Provenance Challenge 3: VisTrails

University of Utah

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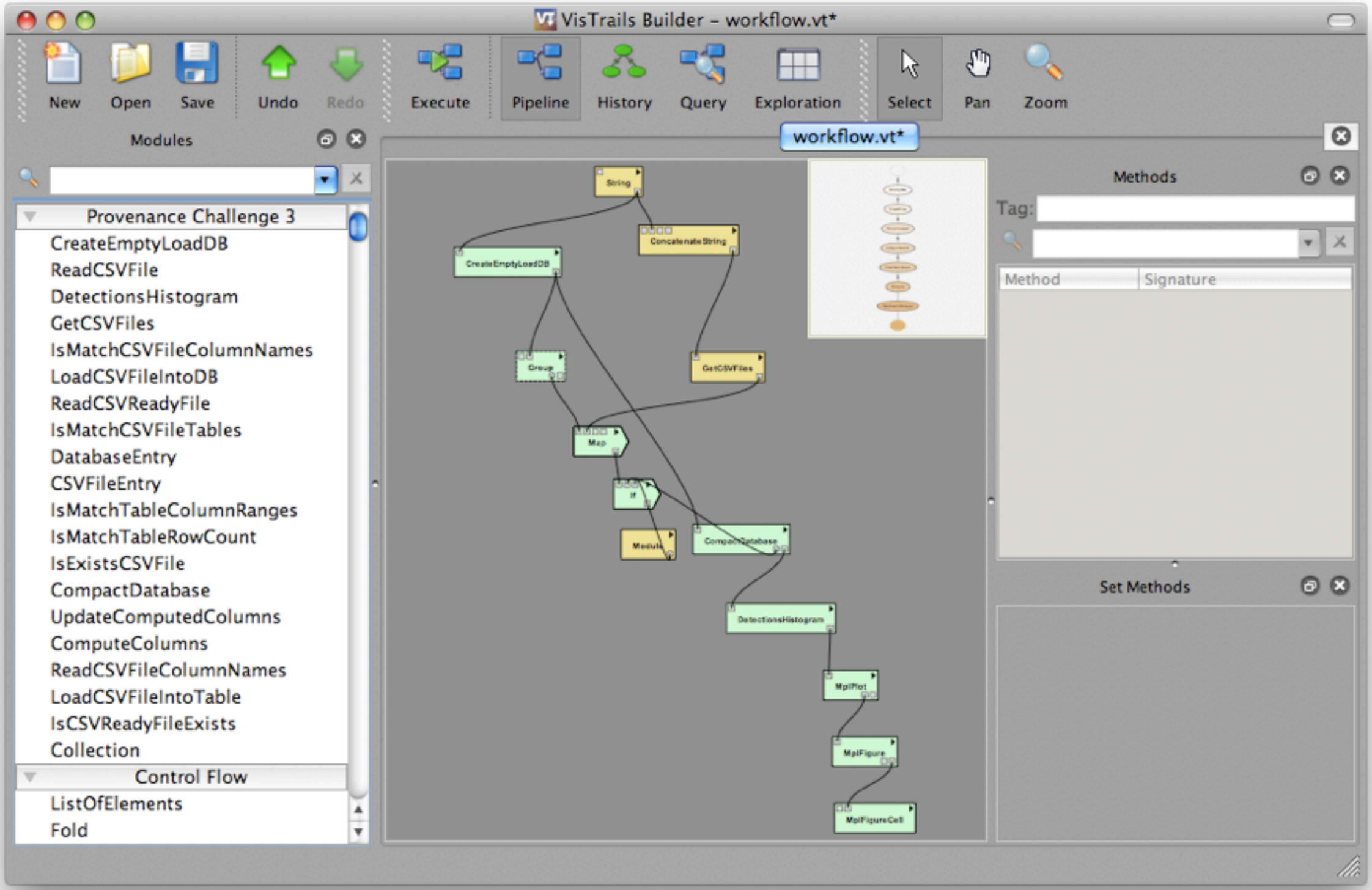
Workflow Implementation



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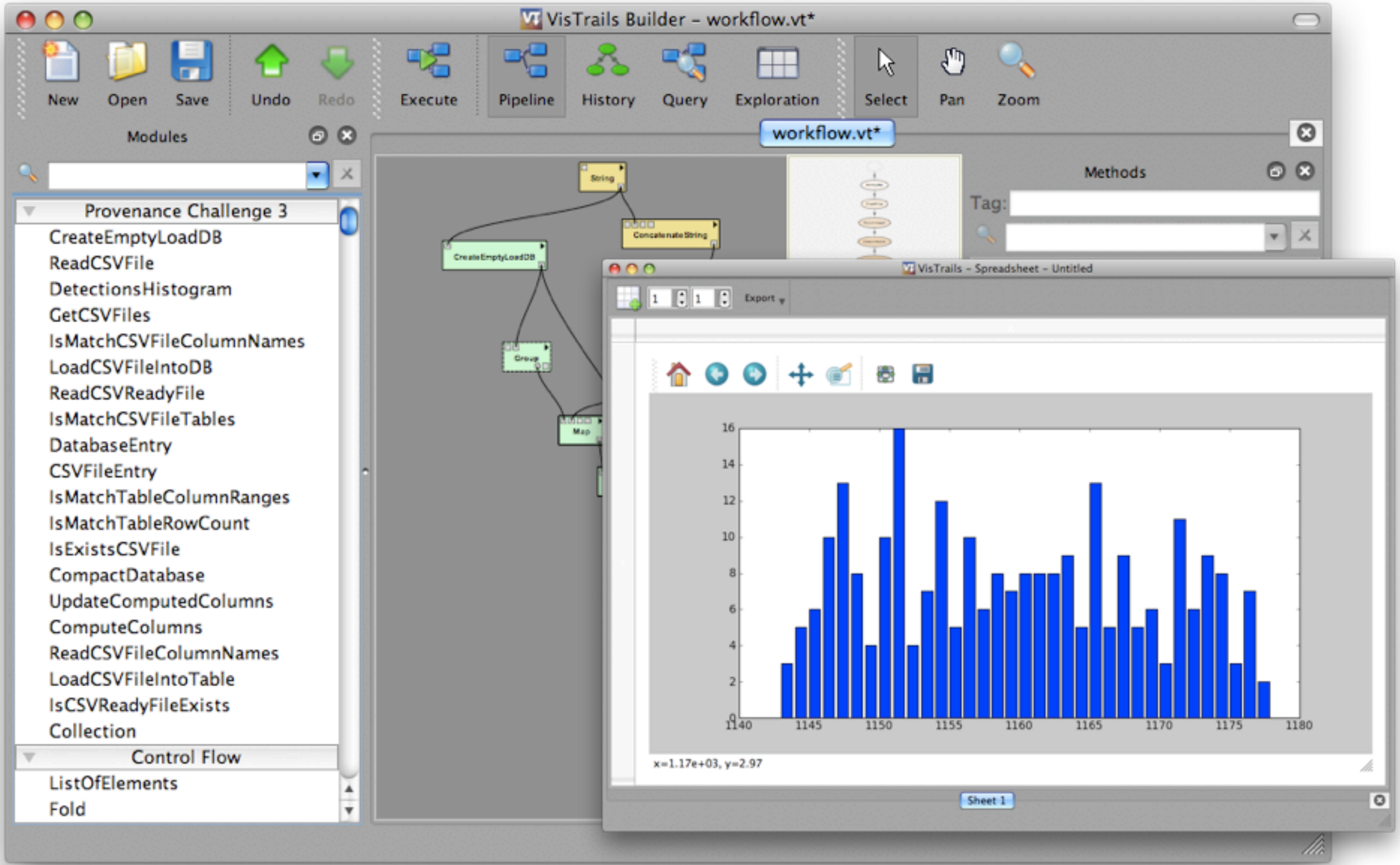

Workflow Implementation

- Rewrote LoadAppLogic code python and MySQL
- Wrapped functions as modules and placed in a new VisTrails package; also added new modules that encapsulate multiple fns
- If-error-then-halt steps automatically handled through ModuleErrors raised by the workflow
- Loops, conditionals supported by VisTrails Control Flow package

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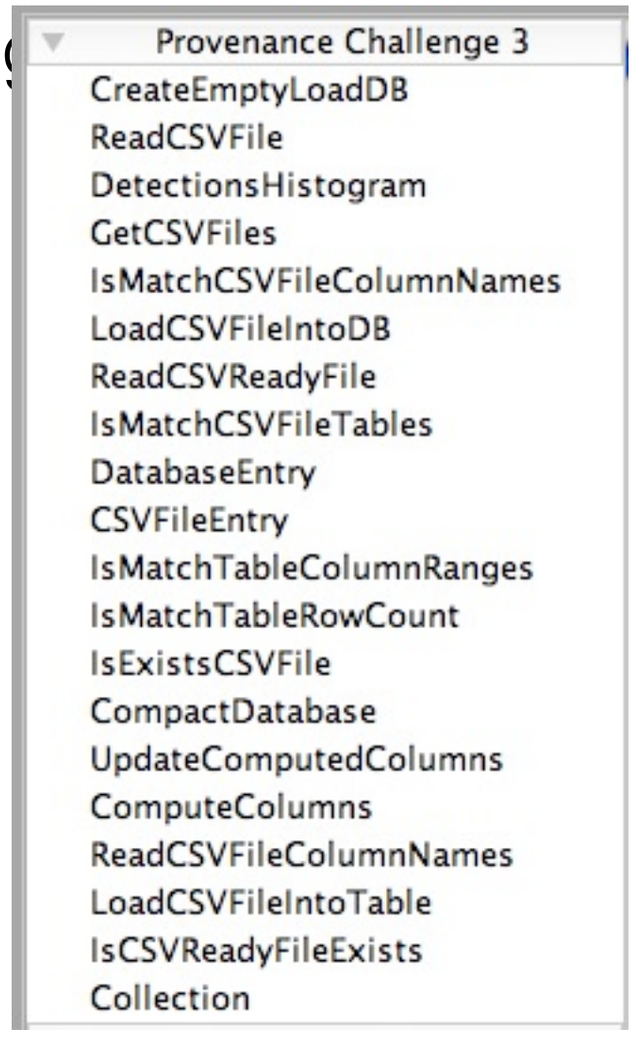

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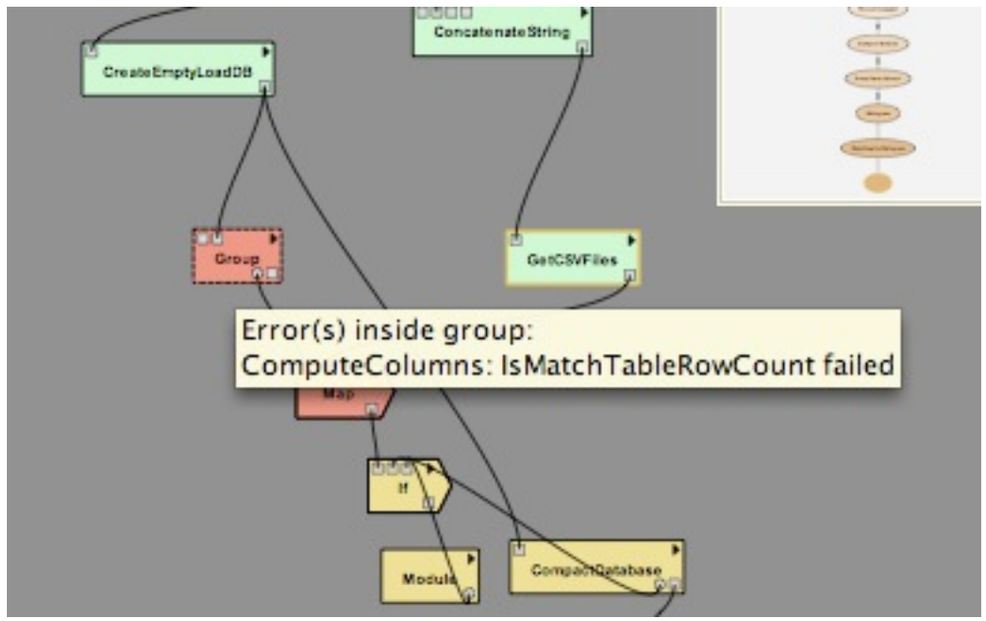

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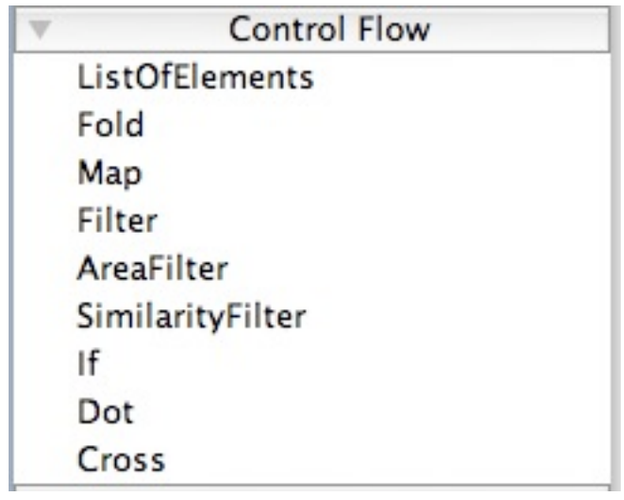
Control Flow

- New package (Fernando Seabra and Rafeal Dahis, UFRJ)
- Fold operations: generalize map-reduce (input collecton + subworkflow)
- Combine operation and list of inputs
- Given finite data collections, workflow will not have infinite loops
- Conditionals: two subworkflows as well as a boolean input
- Control flow modules execute subworkflows as part of their own execution



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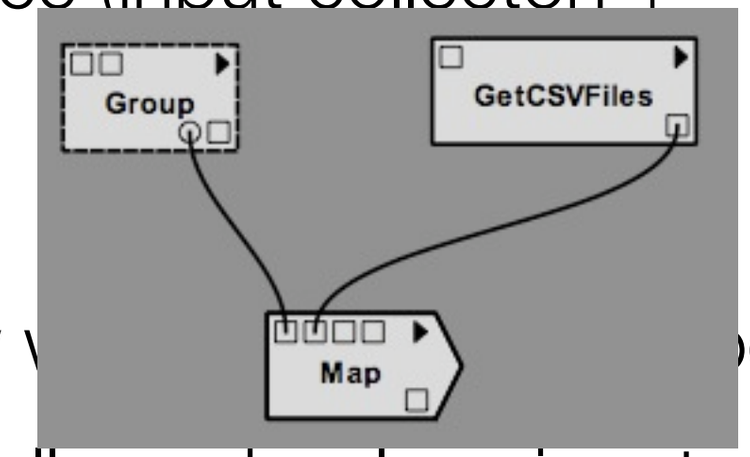

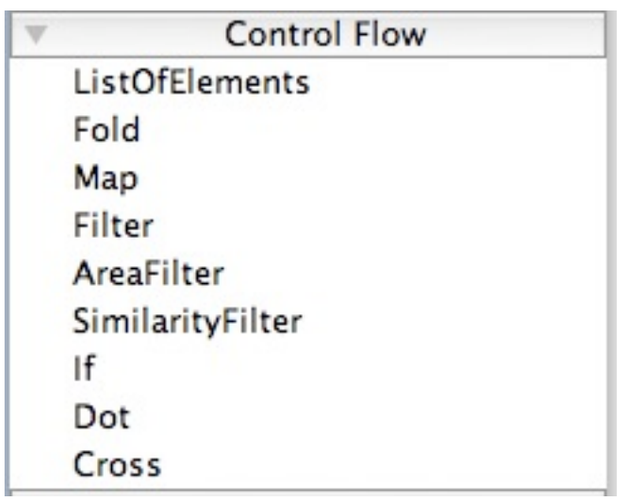

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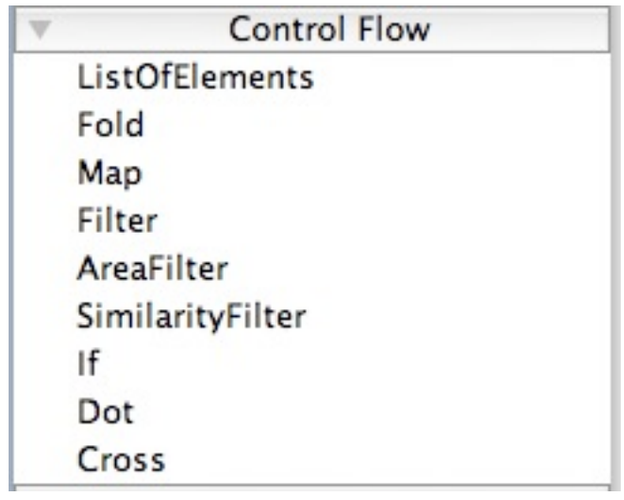

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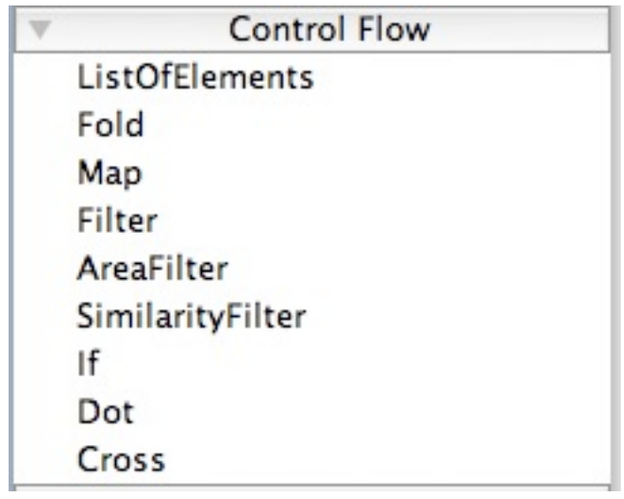
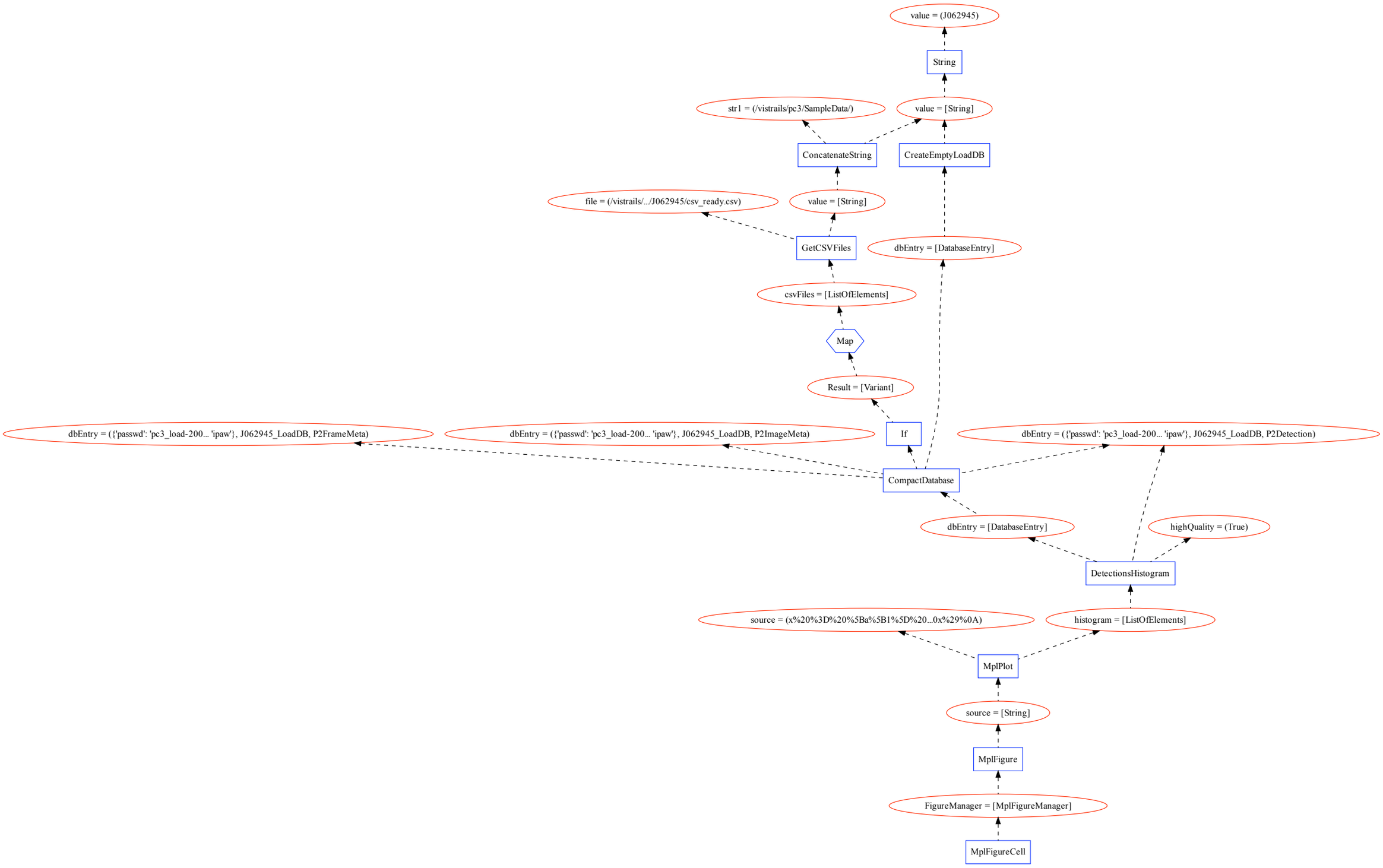


OPM Implementation

- VisTrails produces layers of provenance: workflow evolution, workflow instantiation, and workflow execution
- Execution information is hierarchical (groups, loops)
- OPM is translated from this provenance by combining information from these layers
- OPM is captured as XML using Southampton's XML Schema
- `value` elements store VisTrails entities

OPM Graph


value = (J062945)
String
str1 = (/vistrails/pc3/SampleData/)
value = [String]
ConcatenateString
CreateEmptyLoadDB
file = (/vistrails/.../J062945/csv_ready.csv)
value = [String]
GetCSVFiles
dbEntry = [DatabaseEntry]
csvFiles = [ListOfElements]
Map
Result = [Variant]
dbEntry = ({'passwd': 'pc3_load-200... 'ipaw'}, J062945_LoadDB, P2FrameMeta)
dbEntry = ({'passwd': 'pc3_load-200... 'ipaw'}, J062945_LoadDB, P2ImageMeta)
If
dbEntry = ({'passwd': 'pc3_load-200... 'ipaw'}, J062945_LoadDB, P2Detection)
CompactDatabase
dbEntry = [DatabaseEntry]
highQuality = (True)
DetectionsHistogram
source = (x%20%3D%20%5Ba%5B1%5D%20...0x%29%0A)
histogram = [ListOfElements]
MplPlot
source = [String]
MplFigure
FigureManager = [MplFigureManager]
MplFigureCell

OPM

- Module executions map to **processes**

```
<process id="p2">
  <value>
    <moduleExec cached="0" completed="1" error="" id="3" machine_id="1"
moduleId="2" moduleName="GetCSVFiles" tsEnd="2009-05-14 16:51:46"
tsStart="2009-05-14 16:51:46">
      <annotation id="1" key="used_files" value="[&apos;/vistrails/pc3/
SampleData/J062945/csv_ready.csv&apos;]" />
    </moduleExec>
  </value>
  <account id="acct0" />
  <account id="acct1" />
  <account id="acct2" />
</process>
```

OPM

- Input Parameters (functions) map to **artifacts**

```
<artifact id="a0">
  <value>
    <function id="4" name="value" pos="0">
      <parameter alias="" id="17" name="&lt;no description&gt;" pos="0"
type="edu.utah.sci.vistrails.basic:String" val="J062945" />
    </function>
  </value>
  <account id="acct0" />
  <account id="acct1" />
  <account id="acct2" />
</artifact>
```

OPM

- Annotations map to **artifacts**
  - Save extra information (ie database connection, table names)

```
<artifact id="a35">
 <value>
  <function id="-1" name="dbEntry" pos="0">
   <parameter alias="" id="-1" name="" pos="0"
type="edu.utah.sci.vistrails.basic:String" val="..." />
   <parameter alias="" id="-1" name="" pos="0"
type="edu.utah.sci.vistrails.basic:String" val="J062945_LoadDB" />
   <parameter alias="" id="-1" name="" pos="0"
type="edu.utah.sci.vistrails.basic:String" val="P2Detection" />
  </function>
 </value>
 <account id="acct0" />
 <account id="acct1" />
 <account id="acct2" />
</artifact>
```

OPM

- Connections can be mapped to **artifacts**
  - Transient data: not persisted but exists to show that data was generated and used
  - Output port information captured in provenance

```
<artifact id="a1">
  <value>
    <portSpec id="8" name="value" optional="0"
sigstring="(edu.utah.sci.vistrails.basic:String)" sortKey="-1" type="output" />
  </value>
  <account id="acct0" />
  <account id="acct1" />
  <account id="acct2" />
</artifact>
```

OPM

- Subworkflow executions captured as more specific **accounts**

```
<process id="p17">
  <value>
    ...
  </value>
  <account id="acct2" />
</process>
```

OPM

- Dependencies are generated from workflow specification
  - module functions connected to modules via **used**
  - modules connected to output ports via **wasGeneratedBy**
  - output ports connected to modules via **used**
  - annotations connected to modules via **used** or **wasGeneratedBy**

OPM Queries

- Querying OPM XML was implemented via XQuery.
- Use three transitivity functions:
  - **derivedFrom**: determine all upstream processes that may have contributed the given artifact
  - **triggeredBy**: determine all upstream processes that may have triggered the given process
  - **triggers**: determine all downstream processes that may have been triggered by the given process
- Use database to determine links between existing data and provenance information about that data

Query Example

```
declare namespace opm='http://openprovenance.org/model/v1.01.a';
let $d := doc('workflow_opm2.xml')

(: The user must find the detection value in the DB. Then we find the table artifact :)
let $a := $d//artifact[value/function/parameter/@val = 'P2Detection']

(: return all artifacts upstream containing a P2Detection.csv file :)
return local:derivedFrom($d, $a)[ends-with(value/function/parameter/
@val,'P2Detection.csv')]
```

Importing OPM

- Have XQuery methods to deal with OPM XML data
- Try to make queries the same across systems
- Tested with SDSC OPM in XML with success
- Changes:
  - Identifying processes, artifacts

Discussion

- Locating OPM entities can be difficult
  - No standard naming to define ids with meaningful names
  - `value` field is not easily searched without understanding the schema of that element
- Queries involved database provenance or attempts to obtain granularity finer than the workflow
- Side effects: database entry is provided as input but the function specification shows no change to the underlying database
- Workflow evolution in OPM