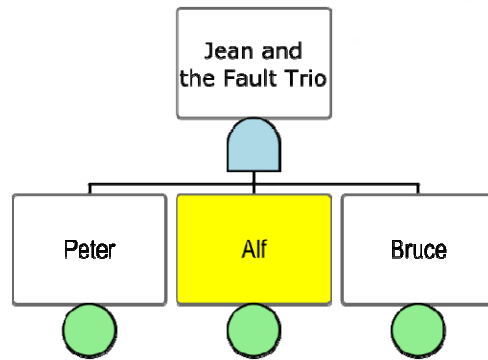
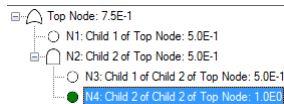


# Fault Tree Overview - Software



R. Alfredo C. Siochi, PhD

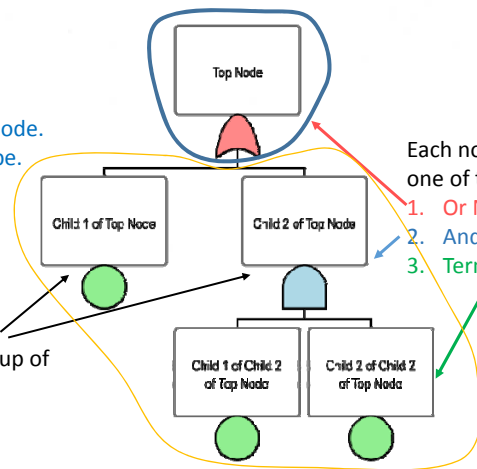
## Anatomy of a Tree - 1



Each element of the tree is a **node**.  
The node includes the gate type.

The collection of all nodes branching off from a node are **descendant** nodes.

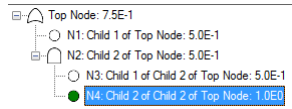
The immediate nodes below a node are **child** nodes. The group of child nodes are **sibling** nodes.



Each node can be one of three types:

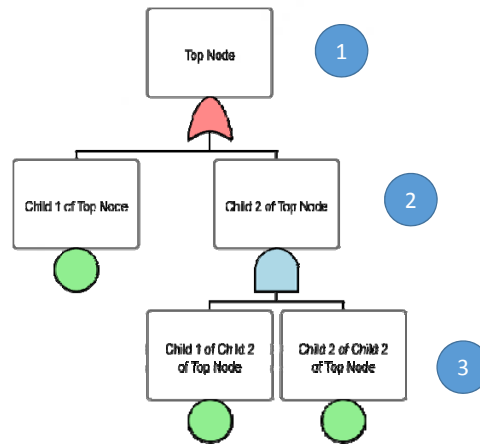
1. Or Node
2. And Node
3. Terminal Node

## Anatomy of a Tree - 2



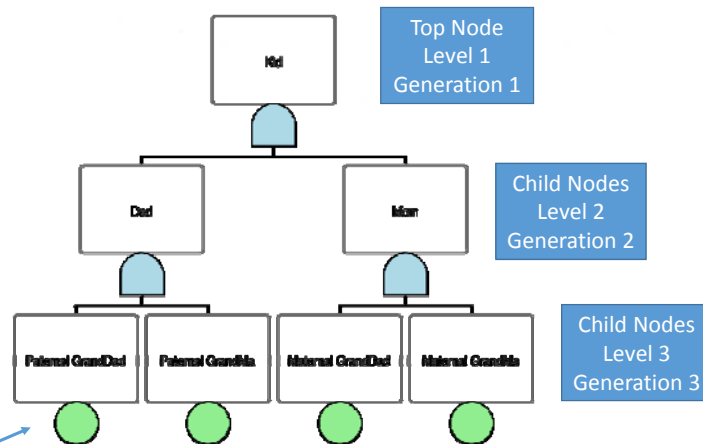
Nodes appear in Layers, or Levels, or Generations, or Steps.... (this one has three).

However, don't confuse the terminology with the reverse family tree...



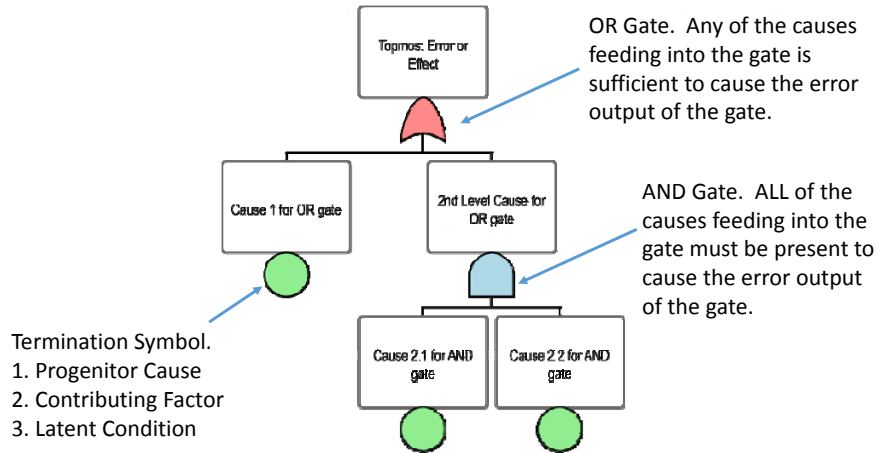
## Reverse Family Tree

When a child is not a child...

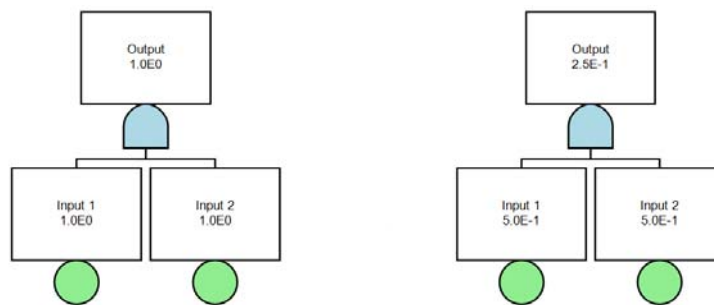


Obviously not terminal. Possibly re-usable in another reverse family tree.

# Anatomy of a Fault Tree

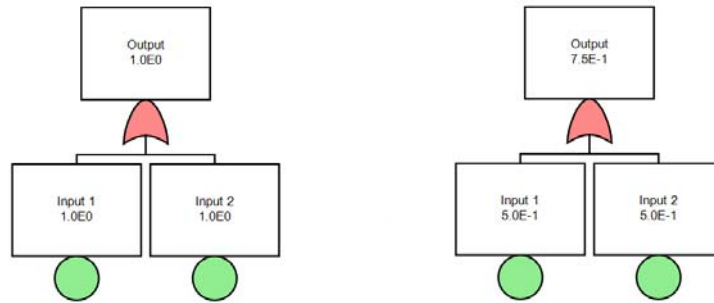


# Boolean Logic – And Gate



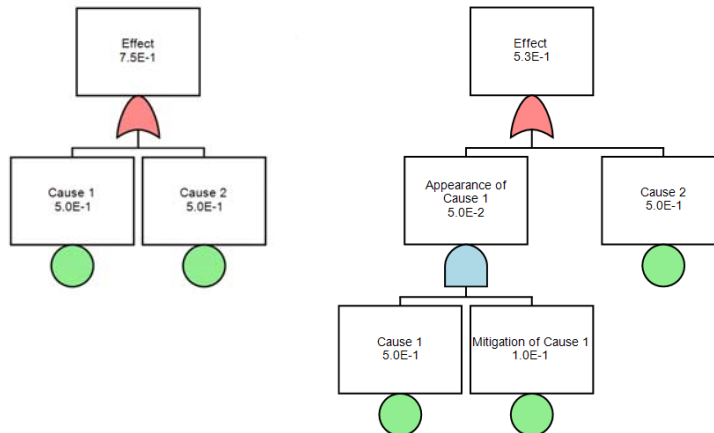
Terminal Nodes can be assigned probabilities.  
 The probabilities for non terminal nodes are computed using Boolean Logic.  
 For And Gates – multiply the probability.

## Boolean Logic – Or Gate

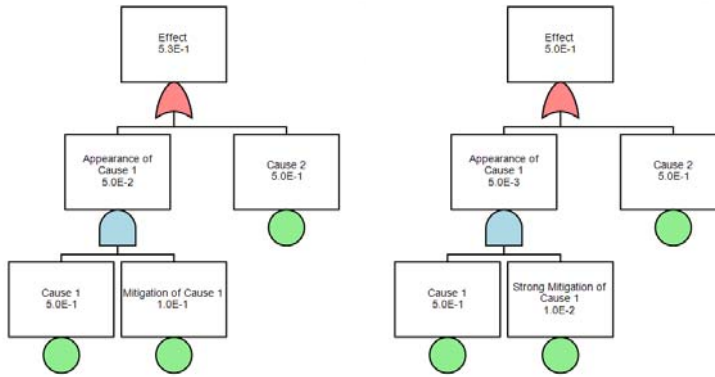


Or Gates: Think of them as a combination of negation and And gates:  
 $A \text{ OR } B = \text{Not} (\text{Not } A \text{ AND } \text{Not } B) = 1 - \{(1-pA)(1-pB)\}$

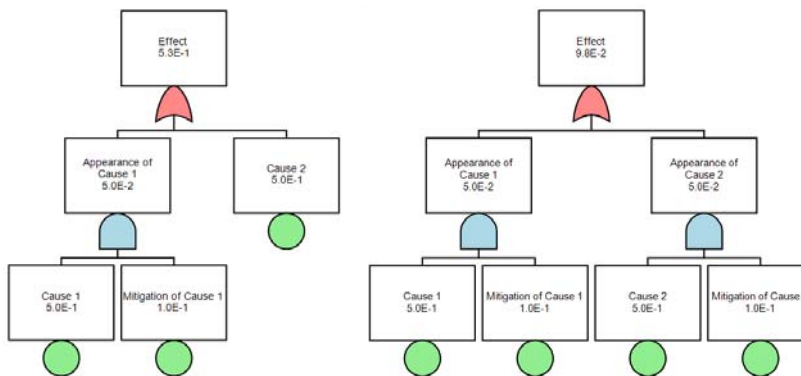
## Mitigation uses And Gates



## Assessing Mitigation – stronger mitigation

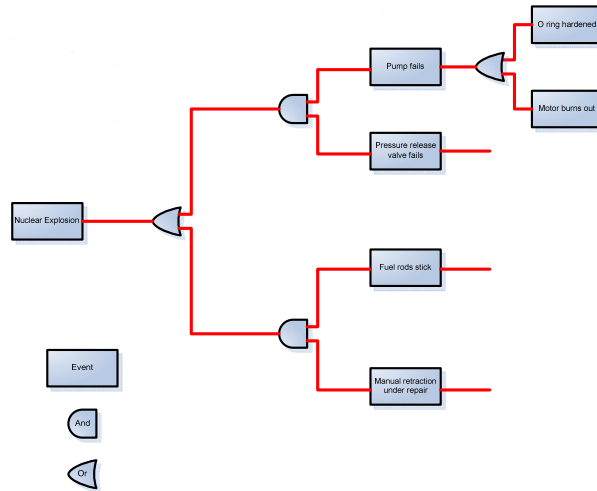


## Assessing Mitigation – added mitigation

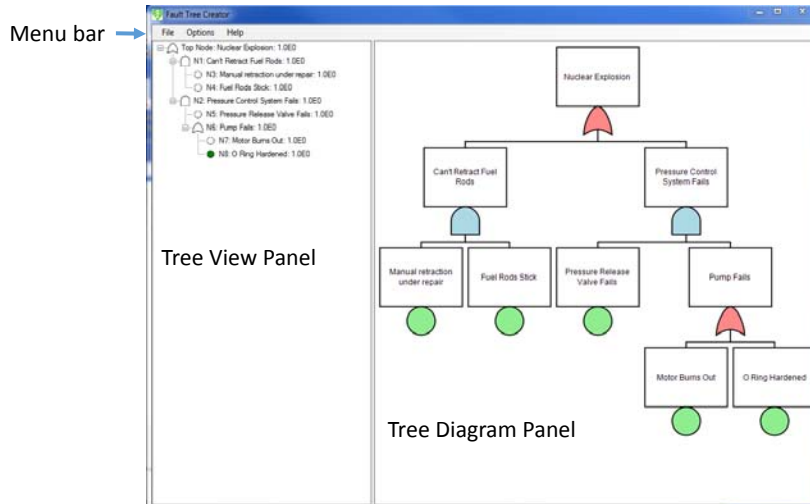


# Software Tutorial

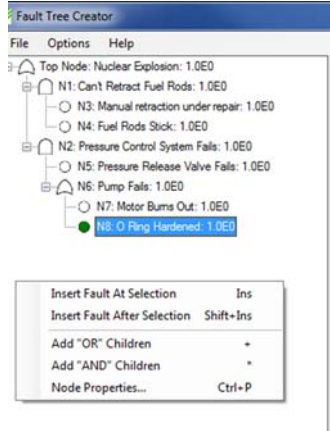
- Recreate The Tree on Paper
- Note the software only works top – down
- The charts by Bruce are left - right



# Fault Tree Creator



## Tree View Panel context menu



Shortcuts are next to the menu items on the tree view panel  
CTRL + space bar will also change node properties.

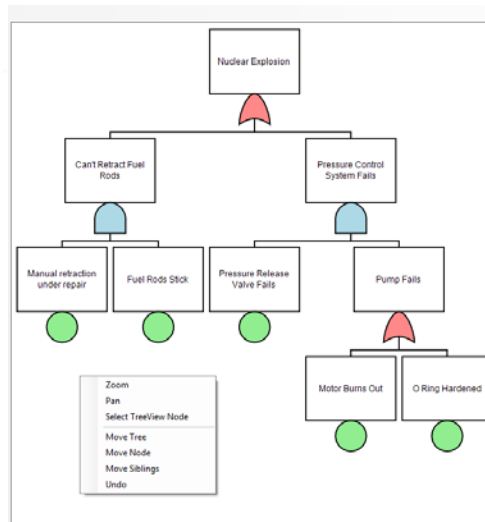
## Tree Diagram Panel context menu

These are all navigation items or position refinement items.  
No short cut keys.

Selecting an item puts the mouse in that mode.

Click and Drag the mouse to zoom, pan, move a tree, move a node, or move siblings.

In "Select TreeView Node" mode, you can click on a node in the tree diagram, and it will be selected in the tree view panel.



## File -> New

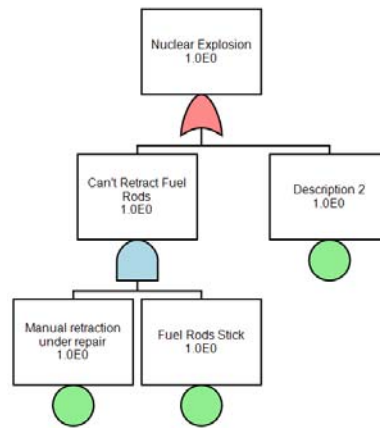
- Navigate to the desired fault tree and give it a name “demoTree”
- Note that a tree with an OR node and two terminal nodes is created.
- Expand the Top Node by clicking on the plus sign
- Select the Top Node
- Hit CTRL – space bar OR CTRL – P
- The Property Dialog box opens.
- Enter the Description “Nuclear Explosion”

## Danger ....

- The Fault Tree Software requires a description for each node. You can't have plain gates. How do we reconstruct Peter's Fault Tree?
- The next Level in Peter's tree has two AND nodes.
- Select the node N1.
- Hit the asterisk (\* or 8) key. No need to hold down the shift key. You will get an AND node.
- Two terminal nodes are always created.
- Select node N3, hit CTRL-space bar, and enter “Manual retraction under repair”.
- Select node N4, hit CTRL-space bar, and enter “Fuel Rods Stick”.
- Select node N1, hit CTRL-space bar, and enter “Can't Retract Fuel Rods”.
- Note how we had to add the description for node N1.



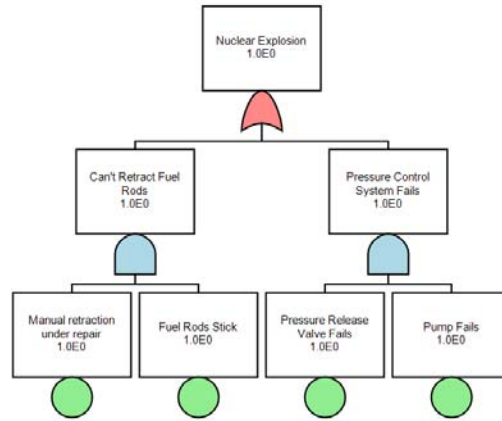
Where we are so far...



Now the other branch...

- Select node N2.
- Hit CTRL-space bar. Enter “Pressure Control System Fails”
- Select node N2.
- Hit the asterisk (8) key. Think of this as “multiply”, or the “AND” node key. This converts the node N2 from a terminal node to an “AND” node.
- Select node N5, hit CTRL-space bar, and enter “Pressure Release Valve Fails”.
- Select node N6, hit CTRL-space bar, and enter “Pump Fails”.

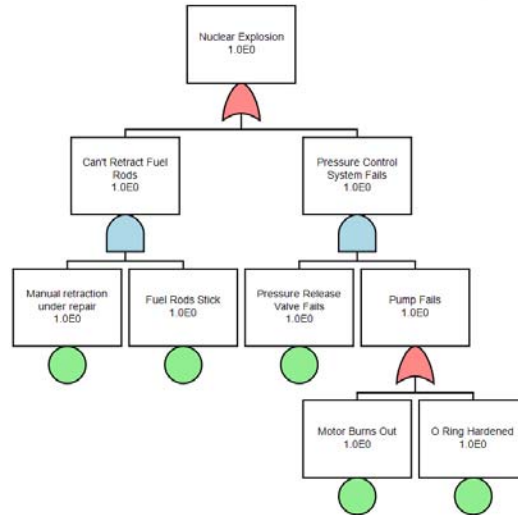
Where we are so far...



## The Last Level

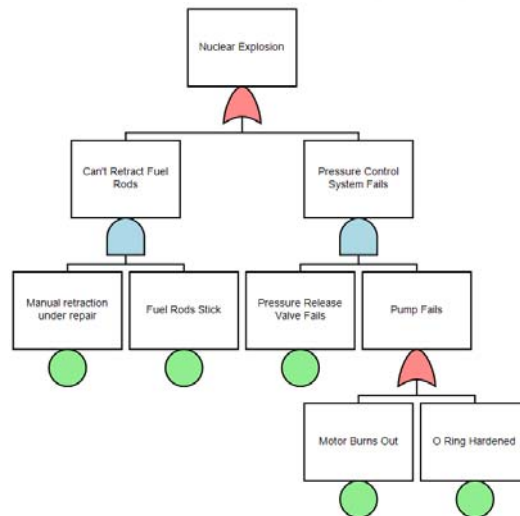
- Select node N6
- Hit the equals or plus key. No need to hold down shift.
- You have just turned a terminal node into an OR node.
- Click on the plus sign to expand the node and see the child nodes N7 and N8.
- Ok... your turn... change the descriptions on N7 and N8 to match Peter's tree. (select the node and hit CTRL-space bar)
- N7 "Motor Burns Out"
- N8 "O Ring Hardened"

# Final Tree



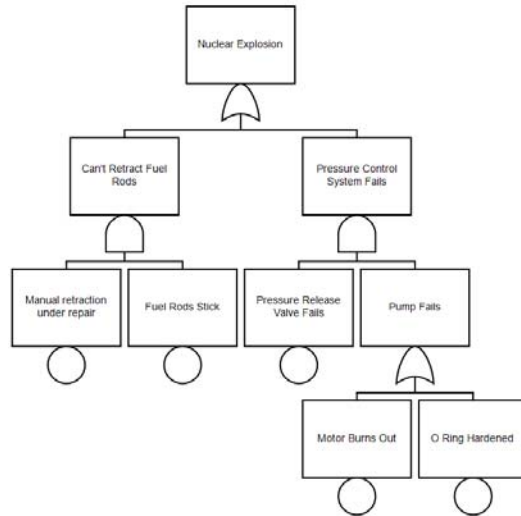
# Some Clean Up options - 1

- We don't know the probabilities, you might want to turn it off.
- Options →  
Graphic →  
No  
Probability



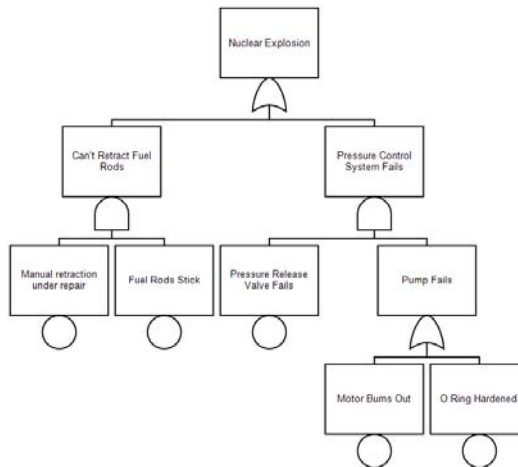
## Some Clean Up options - 2

- Maybe this is for a black and white publication
- Options →  
Graphic →  
No Color



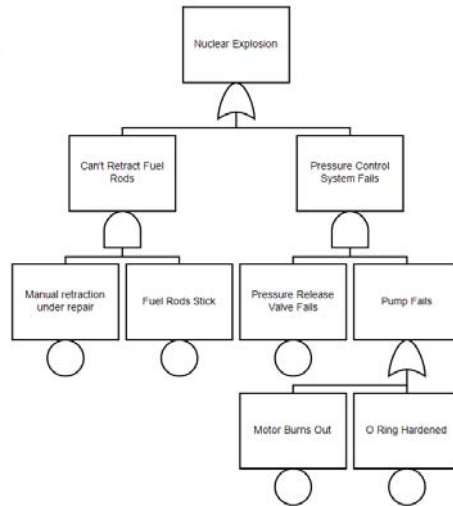
## Mine doesn't quite look like that...

- Maybe you didn't have the selection
- Options →  
Graphic →  
Tighten



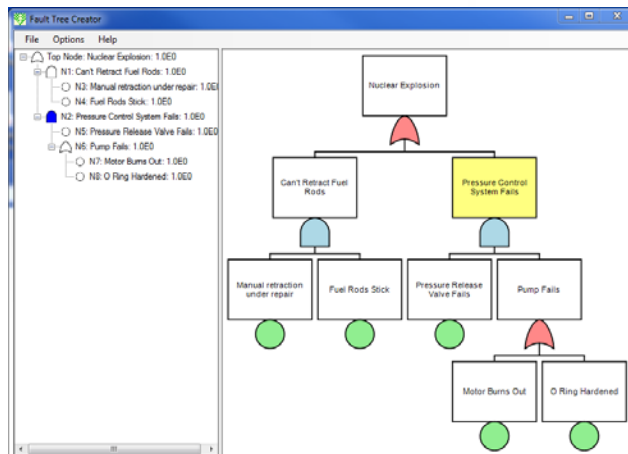
## If you're really saving space...

- Right Click on the tree diagram. In the context menu that appears, select "Move Siblings"
- Drag the bottom nodes to the right to reduce the width of the tree



## Where am I in the tree ?

- Options → Highlight Selected Node
- Turning this on will show, highlight in yellow, the selected node.



## Next Exercise

- Take your paper chart for the Fault Tree you created in exercise 1 and re-create it in the Fault Tree software.

## Cheat Sheet – creating content

- File → New to create and save a basic tree.
- Right mouse click to open pop-up menus. They have these shortcuts:
- With a Node selected:
  - Change node properties: CTRL – space bar
  - Convert terminal node to AND node with 2 children: 8 key (\* on numeric keypad)
  - Convert terminal node to OR node with 2 children: = key (+ on numeric keypad)
  - Remove children from a node (converts to terminal node): - key
  - Toggle AND to OR node or vice versa: CTRL-T
  - Insert a terminal node (fault) at the selection location: INS key
  - Insert a terminal node (fault) after the selection location: SHIFT and INS keys
  - Delete a terminal node: DELETE key (not backspace).
- Not all operations are permitted. Use the pop-up menu to see what is permitted. Minor bug – after an operation you have to move from one node to another then back to the node to refresh the permitted operations.

## Cheat Sheet – customizing the diagram (right panel of the software)

- All operations are via a right mouse click to get a pop-up menu
- Choose the customization mode from the pop-up
- Click, or Click and drag as needed.
- Modes:
  - Zoom
  - Pan
  - Select Tree View Node (clicking on a fault in the diagram on the right panel selects the fault in the left panel)
  - Move Tree
  - Move Node
  - Move Siblings
  - Undo (undoes the move only)

## Cheat Sheet – Options Menu

- Graphic
  - Tighten (brings nodes in closer)
  - No Color
  - No Probability
- Draw Selected Tree
  - This will pan and zoom the right panel diagram to show the node (and its children) that is selected on the left panel
- Highlight Selected Node
  - Selecting a node on the left panel will highlight (in yellow) the corresponding node in the diagram on the right panel.
- Snap to Object Grid
  - Helps with aligning nodes when you move them in the right panel.

## Cheat Sheet – Close, Save and Export

- Close – closes the current file without quitting. To quit the application, use File → Exit
- File → Save to save your current work to the file of the same name.
- File → Save As to save your work as a new file.
- Export Visible Diagram As →
  - Bitmap, GIF, JPEG, PNG, TIFF
  - This will create an image file of the visible content of the right panel
- Export .svg
  - This will export the entire diagram, even parts that are off the screen, as a scalable vector graphics file. You will have the best resolution possible with this. You can use other graphics programs to manipulate this as needed. (Inkscape and GIMP are my freeware favorites for this purpose.)