Porgy Documentation

Release 2.0

Tulip Team

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PORGY is an interactive visual environment, based on Tulip, for modelling complex systems through graphs and graph rewriting rules. Graph rewriting systems appear as a powerful formalism to capture and study phenomena occurring in complex systems, such as the evolution of bio-molecular networks, adhoc communication networks or interaction nets.

CHAPTER

ONE

PORGY USER INTERFACE

This section describes the **Porgy** user interface. If you need some additional information on an element move the cursor on it and press **F1** on Windows or Linux and the help key on Mac to gain access to the help page.

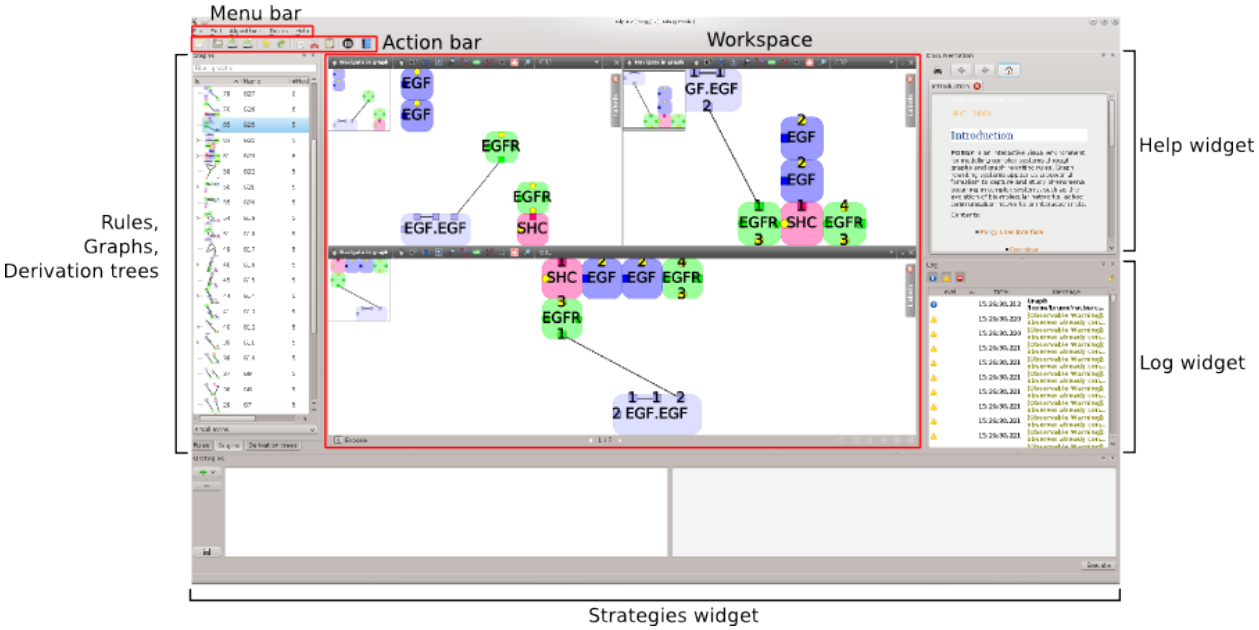


Figure 1.1: Overview of the *Porgy* interface

1.1 Menu

- **File: Contains the usual file operations, see the Tulip user manual for additional information about this menu.**
  - **New**: Clear the current session and create a new empty one.
  - **Open**: Open a saved session.
  - **Save**: Save the current session.
  - **Save As**: Save the current session in a new file.
  - **Exit**: Quit the software.
- **Edit:**

  - **Undo**: Undo the last operation.
  - **Redo**: Redo the last undo operation.
  - **Copy**: Copy the selected portnodes and edges from the active view to the clipboard. *This option is only available if the active view is a Rule view or a graph view.*
  - **Cut**: Cut the selected portnodes and edges from the active view. *This option is only available if the active view is a Rule view or a graph view.*
  - **Paste**: Paste the portnodes and the edges from the clipboard to the active rule view. *This option is only available if the active view is a Rule view or a graph view.*
  - **Select all**: Clear the selection then add the portnodes and the edges present in the active view.
  - **Deselect all**: Clear the selection.
  - **Invert selection**: Invert the selection. Selected elements become unselected and unselected become selected.
  - **Delete selection**: Delete portnodes and edges selected in the active view. *This option is only available if the active view is a Rule view or a graph view.*
  - **Property manager**: Allows users to select the properties to use during rewriting operations as matching parameters (for more information, consult *Property Manager*).
- **Algorithm: Allows the user to compute and apply algorithm.**
  - **Measure**: Compute and assign a value to the 'viewMetric' property of graph elements. For example, when running the 'Portnode's degree' algorithm, the degree (the number of neighbors) is computed and stored, for each portnode, into its 'viewMetric' property.
  - **Selection**: Selects nodes and/or edges based on advanced criteria. (Selecting means assigning the 'viewSelection' property).
  - **General**: Contains all the base porgy algorithms. This menu is made for an advance use of Porgy.
- **Docks**: Allows to show and hide dock widgets in the Porgy user interface.
- **Windows**: Manages the sub-windows of the view window.
- **Help**: Gives access to this documentation.

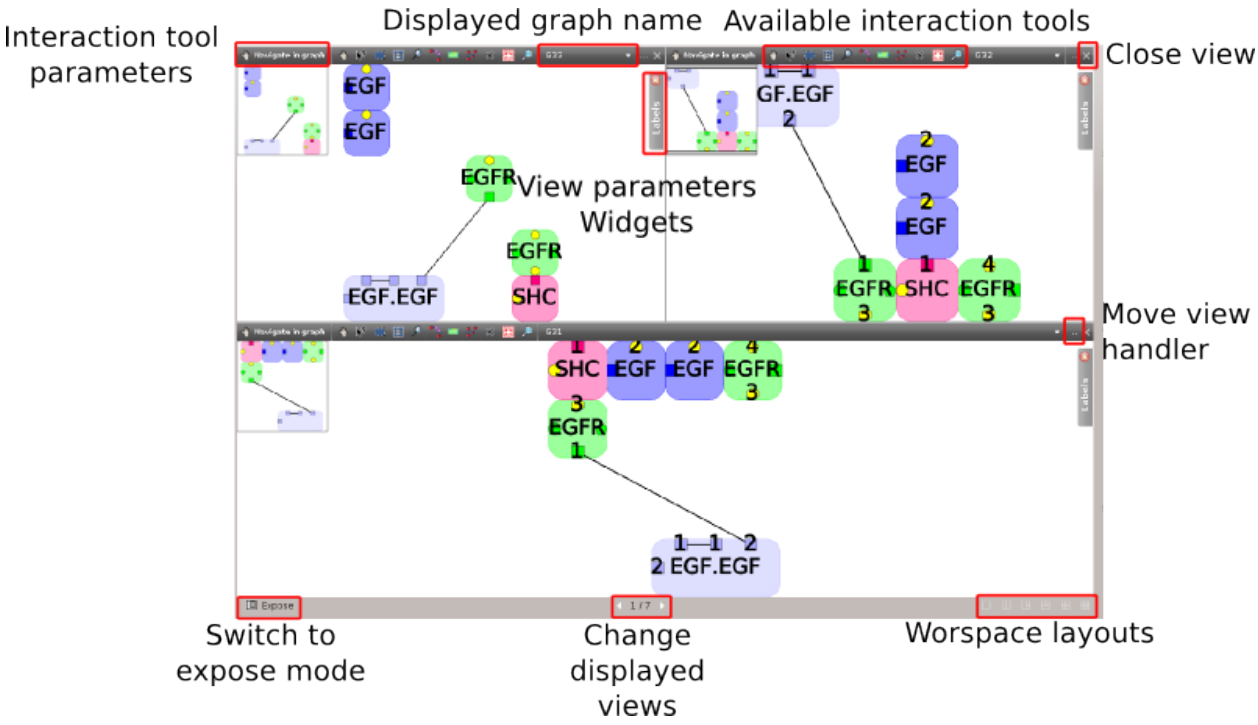
1.1.1 Toolbar

- **New**: Clear the current session and create a new empty one.
-  **Open**: Open a saved session.
-  **Save**: Save the current session.
-  **Save As**: Save the current session under a specific name.
-  **Undo**: Undo the last operation.
-  **Redo**: Redo the last undo operation.
-  **Copy**: Copy the selected portnodes and edges from the active view to the clipboard. *This option is only available if the active view is a Rule view or a graph view.*

- **Cut**: Cut the selected portnodes and edges from the active view. *This option is only available if the active view is a Rule view or a graph view.*
- **Paste**: Paste the portnodes and the edges from the clipboard to the active rule view. *This option is only available if the active view is a Rule view or a Graph view.*
- **Snapshot**: Take a snapshot of the current view.
- **Help**: Show the help widget.

1.2 Workspace/Views

The workspace is the central place where the visualizations are displayed. Every time a graph, a rule or a derivation tree is opened, its corresponding view will be displayed in this space. If one or more views are already present in the workspace, the new one will be set in the last position. More information concerning the specific views can be found in *Presentation of the views*.



1.2.1 Navigating into the views

There is different ways to switch the views displayed in the workspace:

- **Change the workspace layout:** using the control buttons located at the bottom-right of the workspace, you can change the number of views displayed at a same time. Some layouts are only available when enough views are opened simultaneously and the required number of views is reach. By default only one view is displayed at once.

- **Switch displayed views:** the current view can be changed by clicking on the left or right arrow buttons located at the bottom of the workspace.
- **Use the Expose mode:** click on the expose button at the bottom left of the workspace to switch to the *Expose mode*. In this mode, each view is represented by a preview and can reordered by drag and dropping.
- **Reorder the views in the workspace:** drag and drop the view using the move view handler located in the top-right corner of each view.

1.2.2 Configuring a view

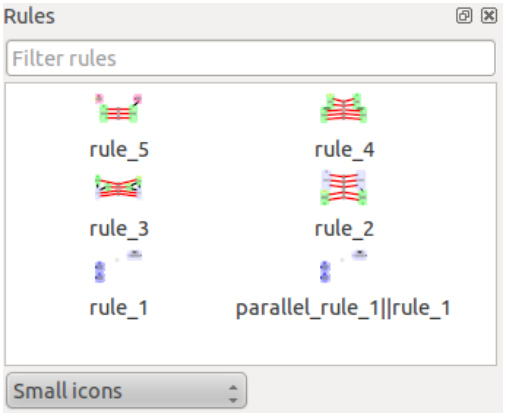
The list of the configuration widgets for each view appear in as tabs at the top-right corner of each view. To edit those parameters, just click on a tab to expand the configuration widget. Click on the small cross in the tab to close the opened widget.

1.2.3 Changing the current interaction tool

To select an interaction tool just click on the icon of the interaction tool you want in the list. The current interaction tool button will be updated with the tool name and icon.

Some interaction tools can be configured by clicking on the interaction tool button at the top left side of the view toolbar. The configuration widget will pop up. If the interaction tool cannot be configured a short description of the tool will appear. To close the configuration widget click again on the current interaction tool button.

1.3 Rule widget



Click on **Rules** tab to access to the Rules management widget. Here one can create, visualize and destruct rules. Use the text line at the top of the widget to filter rules using rule names.

There is four preview mode :

- **List**: Display the rules in a list without any preview
- **Small icons**: Rules are shown using a small preview icon.
- **Medium icons**: Intermediate sized icons.
- **Large icons**: Enlarged rule previews.

To display an even bigger preview of a rule, hover it with your mouse cursor and wait a second.

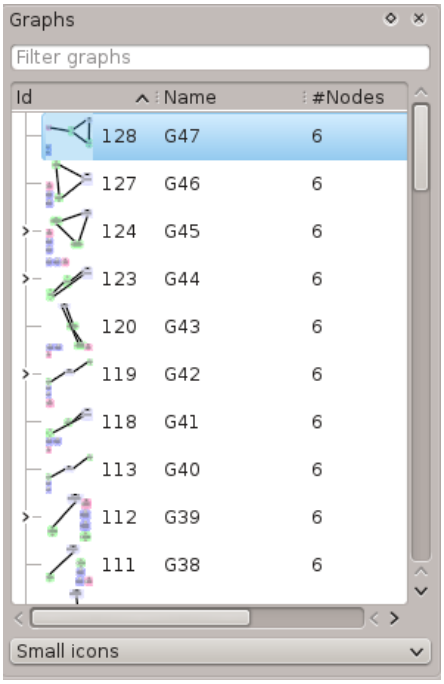
1.3.1 Contextual menu

By right-clicking in the rule widget, a menu appear offering the following options:

- **Show** : A rule must be selected to enable this action. Displays a visualization/edition view for the selected rule. One can also double click on the rule or drag and drop the view on the workspace to display it.
- **Create new** : Create a new empty rule.
- **Rename** : Rename the hovered rule.
- **Clone** : A rule must be selected to enable this action. Clone the selected rule, i.e create a copy of the rule with the same port nodes and the same values.
- **Delete** : A rule must be selected to enable this action. Delete the rule. If the rule is used in an existing graph it cannot be deleted.
- **Import** : Open a file browser window allowing to import one or several rules previously exported (files must have the appropriate extension: *x.porgy.rule*).
- **Export** : Independently save the currently hovered rule for later import.

More information concerning the Rule view is available in the *Rule View* section.

1.4 Graph widget



Click on **Graphs** tab to access to the graphs management widget. Use the text line at the top of the widget to filter them using names.

There is four preview modes:

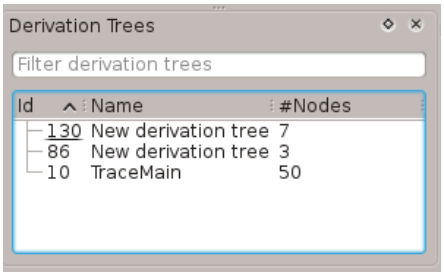
- **No icons**: Do not display previews.
- **Small icons**
- **Medium icons**

- **Large icons**

To display a larger preview, hover one of the graphs in the list. After a moment, a tool-tip with a larger preview will appear. You can display a visualization/edition view for a graph by double clicking on it or by dragging it and dropping it on the workspace.

More information concerning the Graph view is available in the *Graph View* section.

1.5 Derivation tree widget



Click on **Derivation Trees** tab to access to the Derivation Trees management widget. Use the text line at the top of the widget to filter derivation trees using names. You can display a visualization/edition view by double clicking on it or by dragging it and dropping it on the workspace. There is several kinds of visualizations (see the views section for more information on Porgy views).

- **Derivation Tree view**: This is the general visualization for derivation trees.
- **Scatter plot 2D view**
- **Histogram view**
- **Small multiple view**

To rename a derivation tree select it and click with the left button on the it's name. Input the new name then press return to validate the new name. If you press the escape button the edition will be canceled.

1.5.1 Contextual menu

A right-click on the existing derivations will propose the following options:

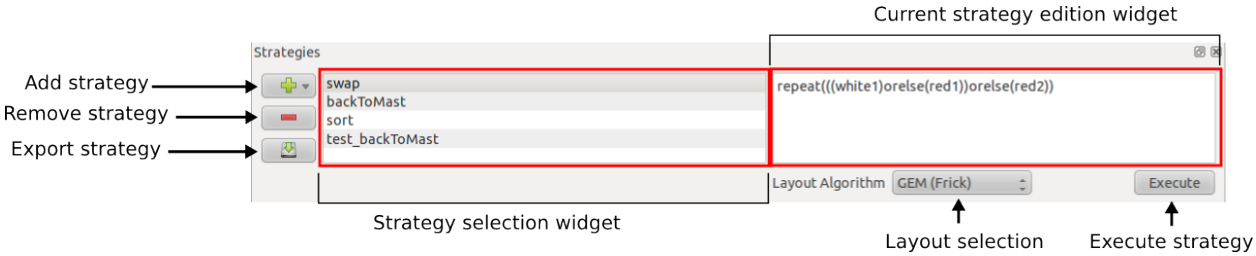
- **Show** : Create a visualization/edition view on the workspace. One can also double click on the rule or drag and drop a list element on the workspace to display it.
- **Create new** : Create a new derivation tree based on the graphs selected in the main derivation tree.
- **Delete** :Destruct the selected element. One cannot delete the main derivation tree.

More information concerning the derivation tree view is available in the *Derivation Tree view* section.

1.6 Strategy widget

This widget handle all the strategies' management actions.

- **Add strategy :**
  - **Create an empty strategy**



  - **Strategy from derivation tree** : try to compute the strategy from the selected graph elements in the main derivation tree.
  - **Import from a file** : load a strategy from a file. The new strategy will have the name of the file loaded without the file extension.

- **Remove strategy**: remove the selected strategy
- **Export strategy** : save the selected property on the disk.

1.6.1 Edition

When selecting a strategy by clicking on its name in the widget, its code appear in the editor on the right. From here, instructions can be typed to specify in details how the rules can be applied. A complete syntax and set of instruction exist and the entire grammar can be consulted in details in the following section.

1.7 Log widget

This widget will display the information, warning and error messages send by porgy.

CHAPTER

TWO

PRESENTATION OF THE VIEWS

You will find here additional information on each of the views available in Porgy.

2.1 Rule View

This is the visualization/edition view for all the rules.

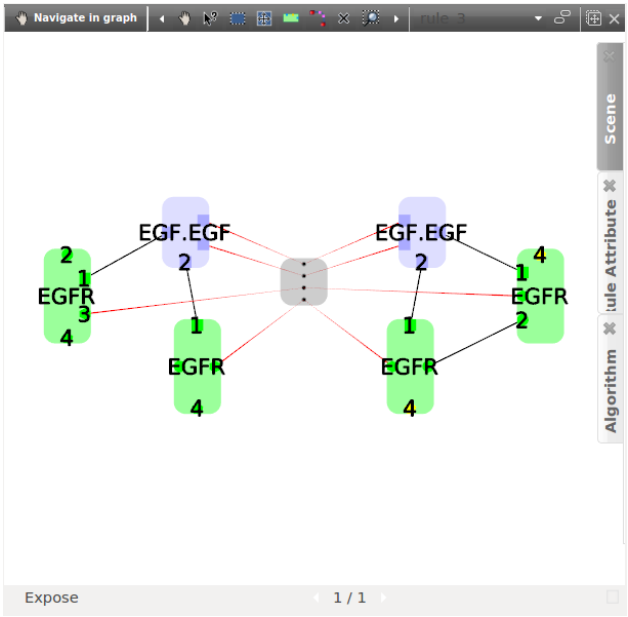


Figure 2.1: The *Rule view* allows to create, customize and visualize rewriting rules

2.1.1 Interaction tools

You will find in it the following interactors:

- **Navigation**: move, rotate and zoom the view. Zooming behavior: the point under the cursor is moved closer to the center.
- **Get information**: click an element (portnode or edge) and Porgy displays all available properties of that element in the properties widget.

-  **Rectangle selection**: select all elements touching the selection box (the previous selection is replaced, but can be recovered with Undo). With Shift, the newly selected elements are added to the current selection; with Ctrl (Alt on Mac), the selected elements are removed from the current selection.
-  **Selection edition**: modify the shape and position. Shift-click modifies only coordinates. Ctrl-click modifies only size. Left-click outside the selection resets the selection.
-  **Edit edge bends**: click on an edge to select it (with this tool), then Shift-click to add a new bend, click a bend to move it, or Ctrl-click (Alt on Mac) to remove a bend.
-  **Add portnodes**: allow the user to create,edit and add portnodes. Edges can also be added between ports only by clicking the source node first then the target node. Optionally bends may be added by clicking outside of a node.
-  **Delete element**: click a portnode or edge to delete it.

2.1.2 Configuration

The following options can be customized using the tab on the right-side of the view:

- **Scene**: identical to the options available in **Tulip**; allows to customize the view.
- **Rule Attribute: contains all the specific options of the current rule**
  - *Layout algorithm*: select the layout algorithm to perform on the rewritten graph after applying this very rule.

2.1.3 Contextual menu

Perform a right-click (**Ctrl**-click Mac) to display this menu:

- **Center view**: move the camera the view all the elements.
- **Redraw**: redraw the rule and center the view.
- **Take snapshot**: open the screenshot tool.
- **Selection**: allows you to select specific parts of the rule.

2.2 Graph View

This is the visualization/edition view for graphs.

2.2.1 Interaction tools

You will find in it the following interactors:

-  **Navigation**: move, rotate and zoom the view. Zooming behavior: the point under the cursor is moved closer to the center.

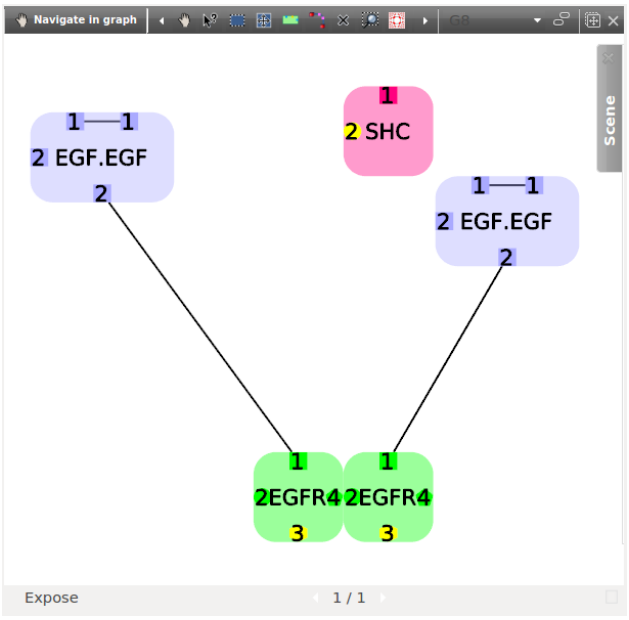


Figure 2.2: The *Graph view* is used to display the different graphs and states of the derivation tree. The view also allows first the creation then the edition of the states elements.

- **Get information**: click an element (portnode or edge) and Porgy displays all available properties of that element.
- **Rectangle selection**: select all elements touching the selection box (the previous selection is replaced, but can be recovered with Undo). With Shift, the newly selected elements are added to the current selection; with Ctrl (Alt on Mac), the selected elements are removed from the current selection.
- **Selection edition**: modify the shape and position. Shift-click modifies only coordinates. Ctrl-click modifies only size. Left-click outside the selection resets the selection.
- **Edit edge bends**: click on an edge to select it (with this tool), then Shift-click to add a new bend, click a bend to move it, or Ctrl-click (Alt on Mac) to remove a bend.
- **Add portnodes and edges**: allow the user to create,edit and add portnodes. Edge can also be added by clicking the source node then the target node. You can only add edge between two ports.
- **Delete element**: click a portnode or edge to delete it.

2.2.2 Configuration

The following options can be customized using the tab on the right-side of the view:

- **Scene**: identical to the options available in **Tulip**; allows to customize the view.

2.2.3 Contextual menu

Perform a right-click (**Ctrl**-click Mac) to display this menu:

- **Center view**: move the camera to visualize all the ports in the graph.
- **Redraw**: redraw the graph and center the view. You can choose between a force drawing algorithm (GEM (Frick)) or a hierarchical drawing algorithm (Sugiyama (OGDF))
- **Take snapshot**: open the screenshot tool.
- **Save selection**: allow the user to save the current selection in a new local property or in an existing one. Click on **New property** and input the name of the new property to create a new property. To erase an existing one just click on the name of the property to replace. This is useful to create P and Ban properties.
- **Restore selection**: allow the user to replace the current selection by the selected property.

2.3 Derivation Tree view

This is the base view for derivation trees. Displays the graphs present in a derivation tree as a hierarchy. Each edge between two graphs represents the transformation of the source to the destination. A transformation can be an application of a rule (simple rule), an application of a strategy or a modification of the *P* property (Set position).

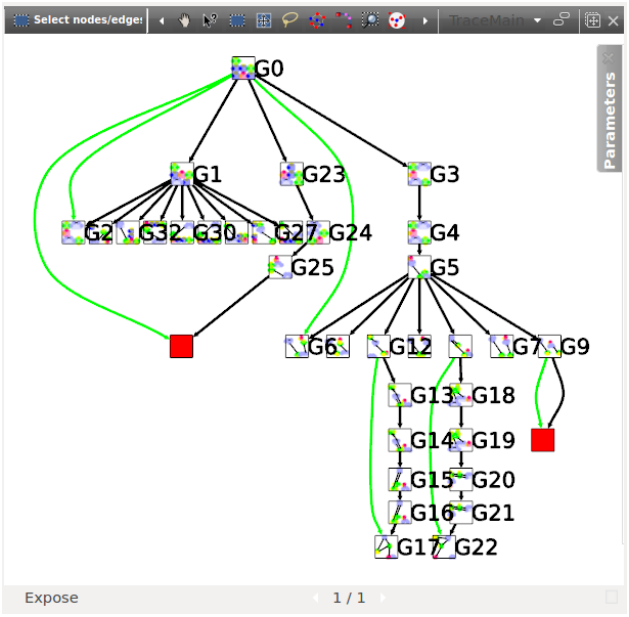


Figure 2.3: The *Derivation tree* view keeps a complete trace of all user operations and can be used to explore the evolution of the graphs after rewriting.

2.3.1 Interaction tools

You will find in it the following interactors:

-  **Navigation**: move, rotate and zoom the view. Zooming behavior: the point under the cursor is moved closer to the center.
-  **Get information: click an element (portnode or edge) and Porgy displays all available properties of that element.** If you hoover an edge it will display the transformation information as a tool tip and it will highlight portnodes involved in this transformation. Here is the color code used when highlighting portnodes

involved in a transformation: * Simple rule: LHS portnodes are in red and RHS are in blue. * Set position: portnodes that are only in the original *P* property are in red, portnodes only in the new *P* property are in blue and portnodes in both old and new are in green.

-  **Rectangle selection**: select all elements touching the selection box (the previous selection is replaced, but can be recovered with Undo). With Shift, the newly selected elements are added to the current selection; with Ctrl (Alt on Mac), the selected elements are removed from the current selection.
-  **Zoom box**: draw a rectangle and zooms on this area.
-  **Open in a new graph view**: click on a graph and it will be displayed a new view.
-  **Selection edition**: modify the shape and position. Shift-click modifies only coordinates. Ctrl-click modifies only size. Left-click outside the selection resets the selection.
-  **Edit edge bends**: click on an edge to select it (with this tool), then Shift-click to add a new bend, click a bend to move it, or Ctrl-click (Alt on Mac) to remove a bend.

2.3.2 Configuration

The following options can be customized using the tab on the right-side of the view:

- **Parameters**:
  - *Labels*: choose whether you wish to display the nodes or meta-nodes labels.
  - *Rendering parameters*: allows you to enable the edge size interpolation or to scale each label size according to their node size.

2.3.3 Contextual menu

Right-click (**Ctrl**-click Mac) to display this menu:

- **Center view**: move the camera the visualize all the elements in the derivation tree.
- **Redraw**: redraw the derivation tree and center the view.
- **Take snapshot**: open the screenshot tool.
- **Show Overview**: toggle top left overview

If a graph is present under the cursor some other options are available:

- **Open in a new graph view**: show the graph under the pointer in a new view.
- **Add to/Remove from the selection**: if the graph is present in the current selection remove it else add it.

2.4 Additional trace views

2.4.1 Scatter plot 2D View

This view allows to create 2d scatter plots of graph nodes from graph properties (supported types are Metric and Integer). A scatter plot is a type of mathematical diagram using Cartesian coordinates to display values for two variables for a set of data. The data is displayed as a collection of points, each having the value of one variable

determining the position on the horizontal axis and the value of the other variable determining the position on the vertical axis.

By selecting a set of graph properties, a scatter plot matrix will be displayed for each combination of two different properties. Each scatter plot can then be displayed individually in a more detailed way.

A set of interaction tools are bundled with the view to perform selection, statistical analysis, ...

2.4.2 Histogram view

This view plug-in allows to create frequency histograms from graph properties (supported types are Metric and Integer). By selecting a set of graph properties, frequency histograms are computed and displayed for values associated to nodes (or edges).

This view also allows to map visual properties (colors, sizes, glyphs, ..) of the graph elements with respect to a graph metric in a visual way. These operations can be done with the "Metric mapping" interactor. Many interaction tools are also bundled with the view to perform elements selection, statistical analysis, ...

2.4.3 Small multiple View

This view allows to visualize the transformations between different graphs using small multiples and/or animation. User can add intermediate states to emphasize elements present in the *P* property, the LHS and the RHS.

Small multiples are useful to have an overview of the whole states of the derivation tree. The aim of the animation is to interpolate the change each states to show a video of the change. You see the *film* of the transformations.

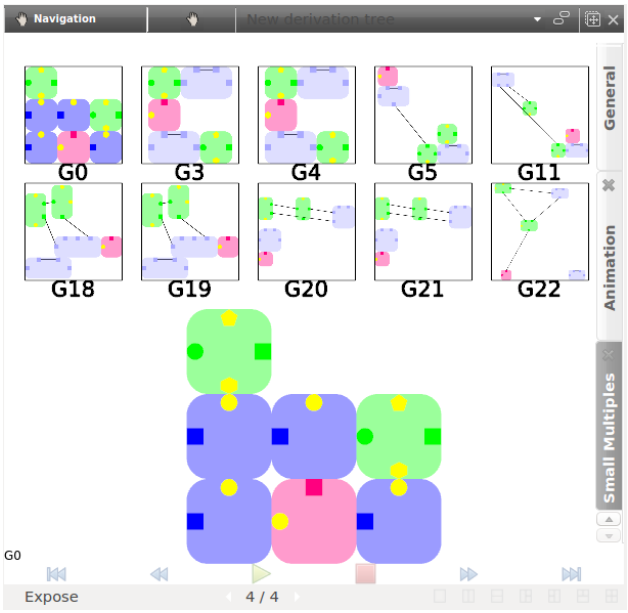


Figure 2.4: The small multiple and animation view which enable to see the evolution of a branch of a derivation tree.

Configuration

- **General**:
  - *Intermediate states*: add the corresponding intermediate states between two states.

  - *Widgets*: customize the view by selecting the widgets to display (Small multiples or Animation).
  - *Node labels*: show or hide the node label and scale the label size in function of the node size

- **Animation**:
  - *Animation duration*: animation duration between two states.
  - *Rule preview*: display or hide a preview of the rule involved in the current transformation if the current transformation involve a rule.

- **Small multiples**:
  - *Rendering parameters*: offers to force the labels of the small multiples to take the whole available space or to have an uniform font size. The margin between each preview can also be customised.
  - *Small multiples layout*: set the display options for the small-multiple view. Go for the default layout or force a specific number of lines.

CHAPTER

THREE

PORGY DATA STRUCTURE

A graph rewriting system is made of these elements :

- **Graph**: the graph being rewritten.
- **Rule**: a transformation rule.
- **Derivation tree**: keeps a trace of each rewrite operation.

Graph and rules are made with a specific graph structure called a **Portgraph**. To be fully understandable, this part of the documentation requires a good knowledge of the Tulip data structure and the latest publication about Porgy (see the Porgy web site and the publication at the GRAPHITE 2014 workshop).

3.1 Portgraphs

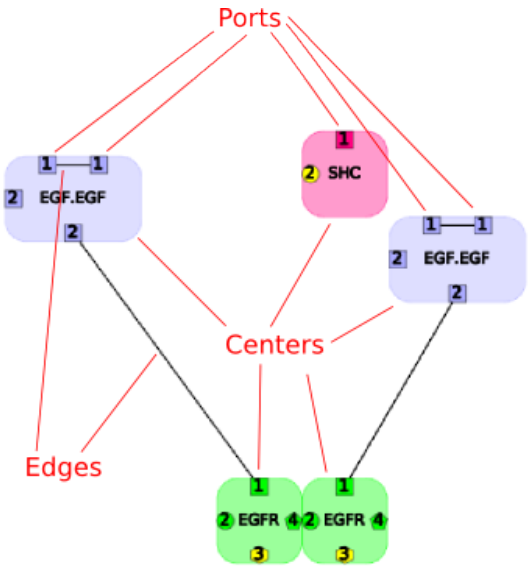


Figure 3.1: A portgraph with 5 nodes.

Nodes of a portgraph have ports and two nodes can be connected by an edge only via ports. Internally, a portgraph node with 4 ports is made with 5 Tulip nodes and 4 edges connected with a star structure. The central node is called ‘’center’‘.

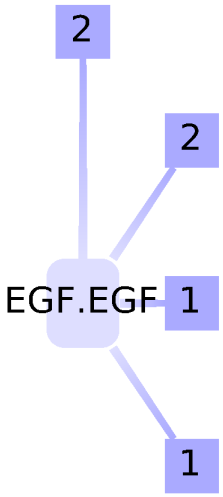


Figure 3.2: Internal structure of a portgraph node

The following Tulip property is used in order to identify correctly each part of a portnode:

- **NodeType**: Integer Property which handle node types. Two possible values: 1 for center and 2 for ports.

3.2 Rules

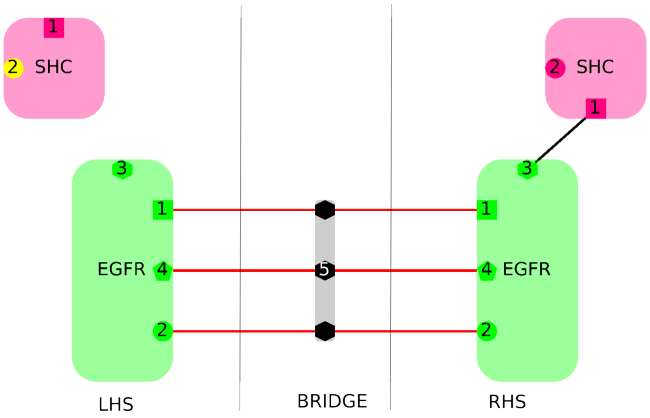


Figure 3.3: Rewriting rule example

A rule is composed of a left-hand side (LHS), a right hand-side (RHS) and a bridge which connects both sides. The red edges represent connections of equivalent ports between LHS and RHS. For instance, the two ports labeled **1** in the LHS EGFR portnode is connected to the RHS EGFR port also labeled **1**. These specific edges allow to restore node properties and their connections to the rest of the graph after rewriting. All connections between the left-hand side and the right-hand side must go through a port of the bridge.

Some additional properties are required to define a rule:

- **Arity: Arity of a LHS port.** Sometimes a port needs to be connected to some other ports in the graph which are not part of LHS. This property is used to indicate the minimum required degree of a port.
- **RuleSide: for nodes and edges indicates in which part of the rule the element is (Integer property).** There are four possible values: **1** for *LHS*, **2** for *RHS*, **3** for the *bridge* (red edges for instance), **4** to identify *a port of the bridge* and **5** to identify **specific edges** which connect two LHS ports via the bridge. The value **4** is used to indicate which node is the center of the bridge. It is also used for the edges on either side of the bridge. The value **5** is used for edges only when a subgraph of LHS have to be replaced by a single edge. The edge is going from a port *a* of LHS to a port of the bridge, then from this latter to another LHS port called *b*. Then, the rewriting will consist in removing LHS
- **M**: RHS only. When sets to true, the element is added to the current position set after rewriting.
- **N**: RHS only. When sets to true, the element is added to the current ban set after rewriting.

3.3 Graphs

Graphs have some additional properties to keep a trace of each transformation: * **new**: Boolean property set to true if the edge or the portnode is new, i.e. it has been created or modified by the last transformation.

The morphisms between a rule LHS and a graph *G* are saved as subgraphs of *G*. Each subgraph is the instantiation of a rule LHS and uses some specific properties and graph attributes:

- **tag**: Integer property filled with the Tulip id of the corresponding node or edge in the rule LHS.
- **P Property**: graph attribute which handles the property name used as the position set or *NoPosition* if positions were not used.
- **Ban Property**: graph attribute which handles the property name used as the ban set or *NoBan* if ban was not used.
- **rulename**: graph attribute which handles the name of the rule used.

3.4 Derivation trees

The nodes of the derivation tree are Tulip metanodes associated to each generated graphs. There is a black or purple edge between two metanodes *a* and *b* if the application of a rule transforms a source graph *a* into a destination graph *b*. The label of the metanodes (on the left side of each node) is the name of the graph. The result of a strategy is represented by a green edge between the source graph and the result of the strategy. A red node indicates a failure, i.e. a rewriting operation was not possible.

The edges of the derivation tree has many properties which handles all parameters of the rewriting operations:

- **Type**: Integer property which can be *0* to indicate a standard metanode of *1* to indicate that the node is a failure node.
- **Transformation_Ban_PropertyName**:
- **Transformation_Instance**:
- **Transformation_PPropertyName**:
- **Transformation_Parallel_Information**:
- **Transformation_Rule**:

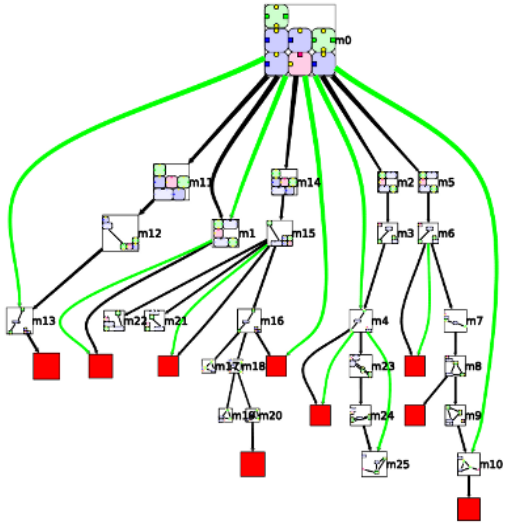


Figure 3.4: Example of a derivation tree.

CHAPTER

FOUR

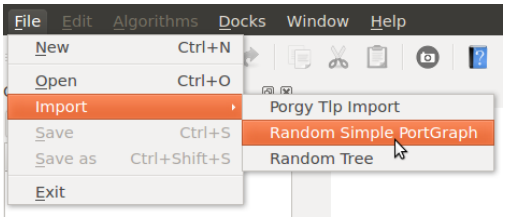
REWRITING IN ACTION - A TUTORIAL

In the following sections, we will explain the guidelines to start working using **Porgy**. We will:

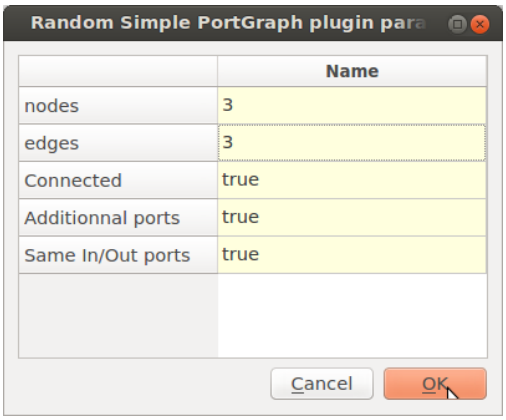
- start using a random graph,
- create a few different rules using specific properties for the pattern matching,
- apply the rules a few times separately,
- create a strategy for applying the rules in a specific order and, finally,
- execute the strategy some times to obtain a few branches on the derivation tree.

4.1 Import new graph

As a starting point, we generate a random simple graph using the appropriate plugin embedded within the platform. After having launched **Porgy**, choose the item *Random Simple PortGraph* in the *File* > *Import* menu.



A new window will open allowing you specify the generation options. We use the following settings:



The options **nodes**, **edges** and **Connected** are specific to the generator and allow to indicate respectively how many nodes and edges the graph will contain and whether or not the graph have to be connected.

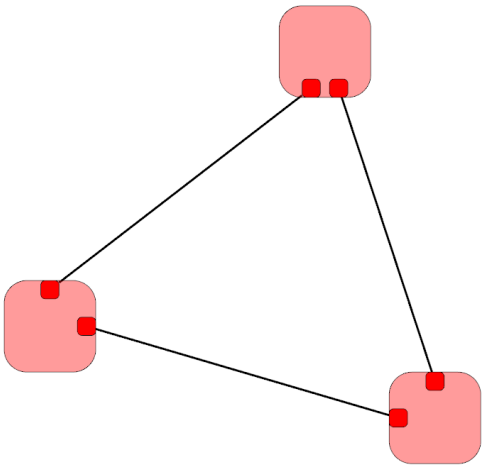
The two remaining options are specific to **Porgy**:

- **Additional ports**: By default, each connection to a portnode is achieved using a different port (*i.e.*, if a node is of degree *X* then, it will have *X* ports, one for each in- or out-coming edge). Enabling the **Additional ports** option will give the exact same number of ports to every portnode while disabling it will reduce the number of ports to one.
- **Same In/Out ports**: By default, edge orientation is not considered in **Porgy**, setting this option to false differentiate the existing ports in two distinctive ones labelled *In* and *Out*. Edges will leave a portnode through an *Out* port and arrive using an *In* port.

Those options are also available when importing a *tlp* graph. A new option is then accessible, proposing to keep the previously used layout or recompute a new one.

The graph is generated and imported in the list of graphs as *G0* (see *Graph widget*). You can see that creating this first graph also create *TraceMain*, the main derivation tree. The list of available traces is available in the *Derivation tree widget*.

If generated using the same parameters, your G0 should be similar to this one:



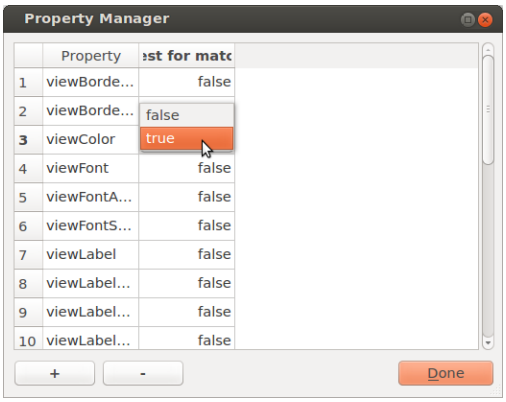
The visual properties of the nodes' and ports' shapes, sizes and colours are using default values. We keep them as such for now.

4.2 Rule creation

With the initial graph imported, we can start the rule creation. For this tutorial, we will create three different rules achieving the following goals:

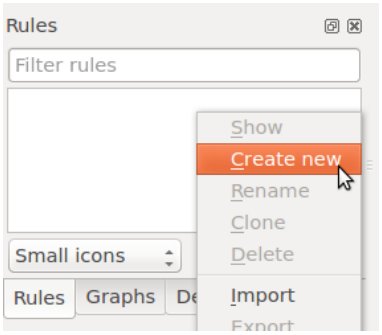
- change the color of a node from *red* to *blue*,
- divide an existing *blue* node in two *yellow* nodes and
- merge three *yellow* nodes in a single *red* node.

The colour will consequently be an important information for our rules and will need to be used as a matching property. To enable this, we must activate the *viewColor* property in the *Property Manager* (accessible in the menu *Edit* > *Property Manager*).



4.2.1 Rule 1: red to blue

One can create a new rule by performing a right click in the *Rule widget* and selecting *Create a new rule* in the contextual menu:



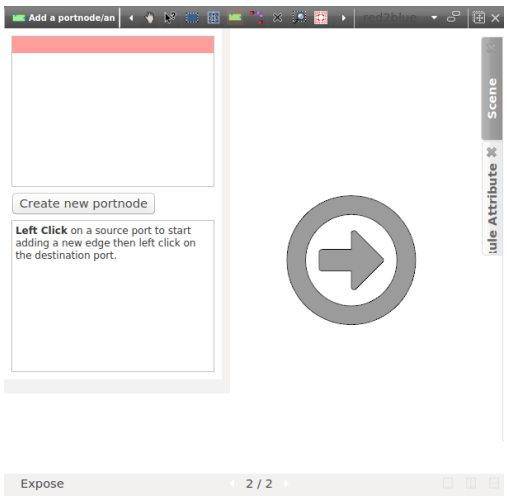
After having specified the name of the newly created rule (we choose to call it **red-blue**), a double click on the rule icon in the *Rule widget* (or using a right click and selecting *Show*) will create a new *Rule View*.

The view only contains a bridge node for now. This element is used to mark the transition between the left-hand side and the right-hand side. We consequently use it as a visual cue indicating the limit between the LHS and the RHS.

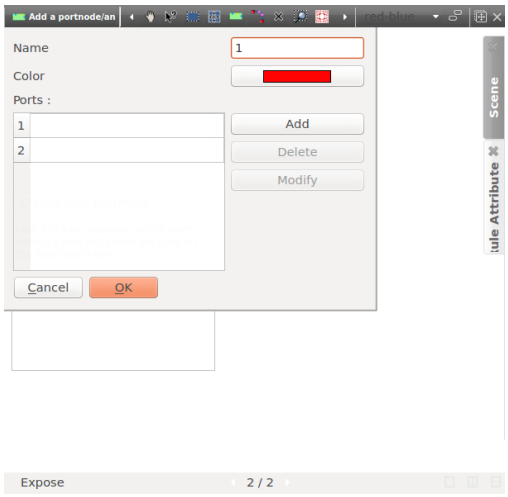
Our rule is supposed to change the color of a node from *red* to *blue*, we thus have to create a *red* node on the left, a blue node on the right and link the two elements appropriately.

Red portnode

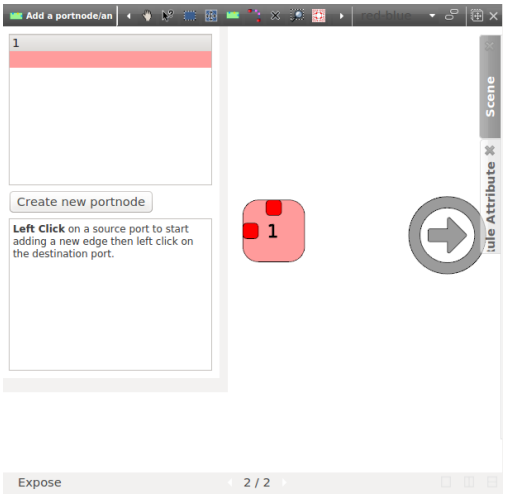
- First, we must select the interactor allowing to create portnodes  .
- Clicking on the name of the interactor display its parameters



- The interactor lists all the different types of existing portnodes. For now, the only one available corresponds to the red portnode similar to those existing in *G0*.
- We will use a slightly modified version of this portnode, double-click on the red element to open the customization widget in which we will change the field *Name* to *1*



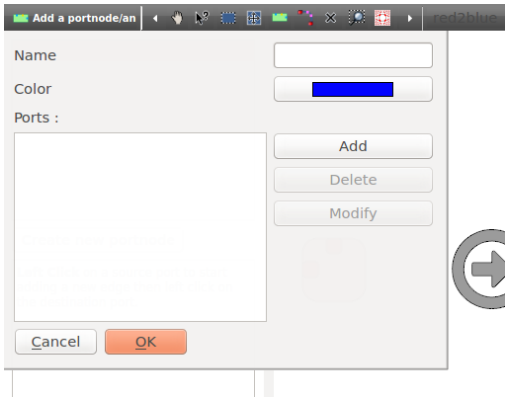
- The new variation of the *red* portnode found in *G0* is now available and is marked as *1* with a red background.
- Click on it in the list to highlight it and click on the *left* of the bridge to create a new portnode in the left-hand side of the rule.



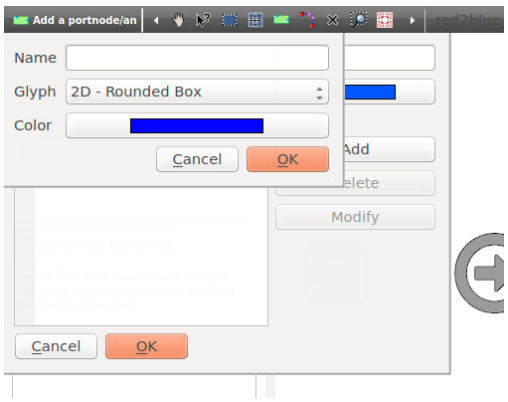
Blue portnode

To add the blue variation of the portnode, we have to create a new portnode.

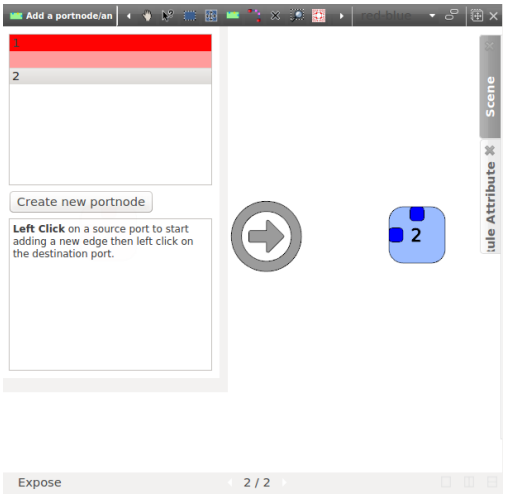
- In the *Add a portnode* interactor parameters, click on the button *Create a new portnode* to display the portnode creator assistant.



- Here we can customized the new portnode by changing its name, colour and number of ports. We set the name to *2* and change the default colour to a light blue (RGB=0,85,255). Each port can also be personalized by adapting their name, shape and colour. We add two ports to our portnode and set their shape to be a *Rounded Box* with a pure blue colour (RGB=0,0,255).



- Once validated, the new type of portnode will appear in the list as a *2* with a blue background. It can then be selected and added to the right of the bridge in the rule.



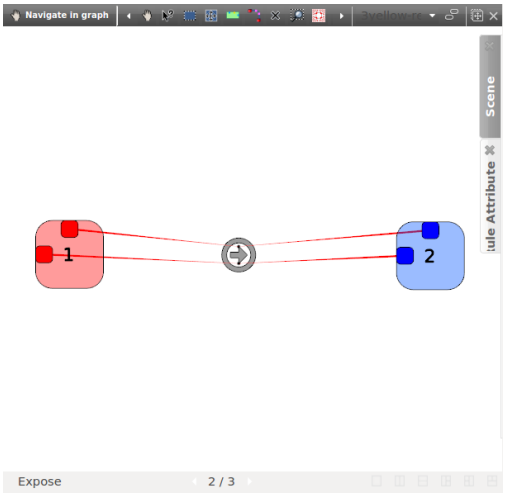
Linking the portnodes

In portgraphs, ports are used as means to connect the portnodes together. In the rules, ports use is twofold:

- they can be used in the left-hand or the right-hand side indifferently to connect portnodes
- they can be used to connect elements from the LHS to the RHS to indicate specific ways to reconnect the transformed elements.

In our example case, the two ports are similar so the fashion followed to reconnect the transformed element is quite simple. We set each distinct port from the LHS to be corresponding to a unique and distinct port in the RHS. To indicate this in the *Rule View*, we will use the same interactor used to add portnodes.

- Click on a port of the *red* portnode then click on a port of the *blue* portnode.
- Repeat the process with the two other ports.



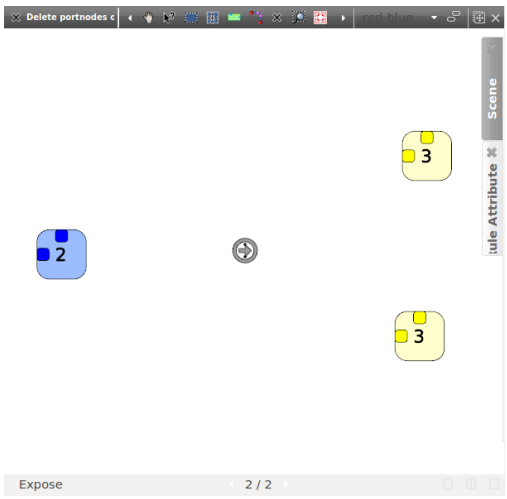
Red edges connecting the LHS to the RHS are created with these operations. In our case, they will be used to reconnect the edges attached to the *red* portnode.

The **red-blue** rule is now finished and can be directly applied to the graph to start rewriting operations. If your are impatient to proceed, consult the *next section* to find out how to apply a rule otherwise, there is still two rules to create.

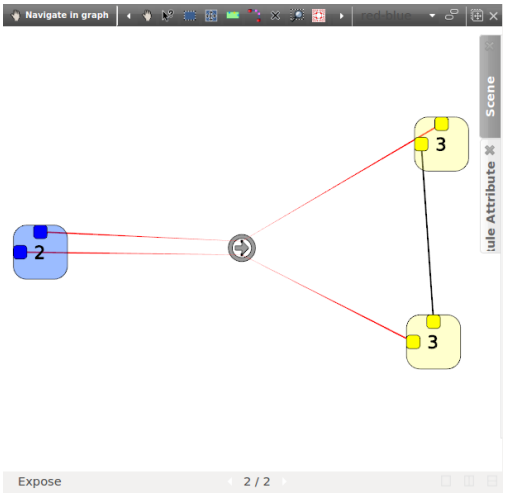
4.2.2 Rule 2: blue to yellow

Now that the bases have been set, we are able to move a bit quicker. This second rule have to divide an existing *blue* node in two *yellow* nodes.

- As previously seen, we start by creating a new rule (in the *Rule widget*, right-click then *Create new*) called **blue-2yellow**.
- We add a *blue* portnode on the left of the bridge.
- We create a new portnode variation with two ports following the steps previously shown for the *blue* portnode creation. The portnode name is set to *3* and its colour is changed to a light yellow (RGB=255,255,127) while its ports receive a primary yellow (RGB=255,255,0).
- We then add two *yellow* portnodes on the right of the bridge.



- Deciding how to connect the transformed elements is a bit more specific this time as we divide the *blue* portnode in two different portnodes. We choose to reroute the edges connected to a *blue* port toward only one *yellow* port. The two *yellow* portnodes, result of the transformation, are connected through their unused ports. The edge is created by clicking on each port successively when using the interactor  .

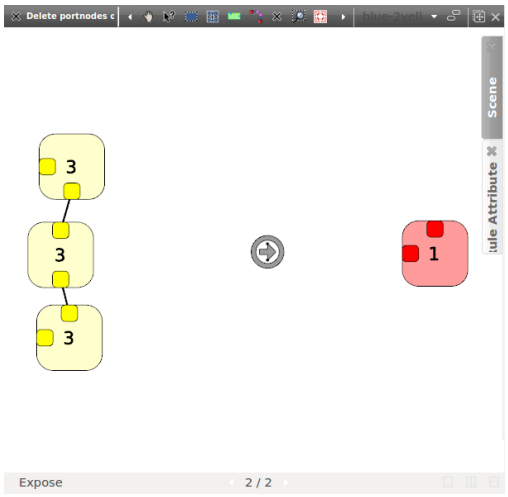


This achieve the rule **blue-2yellow** which is now ready to be used in a rewriting operation.

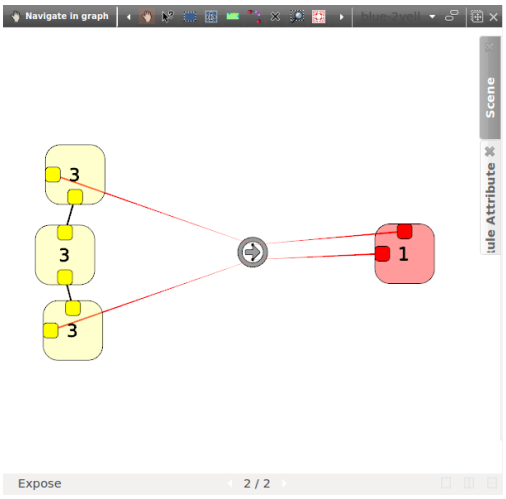
4.2.3 Rule 3: yellow to red

With the two previous rules achieved, this last one will be set in no time. We simply want to merge three *yellow* nodes in a single *red* one.

- We create a new rule which we call **3yellow-red**.
- All the type of nodes have been created before so we only have to place and connect three yellow nodes on the left of the bridge and a single red one on the right.



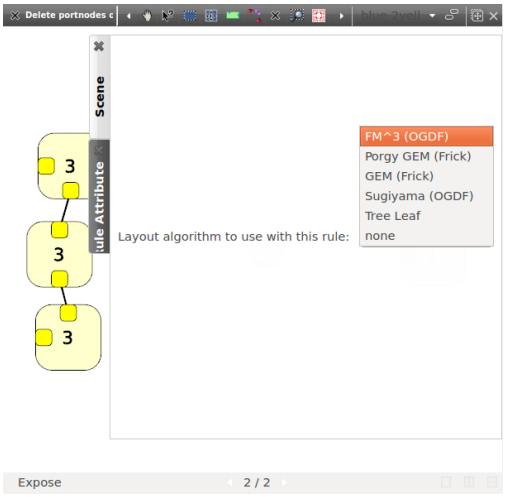
- We then connect the *yellow* portnodes to the two remaining ports to the *red* portnode.



With the three rules **red-blue**, **blue-2yellow** and **3yellow-red** now ready, we can focus on their application to the graph *G0*. Let us see how we can use each of these rules to transform our initial graph.

4.2.4 Layout algorithm

Upon rule application, and particularly when the number of elements appearing is greater than the number of elements being replaced, the layout can become unclear. In those case, it is advisable to redraw the graph altogether. This can be done by selecting a layout in the *Rule View* under the tab *Rule Attribute*:



Be aware that, when visualizing large number of elements, redrawing the graph can disturb the mental map of the user because of the possible change of each node position.

In our case, we choose the *FM^3* layout, a force directed layout quick to compute and which gives generally good results. We apply this modification to all the rules previously created, however, the rule **blue-2yellow** is the one to which it will profit the most.

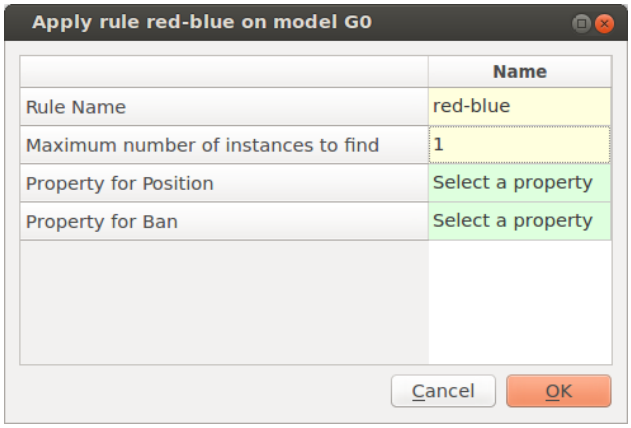
4.3 Applying a rule

In **Porgy** there is two way to apply a rule, either by launching it directly from the *Rule widget* or by using the *Strategy widget*. Both methods are working with drag and drop actions on a graph or onto a node of the derivation tree.

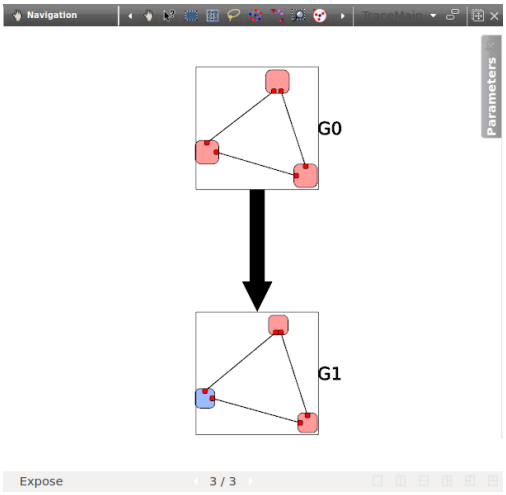
The application of a rule to a given graph consists in two phases: find at least one instance of the left-hand side of the rule inside the graph, then replace this instance by the right-hand side of the rule.

Let us try to apply the rule **red-blue** on *G0*:

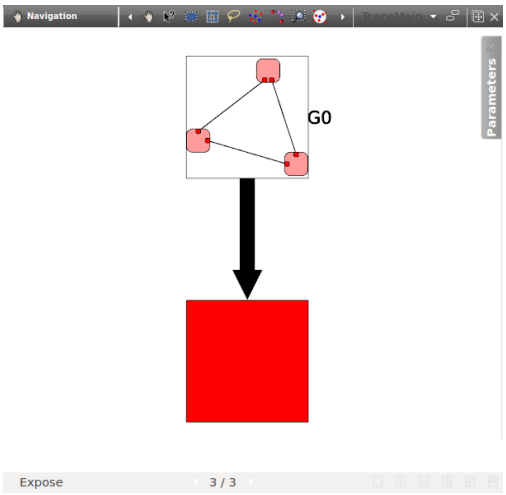
- First, we need to visualize the derivation tree, such action can be achieved by double-clicking on the current trace called *TraceMain* in the *Derivation tree widget* (using the *Show* action in the contextual menu appearing with a right-click on the trace produces similar result).
- The *Derivation Tree view* and the thumbnail representing *G0* have to be visible in the workspace to continue.
- Now, in the *Rule widget*, drag the rule **red-blue** on *G0*. A new window will appear in which we set the *Maximum number of instances to find* at *1* to only generate one new state:



- The application will generate a new graph called *G1* in which the rule **red-blue** has successfully been applied.



Because the initial graph *G0* only contains *red* portnodes, the rules using *blue* and *yellow* portnodes cannot successfully be applied on it. If we tried to drag one of those rules and drop it, we will end up with an invalid state shown as a red thumbnail.



Applying the rules by hand allows to test if everything is going according to plans however, strategies can be used to automatized the process and avoid to perform the transformations manually.

4.4 Strategies

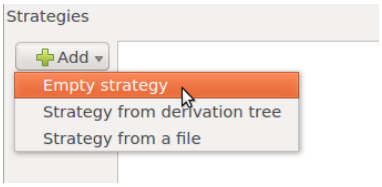
A strategy is a small script language created to improve the rule rewriting possibilities. In this example, we will see how to write simple strategies and transform the graph by automatically applying the rules previously created.

The strategy allows us to choose how we wish to apply each rule. In our case, no specific behaviour or model is given, we thus decide to try applying each rule as many time as possible and see the results obtained.

As seen before, only the rule **red-blue** can be applied in the beginning. Applying it once will allow us to launch the **blue-2yellow** rule afterward but we will then be blocked as the last rule, **3yellow-red**, requires three yellow portnodes to be applied. If we apply the first two rules three times each, we can then apply the last rule two times and obtain two *red* portnodes.

4.4.1 Repeat a rule application

The first step is to create a new strategy. This can be achieved in the *Strategy widget* by clicking on the **+ Add** button and selecting the option *Empty strategy*:



You can rename a strategy by double-clicking on it. We call our own **A** for simplicity. This first strategy will apply each rule as many times as possible in the logical order: **red-blue**, **blue-2yellow** and **3yellow-red**. To do so, we can use the *repeat* command and thus create the strategy as follow:

```
repeat(red-blue);
repeat(blue-2yellow);
repeat(3yellow-red)
```

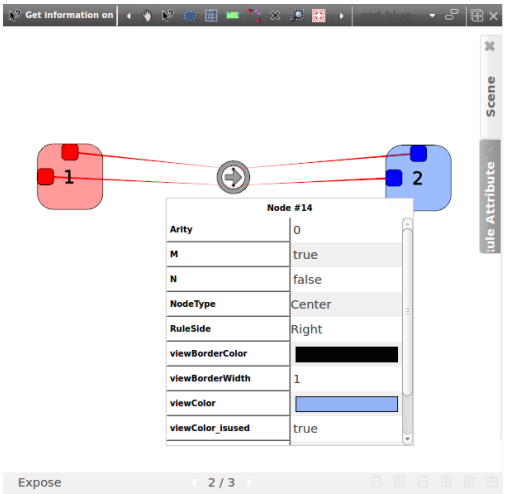
Applying this strategy immediately on *G0* will not produce the expected result as only the first repeat will seem to be executed. Before doing so we need to consider the *Position* and *Ban* properties.

4.4.2 The *Position* set

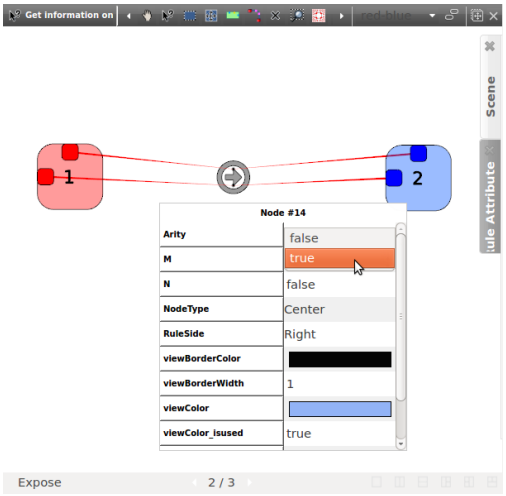
When creating a rule, you can specify whether you want the newly created right elements to be considered afterwards as possible match for rule application. More formally, at the beginning of a strategy application, all the elements of the targeted graph are available for rewriting and thus are in the *Position* set. With each rule application within the strategy, the right-hand side elements are by default moved out of the *Position* set where they become no longer available for matching as left-hand side elements.

To use the strategy, we must specify for each element in the right-hand side of the rules used whether they are put in the *Position* set for further operation or if they are left out. This can can be achieved in the *Rule View*. We present the steps to follow using the **red-blue** rule.

- First select the *Get information* interactor 
- Then click in the middle of the *blue* portnode and a widget will appear



This tool allows you to customize some of the visual properties of the selected element as well as a few others. Currently, we are interested in the **M** property initialized at *false* by default. **M** is used to indicate if the element is transferred into the *Position* set after the rewriting operation; we thus set the property to true:

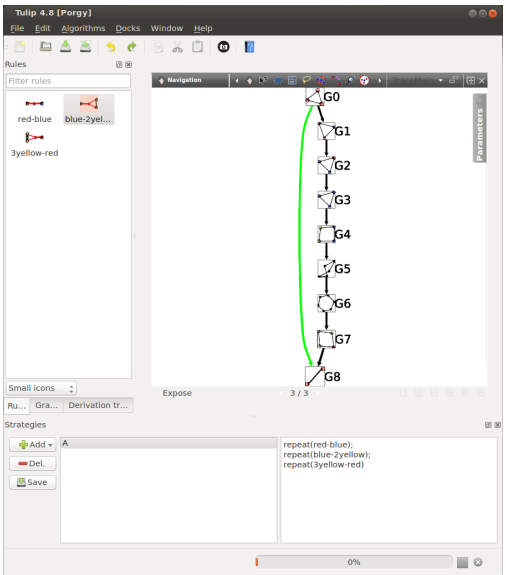


Trying to launch the strategy **A** on *G0* now will produce a better but still incomplete result. The step explained above must be repeated for each portnode located on the right-hand side of each rule.

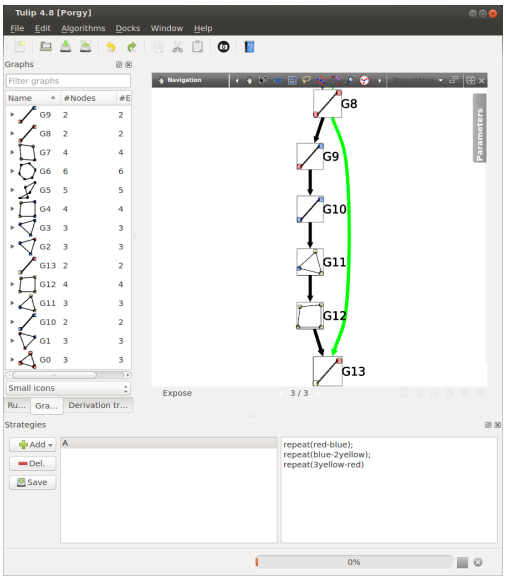
4.4.3 Strategy application

Once all those changes are completed, we can apply the strategy **A** to *G0*. To do so, proceed similarly to a rule application:

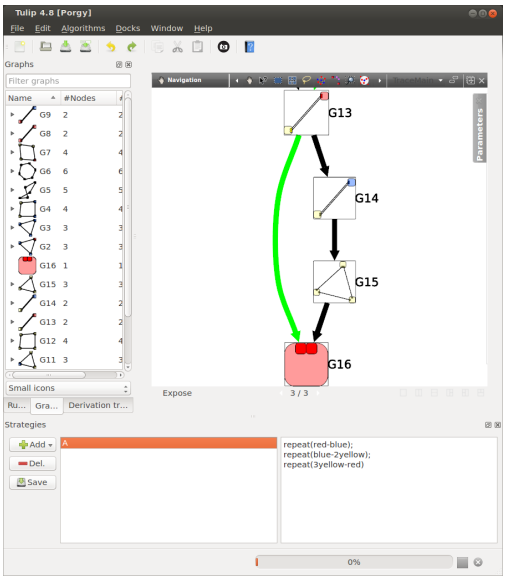
- The *Derivation Tree view* must be displayed and the graph targeted, *G0*, have to be visible.
- Drag and drop the name of the strategy upon *G0* and wait for the computation to be over
- You will obtain a derivation tree with eight new states:



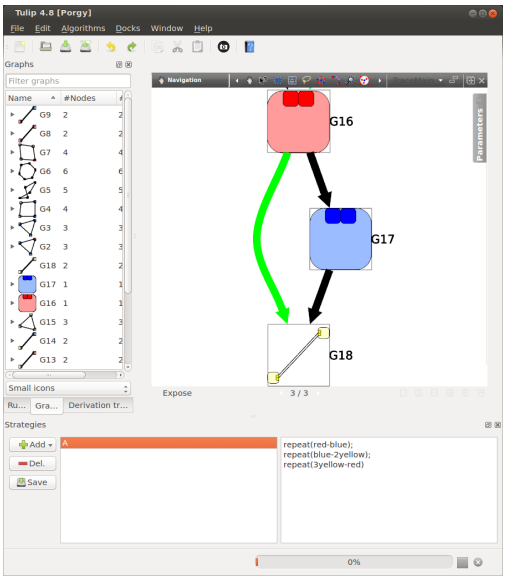
The graph *G8* contains two *red* portnodes, allowing us to apply the strategy once again. By drag and dropping **A** on *G8*, we obtain five new states:



The graph *G13* at the end of the derivation tree contains one *yellow* portnode and one *red* portnode. We can thus apply the strategy once more with a drag and drop on *G13*:



Three new states are created leaving us with a single *red* portnode. After a final strategy application, we end with the following graph:



No more rules can be applied from here, leaving us with nineteen states and 2 *yellow* portnodes.

4.5 Afterword

Congratulations, you have completed this tutorial. You now are familiar with the basic inner mechanics of *Porgy*, restart from scratch and create your own rewriting rules and starting graph or open a graph from *Tulip* and import the rules and start rewriting!

There is still nonetheless much to see. Consult *Porgy in details* for more information on the advanced possibilities of the platform and discover more on the *Property Manager*, on how to customize the matching and the grammar of the *strategy language*...

CHAPTER

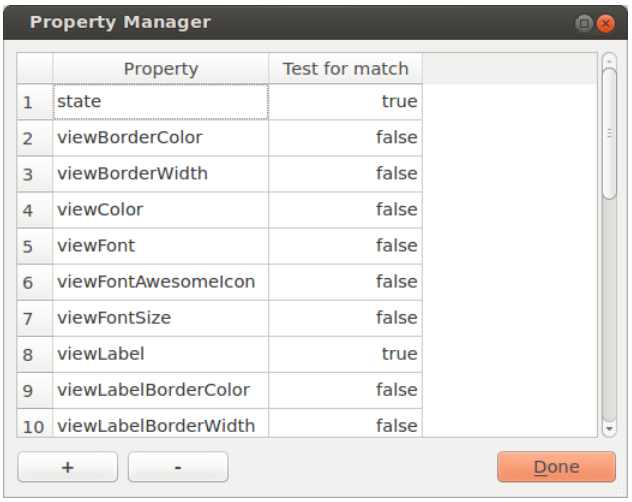
FIVE

PORGY IN DETAILS

In the following section, you will find information on the advanced functionalities of *Porgy*. We will consider from here that you have successfully achieved the *tutorial* presenting how to create rules and apply them. We will thus base all the explanations in the direct continuity.

5.1 Property Manager

The **Property Manager** is available in the *Edit* menu. The widget will display all the properties existing in the current graph and give you the possibility to select any possible combination of those properties to use as matching criterion.

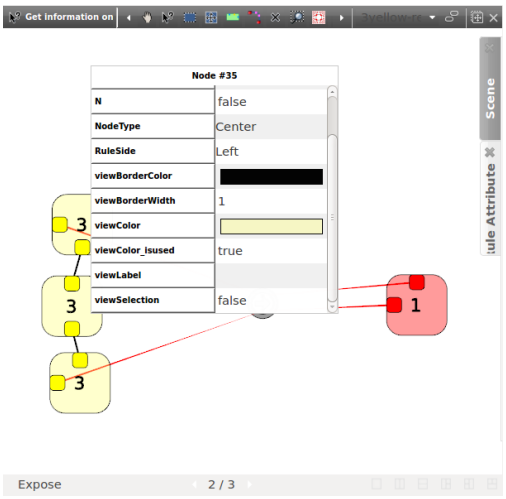


For instance two portnodes with different names but with a similar number of ports will be considered as similar elements by default. If you wish those two elements to be distinguish from each other, you can select the property *viewLabel* (containing their respective names) in the **Property Manager**. From now on, the subgraph matching operation will consider the selected property as an additional condition for the matching to be successful. In the screenshot above, the *state* and *viewLabel* properties have been selected by double-clicking in the second column on the appropriate lines; doing so makes a combo-box appear, offering to set the value to *true* or *false*.

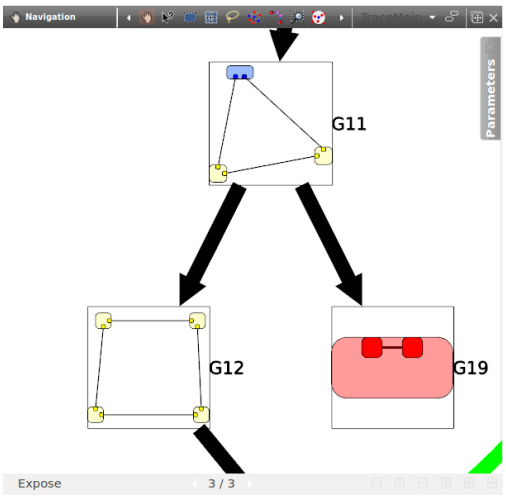
New properties can be created by clicking the **+** button and outdated ones can be deleted by selecting them and using the **-** button. Please remember that the visual properties (whose name begin with *view*) are crucial for the visualizations and thus will be restored to their default value if deleted.

5.1.1 Optional matching

Finer control over the selected properties can be achieve when editing each rule, allowing for instance to only check the value on specific elements. When editing a rule in the *Rule View*, you can use the *Get information* interactor to open a widget listing the value of the properties of an element. For instance, in the case of the rules created in the previous tutorial, we take a peek at the values for the properties of the middle *yellow* portnode in rule **3yellow-red**:



The selection of the *viewColor* property in the *Property Manager* generates a boolean property called *viewColor_isused*. When set to *true*, the corresponding property is checked for this element during the matching. When set to *false* however, the property is still generally checked for the matching but the current element becomes an exception. If we set the *viewColor_isused* property value to *false* for the middle *yellow* portnode and its ports, any chain of three elements with *yellow* portnodes at its extremities will match. Applying the modified **3yellow-red** rule to *G11* in the derivation tree generated during the tutorial illustrates this perfectly:

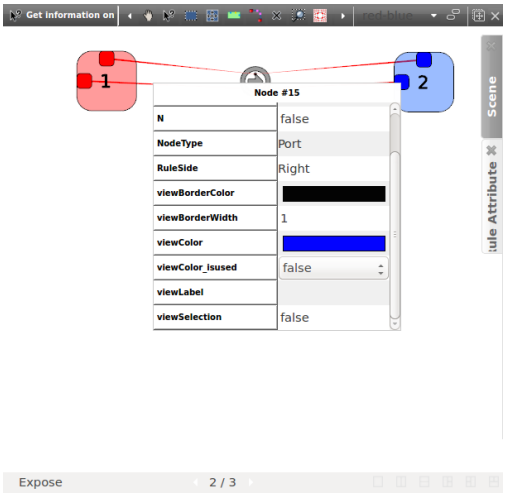


G19 is generated with the **3yellow-red** rule application on *G11*, a result impossible to obtain for the original rule as *G11* only contains 2 *yellow* portnodes. This advanced checking possibility allows further control on the transformations and very fine tuning over the operations we are able to perform.

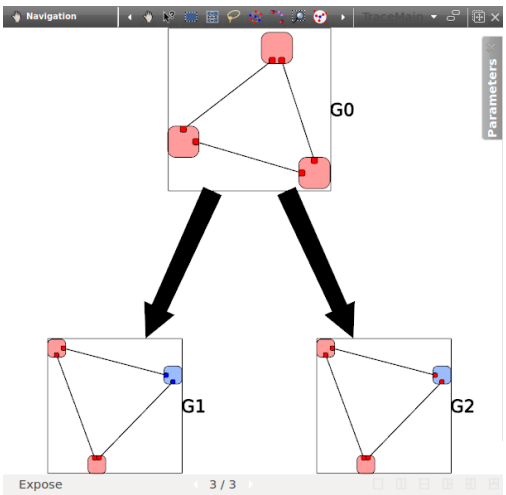
5.1.2 Copying values during rewriting

The boolean property (*_isused*) created after selecting a matching property in the **Property Manager** can also be modified on the elements of the right-hand side. This can be used to specify which value to affect during the rewriting process. We consider the graph used in the tutorial, the rule **red-blue** and the matching property *viewColor* to illustrate the process.

- After having selected *viewColor* in the **Property Manager** as a matching condition, the boolean property *viewColor_isused* is created.
- We select both of the blue ports and update their value for *viewColor_isused* to false.



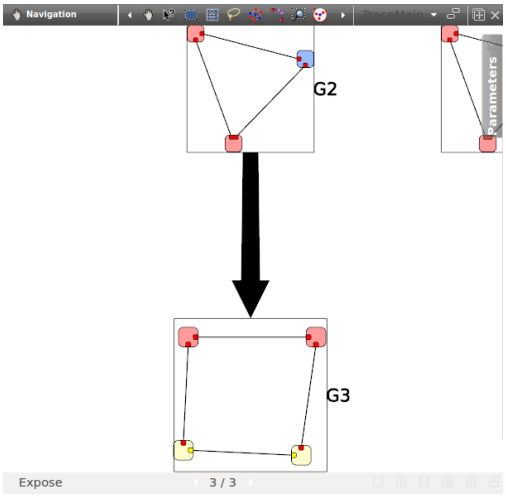
- After applying the changed **red-blue** rule, we can witness the difference between the normal result (in *G1*) and the modified version (in *G2*) as the ports colours have not changed according to the visual information given by the rule.



When set to *true*, the **_isused* property indicates the value given by the element in the right-hand side will be the one rewritten. This is the default behaviour thus the ports rewritten are blue (like *G1*), as expressed visually by the corresponding elements in the right-hand side. However, when set to *false*, the value selected is the one obtained from the matching elements corresponding to the linked element of the left-hand side. As a result, the application of the modified rule transform the *red* portnode in a *blue* portnode with red ports.

A similar treatment can applied to the **blue-2yellow** rule:

- for both of the blue ports in the left-hand side, the *viewColor_isused* property is set to false (desactivate the colour matching for those elements)
- for both of the linked ports in the right-hand side, the *viewColor_isused* property is set to false (keep the original colour of the ports matching the rule)
- we obtain the following rewriting result where both ports keep the original colour of their matching correspondances.



This kind of transformation makes sense when several matching properties are used at the same time but are not relevant in every rule. Specifying the local matching properties and whether the value must be passed to the rewritten element allows to rewrite and transform the graph in different ways. Please note that this behaviour is only available for ports as they are the sole elements in the right-hand side to be linked to other elements in the left-hand side.

5.2 The *Ban* property

We have mentioned the *Position* property in the previous tutorial however a second property, the *Ban* property, can be used to limit the elements available for the rule application.

Basically, an element can be in the *Position* set, in the *Ban* set or neither of those (neutral). When looking for elements during the matching of the LHS for each rule, at least one of the elements of the left-hand side has to be within the *Position* set for the matching to be valid. The matching will be impossible if all of the elements are *neutral*.

The *Ban* set is the exact opposite of the *Position* set, as such the elements *banned* will be plainly ignored during the matching step. The elements in the right-hand side of a rule can be send to the *Ban* set after the rewriting operation by setting the **N** property of each of those elements to *true*.

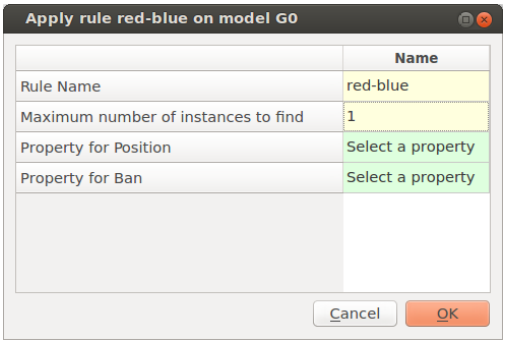
Please note that the *Ban* property takes priority over the *Position* property.

5.3 Checking a rule application on a graph

The application of a rule is made by a drag and drop of a rule to:

- a graph metanode in the derivation tree view. If the operation is valid a green square will appear.
- a graph view.

Once you drop the rule a parameter configuration widget will appear to configure the rule application.



You can customize these parameters:

- **Rule Name**
- **Maximum number of instances to apply**: the maximum number of matching to compute..
- **Position**: the boolean property that defines a subgraph of the graph. This subgraph is used to restrict the search of the instances of the left-hand side of the rule. When one tries to find the instances *I* in *G*, at least one node of each *I* must be in the *Position* set. It is possible to define more than one set *Position*.
- **Ban**: similar to *Position* but with the *Ban* property.

If the process works, the resulting graph will appear in the derivation tree, else a red state will appear.

5.4 Strategies

A strategy is a small script language created to improve the rule rewriting possibilities.

5.4.1 Syntax of the Strategy Language

Let *L*, *R* be port graphs; *M*, *N* positions; $n \in \mathbb{N}$; $\pi_{i=1\ldots n} \in [0,1]$; $\sum_{i=1}^{n} \pi_i = 1$;

Let *attribute* be an attribute label in $\nabla_{\mathscr{A}}$; $e \in \mathcal{E}_{\nabla}$ a valid expression without variables;

	(Strategies)	S	::=	$A\|U\|C\|S;S$
			|	if(S)then(S)else(S) | (S)orelse(S)
			|	repeat(S) | while(S)do(S)
			|	ppick($S_1, \pi_1, \ldots, S_n, \pi_n$) | try($S$) | not($S$)
Rewriting	**(Basics)**	B	::=	Id | Fail
	(Applications)	A	::=	B | all(T) | one(T)
	(Transformations)	T	::=	$L_W \Rightarrow R_M^N$ | $(T\|\|T)$
Scope	**(Update)**	U	::=	setPos(D) | setBan(D)
			|	update(*function_name* {*parameters_list*})
	(Positions)	D	::=	all(F) | one(F)
	(Focusing)	F	::=	CrtGraph | CrtPos | CrtBan | Property(F, ρ)
			|	Ngb(F, ρ) $\|F \cup F\|F \cap F\|F \setminus F\|$ (F) $\|\emptyset$
	(Comparison)	C	::=	$F = F\|F! = F\|F \subset F\|$ isEmpty(F)
Properties	**(Properties)**	ρ	::=	*Elem*, *Expr*
		Elem	::=	Node | Edge | Port
		Expr	::=	*attribute Relop e* | True
		Relop	::=	$== \|! == \| > \| < \| >= \| <=$