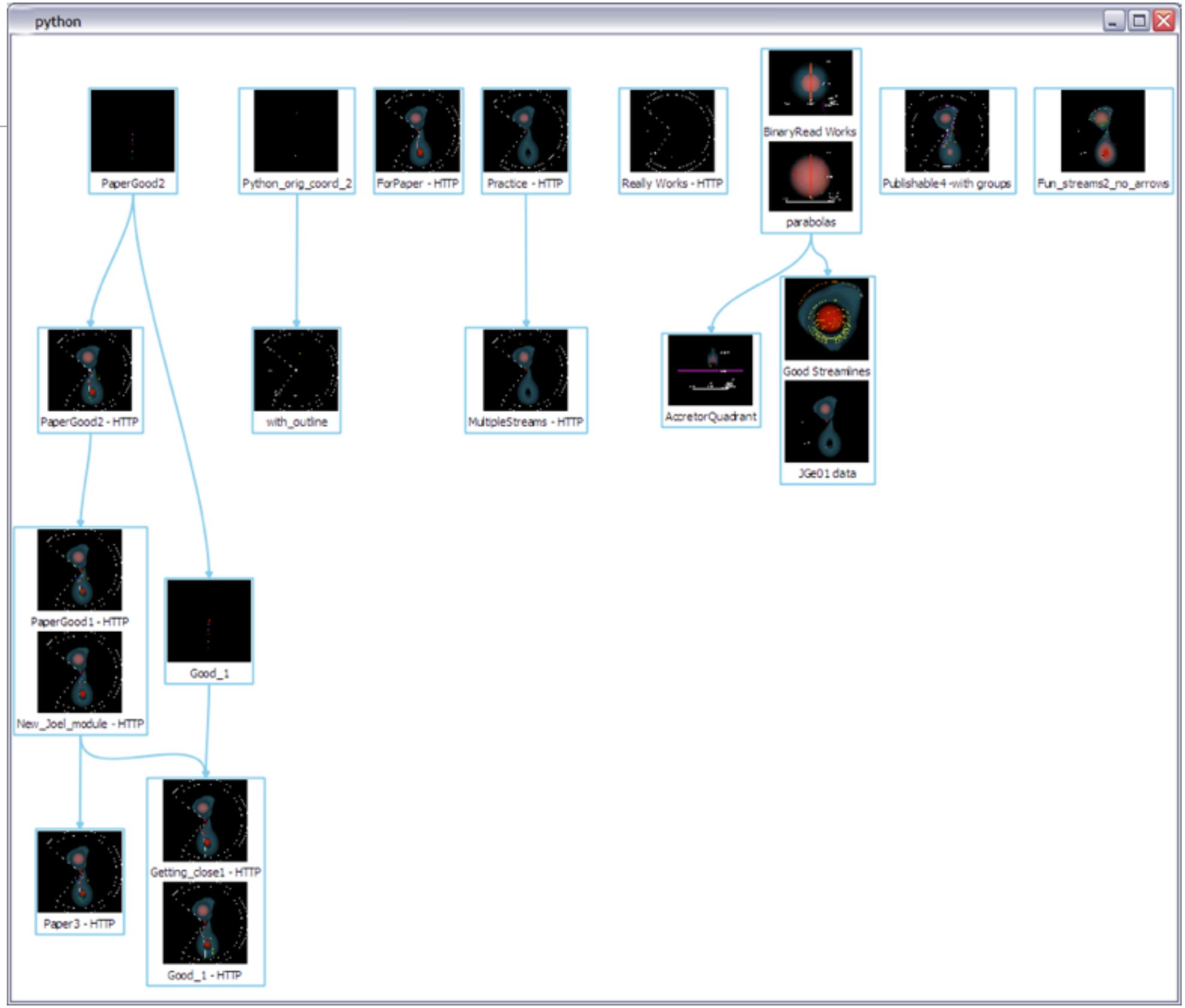
Pipeline Acquisition and Analysis

- Pipelines
  - Can be built from scratch
  - Can be selected from a collection of pipelines
    - relevant pipelines
    - important parameters and associated values



Hasse Diagram

A Hasse diagram is a tree where each node corresponds to a group of isomorphic graphs, and edges between a parent and a child node indicate containment



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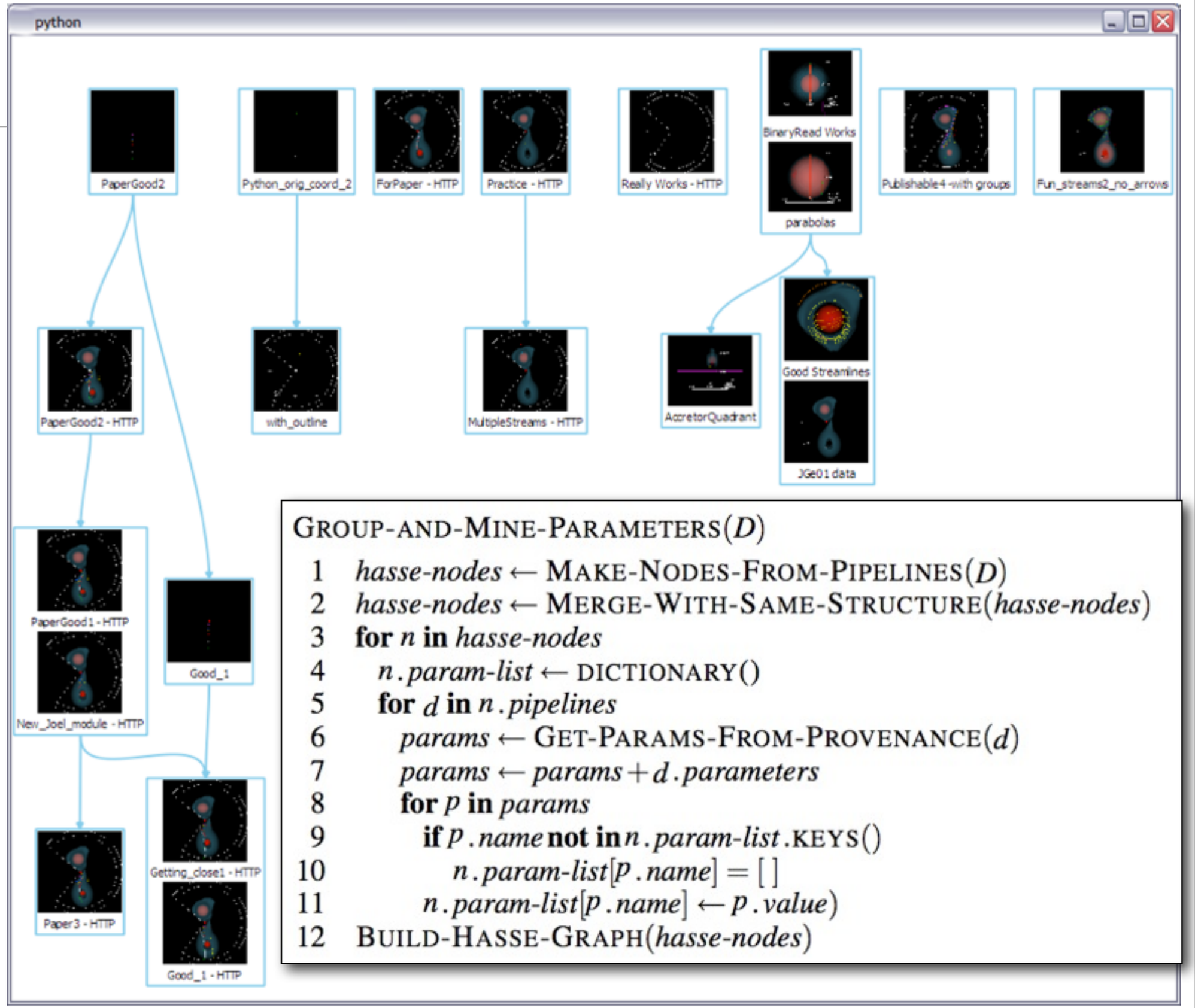
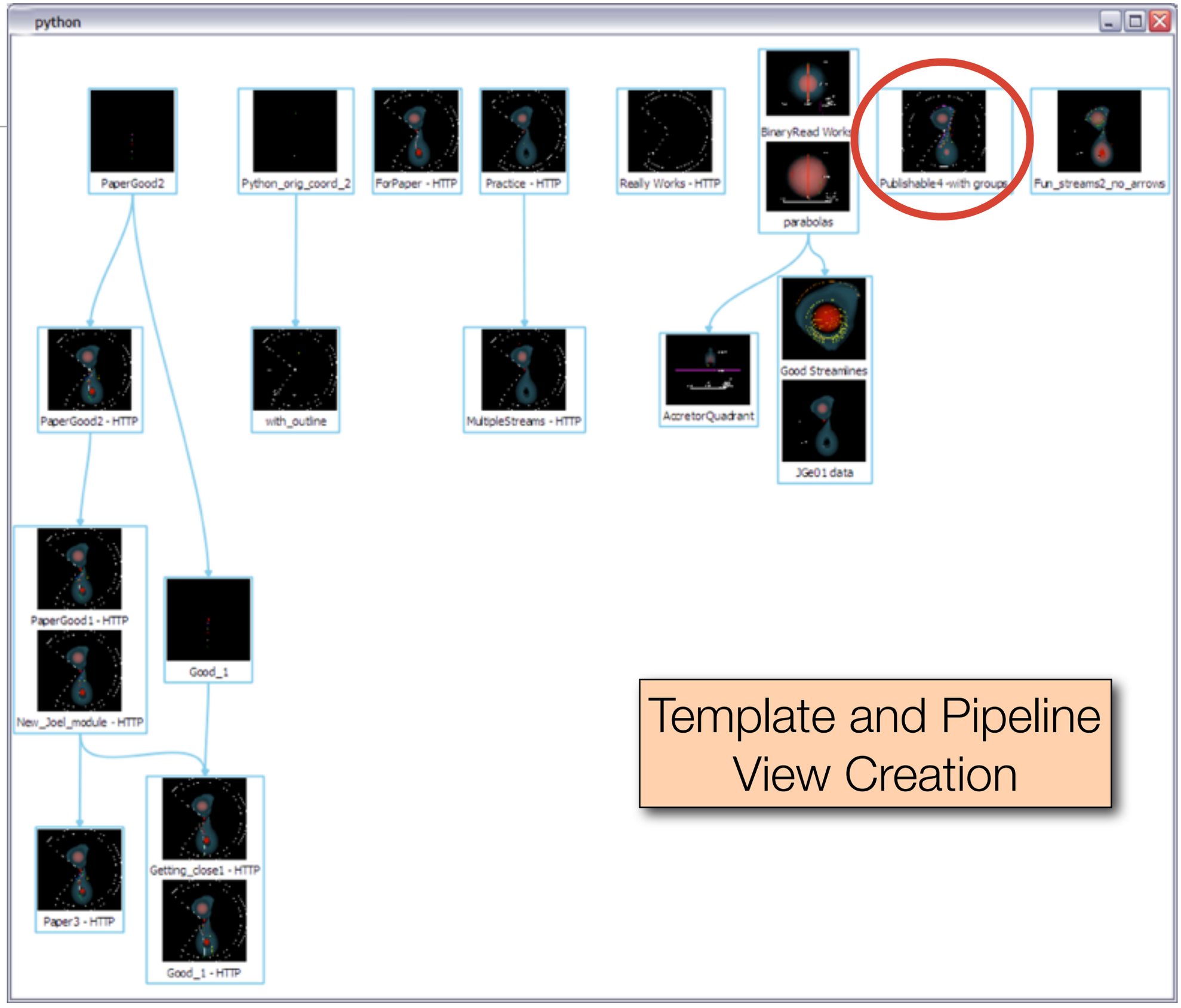


Hasse Diagram

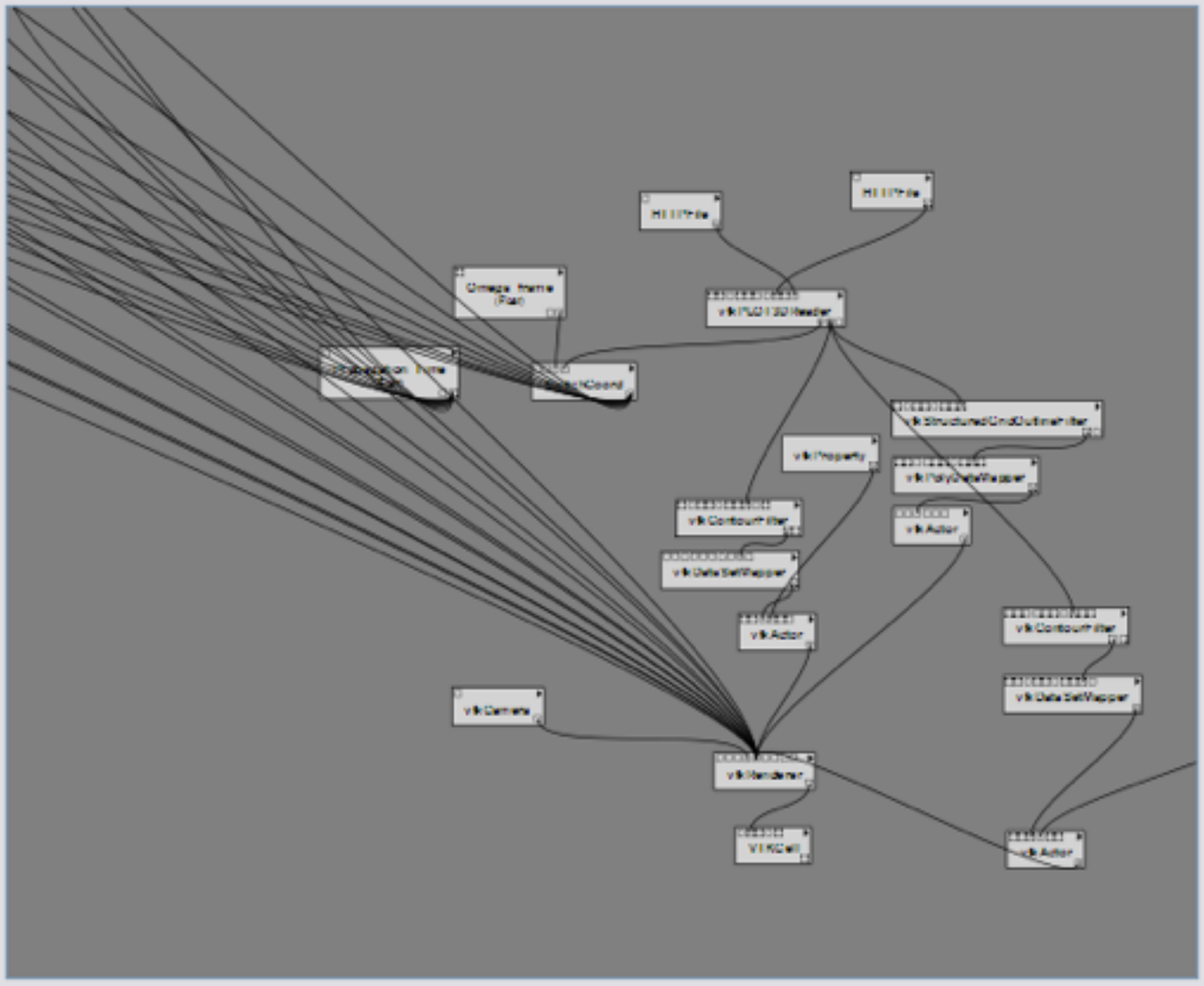


Template and Pipeline View Creation

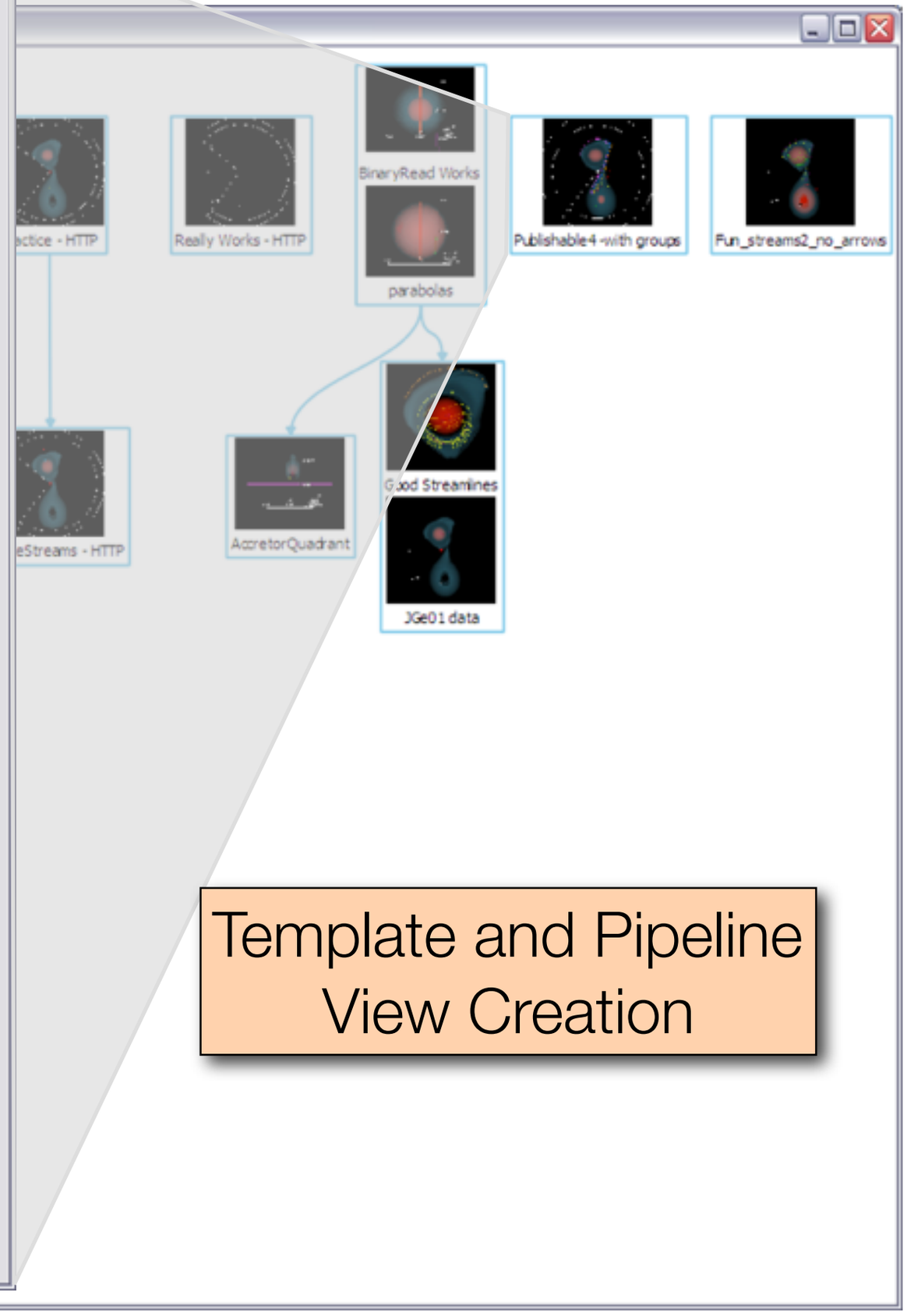
Pipeline View Preview

Parameters

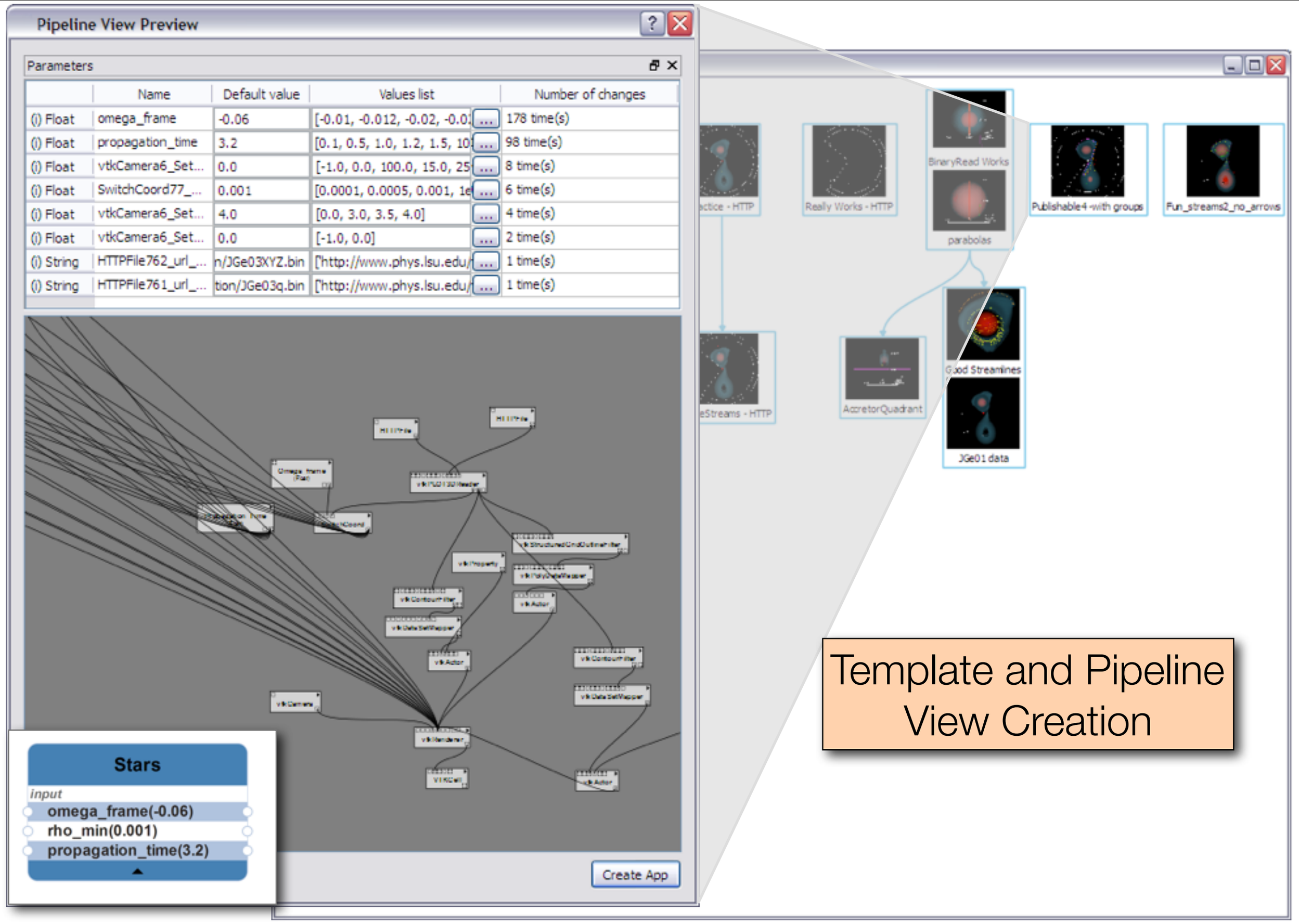
	Name	Default value	Values list	Number of changes
(i) Float	omega_frame	-0.06	[-0.01, -0.012, -0.02, -0.0 ...	178 time(s)
(i) Float	propagation_time	3.2	[0.1, 0.5, 1.0, 1.2, 1.5, 10 ...	98 time(s)
(i) Float	vtkCamera6_Set...	0.0	[-1.0, 0.0, 100.0, 15.0, 25 ...	8 time(s)
(i) Float	SwitchCoord77_...	0.001	[0.0001, 0.0005, 0.001, 1e ...	6 time(s)
(i) Float	vtkCamera6_Set...	4.0	[0.0, 3.0, 3.5, 4.0] ...	4 time(s)
(i) Float	vtkCamera6_Set...	0.0	[-1.0, 0.0] ...	2 time(s)
(i) String	HTTPFile762_url_...	n/JGe03XYZ.bin	['http://www.phys.lsu.edu/ ...	1 time(s)
(i) String	HTTPFile761_url_...	tion/JGe03q.bin	['http://www.phys.lsu.edu/ ...	1 time(s)



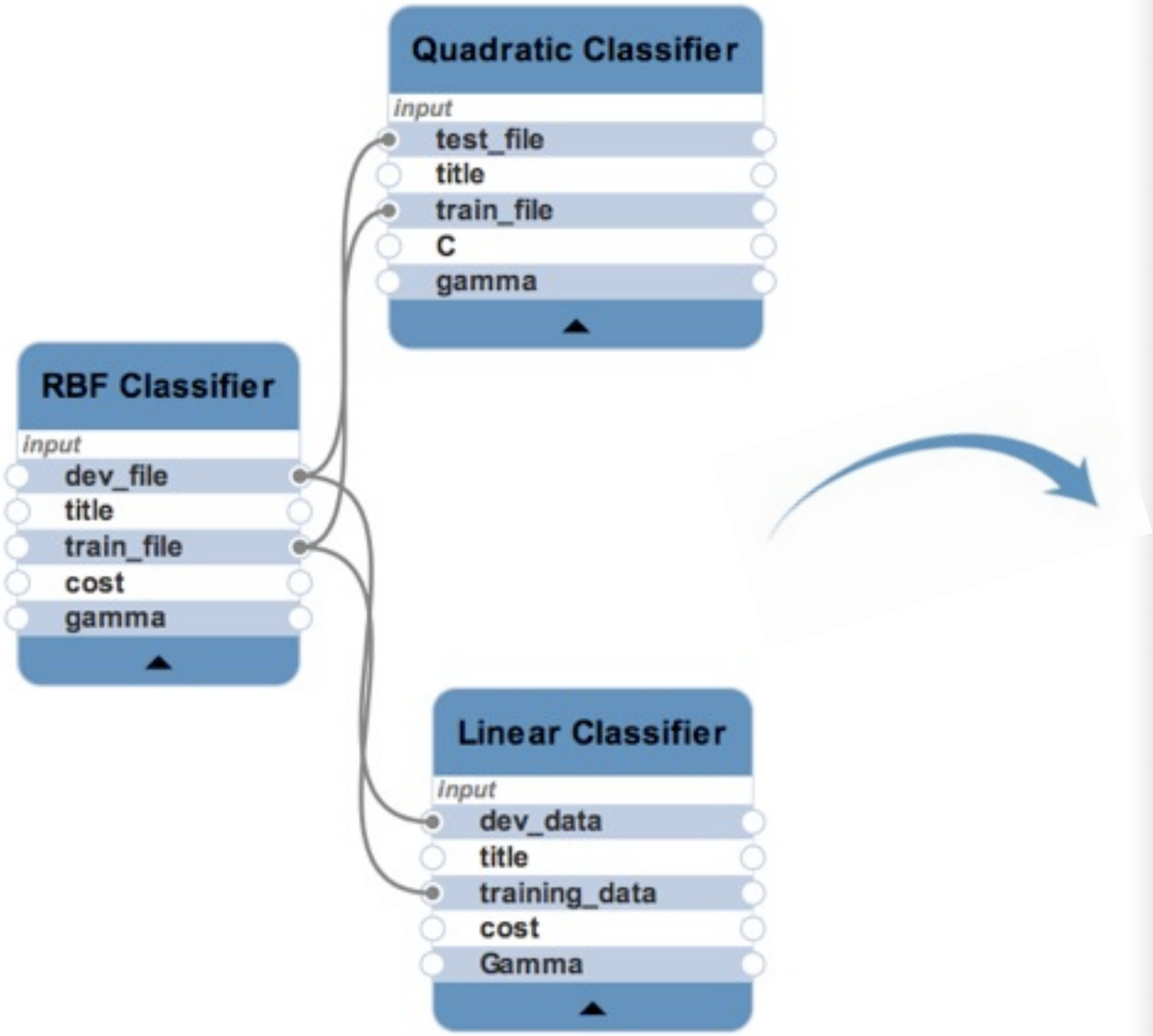
Create App

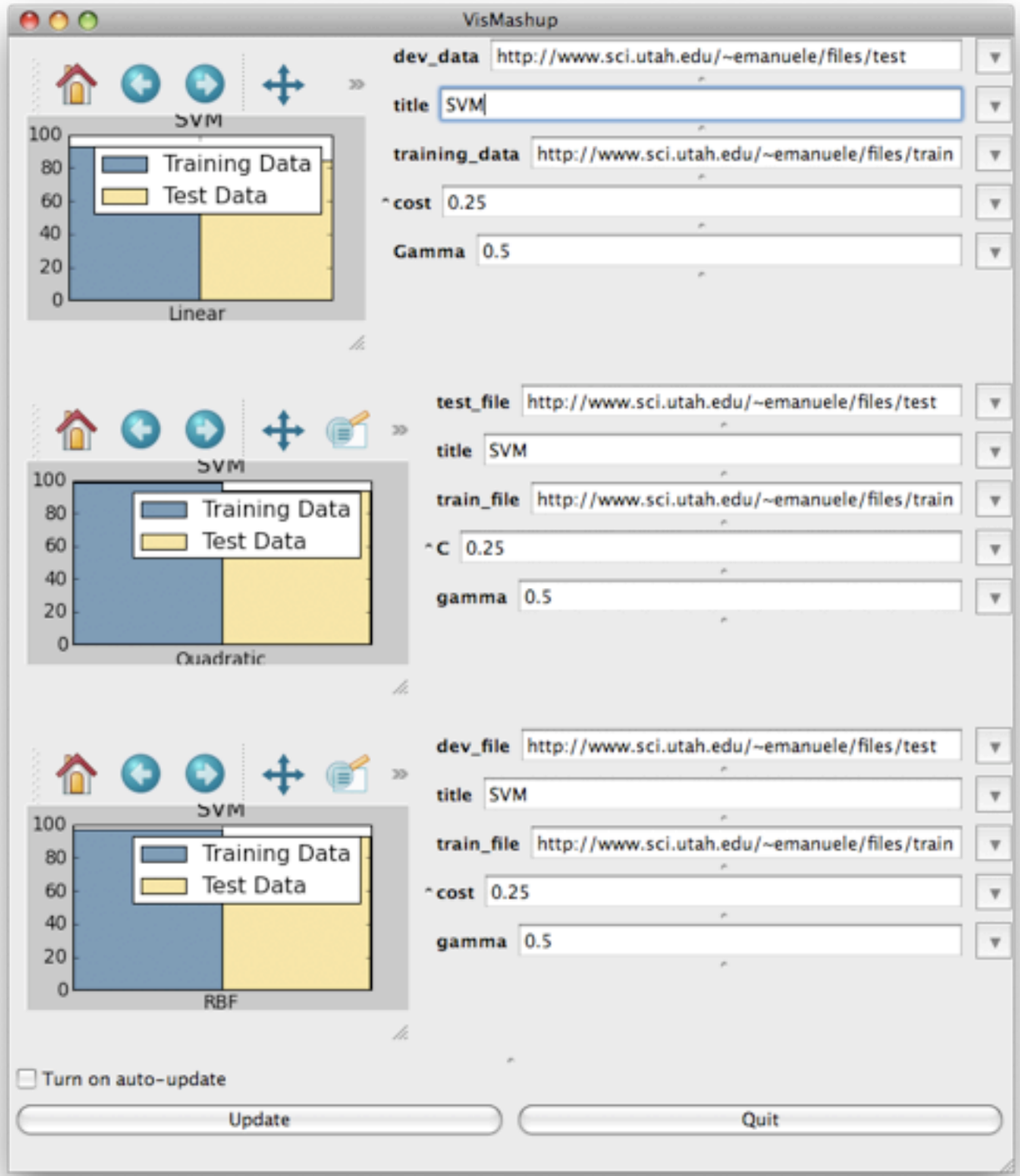


Template and Pipeline View Creation


Pipeline View Preview
Parameters
Name
Default value
Values list
Number of changes
(i) Float omega_frame -0.06 178 time(s)
(i) Float propagation_time 3.2 98 time(s)
(i) Float vtkCamera6_Set... 0.0 8 time(s)
(i) Float SwitchCoord77_... 0.001 6 time(s)
(i) Float vtkCamera6_Set... 4.0 4 time(s)
(i) Float vtkCamera6_Set... 0.0 2 time(s)
(i) String HTTPFile762_url_... n/JGe03XYZ.bin 1 time(s)
(i) String HTTPFile761_url_... tion/JGe03q.bin 1 time(s)
Stars
input
omega_frame(-0.06)
rho_min(0.001)
propagation_time(3.2)
Create App
BinaryRead Works
parabolas
Really Works - HTTP
Publishable4 -with groups
Fun_streams2_no_arrows
AccretorQuadrant
Good Streamlines
JGe01 data
Template and Pipeline View Creation

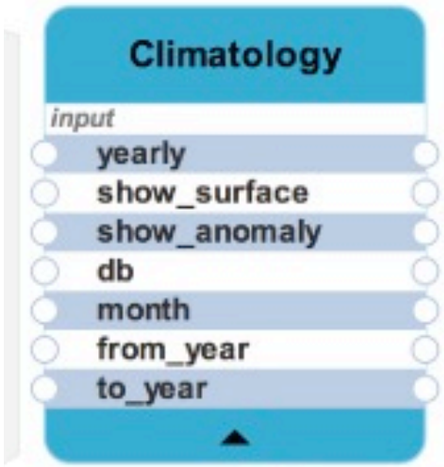
Medley Creation and Mashup Generation





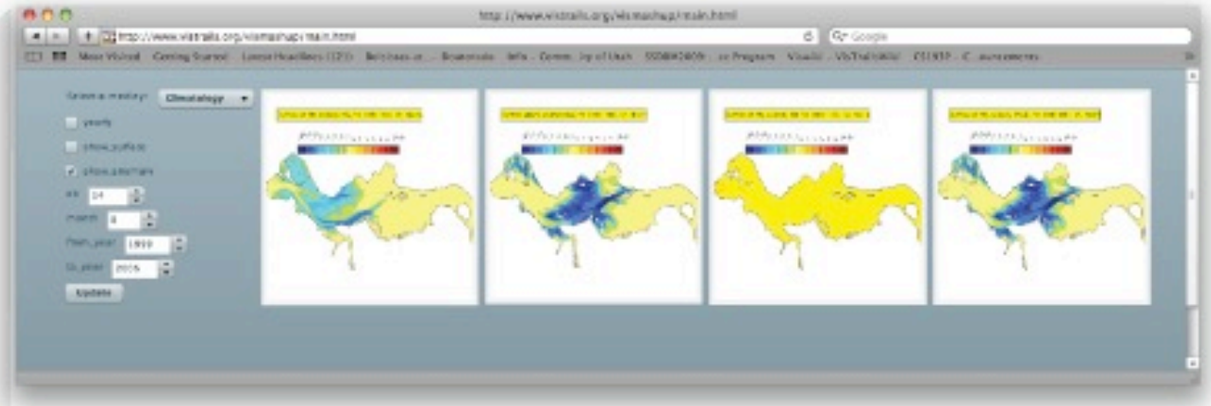
Medley Creation and Mashup Generation

Create Simplified View

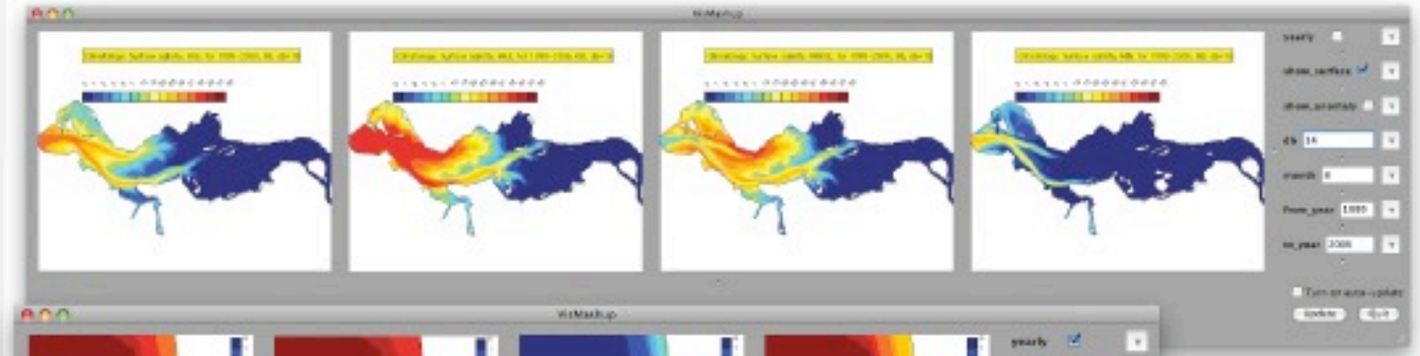


Add to Medley

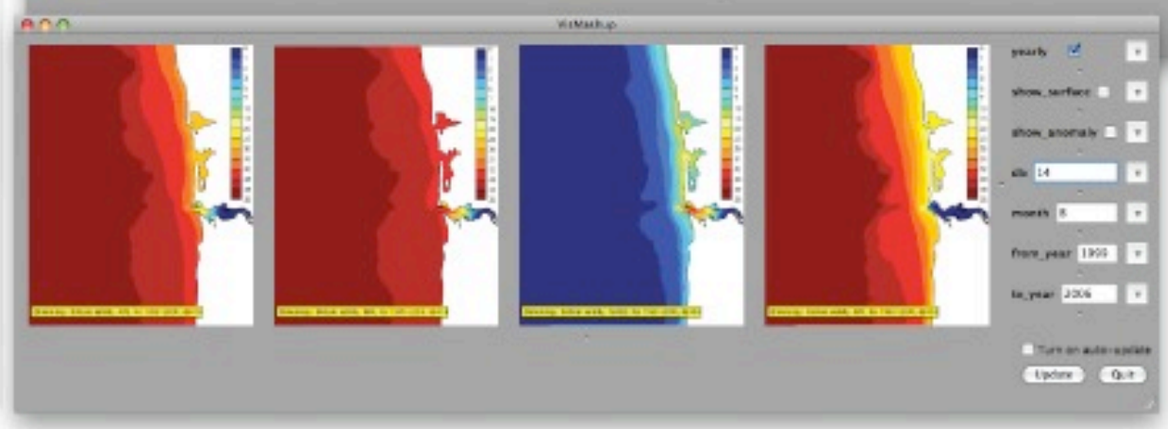
Create App



Web



Desktop



Run App

Case Study:
Sharing Astrophysics Analyses

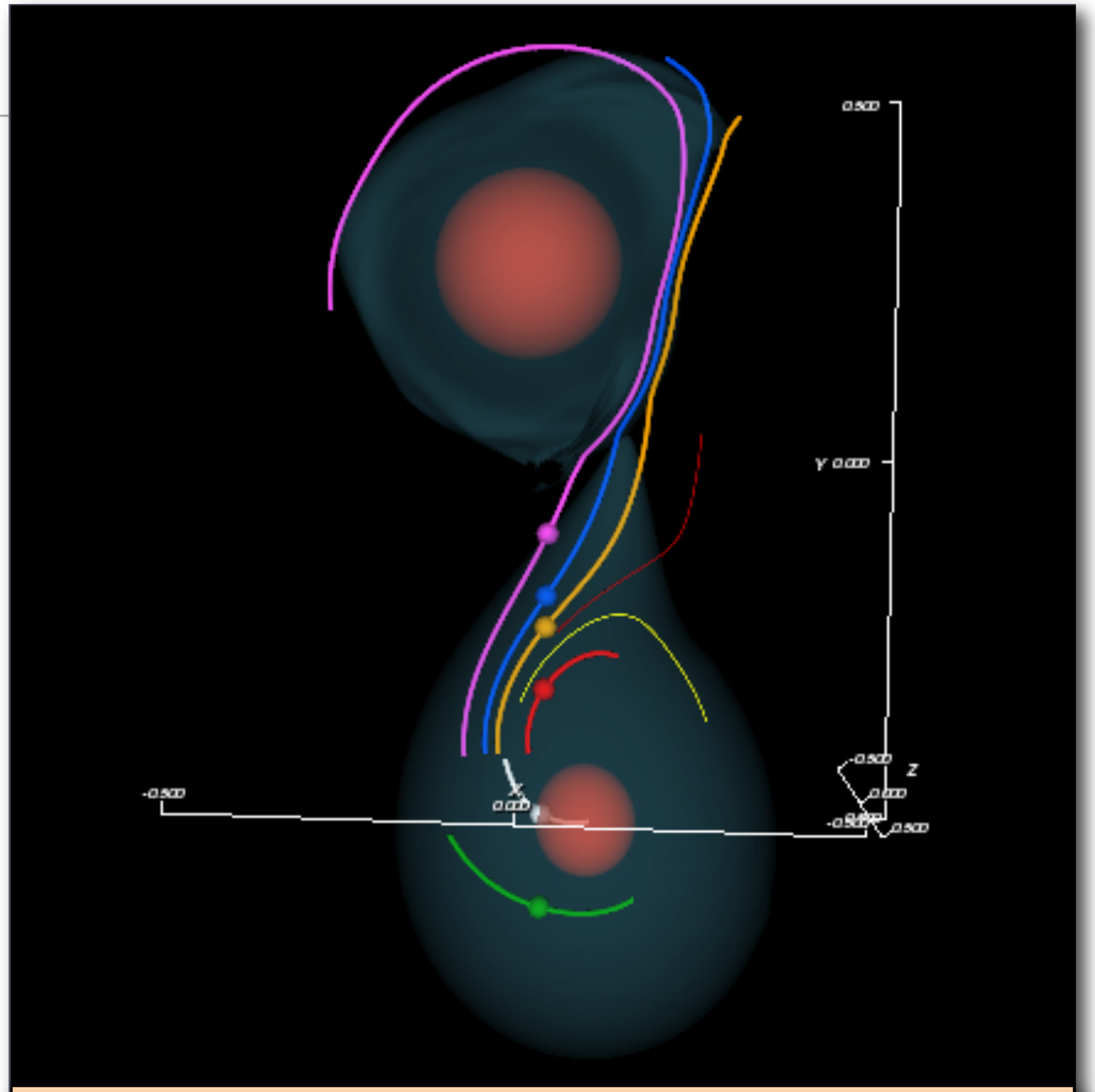
Professor Joel Tohline's group Louisiana State University (LSU)

- Computational fluid dynamics (CFD) techniques are used to model various astrophysical phenomena
  - simulation of mass-transfer instabilities in binary star systems
- Visualization tools and techniques to help them explore the results of simulations (VisTrails: VTK + custom analysis modules)

http://www.phys.lsu.edu/~tohline/vistrails/

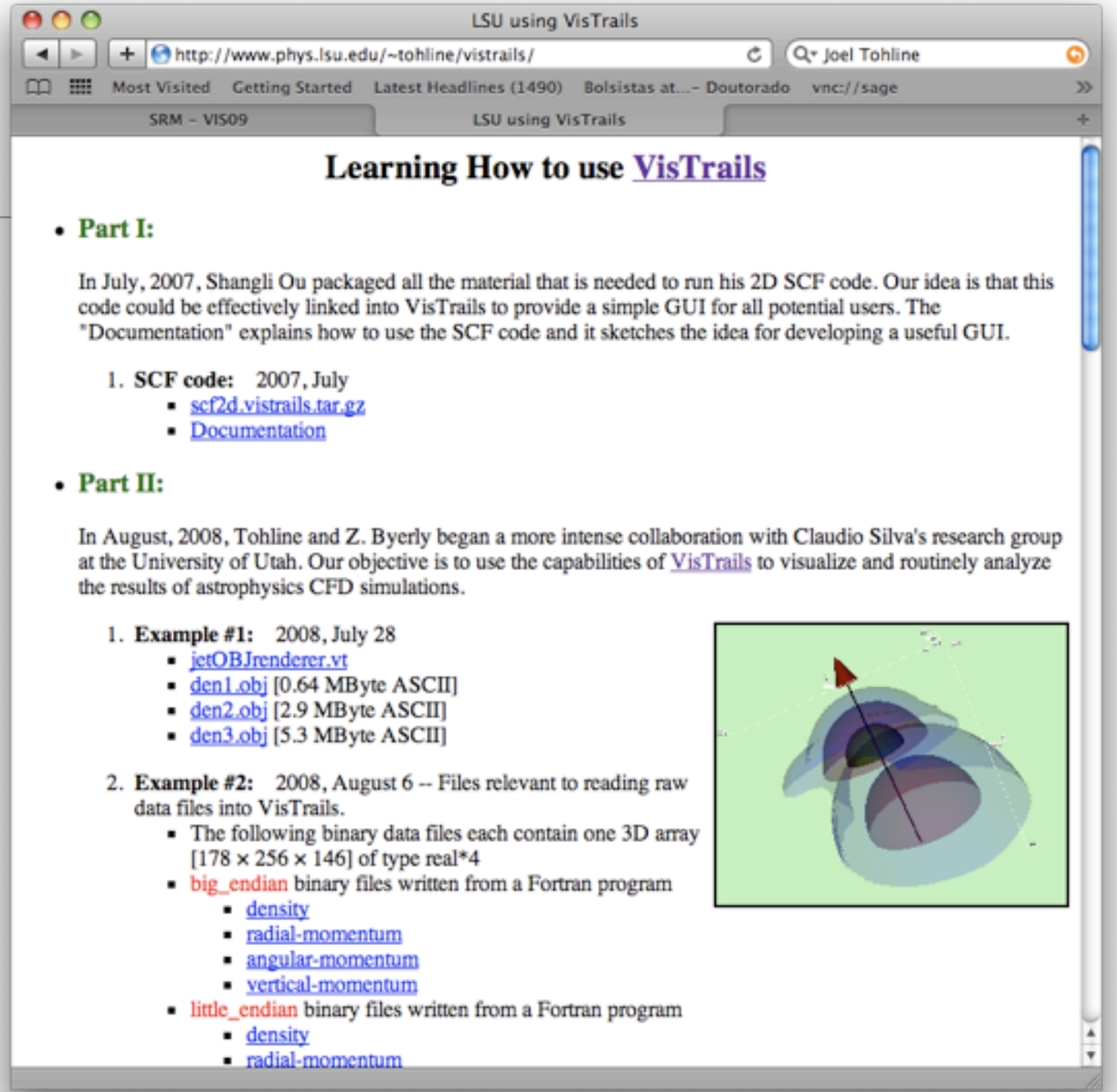
Binary Star System

- Two stars orbiting around a common center of mass with an orbital period *P*
- When the system is viewed from a frame rotating with an angular frequency $\Omega_{frame} = 2\pi/P$, the system will appear stationary
- During a simulation, *P* and Ω_{frame} are expected to vary

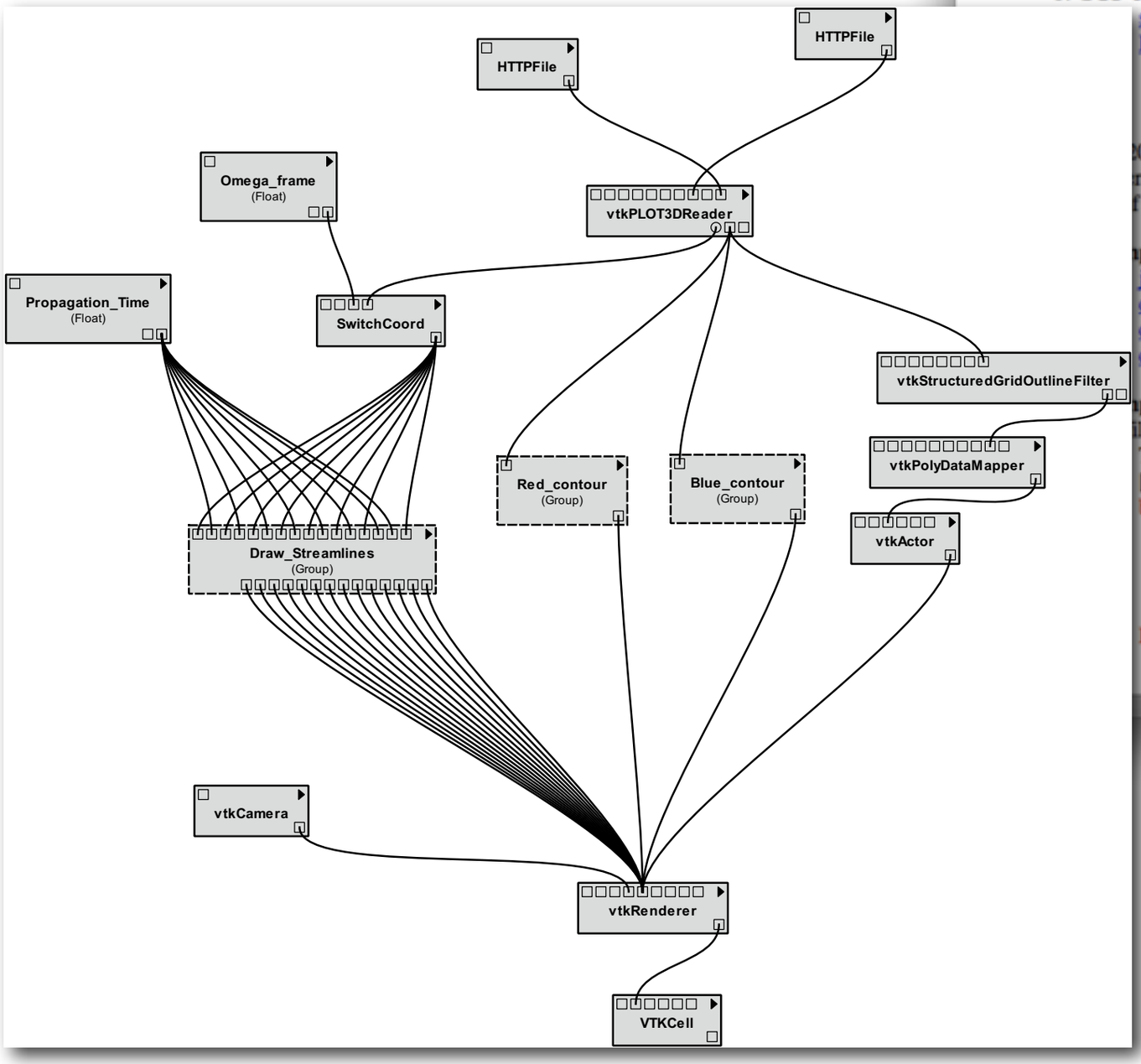


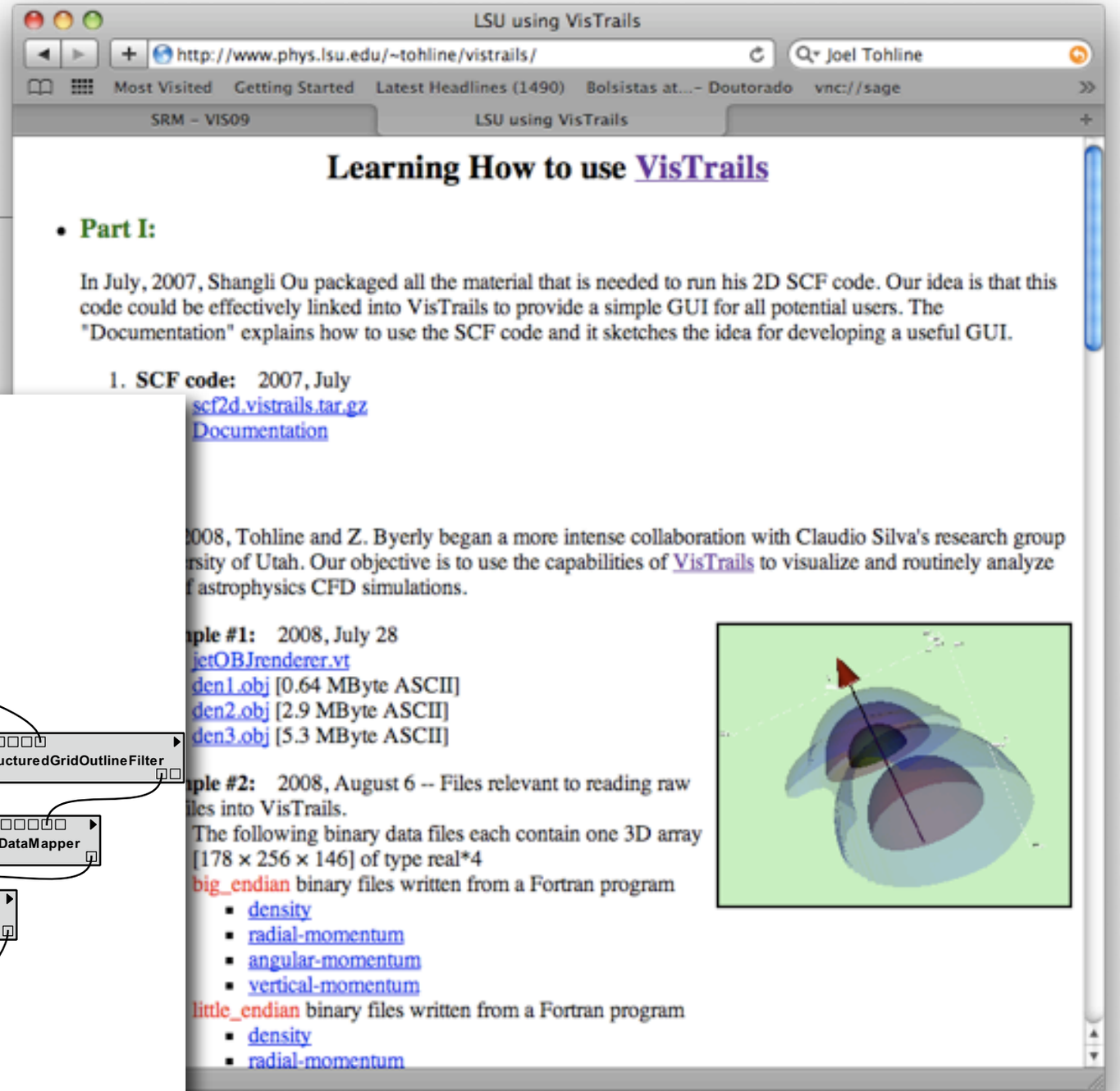
What is the best measure of the true orbital period of the binary system?

Using VisTrails

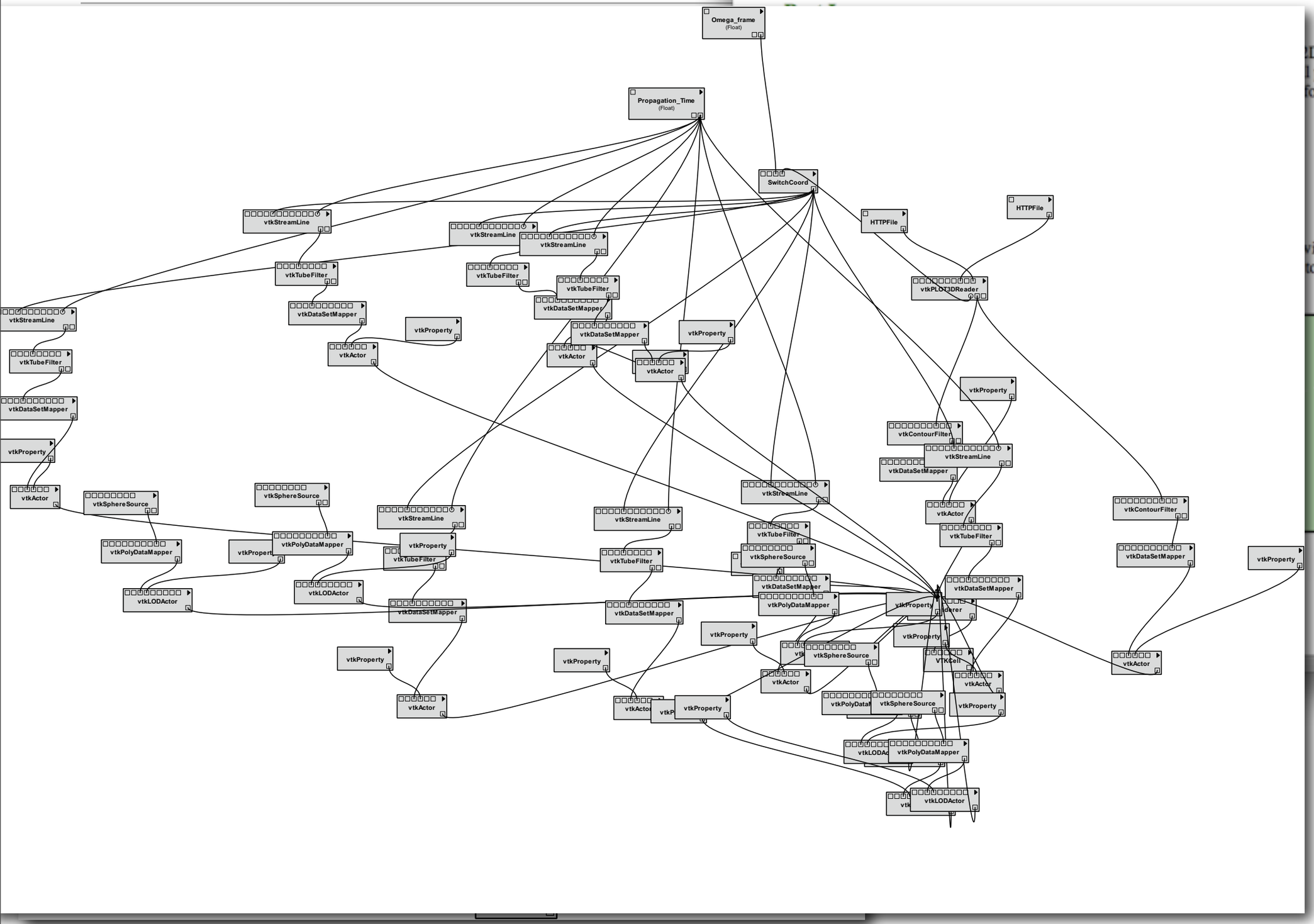


Using VisTrails

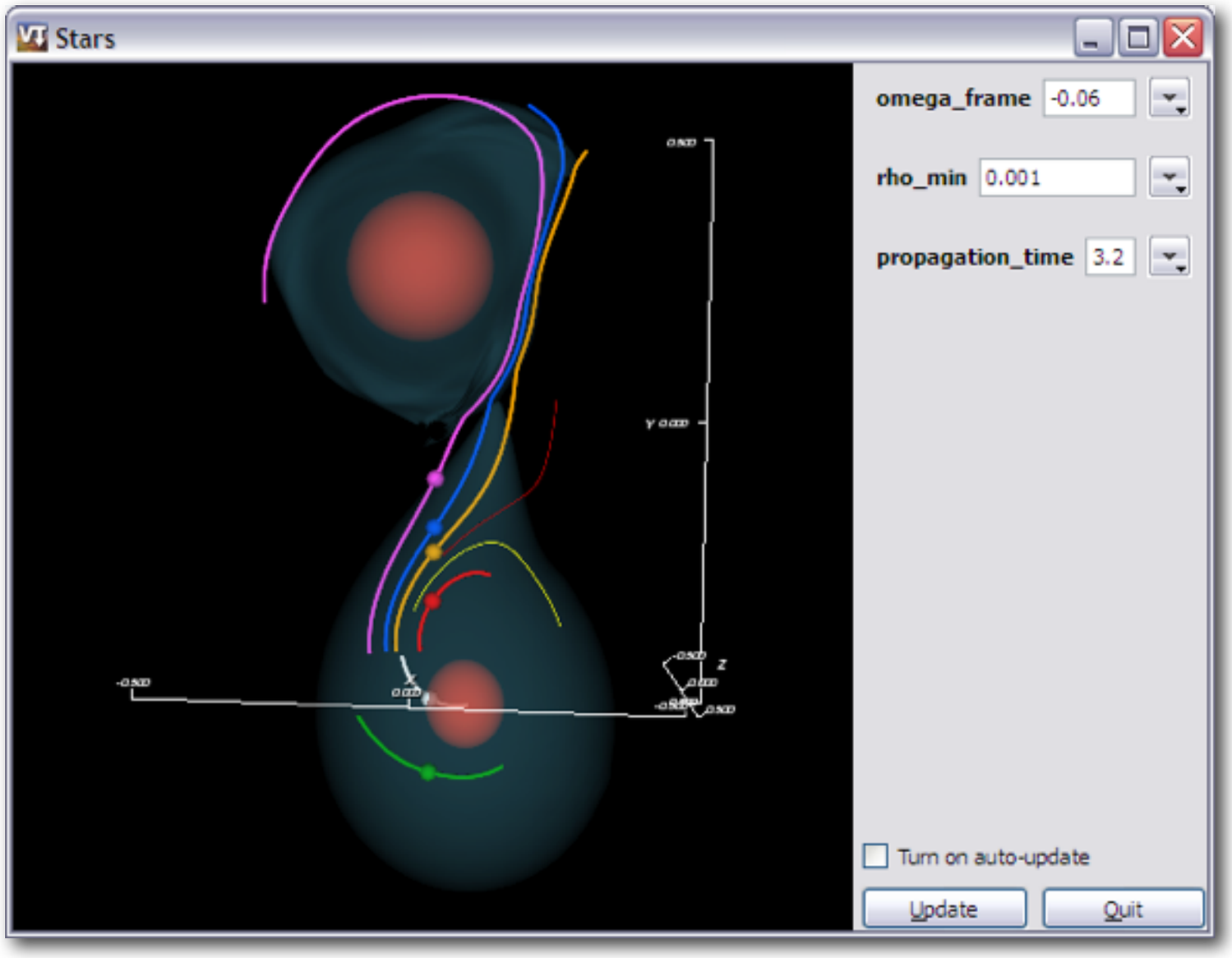




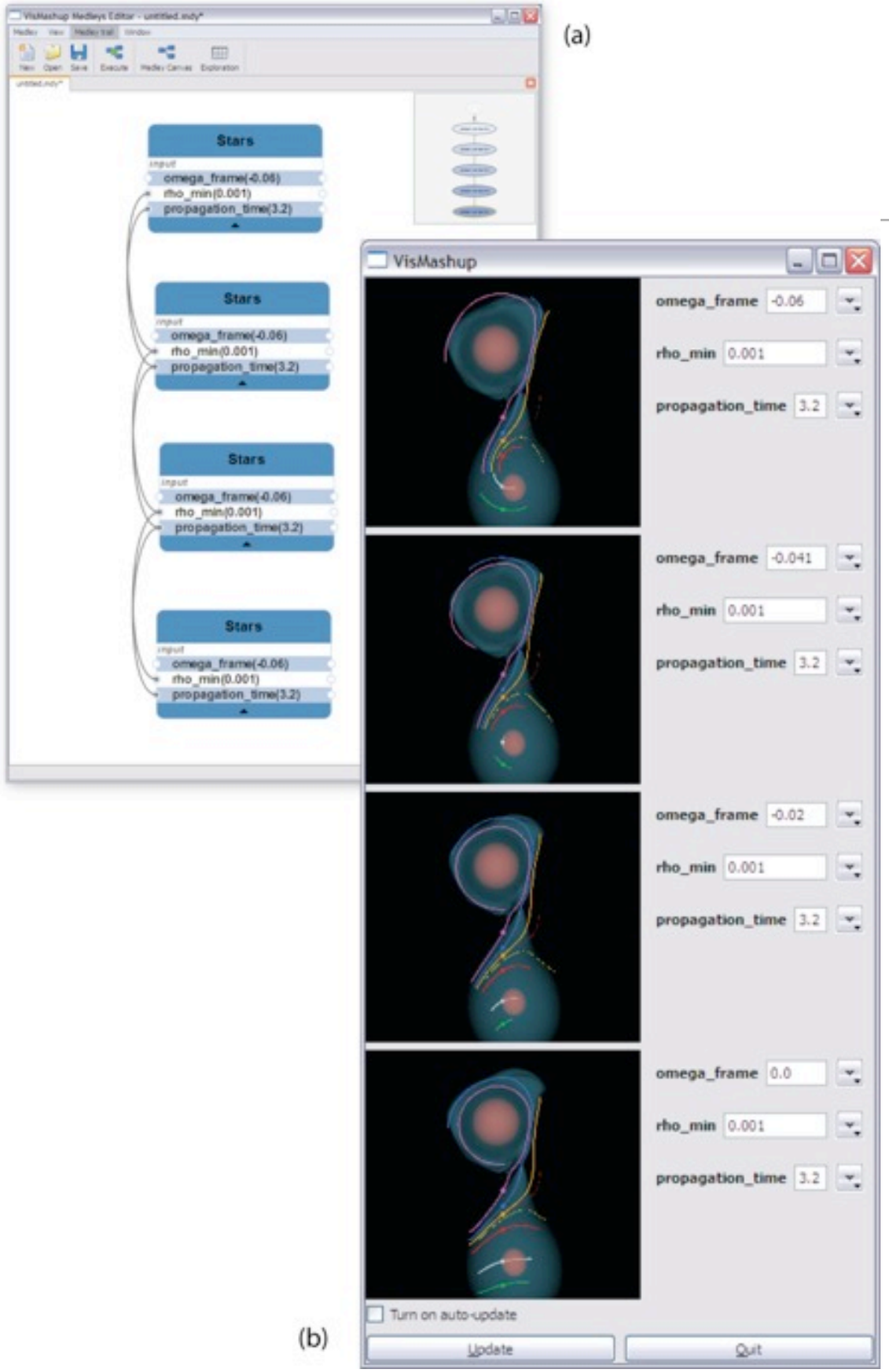
Using VisTrails



Using VisMashups



Using VisMashups



Video

Limitations

- Visualization systems must provide:
  - access to pipeline specifications
  - ability to identify and change pipeline components
  - ability to execute pipelines
- The produced mashups are not a substitute for more comprehensive, domain-specific applications such as CDAT
- The integration of different libraries can sometimes be complicated by a number of practical issues (GUI toolkit)
- Automatic layout does not guarantee the most appropriate and intuitive interface is created

Conclusions and Future Work

Lots of work to do! (-:

- VisMashup simplifies the creation of custom visualization applications
  - Developers can quickly assemble custom applications, leveraging an existing collection of visualization pipelines and their provenance
- Evaluation of effectiveness and usability
- Explore more sophisticated techniques for mining pipeline collections
- Build mashups collaboratively

Acknowledgments

CAPES

Thanks to Joel Tohline for the Astrophysics case study