

Appendix

Computer Modelling of Flowgraphs[†]

While formulating, manipulating and solving small flowgraphs on paper is straightforward and insightful, it can nevertheless be very helpful to have a patient and capable machine assistant to remove the drudgery, avoid mistakes and save on paper. Here we describe such a computer application which enables flowgraph modelling on a screen. This software is freely available as an internet application, used as a Java applet within a web browser. What follows is an outline of how to make use of this tool.

The program can be accessed at the following web address:

<http://www.geoffwyatt.com/flowgraphs/>

When the applet is loaded, a blank screen appears with a toolbar header. There are three “modes of operation” represented by the cluster of three icons on the left of the toolbar: *node creation*, *arc creation* and *transmittance measurement*.



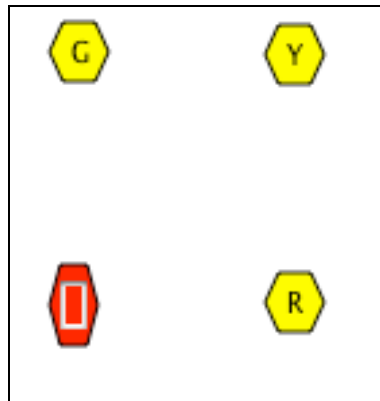
The other icons on the toolbar are *scissors* for deleting selected objects, a *reversing arrow* for causality reversal (this should be treated with care), an *undo and redo* pair of icons, and a *loop-reckoner*.



The program opens in *node creation* mode. To create a layout of **nodes**, double-click in various places in the blank area. When a hexago-

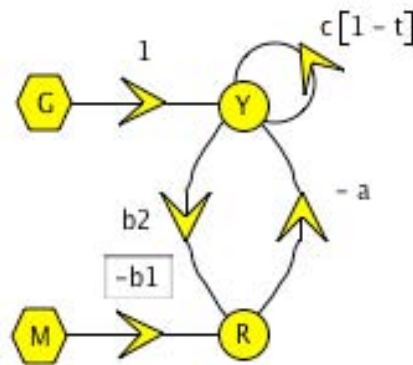
[†] The computer program described here was written by Thomas K. Wyatt.

nal node appears you can give it a label from the keyboard. Double-clicking on the node allows you to rename it. Click-drag moves the node.



To create **arcs** you may either:

- (i) Switch to *arc creation* mode (click the middle icon of the cluster of three on the left of the toolbar) and connect pairs of nodes by click-dragging; or
- (ii) Remain in *node creation* mode and RightClick-Drag (on a PC) or Control-Click-Drag (on a Mac) to connect pairs of nodes.



Move arcs by click-dragging on an arrowhead. The default arc transmittance is 1. It can be changed by double-clicking the existing transmittance, and its position near the arrowhead can be changed by

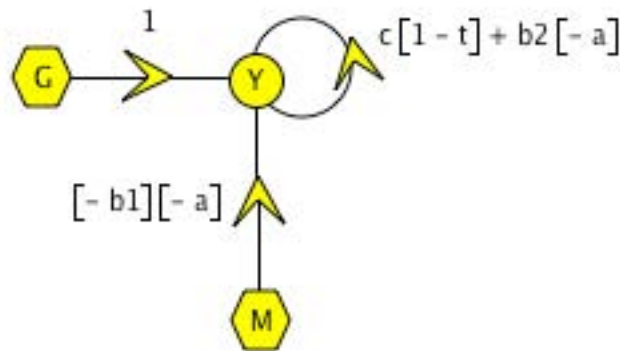
click-dragging. A **self-loop** is created if an arc is drawn from a node back to itself.

Exogenous nodes remain as hexagons; endogenous nodes are circles. If you draw another (forward or reverse) connection between two nodes that are already connected, then one arc may be drawn on top of the other. Simply click-drag the arrowhead to separate them.

Click-dragging from an empty point on the screen will **mark** all those parts of the flowgraph enclosed by the cursor-created rectangle. These can now **move as a group** on click-dragging, remaining locked together.

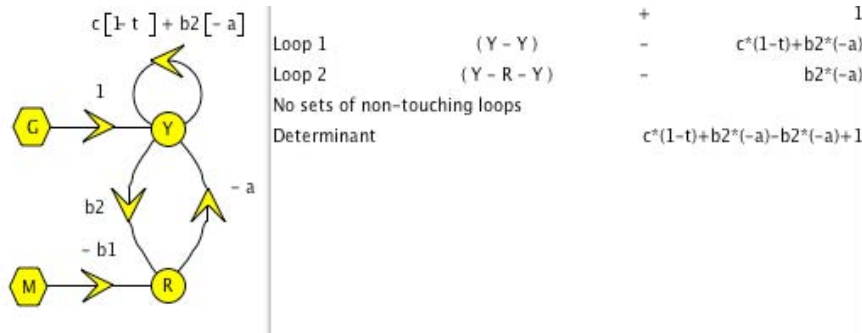
To **delete** a node or an arc, click on it and use the *scissors* on the toolbar.

To **absorb** a node, Right-click (PC) or Command-click (Mac) on the node and select “Eliminate Node” from the contextual menu. The flowgraph will change as a result, creating new arcs, and may need to be rearranged. This operation, and all others above, can be reversed with the *undo/redo* button on the toolbar.



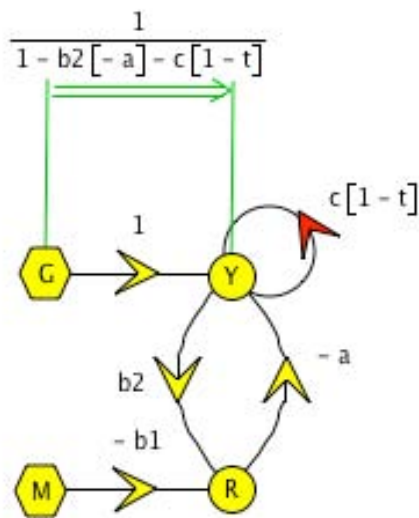
The *R* node has been absorbed

A table of **loops** and the **system determinant** are displayed in a separate box when you click on the *loop-reckoner* button. Passing the cursor over these items in the box causes the relevant loop on the flowgraph to be emboldened.



Loops identified and system determinant calculated

To measure **transmittances** click on the *transmittance measurement* button on the toolbar (it shows a tape measure below two connected nodes) and then click-drag from the originating node to the destination node. Note that it only makes sense to calculate a transmittance from an exogenous to an endogenous node. You may find that the transmittances (including loop transmittances) may not be expressed in the simplest form—it is up to the user to do any algebraic simplifications. The measurement arrow can be dragged to a more convenient location on the screen if desired. Double-clicking on the measurement arrow pulls up a separate box which shows how the transmittance is composed of path transmittances and co-factors from non-touching loops.



Note that the graphs you create cannot be saved or copied as manipulatable objects, though you can save them, frozen, as picture files with a screen- or window-capture utility—*i.e.* in Windows use the PrintScreen or Cntrl-PrintScreen command from the keyboard, or in Mac OSX use the “Grab” application. The picture can then be pasted into another application like a paint program or a word processor. To **print out**, again use a screen- or window-capture utility.