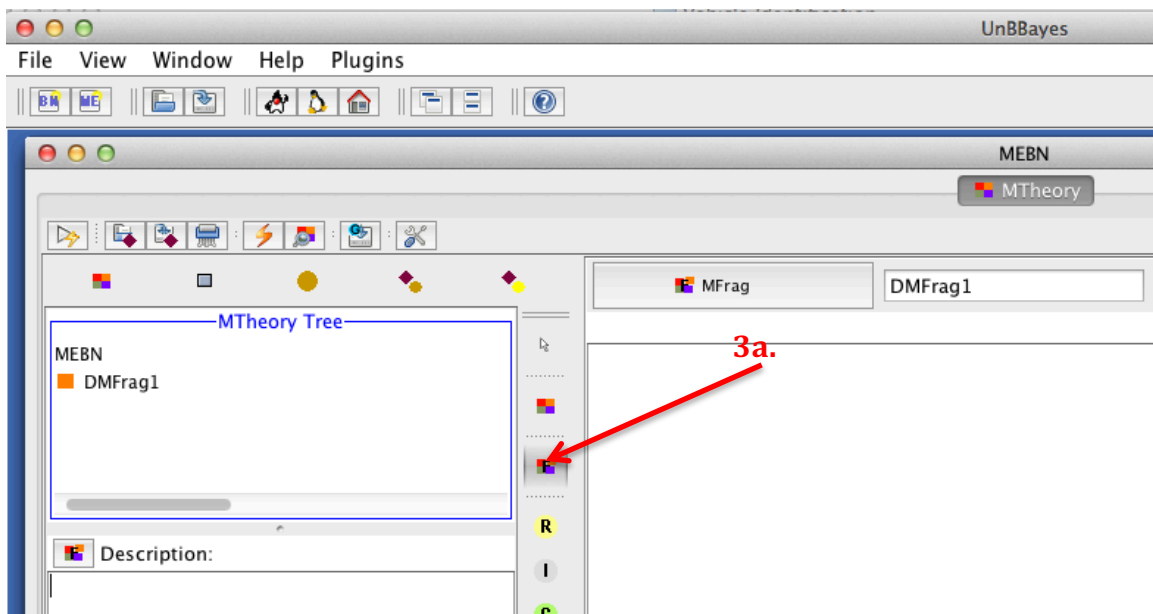
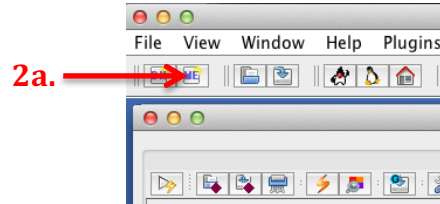


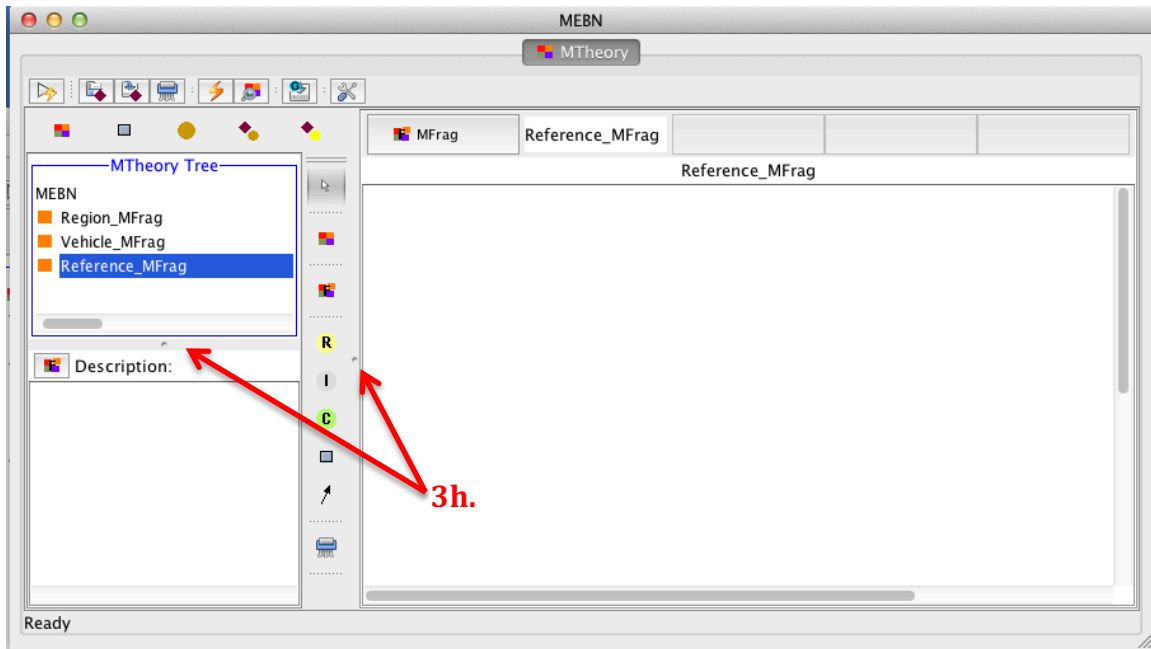
Simple Vehicle Identification MTheory: A UNBBayes-MEBN Tutorial

1. Start UnBBayes
 - a. Double-click the unbbayes.jar file.
(On Windows you can also run unbbayes.bat; on Linux you can run unbbayes.sh)
2. Create new MTheory
 - a. Click “New MEBN” button on toolbar just below main menu bar.
3. Make 3 new MFrag
 - a. Click “New MFrag” button at left of MFrag editing pane.
 - b. In the MFrag name field, highlight “DMFrag1” and type “Region_MFrag.” Hit “Enter.”

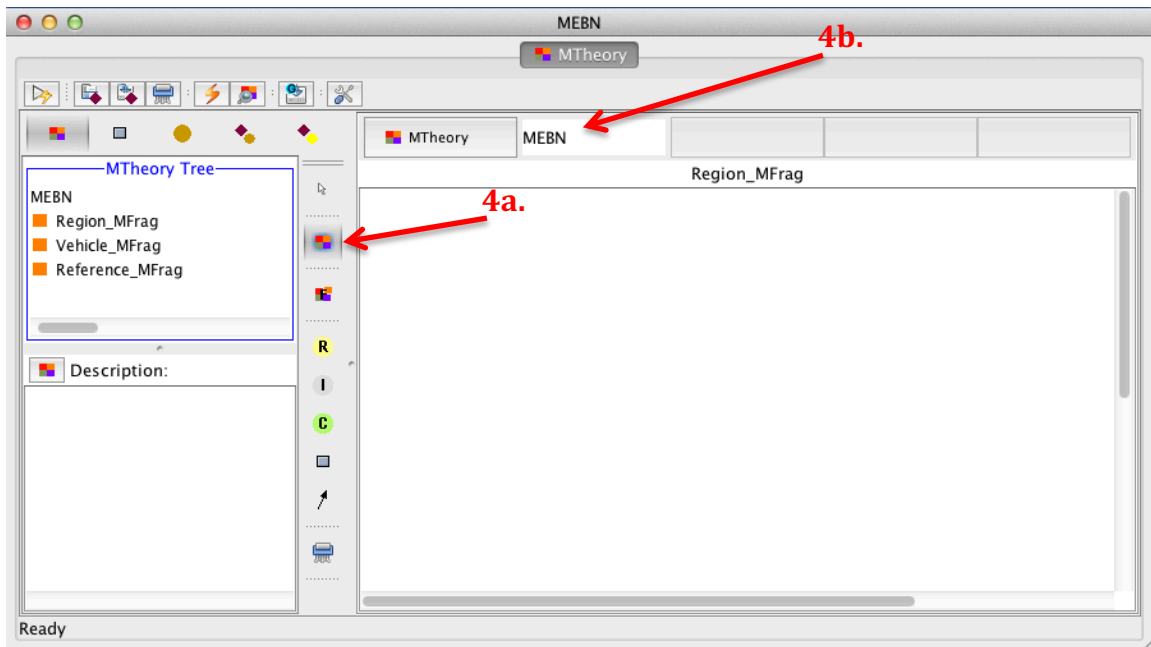


- c. Click “New MFrag” button at left of MFrag editing pane.
- d. In the MFrag name field, highlight “DMFrag2” and type “Vehicle_MFrag.” Hit “Enter.”
- e. Click “New MFrag” button at left of MFrag editing pane.
- f. In the MFrag name field, highlight “DMFrag3” and type “Reference_MFrag.” Hit “Enter.”
- g. You now have three blank MFrag as shown below.

- h. Note that you can resize windows by dragging the window borders as shown below.

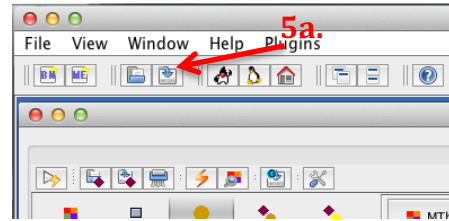


4. Rename your MTheory.
- Click "Edit MTheory" button at left of MFrag editing pane as shown below.
 - Highlight the text "MEBN" in the MTheory name field and change to "SimpleVehicleID_MTheory. Hit "Enter."



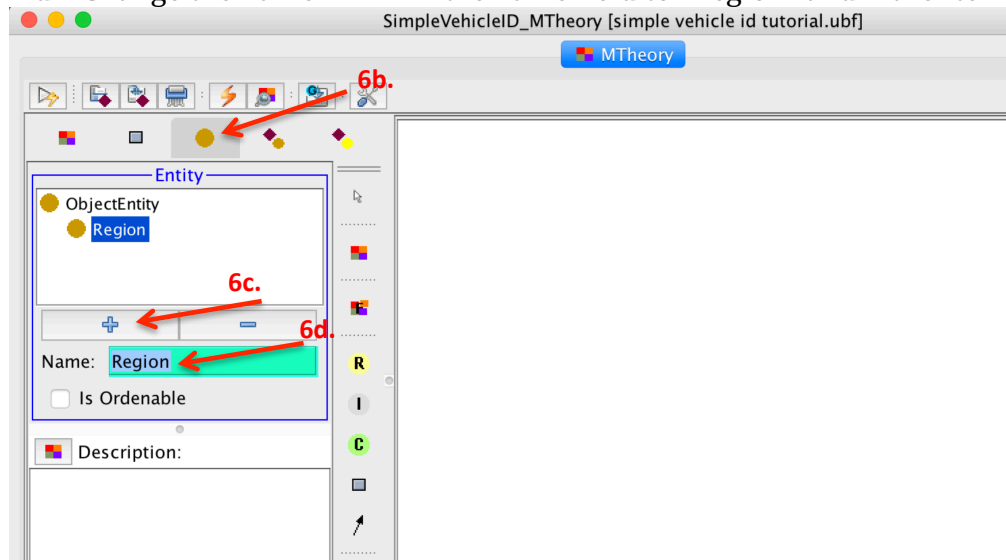
5. Save your empty MTheory.

- a. Click on “Save Net” button on toolbar just below main menu bar.
- b. Type “SimpleVehicleID.ubf” in the file name box and push “Save” button.



6. Define object types.

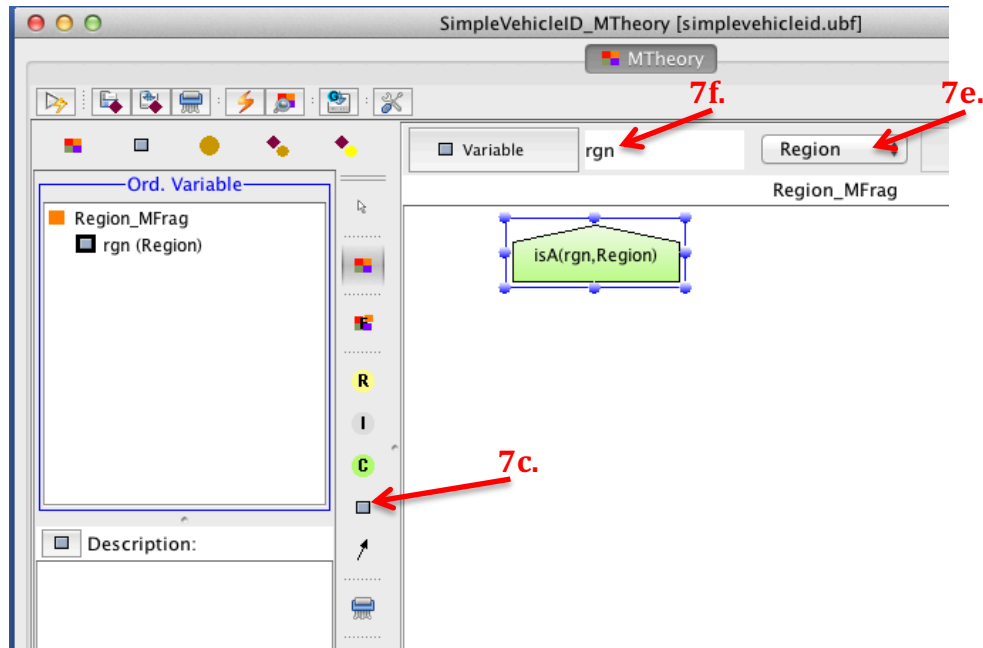
- a. Click “Show entities of the MTheory” button above the MTheory tree.
- b. Highlight “ObjectEntity” as the parent entity type.
- c. Click “+” to add a new entity type. (You may want to expand the size of the Entity pane by dragging the window border as described in 3h.)
- d. Change the name “EX2” in the name field to “Region” and hit “enter.”



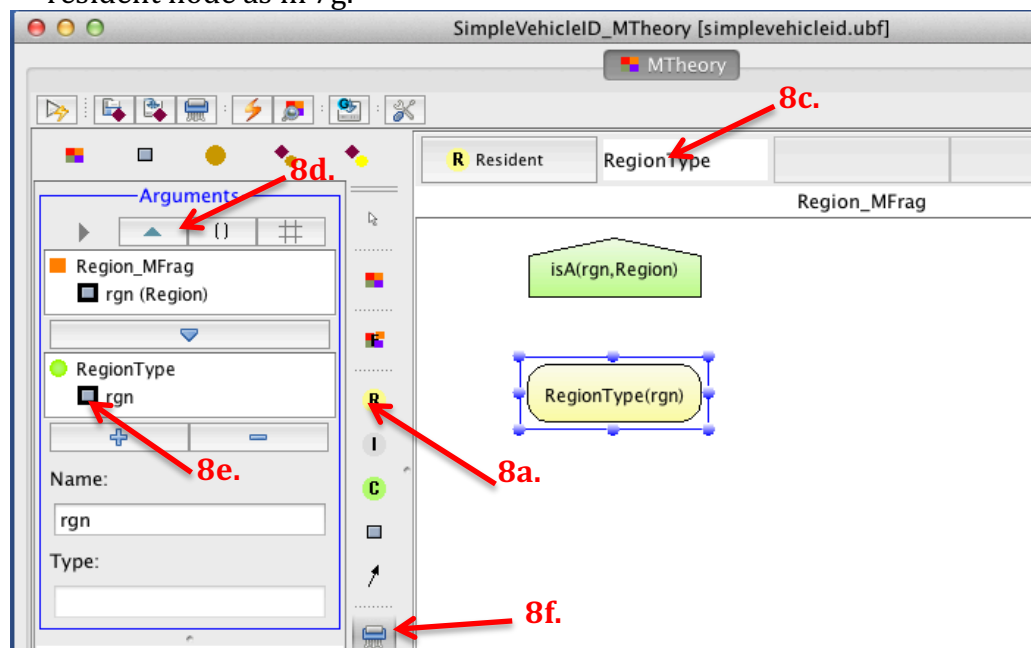
- e. Highlight ObjectEntity and Click “+” again.
- f. Change the name “EX3” in the name field to “Vehicle.”
- g. Save your MTheory again. You may want to keep partial models at different stages. To do this, you can use the “File > Save as...” menu item, click on the file, and then edit the name to “SimpleVehicleID_v2.ubf” to indicate the version number.

7. Define IsA context node in the Region MFrag.

- a. Click “Edit the MTheory” button (see 4a.)
- b. Double-click “Region_MFrag” in the MTheory tree. Make sure “Region_MFrag” appears above the editing pane.
- c. Click the “Insert Ordinary Variable” button at left of editing pane.
- d. Move cursor to top of the MFrag palette and click to drop an IsA node into the MFrag.
- e. Select “Region” from the drop-down list of types.
- f. Change the name “OX1” to “rgn” in the ordinary variable name field.
- g. Right-click on the IsA node and select “Resize to fit text” or resize by dragging the node border. Your MFrag should now look like the figure below.



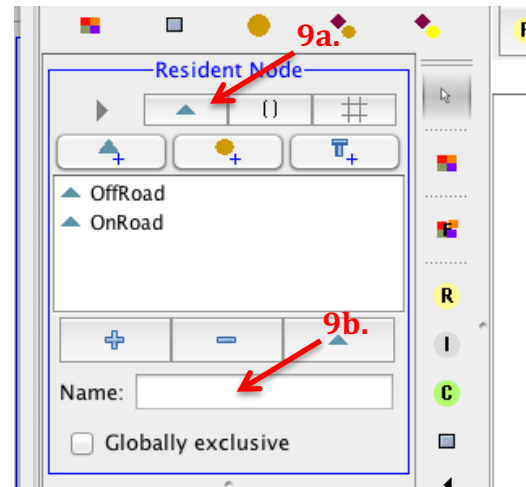
8. Define resident node in Region MFrag.
 - a. Click the “Insert Resident Node” button at left of editing pane.
 - b. Move cursor onto palette below the IsA node and click to drop a new resident node onto the palette.
 - c. Highlight the name “RX1” in the name field at the top of the editing pane and change to “RegionType”. Hit “Enter.” Resize the new resident node as in 7g.
 - d. In the Resident Node pane, click the “Edit Arguments” button shown as “()” to select the ordinary variable for this resident node. You may need to resize the top-left pane as described in 3h.
 - e. Double-click on “rgn (Region)” to insert the ordinary variable. Resize the resident node as in 7g.



- f. If you accidentally drop an extra node onto the diagram, you can remove it with the shredder button to the left of the editing pane.

9. Define states for the resident node.

- a. Click on the “Edit States” button in the top-left pane. The name of the pane will change from “Arguments” to “Resident node.”
- b. Type “OffRoad” into the name field and push Enter or the “+” button. A new state will appear in the states pane.
- c. Type “OnRoad” into the name field and push Enter or the “+” button. A new state will appear in the states pane as shown to the right.

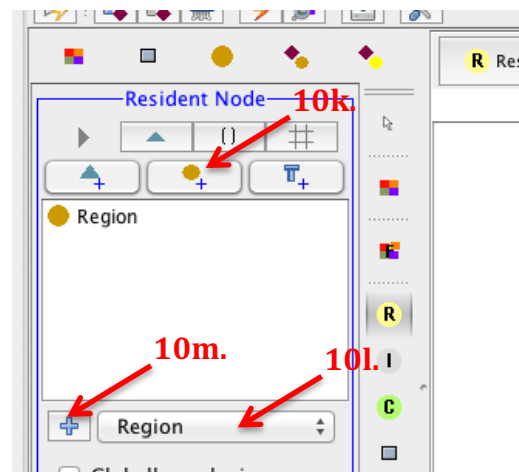


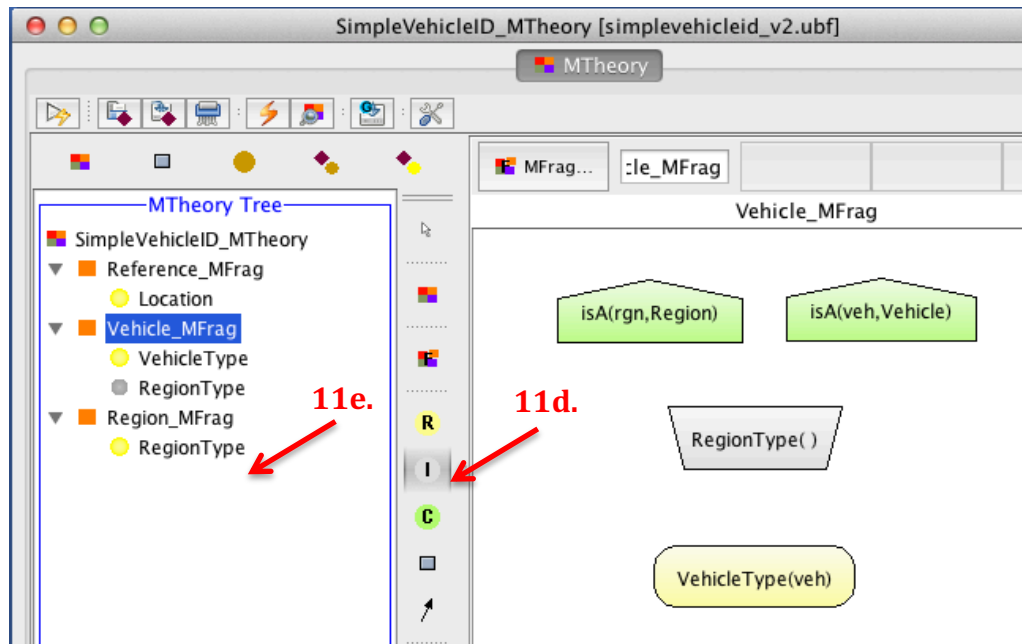
- d. Save your MTheory again with a new version number.

10. Define nodes and states for the Reference MFragment.

- a. Click “Edit the MTheory” button (see 4a.)
- b. Double-click “Reference_MFragment” in the MTheory tree. Make sure “Reference_MFragment” appears above the editing pane.
- c. Click the “Insert Ordinary Variable” button at left of editing pane. (See 7c.)
- d. Move cursor to top of the MFragment palette and click to drop an IsA node into the MFragment.
- e. Select “Vehicle” from the drop-down list of types.
- f. Change the name “OX1” to “veh” in the ordinary variable name field.
- g. Click the “Insert Resident Node” button at left of the editing pane. (See 8a.)
- h. Move the cursor onto the palette below the IsA node and click to drop a new resident node onto the palette.
- i. Highlight the name “RX2” in the name field at the top of the editing pane and change to “Location.” Hit “Enter.” Use Edit Arguments “()” to add the veh ordinary variable as an argument (See 8d.)

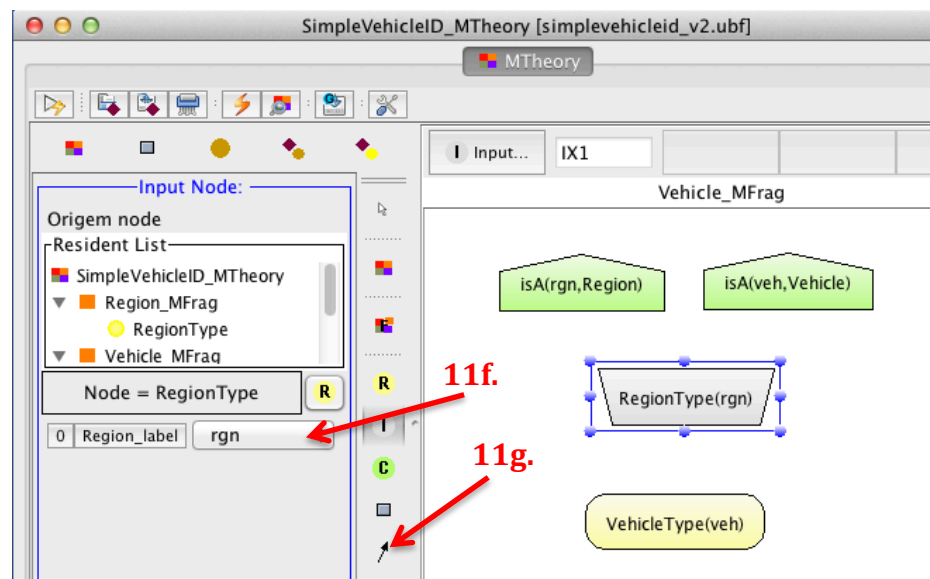
- j. Click on the “Edit States” button in the top-left pane.
- k. Click “Insert object entity states” button to indicate that the Location(veh) random variable has entity instances for its states.
- l. Select “Region” from the drop-down menu of entity types.
- m. Click “+” to indicate that the Location(veh) random variable has Region instances as its states.
- n. Resize both nodes in the MFragment as described in 7g.



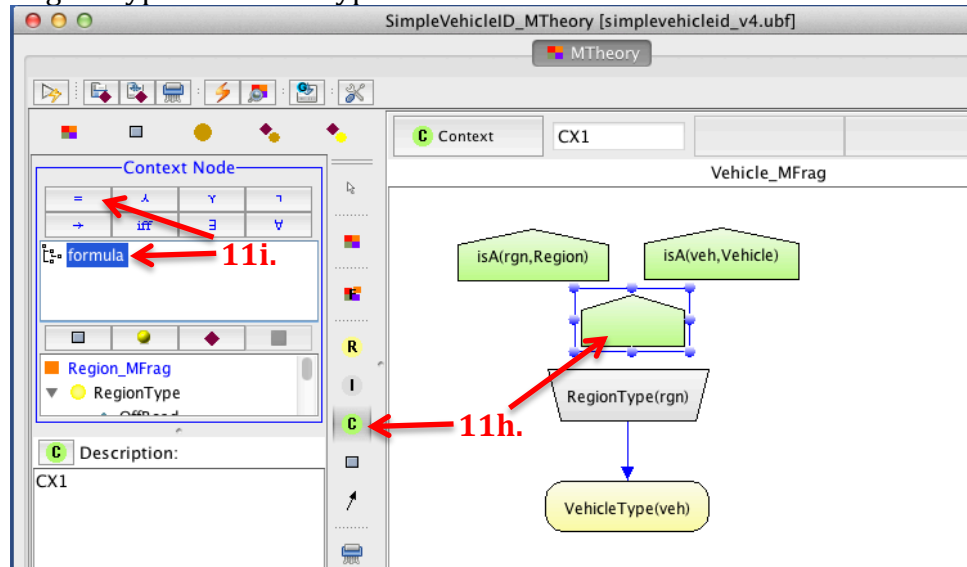


11. Define nodes and states for the Vehicle MFrag.

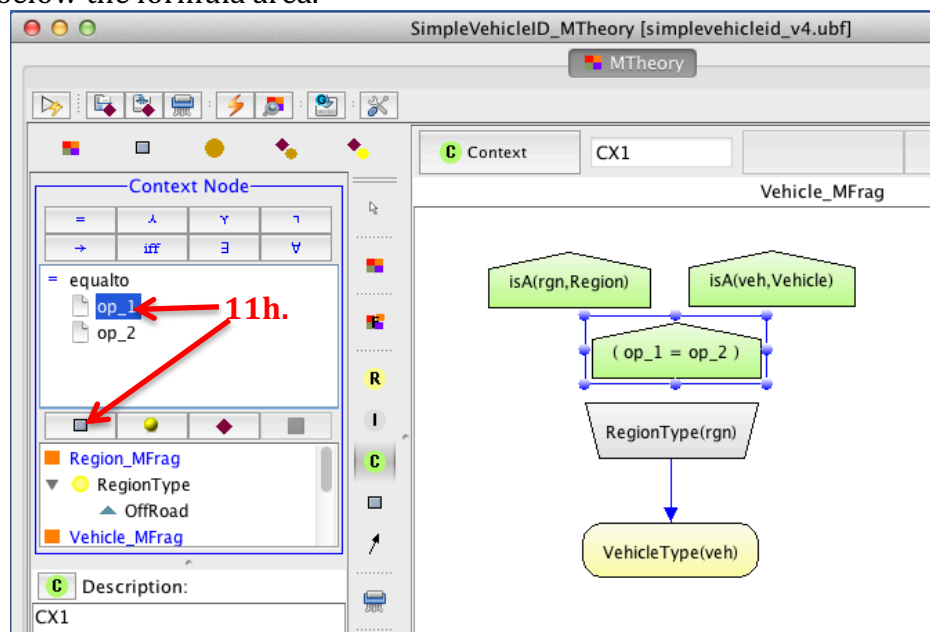
- Click "Edit the MTheory" button (see 4a.) and double-click "Vehicle_MFrag" in the MTheory tree.
- Add two IsA nodes: IsA(veh, Vehicle) and IsA(rgn, Region) as described in Steps 7 and 10 above.
- Insert a resident node VehicleType(veh) as described in Step 8 above. Give it category states Tracked and Wheeled as described in Step 9 above.
- Click "Insert input node" at the left of the editing pane. Click on the editing pane to drop a new blank input node into the MFrag.
- Find "RegionType" in the Resident List and double-click to point the new input node to the RegionType random variable in the Region MFrag.



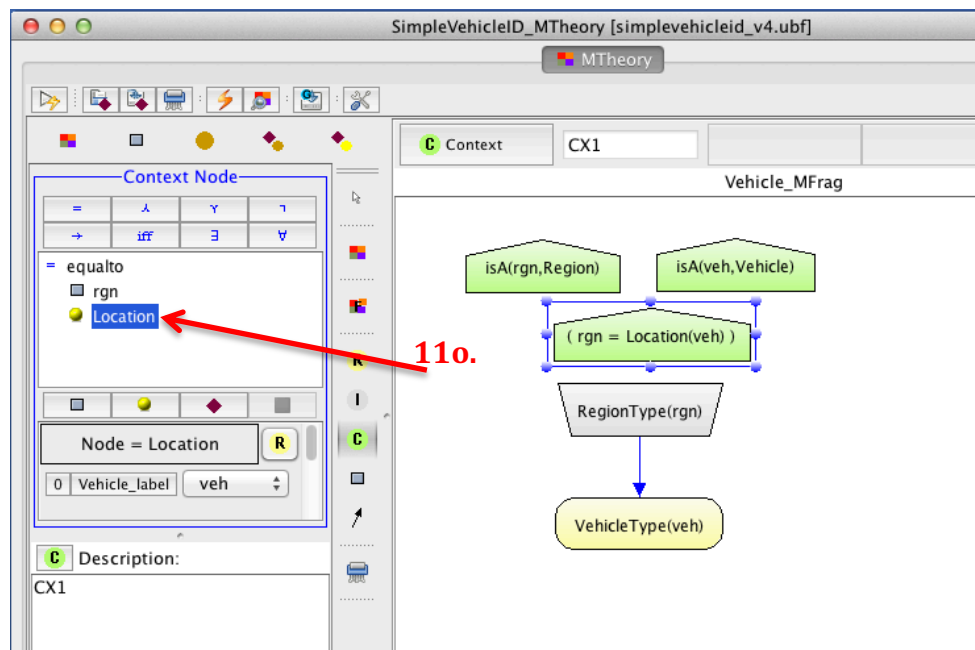
- f. Click the RegionType input node and select “rgn” from the drop-down list of arguments. Resize the RegionType input node.
- g. Select the arc tool from left of the MFrag pane and draw an arc from RegionType to VehicleType.



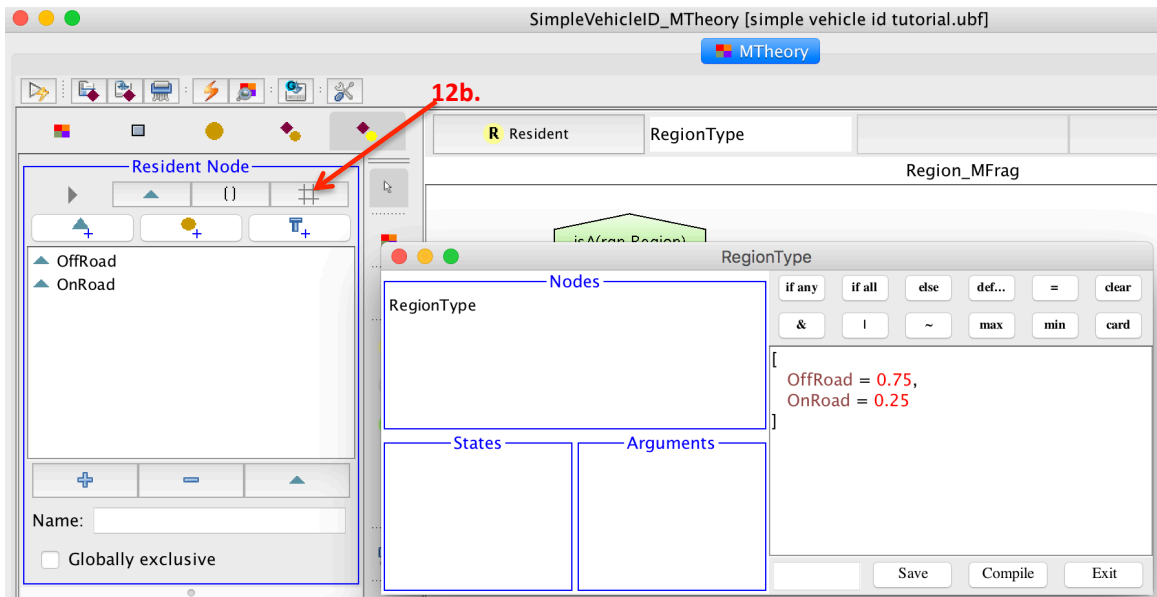
- h. Add the reference context node. Click “Insert context node” to the left of the editing pane and insert a blank context node onto the editing pane. This reference node will represent the knowledge that the link between the RegionType of a region and VehicleType of a vehicle applies when the vehicle is located in the region.
- i. Click “formula” in the Context Node pane at the upper left of the window.
- j. Click the “=” button above the formula area. The expression (op_1=op_2) will appear inside the context node.
- k. Highlight “op_1” in the formula area. Click the “Add ordinary variable” button below the formula area.



- l. Double-click “rgn” in the list of ordinary variables that appears below the row of buttons. Notice that “op_1” changes to “rgn” in the context node.
- m. Highlight “op_2” in the formula area. Click the “Add node” button.
- n. Double-click “Location” in the list of nodes that appears below the row of buttons. Notice that “op_2” changes to Location() in the context node.
- o. Double-click “Location” in the formula area to produce a drop-down list of arguments in the area below the row of buttons.
- p. Choose “veh” from the list of arguments. Now the context node $\text{rgn} = \text{Location}(\text{veh})$ is complete.
- q. Save your MTheory. You now have the structural part of your probabilistic ontology! Our next step is to define the probabilities.



12. Define local distribution for RegionType random variable.
 - a. Click “Edit the MTheory” button and double-click “RegionType” random variable in the MTheory tree. (If you do not see the random variable, you can expand the Region MFrag to show its random variables by clicking on the triangle to the left of the MFrag name. Or you can double-click the MFrag and then select the RegionType random variable in the editing pane.)
 - b. With the RegionType node selected, click the distribution button “#” in the Resident Node area. A box will pop up for the distribution.
 - c. Click the “default” button. A formula will appear in the blank node window.
 - d. Change the word “formula” after each of the states to 0.75 for OffRoad and 0.25 for OnRoad. Be careful not to erase the comma after the probability for the first state.
 - e. Click “Compile.” You should see a message that the table compiled successfully. Click “Save,” and then click “Exit.” (*Make sure you click “Save” or your edits will be lost.*)



13. Define local distribution for VehicleType random variable.

- Click "Edit the MTheory" button and double-click "VehicleType" random variable in the MTheory tree. (If you do not see the random variable, you can expand the Vehicle MFrag to show its random variables by clicking on the triangle to the left of the MFrag name. Or you can double-click the MFrag and then select the VehicleType random variable in the editing pane.)
- With the VehicleType node selected, click the distribution button "#" in the Resident Node area. A box will pop up for the distribution.
- Click the "if any" button. A formula will appear in the blank node window.
- Change the text "paramSubSet" to "rgn". (You can type it directly, or you can double-click "paramSubSet" to select it, click "RegionType" to select it, and then double-click "rgn" in the Arguments area.)
- Change the text "booleanFunction" to "RegionType=OffRoad". (You can type it directly, or you can select the text "booleanFunction", click the "=", select the text "Node", double-click "RegionType" in the Nodes area, then select the text "NodeState" and double-click "OffRoad" in the States area.)
- Change the word "formula" after each of the states to 1 for Tracked and 0 for Wheeled. Be careful not to erase the comma after the probability for the first state. You have told UnBBayes that when RegionType is OffRoad, then VehicleType must be Tracked.
- Now place the cursor after the "]" and click the "else" button. Change the word "formula" after each of the states to 0.1 for Tracked and 0.9 for Wheeled. Be careful not to erase the comma after the probability for the first state. You have told UnBBayes that when RegionType is OnRoad, the VehicleType is probably (90%) Wheeled.
- Click "Compile." You should see a message that the table compiled

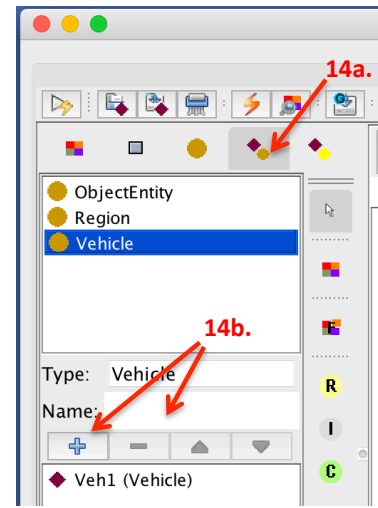
```
if any rgn have (RegionType = OffRoad ) [
  Tracked = 1,
  Wheeled = 0
]
else [
  Tracked = 0.1,
  Wheeled = 0.9
]
```

successfully. Click “Save,” and then click “Exit.” (*Make sure you click “Save” or your edits will be lost.*)

- i. Now you have a complete probabilistic ontology. Congratulations! You can observe your whole MTheory by clicking the “See MTheory” button (MTheory symbol with a magnifying glass on the top menu). You can return to Edit mode by clicking the clipboard button. Save your model with a new version number.

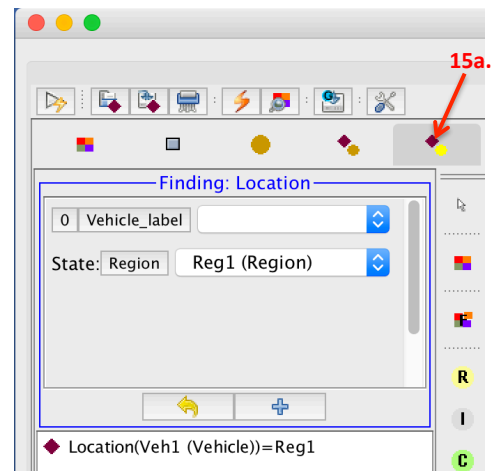
14. Now that we have a probabilistic ontology, we are going to define some instances. We will start with one vehicle and one region.

- a. Click “Show entity instance editing pane”. Highlight “Vehicle” in the list of entity types that appears in the upper left pane.
- b. Type “Veh1” in the Name field and click “+” or hit the Enter key. You have defined an object instance called “Veh1”.
- c. Now define a region instance called “Reg1”.
- d. Save the MTheory with a new version number.



15. Now we will tell UnBBayes where Object1 is located.

- a. Click “Show findings editing pane”.
- b. Highlight “Location(0)”
- c. Click the pencil to bring up the finding: Location pane.
- d. Choose “Veh1” from the drop-down menu of arguments and click “+” to add a finding that Veh1 is located in Reg1.
- e. Save the evidence. UnBBayes keeps findings in a separate file from the MTheory and entity instances. Choose “Save Knowledge Base” and enter the filename “SimpleVehicleID.plm”.

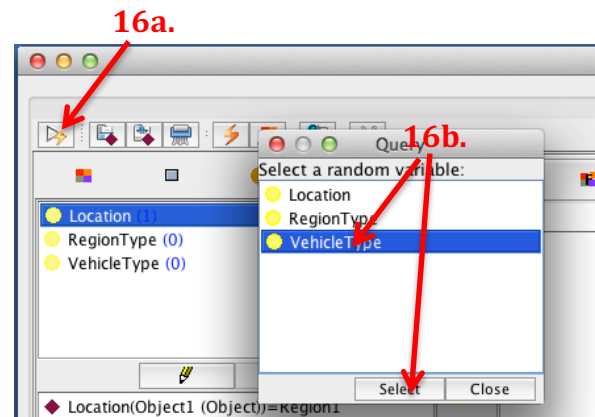


16. We are now ready to run a query.

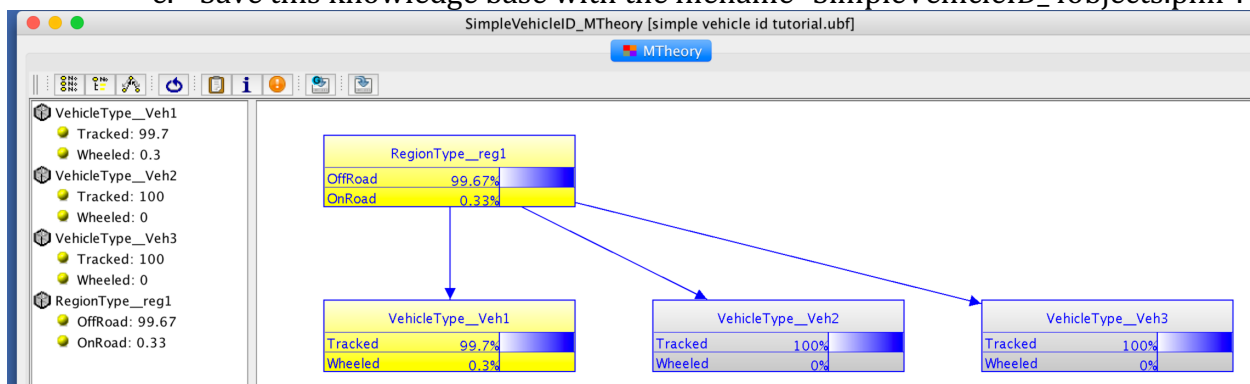
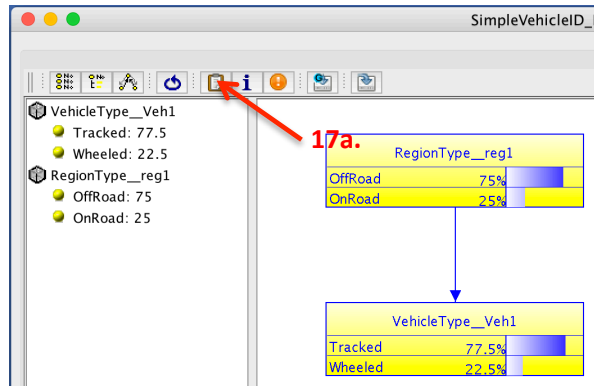
- a. Click the “Execute Query” button.
- b. In the popup query window, highlight “VehicleType” and push the “Select” button.
- c. Select “Veh1” from the drop-down menu of entity instances.
- d. Click the “Execute” button. A Bayesian network will appear.

17. Add some more entities and evidence.

- a. Click the “Return to edit mode” button to return to editing the MTheory.



- b. Add three more object instances, named Veh2, Veh3 and Veh4.
- c. Add evidence that the new objects are located in Reg1 and that Veh2 and Veh3 have VehicleType equal to Tracked.
- d. Run the same query again. That is, repeat Step 16. Notice that the situation-specific Bayesian network has more nodes than before. Notice also the change in beliefs about the VehicleType of Veh1 and the RegionType of Reg1. Do these changes seem reasonable to you? Notice that even though Veh4 is located in Reg1, VehicleType(Veh4) does not appear in the situation-specific Bayesian network. This is because it is not needed to compute the result of the query. Try also running a query on VehicleType(Veh4). What do you see?
- e. Save this knowledge base with the filename “SimpleVehicleID_4objects.plm”.



18. Now try adding another node “Speed” to represent the vehicle speed, as shown below.

- a. Add the Speed(veh) node to the Vehicle MFrags as in Step 11 above.
- b. Give it states “Slow” and “Fast”.
- c. Draw an arc from VehicleType(veh) to Speed(veh).
- d. Give it the distribution as shown below.
- e. Try different evidence and different queries. Notice that the situation-specific Bayesian network will include only the nodes necessary to answer your query. See the examples below with the same MTheory, the same four objects, and different evidence.

