

# TUTORIAL ON HIERARCHICAL DECISION MODELS (AHP)

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# Tutorial for the SuperDecisions Software

## PART 1. HOW TO USE *SUPERDECISIONS* TO BUILD AHP HIERARCHICAL DECISION MODELS

There are two tutorials. This first one is on how to create hierarchical AHP decision models using the *SuperDecisions* software and do the personal decision exercises such as choosing a place to go on vacation. The second tutorial is on how to create network ANP decision models for decision making with dependence and feedback and complex Benefits, Opportunities, Costs and Risks models.

We start by showing how to build an Analytic Hierarchy Process (AHP) hierarchical decision model.

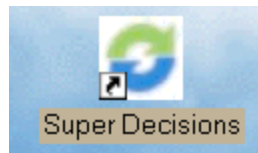
### INSTALLING THE SUPERDECISIONS SOFTWARE

To Install the *SuperDecisions* software insert the CD in the CD drive on your computer. Click on Start, then on Run and run the Setup file to install the software. If this file does not automatically appear, click on the My Computer icon on the desktop, then click on the icon for the CD drive and on the file Setup.exe. Serial number to install the software:

**A846-64DXB-47EB**

It will be valid until May 2004. You may download an updated version free and serial number free from [www.superdecisions.com](http://www.superdecisions.com) when this software expires.

- To start the program click on the icon that has appeared on the desktop of your computer or go to Start/Programs/Super Decisions:



# INTRODUCTION TO BASIC CONCEPTS

This lesson describes how to build the simplest decision model that has a goal, criteria and alternatives, make judgments (paired comparisons), and compute the results to find the best alternative.

## CLUSTERS AND ELEMENTS

A hierarchical decision model has a goal, criteria that are evaluated for their importance to the goal, and alternatives that are evaluated for how preferred they are with respect to each criterion. An abstract view of such a hierarchy is shown in Figure 1. The goal, the criteria and the alternatives are all elements in the decision problem, or nodes in the model. The lines connecting the goal to each criterion means that the criteria must be pairwise compared for their importance with respect to the goal. Similarly, the lines connecting each criterion to the alternatives mean the alternatives are pairwise compared as to which is more preferred for that criterion. Thus in the hierarchy that is shown there are six sets of pairwise comparisons, one for the criteria with respect to the goal and 5 for the alternatives with respect to the 5 criteria.

A *SuperDecisions* model consists of clusters of elements (or nodes), rather than elements (or nodes) arranged in levels. The simplest hierarchical model has a goal cluster containing the goal element, a criteria cluster containing the criteria elements and an alternatives cluster containing the alternative elements as shown in Figure 1. When clusters are connected by a line it means nodes in them are connected. The cluster containing the alternatives of the decision must be named *Alternatives*. Nodes and Clusters are organized alphabetically in the calculations, so an easy way to control the order is to preface the names with numbers.

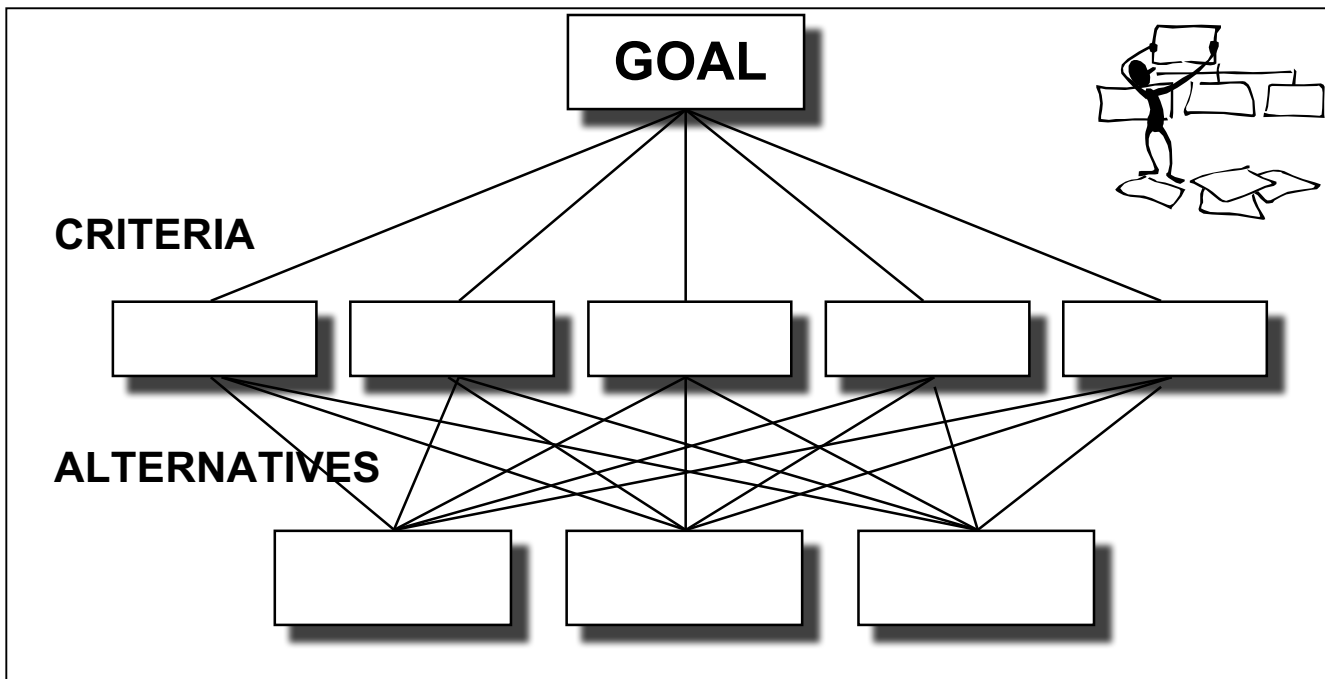
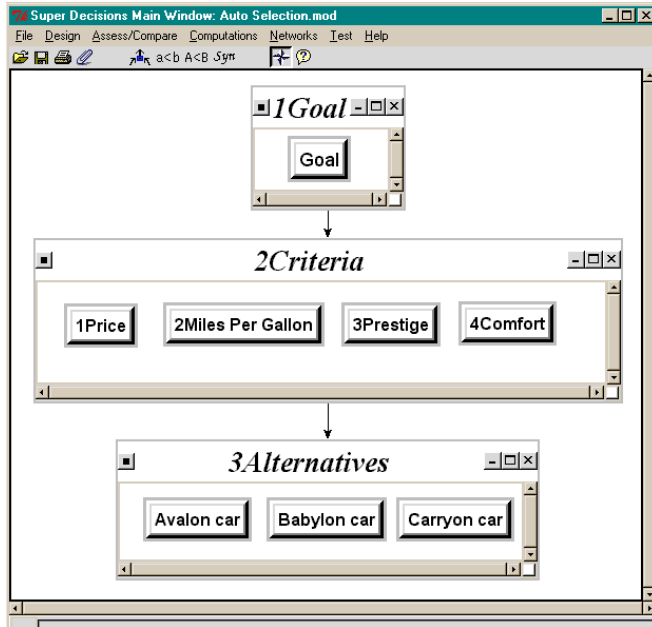


Figure 1. Abstract Representation of a Decision Hierarchy




*We are indebted to Professor Saul Gass for this model. He came up with these fictitious car names to avoid any complaints from actual car manufacturers. Since then, however, an actual car named Avalon has come to the market. We stick by our guns. These names are not intended to represent any actual car that is currently being sold or ever was. Any resemblance is entirely coincidental.*

**Figure 2. SuperDecisions Hierarchical Model for Selecting a Car.**

The model in Figure 2, *Car Hierarchy.mod*, is included with the sample models for the *SuperDecisions* software.

- To load this model click on the Help command, then on Sample Models and select Car Hierarchy.mod.

When clusters are shown connected with a line, it means elements in them are connected. To see which nodes are connected from a source or “parent” node, turn on the “Show Connections” icon  and place the cursor over the parent node. The nodes to which it is connected will then be outlined in red as shown in Figure 3.

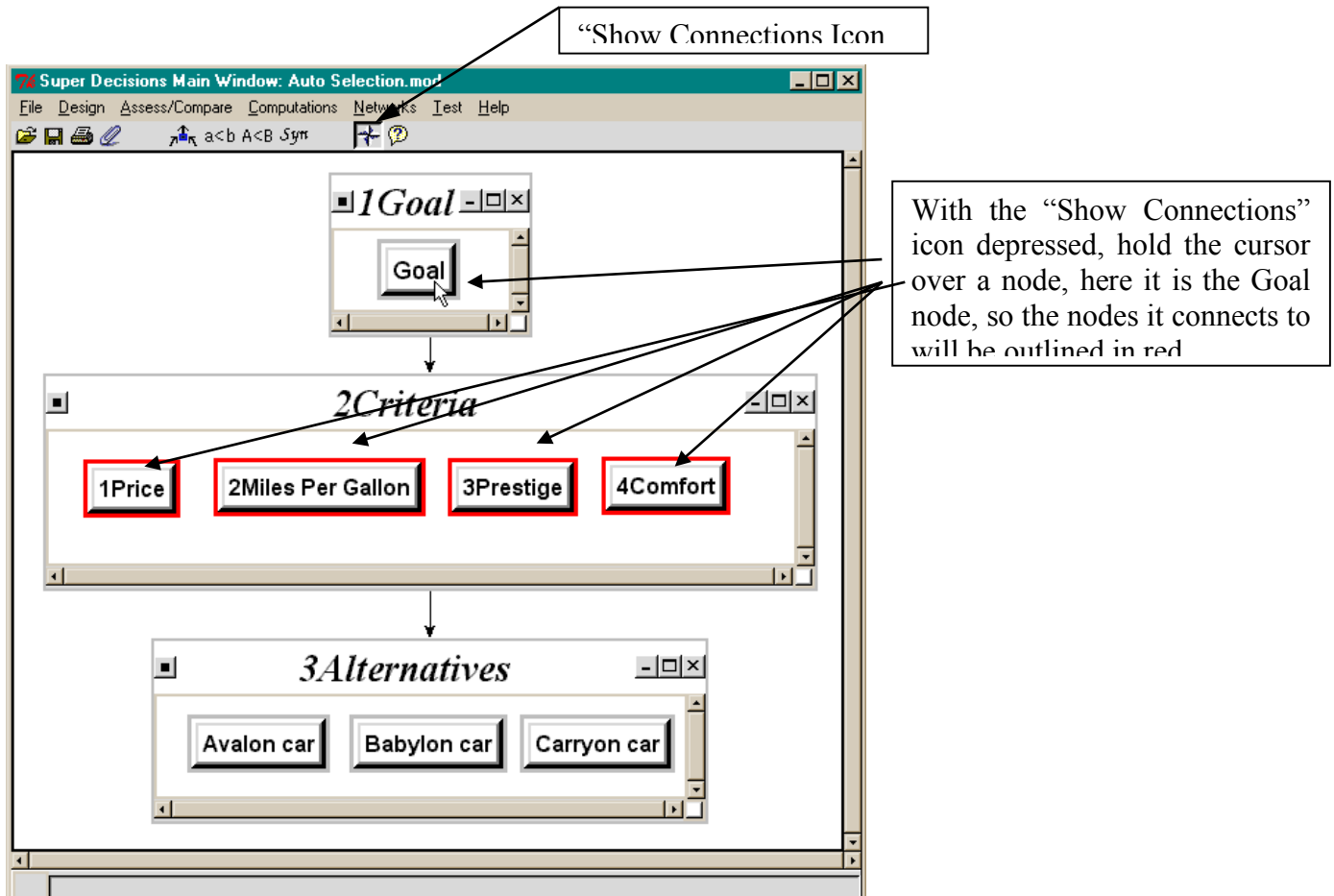


Figure 3. Turn on “Show Connections” Icon to see Element Connections.

Each criterion node is also connected to the alternatives. Place the cursor over each criterion in turn to highlight the alternatives for each.

In a hierarchical *SuperDecisions* model clusters are connected by arrows going in one direction from top to bottom. In network models, covered in the next chapter, clusters may be connected with arrows going both ways and also may be connected to themselves with a loop.

In a hierarchical structure like that shown in Figure 3, each comparison set is made up of a parent node and the nodes it connects to in the cluster below. There are five sets of pairwise comparisons to do for this model: the criteria with respect to the goal, and the alternatives with respect to each of the four criteria.

### SHOWING THE PAIRWISE COMPARISONS FOR THE CRITERIA WITH RESPECT TO THE GOAL

In this model the pairwise comparisons have already been completed.

- To see the pairwise comparisons for the criteria with respect to the goal, left-click on the Goal node inside the Goal cluster to select it.
- Select the Assess/Compare, Node Comparisons command

- Click on the button “Do Comparison” to show Figure 4.

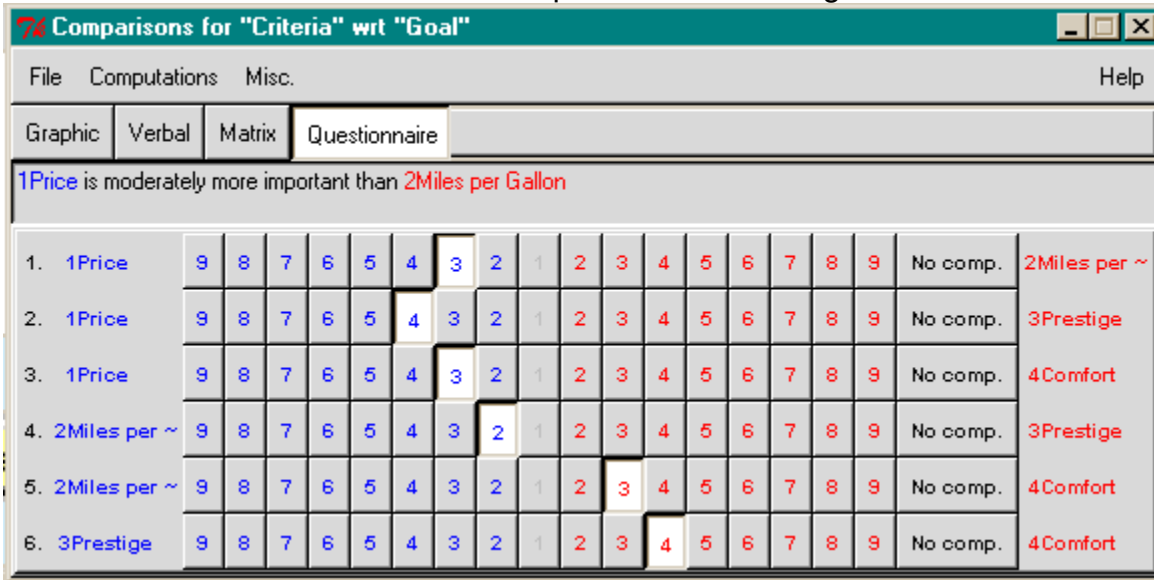


Figure 4. The Questionnaire Comparison Screen

- Click on the Matrix button to see the equivalent Matrix comparison screen shown in Figure 5. Click on Graphic, then Verbal.

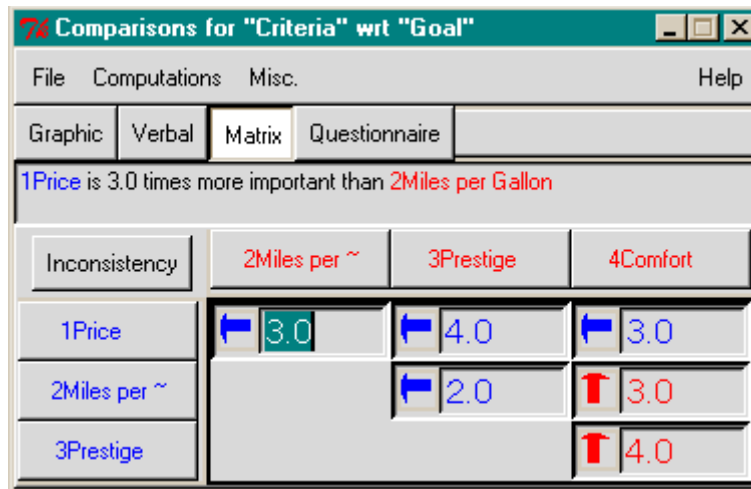


Figure 5. The Matrix Pairwise Comparison Screen

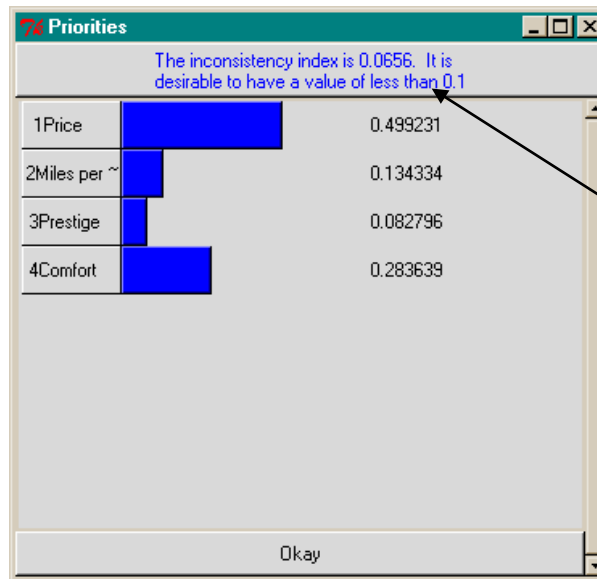
A number in the matrix is a dominance judgment. Blue indicates the element listed at the left is dominant (more important, more preferred,...) than the element listed at the top. Red indicates that the element listed at the top is dominant. A judgment of 1.0 means they are equal, a judgment of 3.0 means moderately or three times as much (if you are dealing with measureables), and 9.0 means nine times as much. You should group your elements into homogeneous clusters so that it is not necessary to use a number larger than 9. The Fundamental Scale for judgments is shown in Table 1.

**Table 1.** The Fundamental Scale for Making Judgments

1	Equal
2	Between Equal and Moderate
3	Moderate
4	Between Moderate and Strong
5	Strong
6	Between Strong and Very Strong
7	Very Strong
8	Between Very Strong and Extreme
9	Extreme
Decimal judgments, such as 3.5, are allowed for fine tuning, and judgments greater than 9 may be entered, though it is suggested that they be avoided.	

When a number greater than 9 is suggested by the inconsistency checking, this means that the elements you have grouped together are too disparate. You may input a number greater than 9, but perhaps you should re-organize your structure so that such a comparison is not required. It will do no great damage to allow numbers up to 12 or 13, but you should not go much beyond that.

- Click on the Computations, Show New Priorities command to see the results of this pairwise comparison shown in Figure 6.



The inconsistency index is shown here. At 0.065 it is less than 0.10 so no correction of judgments is needed.

**Figure 6.** The Results of the Pairwise Comparisons

Here the inconsistency is 0.0656, so it is not necessary to correct any judgments.

- To see the judgment that is most inconsistent click on the Computations, Most Inconsistent (ala Expert Choice) command.



Building a hierarchy is as much an art as it is a science. Following are some guidelines:

Guideline 1: Try not to include more than seven to nine elements in any cluster or grouping of elements because experiments have shown that it is cognitively challenging for human beings to deal with more than nine factors at one time and this can result in less accurate priorities.

Guideline 2: Try to cluster elements so that they include elements that are "comparable", or do not differ by orders of magnitude. In other words, try not to include items of very small significance in the same cluster as items of greater significance. The purpose of a hierarchy is to cluster the more important elements together and the less important elements together.

By keeping these two simple guidelines in mind, you will be able to model complex decisions correctly and efficiently.

### **DIFFERENTIATING BETWEEN OBJECTIVES AND CRITERIA**

Often the words criteria and objectives are used interchangeably. A criterion is a principle or a standard that things are judged by while an objective is something that is sought or aimed for. The elements in a cluster may be thought of as objectives, or as criteria, depending on the model you are creating.

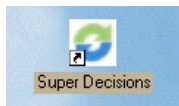
## **EXERCISE ONE - BUILDING A HIERARCHICAL MODEL**

In this exercise you will build a model and perform pairwise assessments throughout. You will then synthesize to get your results and perform sensitivity analyses.

Your goal will be to find the best vacation place. We suggest you limit the number of criteria to four, and the places to three or four. You may enter your own criteria and vacation places. Criteria might be cost, night life, friends, shopping, ocean, scuba diving, hiking, golfing, ease of getting to, climate, attractions, etc.

### **CREATING A MODEL TO PICK THE BEST VACATION PLACE**

Double click the *SuperDecisions* shortcut icon on the desktop:



or click the Windows Start key, select Programs, select *SuperDecisions* program group and then select *SuperDecisions*. A blank Main Window will appear

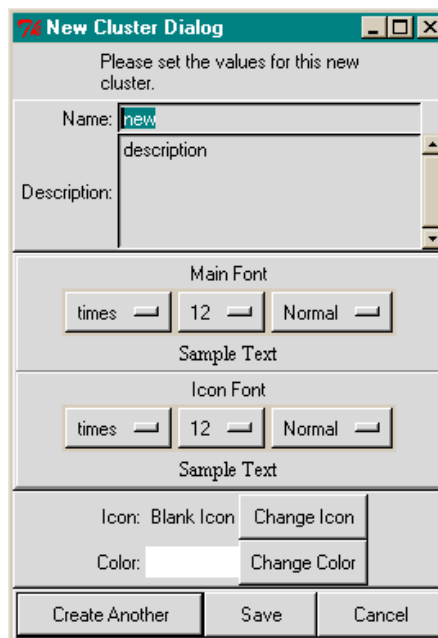
### **CREATE GOAL, CRITERIA AND ALTERNATIVE CLUSTERS**

- From the Main Window menu, select Design, Cluster, New to create the first cluster. The new cluster dialogue box will appear as shown in Figure 7.
  - Shortcut: Press <Shift> <n> simultaneously, that is, capital letter N, with your cursor located on the background of the Main Window.

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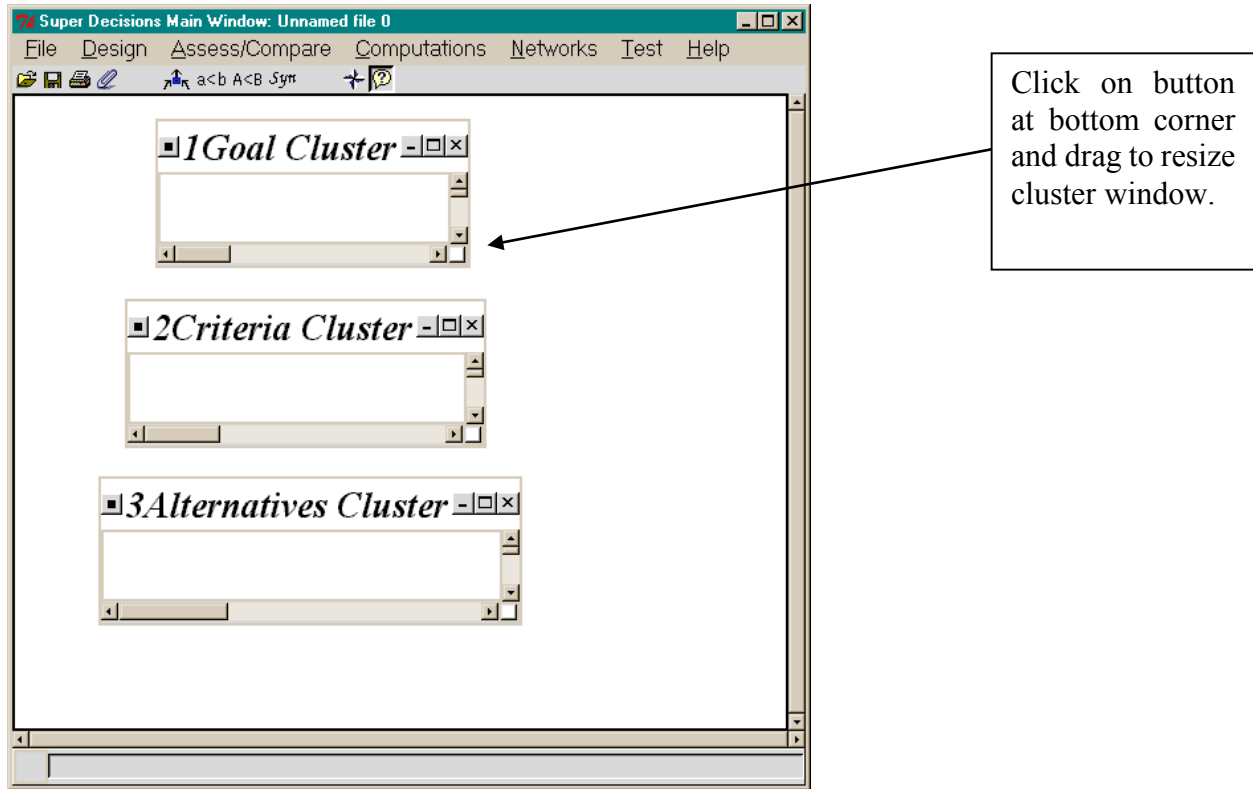
- Start the names of the clusters with numbers to control their order as they are displayed in alphabetical order in the supermatrices.
- Type *1Goal* for the name and “This is the goal cluster, the top level in a hierarchical model” for the description. Select the “Create Another” button to create the next cluster. To change the font click on the buttons under Main Font and make your choices from the dropdown menus. For the model to appear as it does in Figure 3, set the main font to New Times Roman, 28, Bold Italic.



**Figure 7.** New Cluster Dialogue Box.

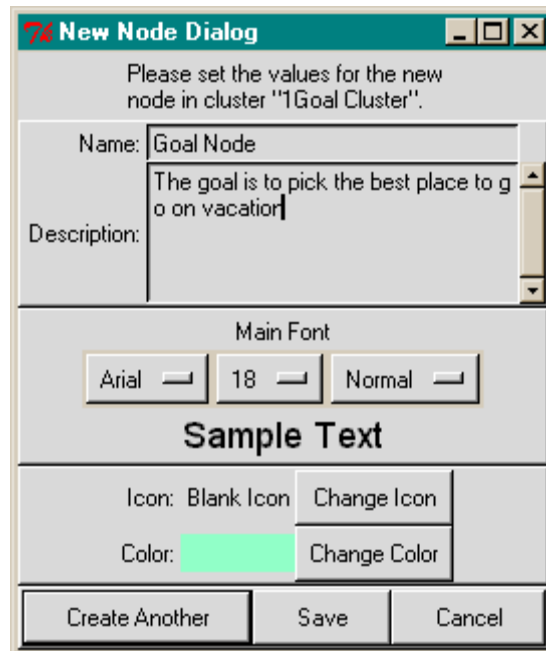
- Type *2Criteria* in the new cluster dialogue box with the description “Criteria for selecting a vacation place,” and again select the “Create Another” button to create the next cluster.
- Type *3Alternatives* with the description “Alternative vacation places” and click the ”Save” button to save and terminate the process of adding new clusters.

Arrange the clusters as shown below by clicking on the title bar and dragging.



### CREATE THE ELEMENTS INSIDE THE CLUSTERS

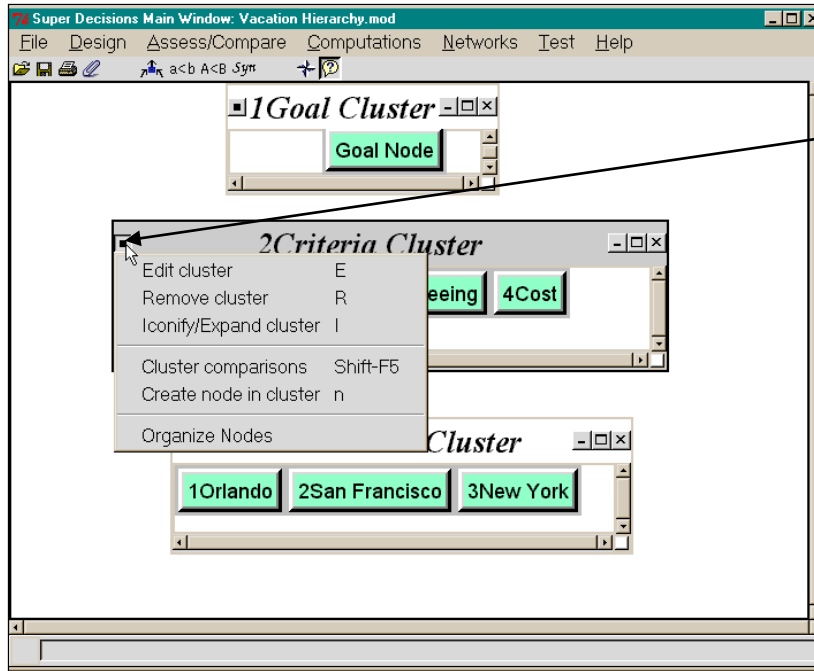
- Select Design, Node, New then select *1Goal* from the list of clusters that appears to show you wish to enter the element in that cluster. Enter *Goal Node* in the Name field and a description in the Description field. To pick a background color for the node click on the “Change Color” button and select a color. Select the font you prefer. Press Save to end the process of entering nodes in this cluster.



- *Shortcut to create new node: Locate your cursor on the background of the goal cluster window and press the letter <n>.*
- *Another shortcut to create new node: Right click on the background of the cluster to get a drop down menu of commands and select “create node in cluster”*

**ADD THE NODES AND THEIR DESCRIPTIONS TO THE OTHER CLUSTERS:**

- **2Criteria Cluster**
  - 1Activities: Activities one can engage in
  - 2Nightlife: Things to do at night
  - 3Sightseeing: Sightseeing
  - 4Cost: Cost including travel, accommodations and activities
- **3Alternatives Cluster**
  - 1Orlando: Orlando has excellent activities, decent nightlife and is moderate in cost.
  - 2San Francisco: San Francisco has moderate activities, above average night life, great sightseeing and can be costly.
  - 3New York: New York has excellent activities, excellent nightlife, very good sightseeing and can be very costly.




Click on top left corner for menu. Select Organize Nodes horizontally to line up the nodes and find any that may have disappeared from view.

## CONNECT THE ELEMENTS

No lines connect the clusters yet because the elements within them are not connected.

### TO CONNECT THE GOAL NODE TO THE CRITERIA NODES:

- Select the Design, “Node connections from” command. In the list that appears click on the node named Goal that is to be the parent or source node. In the list that now appears, left click on the criteria nodes to select them.
  - *Shortcut: To connect using the “Make Connections” icon  , left click on the icon to depress it and turn on the connections mode, then left click on the source node and right click on each of the nodes it connects to. To turn off the connections mode, right click the icon again to un-depress it.*
  - *Shortcut: To disconnect, left click on the source node and right click on any of the nodes that are outlined in red (that were previously connected to it) to disconnect.*

### TO CONNECT THE CRITERIA TO THE ALTERNATIVES:

- Select the Design, “Node connections from” command. In the list that appears click on the node named 1Price that is to be the parent or source node. In the list that now appears, left click on all the alternatives to select them.
- Connect the rest of the criterion nodes to the Alternative nodes in turn.

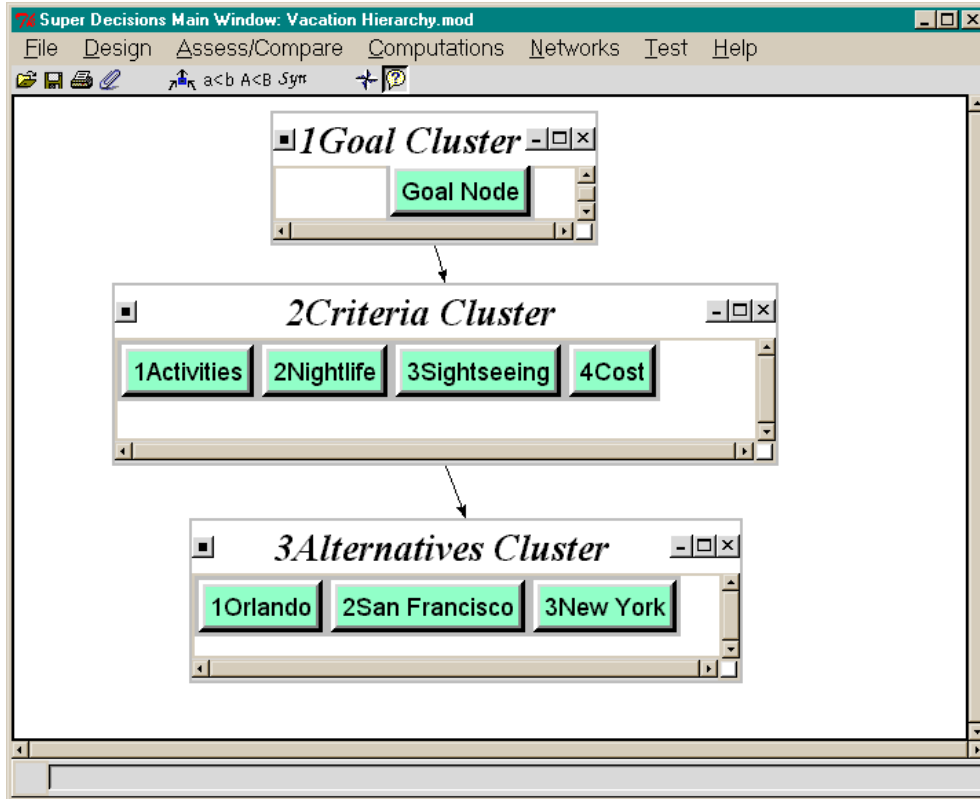
### SHORTCUT FOR CONNECTING ALL THE NODES IN A CLUSTER AT ONCE:

- Press the <Shift> key and hold it down while left clicking on one of the nodes in the cluster. This selects all the nodes in that cluster as source nodes. (*Make sure the “Make Connections” icon is turned on, that is, depressed.*)

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- Move to the cluster with nodes to be connected from the source nodes, press the <Shift> key and hold it down while right clicking on one of the nodes in the “to” cluster. This selects all the nodes and connects all the previously selected source nodes to them.

## THE COMPLETED MODEL



**THE NODE MENU FOR RENAMING NODES, REMOVING THEM, MAKING AND HIGHLIGHTING CONNECTIONS, AND ENTERING THE COMPARISON MODE:**

- Right click on a node to get its dropdown menu shown below from which you can perform operations on that node:

Edit node	e
Remove node	r
Node connexions from	F2
Hilight nodes connected to this one	F3
Hilight nodes connected from this one	F4
Unhighlight Nodes	Shift-F4
Node compare interface	F5
Make/show subnetwork	
Remove subnetwork	

## SAVING YOUR MODEL

These commands for saving a model are located on the File menu.

- **File, Save** saves a copy of your model in the directory you designate as a file with the extension .ahp
- **File, Save As** is used to save your model under a new name. The old file is closed and you continue working in the new file. It is useful to save successive versions such as car1.ahp, car2.ahp, car3.ahp and so on about every 30 minutes so you always have a recent copy you can restore in case of an unforeseen problem.
- **File, Advanced Save** can be used to compress models to a smaller size file with the extension .mod.gz. Such models can be opened in the usual way with the File, Open command, but it may take a little longer.
- **File, Configure, General tab** Go to the General tab in the configure dialogue box to set the automatic saving interval for models. The un-do command is currently disabled.

Next you will learn how to make judgments or pairwise comparisons about the criteria and alternatives in your model.

### ASSESSMENTS / PAIRWISE COMPARISONS OVERVIEW

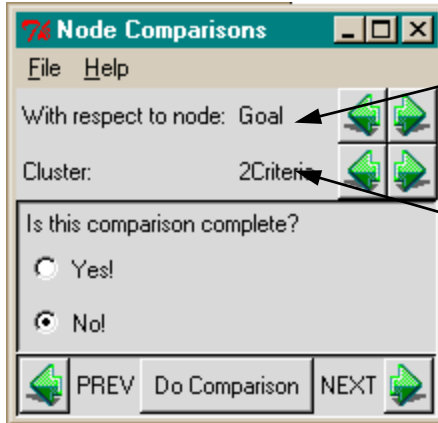
One of the major strengths of the AHP is the use of pairwise comparisons to derive accurate ratio scale priorities, as opposed to using traditional approaches of "assigning weights" which can also be difficult to justify. Pairwise comparison is the process of comparing the relative importance, preference, or likelihood of two elements (for example, criteria) with respect to another element (for example, the goal) in the level above to establish priorities for the elements being compared. Pairwise comparisons are carried out for all the parent/children sets of nodes.

The nodes that are to be pairwise compared are always all in the same cluster and are compared with respect to their parent element, the node from which they are connected. This results in "local priorities" of the children nodes with respect to the parent.

Select the Assess/Compare, Node comparisons command to start the comparison process. If a node has been selected by clicking on it prior to starting the comparisons, that node will be the parent node in the first set of comparisons to come up. If no node has been selected, the first node in the first cluster will be the parent. The parent node and the cluster where the children nodes are located are specified in the node comparison dialogue box that appears.

Click on the Do Comparison button to start the comparison process. The pairwise comparison process starts in the mode that was last in use, or in the Questionnaire mode the first time. There are four pairwise comparison assessment modes. To switch from one mode to the other click on the tab at the top. When a judgment entered in one mode is recorded in one mode, the same judgment is recorded in all the modes. Calculations are based on the numbers in the Matrix mode (the Questionnaire mode always shows whole numbers, and no numbers are shown in the Graphic and Verbal mode)

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Comparisons are made with respect to the parent node listed here.

The children nodes that are to be pairwise compared are in the cluster listed here.

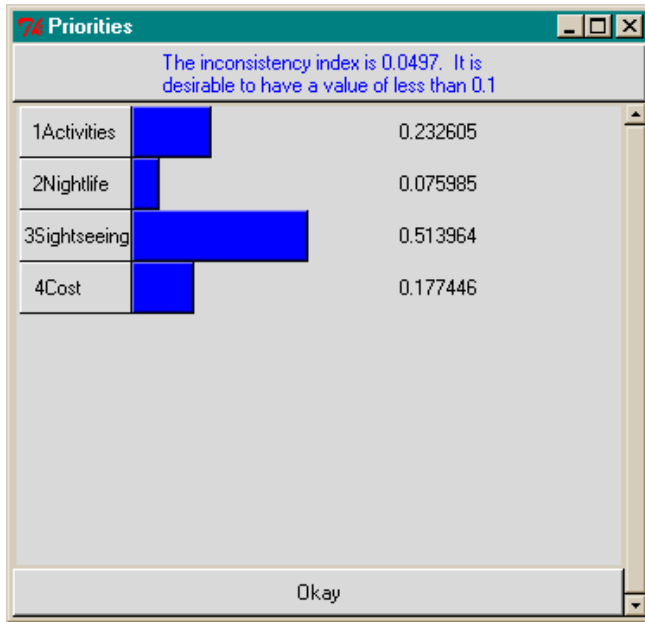
- Questionnaire** In this mode, select the judgment on the side of the most dominant member of the pair, that is, the most important, if it is a criterion as shown below, or the most preferred, in the case of alternatives. To invert the dominance order click on the same judgment on the other side of the 1 in the row, nearer to the more important, or more preferred node.

### QUESTIONNAIRE MODE

	1Activities	2Nightlife	3Sightseeing	4Cost		1Activities	2Nightlife	3Sightseeing	4Cost		1Activities	2Nightlife	3Sightseeing	4Cost		1Activities	2Nightlife	3Sightseeing	4Cost
1. 1Activities	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	2Nightlife
2. 1Activities	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	3Sightseeing
3. 1Activities	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	4Cost
4. 2Nightlife	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	3Sightseeing
5. 2Nightlife	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	4Cost
6. 3Sightseeing	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	4Cost

To show the priorities derived from any of the comparison modes, select Computations, Show new Priorities from the comparison screen menu.

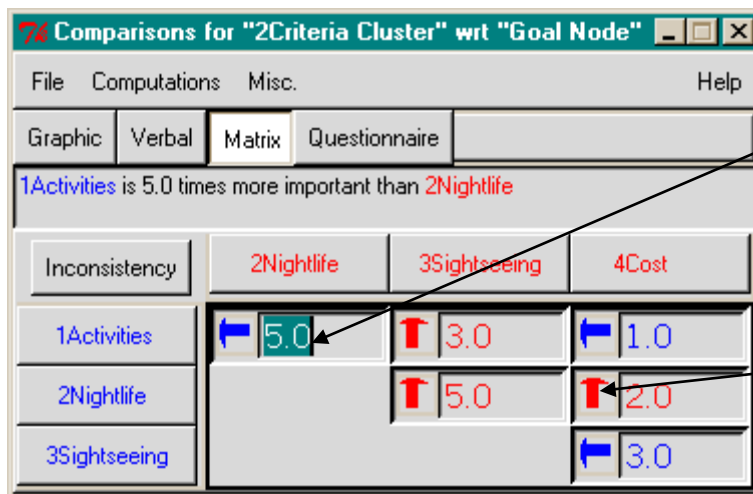




To exit from the comparison mode, click on the x in the upper right hand corner, or select the File Close command.

- Numerical judgments** are made in a matrix using a nine-point scale that represent how many times one element is more important than another. The arrow at the left of the entry points to the dominant element. To switch which element is dominant, left double-click on the arrow.

NUMERICAL OR MATRIX MODE



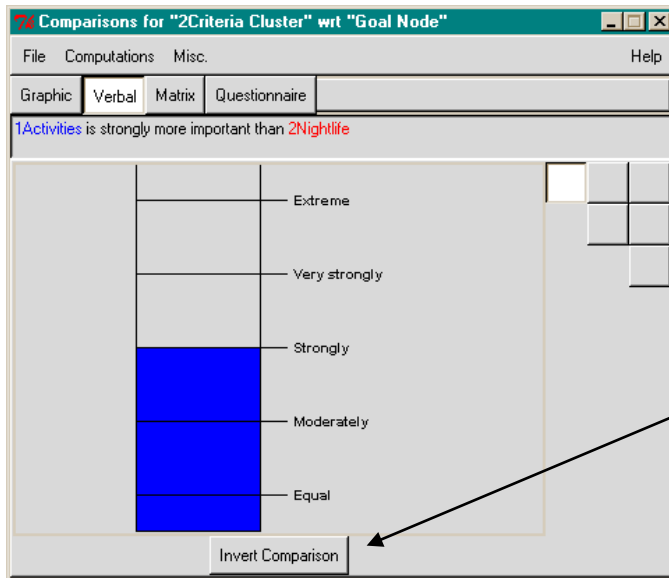
The current judgment is highlighted. Arrow points to dominant element.

Double click arrow to change dominant criterion from price to comfort.

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- **Verbal judgments** are used to compare factors using the words Equal, Moderate, Strong, Very Strong, Extreme. Equal requires no explanation. Extreme means an order of magnitude – about 9 or 10 to 1. Judgments between these words, such as Moderate to Strong are also possible. In the verbal mode the node mentioned first is the dominant one. To invert click the “Invert Comparison” button at the bottom of the screen.

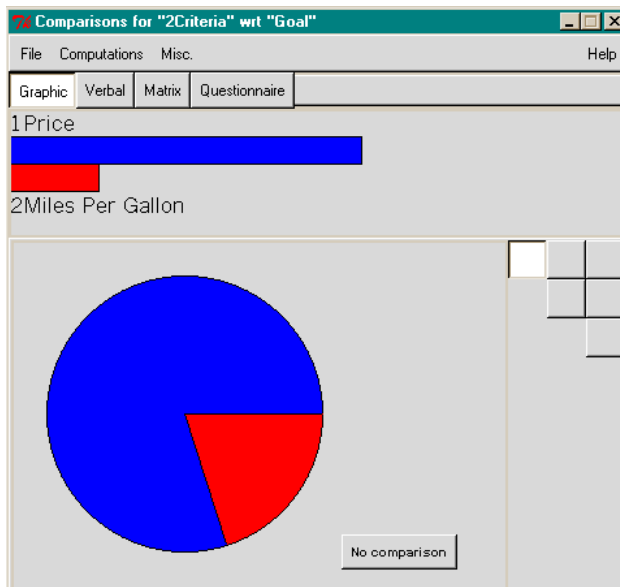
### VERBAL JUDGMENT MODE



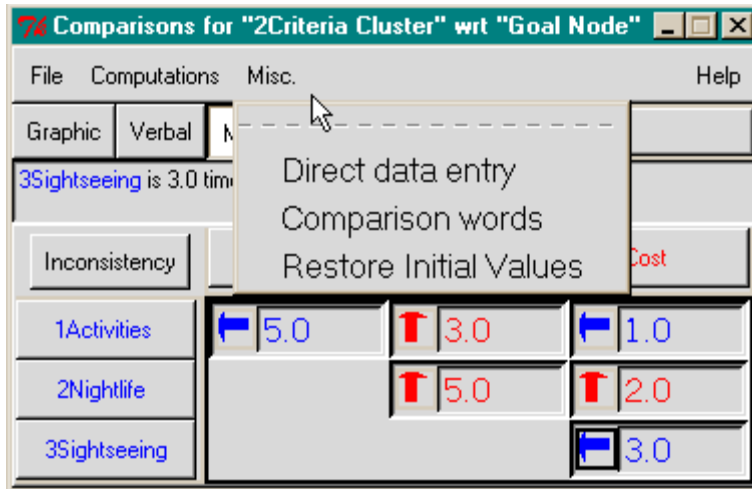
To invert judgment click on the “Invert Comparison” button

- **Graphical judgments** are made by clicking and dragging the pie slice to change the relative size of the pie slice to the circle and the relative length of the two bars until it represents how many times more important one element is than the other.

### GRAPHICAL JUDGMENT MODE

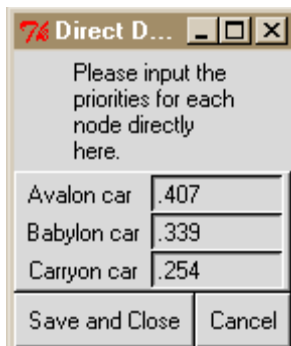


MISCELLANEOUS MENU IN COMPARISONS WINDOW



- Select the command *Direct data entry* to directly enter data values that are converted to priorities by summing and dividing each entry by the total (normalizing to 1).

ENTERING DIRECT PRIORITIES



When entering numbers for preference and higher numbers are better, for example if you were comparing cars for price, enter the data itself. If higher numbers are less preferred, for example, for cost, higher numbers (prices) are less desirable. In this case invert the priorities as shown below. A spreadsheet program, Excel, was used to perform the calculations and create the table below (E-05 means  $10^{-5}$ ).

Car	Price	1/Price	(1/Price)/Total (final priorities)
Avalon	15000	6.667E-05	0.407
Babylon	18000	5.556E-05	0.339
Carryon	24000	4.167E-05	0.254
	Total	0.000164	

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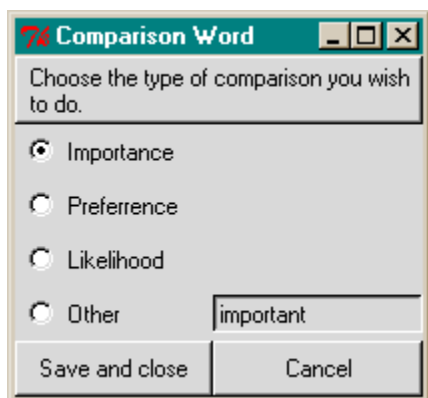
Tip: Even when you have data, as with car prices, it is often better to interpret what the numbers mean to you and use the Questionnaire mode so the final results match your personal values or your personal interpretation of what the numbers mean to you.

Select the command Computations/Priorities to see the results from pairwise comparisons or from direct data such as prices of cars. Prices need to be “inverted” as shown above.

### CHANGING THE PAIRED COMPARISON TYPE

There are three different paired comparison types, **Importance**, **Preference** and **Likelihood**. Or you can select **Other** and enter a word of your own choosing – “beauty” for example. Importance is most appropriate when comparing criteria or criteria. Preference is appropriate when comparing alternatives with respect to a criterion. Likelihood is appropriate when comparing the likelihood of uncertain events or scenarios, such as in risk analysis.

- Select the command Misc./ Comparison words to change the comparison type.



# Improving

- Inconsistency of < 10% is tolerable. However, the software can help improve

**Select Computations > Basic Inconsistency Report**

The most inconsistent judgment is listed first and identified as the Acura TL versus Honda Civic judgment of 4. The blue color indicates row element (Acura) is dominant, red indicates column element dominant. Click on either the Row or Column name to select the cell in question.

Rank	Row	Col	Current Val	Best Val	Inconsist.	Inconsist.	Inconsist.
1.	1Acura TL	3Honda Civic	4.000000	1.998755	0.051549	0.000138	99.73%
2.	2Toyota Camry	3Honda Civic	4.000000	1.995708	0.051549	0.000138	99.73%
3.	1Acura TL	2Toyota Camry	8.000000	15.995712	0.051549	0.000148	99.71%

You may type in the suggested value, a value of your own selection or go on to the next pair..

## MAKING THE JUDGMENTS

Since judgments about the relative importance of the criteria may depend on the alternatives being considered, by making the judgments "bottom up", that is first for the alternatives, then for the criteria, you can be more informed on how important the criteria really are. However, for illustrative purposes, we will make judgments "top down" in this tutorial.

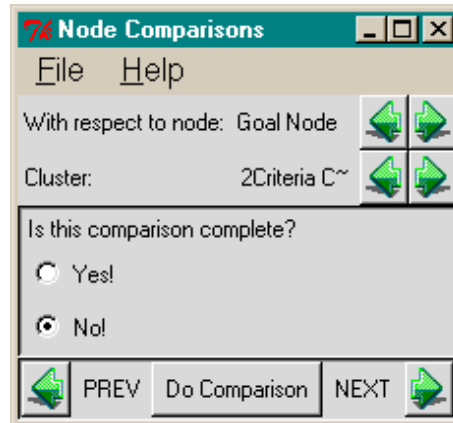
### JUDGE THE CRITERIA WITH RESPECT TO THE GOAL NODE

1. From the Main Screen, left click the Goal (until depressed).
2. Select Assess/Compare, Node from the menu or  $a < b$  on the shortcut bar .
3. Click the "Do Comparisons" button to get into the comparison mode. You may use any of the modes: questionnaire, verbal, matrix or graphical.
4. After making the judgments select Computations, Show new priorities.

## TUTORIAL

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5. If your inconsistency is more than 0.10, select Computations, Most inconsistent ala Expert Choice to find out where it is. Then modify your judgments to improve your inconsistency.
6. Close the comparison model to return to the comparison navigator



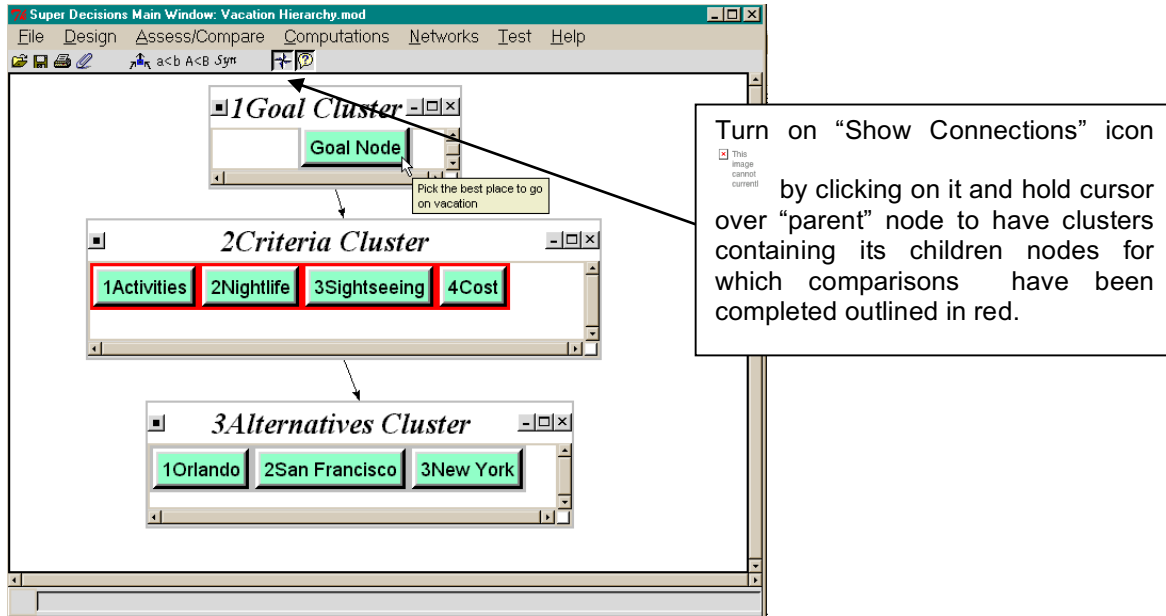
### JUDGE THE ALTERNATIVES WITH RESPECT TO EACH OF THE CRITERIA NODES

1. Click “Yes” to mark the criteria comparisons with respect to the goal as complete. Click the Next button to move to the first criterion, and click the Do Comparison button to get into the comparison mode for the vacation places with respect to the first criterion.
2. Continue the process until all the judgments are finished.


### CHECKING COMPLETED COMPARISONS

To show which comparisons have been completed left click the “Show Node Comparisons” icon  and hold the cursor over the “parent node”, in this case the Goal, to have clusters with completed comparisons outlined in red.

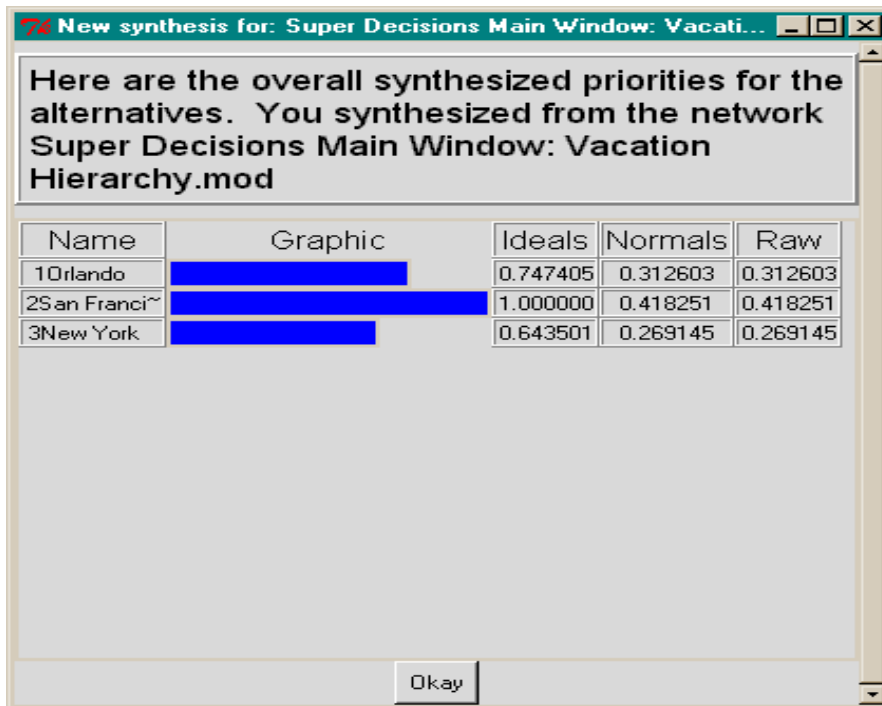
### VIEW WITH “SHOW CONNECTIONS” ICON TURNED ON



## SYNTHESIS - GETTING THE RESULTS

The results for the alternatives are obtained with the Synthesis command in the Main Model View. Select the Computations/Synthesize command, or click the shortcut icon  to see the final results:

### RESULTS FROM THE SYNTHESIS COMMAND



The *Normals* column presents the results in the form of priorities. This is the usual way to report on results. The *Ideals* column is obtained from the *Normals* column by dividing each of its entries

## TUTORIAL

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by the largest value in the column. The *Raw* column is read directly from the Limit Supermatrix. In a hierarchical model such as this one the *Raw* column and the *Normals* column are the same.

These results show that the San Francisco would be the best choice for this decision maker. The “Ideal” column shows the results divided by the largest value so that the best choice has a priority of 1.0. The others are in the same proportion as in “Normals” and are interpreted this way: Orlando is 74.7 % as good as San Francisco and New York is 64.3% as good as San Francisco.

This answer reflects the preferences of the person who made the judgments, incorporating their personal values and desires, and is not an objective assessment of the relative value as a vacation place of Orlando, San Francisco and New York. This result also matches our intuition as we know a high priority was put on activities.

## SENSITIVITY

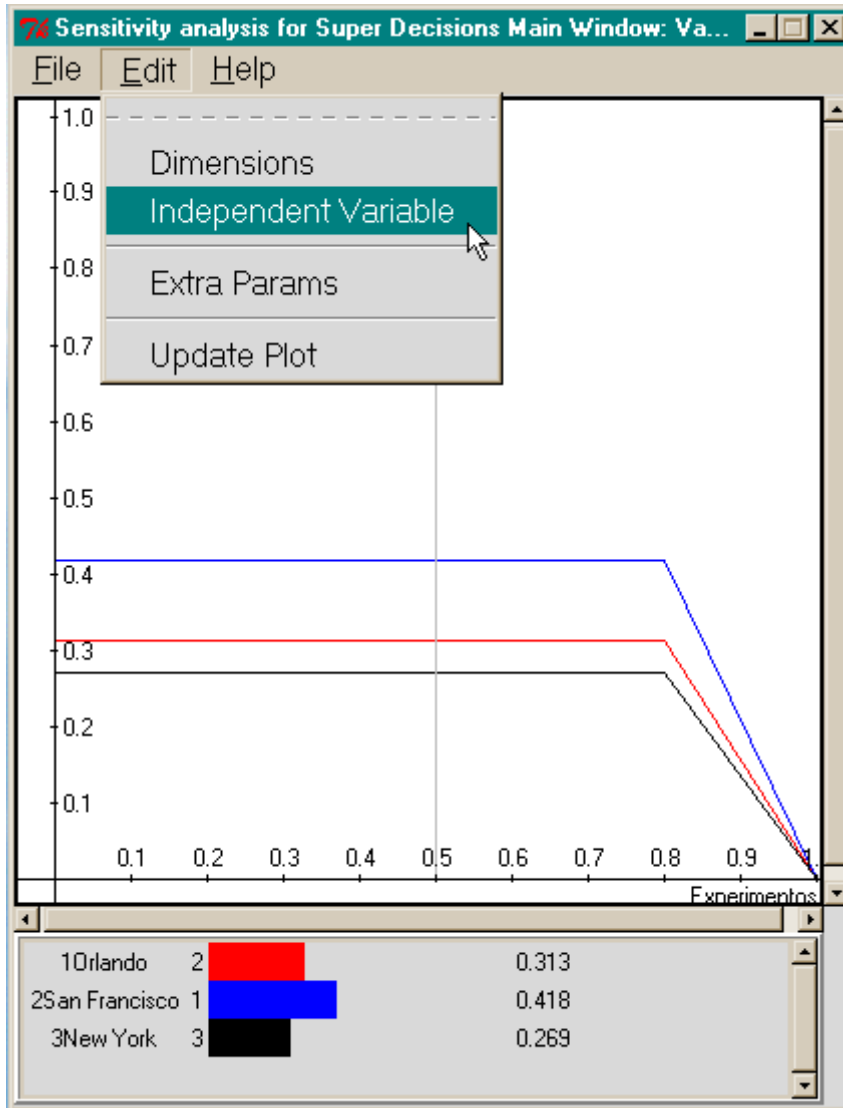
Select the Computations Sensitivity command to get into the sensitivity module.

It is necessary to set the independent variable to see a meaningful sensitivity graph.

There is one line for each alternative in sensitivity windows. In the software they are color coded so that it is easy to see which line corresponds to each alternative, but here in black and white they look the same.

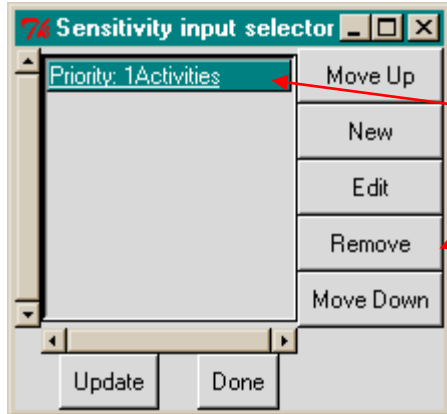
### OPENING SCREEN IN SENSITIVITY MODULE FOR VACATION EXERCISE





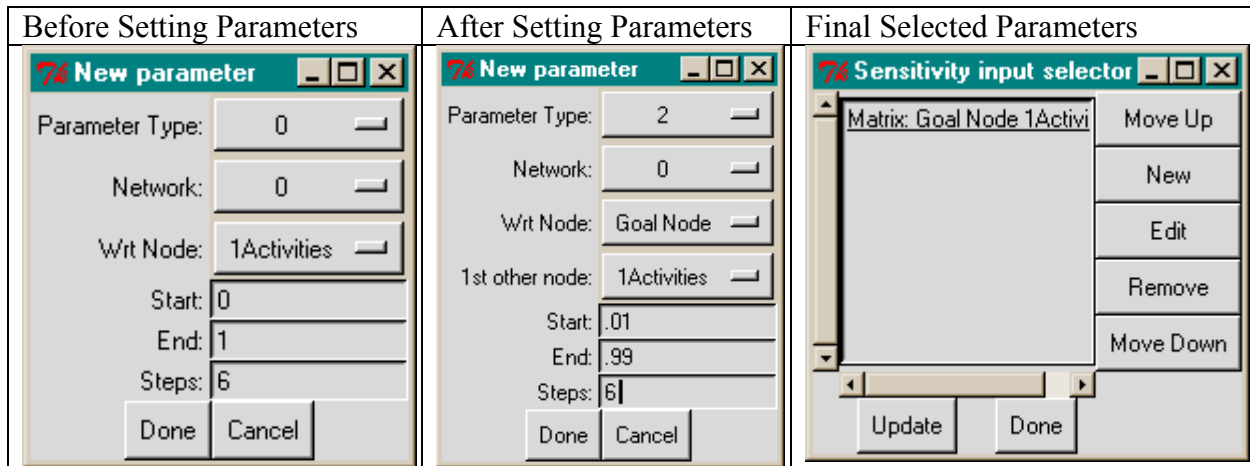
SENSITIVITY INPUT SETTINGS

## TUTORIAL

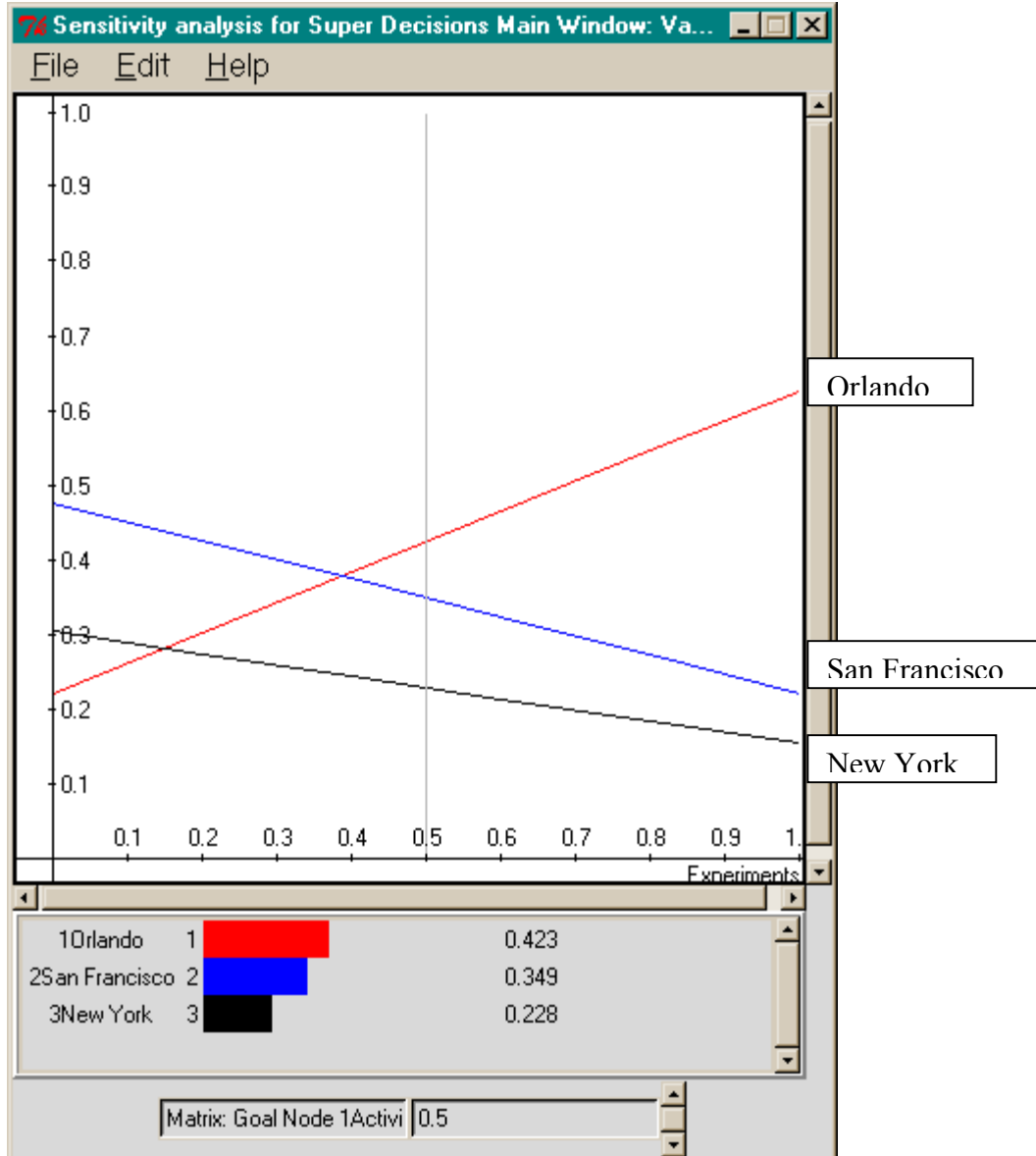


Click the New button in the Sensitivity input selector. The New Parameter dialogue box shown below will appear. Set the new parameters as shown below. Click on Parameter Type button and choose Supermatrix (type 2). The Network is correctly set to 0 for a hierarchical model. Click on the Wrt (With respect to) Node and select Goal. Set Start to .01 and end to .99. This is necessary only for hierarchical models as including the actual endpoints of the interval, 0 and 1, gives a meaningless graph near the endpoints. Click the Done button on the New parameter box, then click the Update button on the Sensitivity input selector.

### SELECTING THE INDEPENDENT VARIABLE AND SETTING THE OTHER PARAMETERS



### THE SENSITIVITY GRAPH FOR ACTIVITIES



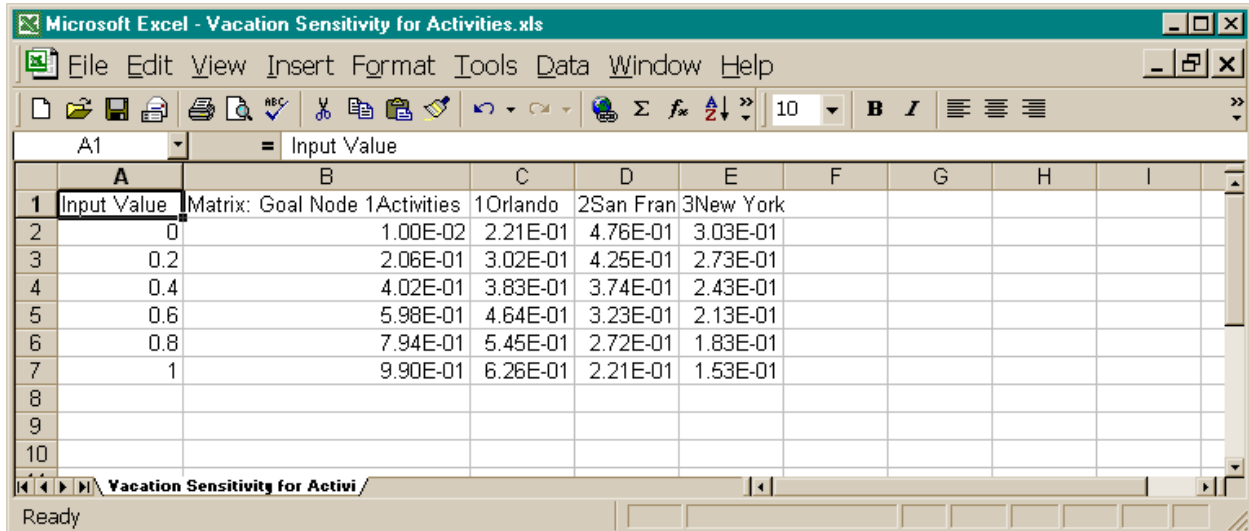
The priority of Activities is plotted on the x axis and the priorities of the alternatives are plotted on the y axis. Click on the blue vertical line and drag it to change the priority of activities. You can then read the corresponding values for the alternatives from the intercept points of the vertical line with the alternative lines. At the point Activities = 0.5, Orlando is about .42, San Francisco is about .35 and New York is about .25. What this graph is telling us is that if the priority of Activities is greater than about 0.4, Orlando becomes the preferred choice. Before that San Francisco is the best alternative.

You can explore sensitivity for the other criteria by returning to the Parameter Selection dialogue boxes and resetting the parameters.

## TUTORIAL

Select the File Save command and enter a name such as *ActivitySensitivity.xls* to save the data from which the graph is constructed. Load Excel and select File Open to import the file using the Excel Wizard. Keep clicking okay til the import finishes.

### THE ACTIVITIES SENSITIVITY GRAPH DATA POINTS AS SHOWN IN EXCEL



	A	B	C	D	E	F	G	H	I
1	Input Value	Matrix: Goal Node 1Activities	1Orlando	2San Fran	3New York				
2	0	1.00E-02	2.21E-01	4.76E-01	3.03E-01				
3	0.2	2.06E-01	3.02E-01	4.25E-01	2.73E-01				
4	0.4	4.02E-01	3.83E-01	3.74E-01	2.43E-01				
5	0.6	5.98E-01	4.64E-01	3.23E-01	2.13E-01				
6	0.8	7.94E-01	5.45E-01	2.72E-01	1.83E-01				
7	1	9.90E-01	6.26E-01	2.21E-01	1.53E-01				
8									
9									
10									

The interpretation of the data shown above is that as the input value, the priority of Activities under the Goal node in the Unweighted Supermatrix, changes from 0 to 1 in six steps the corresponding priorities of the alternatives, shown above, are computed from the Limit Supermatrix.

## THE SUPERMATRICES

The priorities derived from the pairwise comparisons are entered in the Unweighted Supermatrix. Select the Computations/Unweighted SuperMatrix/ Graphical to see how the priorities that were derived in the comparison process appear there.

## UNWEIGHTED SUPERMATRIX

## TUTORIAL ON HIERARCHICAL DECISION MODELS

Super Decisions Main Window: Vacation Hierarchy.mod: Unweighted Super Matrix									
Cluster Node Labels		1Goal Cluster	2Criteria Cluster				3Alternatives Cluster		
		Goal Node	1Activities	2Nightlife	3Sightseeing	4Cost	1Orlando	2San Francisco	3New York
1Goal Cluster	Goal Node	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2Criteria Cluster	1Activities	0.232606	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	2Nightlife	0.075985	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	3Sightseeing	0.513961	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	4Cost	0.177449	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3Alternatives Cluster	1Orlando	0.000000	0.630097	0.163424	0.075057	0.648329	0.000000	0.000000	0.000000
	2San Francisco	0.000000	0.218442	0.296961	0.591727	0.229651	0.000000	0.000000	0.000000
	3New York	0.000000	0.151461	0.539614	0.333216	0.122020	0.000000	0.000000	0.000000
Done									

In a hierarchical model like this, the Weighted Supermatrix is the same as the Unweighted Supermatrix because the clusters are not weighted. Raising the Weighted Supermatrix to powers yields the Limit Matrix from which the final answers are extracted. The final priorities for the Alternatives are in the column under the Goal.

### THE LIMIT MATRIX IS THE FINAL SUPERMATRIX CONTAINING THE ANSWERS

Super Decisions Main Window: Vacation Hierarchy.mod: Limit Matrix									
Cluster Node Labels		1Goal Cluster	2Criteria Cluster				3Alternatives Cluster		
		Goal Node	1Activities	2Nightlife	3Sightseeing	4Cost	1Orlando	2San Francisco	3New York
1Goal Cluster	Goal Node	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2Criteria Cluster	1Activities	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	2Nightlife	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	3Sightseeing	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	4Cost	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3Alternatives Cluster	1Orlando	0.312603	0.630097	0.163424	0.075057	0.648329	1.000000	0.000000	0.000000
	2San Francisco	0.418251	0.218442	0.296961	0.591727	0.229651	0.000000	1.000000	0.000000
	3New York	0.269145	0.151461	0.539614	0.333216	0.122020	0.000000	0.000000	1.000000
Done									

## TUTORIAL

By selecting the Computation Limit Matrix Option and setting the computation method to either of the New Hierarchy options, the Limit Matrix will display the intermediate priorities under every node in the model. This option must be selected each time the model is opened. The default value is the first, Calculus type, which always ends up with only the priorities for the alternatives in each column. for a model that has a hierarchical structure. It is handy to be able to read the priorities of the criteria with respect to the Goal in the first column.

### THE LIMIT MATRIX WITH HIERARCHICAL OPTION CALCULATIONS

Priorities for intermediate nodes now appear in the Limit Matrix.

Cluster Node Labels		1Goal Cluster	2Criteria Cluster				3Alternatives Cluster		
		Goal Node	1Activitie s	2Nightlife	3Sightseein g	4Cost	1Orlando	2San Francisco	3New York
1Goal Cluster	Goal Node	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2Criteria Cluster	1Activitie s	0.116303	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	2Nightlife	0.037992	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	3Sightseein g	0.256980	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	4Cost	0.088724	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3Alternatives Cluster	1Orlando	0.156302	0.630097	0.163424	0.075057	0.648329	0.000000	0.000000	0.000000
	2San Francisco	0.209126	0.218442	0.296961	0.591727	0.229651	0.000000	0.000000	0.000000
	3New York	0.134573	0.151461	0.539614	0.333216	0.122020	0.000000	0.000000	0.000000
Done									

## DEMO OF A RATINGS MODEL

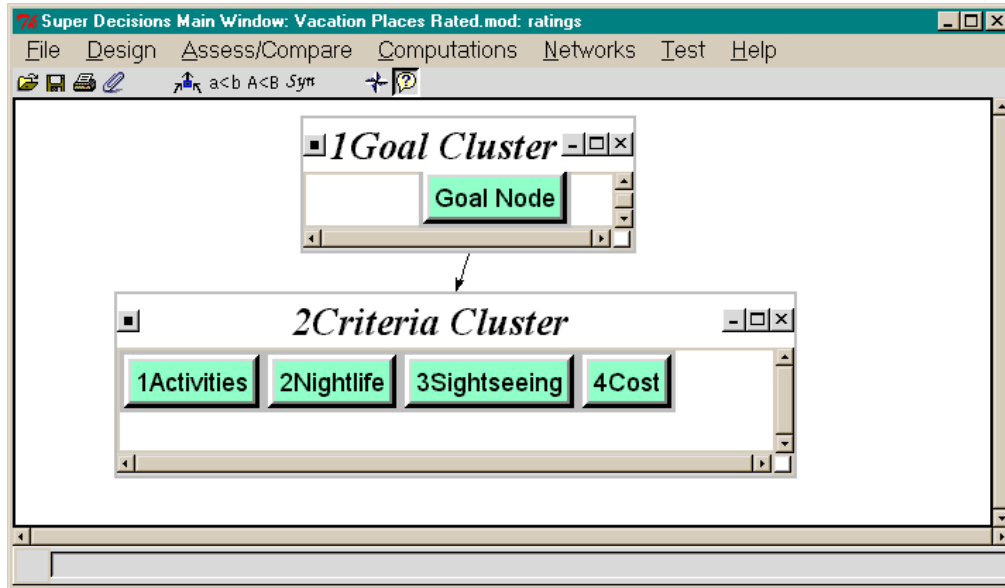
People often "rate" alternatives using words such as High, Medium and Low; or Excellent, Very Good, Good, Fair and Poor with respect to some characteristic they have. We use the same idea and rate alternatives with respect to the criteria. We add one twist and prioritize the ratings words themselves, so that a "High" rating, for example, is twice as good as a "Medium" rating.

We will now have you load a previously created model set up to do ratings. The model to select a vacation place was converted into a Ratings model named *Vacation Places Rated.mod*. We will have you load this prepared model and use it to rate some vacation places. It is located in Sample Models under the Help command.

In this model the vacation places do not appear in the main model. They are in the Ratings module attached to the model. You can see from the title bar that this is a ratings type of model. The advantage of a ratings model is that the evaluation structure is set up and each alternative is evaluated as to how it performs on each criterion. This dramatically shortens the number of judgments required. However, ratings models are only appropriate in very well understood

evaluation settings where knowledgeable people or experts have provided the evaluation structure. They should not be used in new or one-of-a-kind decisions.

VACATION PLACES RATED MODEL – MAIN SCREEN



To get into the Ratings module shown below select the Assess/Compare, Ratings command, or select the Design, Ratings command – both do the same thing. When the ratings module is open, the main screen view is locked. To return to it, close the Ratings window.

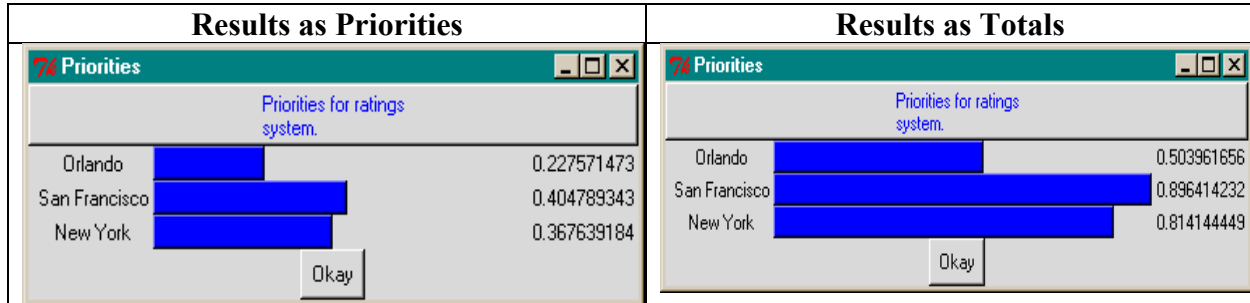
VACATION PLACES RATED MODEL – RATINGS SCREEN

	1Activities	2Nightlife	3Sightseeing	4Cost
	0.2326	0.0760	0.5140	0.1774
Orlando	Excellent	Average	Average	Between \$500 and \$1000
San Francisco	Above Average	Above Average	Excellent	Between \$1000 and \$1800
New York	Above Average	Excellent	Excellent	Between \$1800 and \$2500

## TUTORIAL

The results in a ratings model are obtained with the Calculations, Priorities command. The Synthesis results, in which the Normals column is the same as the Priorities below, can also be obtained in the ratings module or back in the main model with the Computations, Synthesis command.

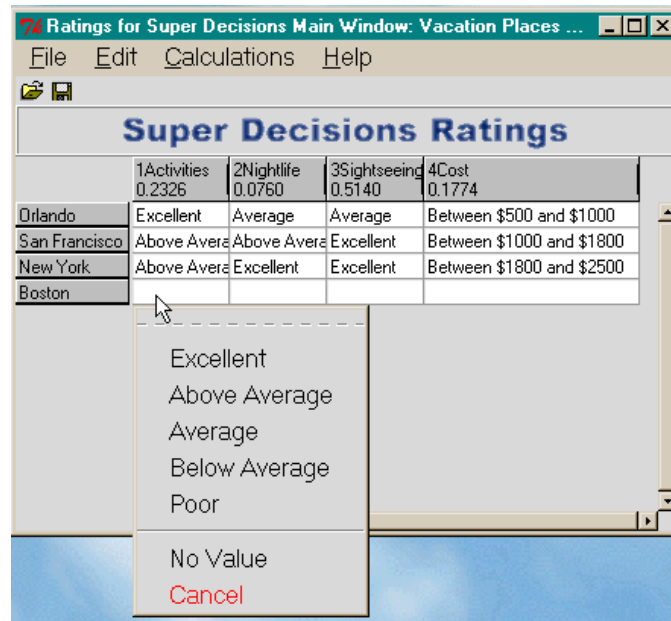
### RESULTS FOR THE ALTERNATIVES DERIVED IN THE RATINGS MODULE



When shown as Totals the results may be interpreted this way: San Francisco, with a priority of .896, is the best, but is still only 89.6% as good as a perfect vacation place would be while New York has %81.4. The Priorities are obtained from the Totals by normalizing, that is, summing the Totals values and dividing by the sum. When shown as priorities the results sum to 1.0.

### NOW TRY ADDING SOME VACATION PLACES:

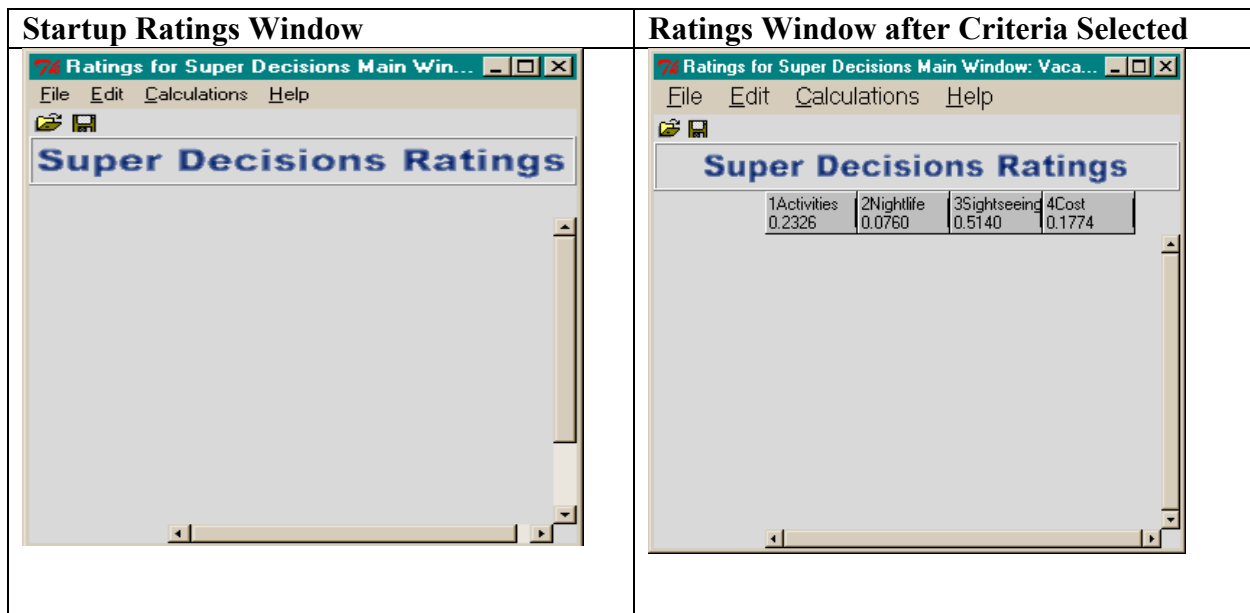
1. Use the command Edit Alternative New to add a new alternative.
2. Click on a cell to show the possible ratings and select the one you want as shown below.
3. After you complete the ratings select the Calculations command and look at both Priorities and Totals to see your results.
4. Close the Ratings window and return to the main screen. Try the Synthesize command to see that the results are the same.



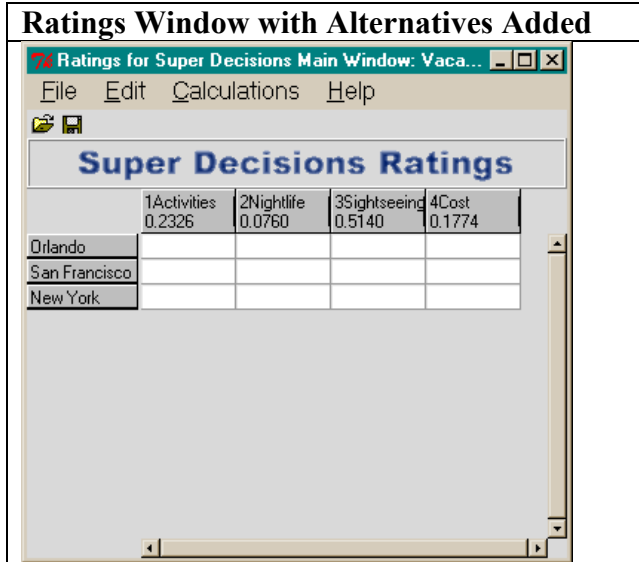


## EXERCISE TWO - CREATING A RATINGS MODEL

- Creating a Ratings Model** We shall show how a Ratings model is created by starting with the previous Vacation example and converting it from a relative model using only pairwise comparisons to a Ratings model where standard categories or “Ratings” are set up for each criterion. The alternatives, the vacation places, are then evaluated or rated against these standards by selecting for each the appropriate category for each criterion.
- First, save a copy of the vacation model you created in exercise one by selecting the File/Save As command and name it “Vacation Ratings Model”. Remove the Alternatives cluster by right clicking on the title bar and deleting it. Select the Assess/Compare Ratings command to create the Ratings spreadsheet. Once the Ratings screen appears, shown below, the Main Model View will disappear and remain “locked out” until the Ratings screen is closed.
- Add Criteria** Select the Edit Criteria New command and click on the nodes from the main model that will be the criteria in the Ratings spreadsheet. Selecting all four criteria brings them into the Ratings spreadsheet. The priorities for the criteria, shown below the names, are the same ones that were established in the main model though pairwise comparison.

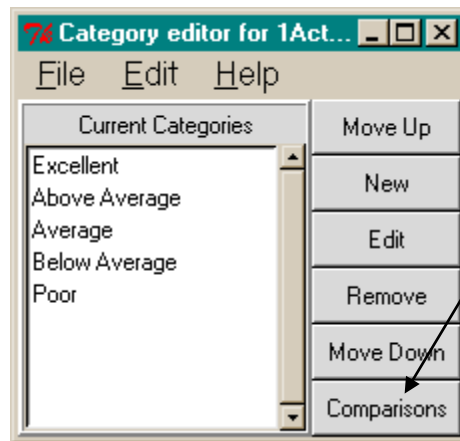


- Add Alternatives** Next, select the Edit Alternatives New command and type the names of the alternatives Orlando, San Francisco, New York. This results in the Super Decisions Ratings table with alternatives added.



- Creating and Prioritizing the Ratings Categories** This step must be done before the alternatives can be rated. Select the Edit Criteria Categories command, choose *Activities* and create categories for it (below):

**CATEGORY EDITOR FOR CREATING CRITERION CATEGORIES**



Click the Comparisons button to pairwise compare categories and establish priorities for them.

Clicking the Comparison button will bring up the following comparison screen where we pairwise compare to establish priorities for the categories. Select the command Computations/Ideal Priorities to see the resulting priorities.

COMPARE THE RATING CATEGORIES FOR ACTIVITIES

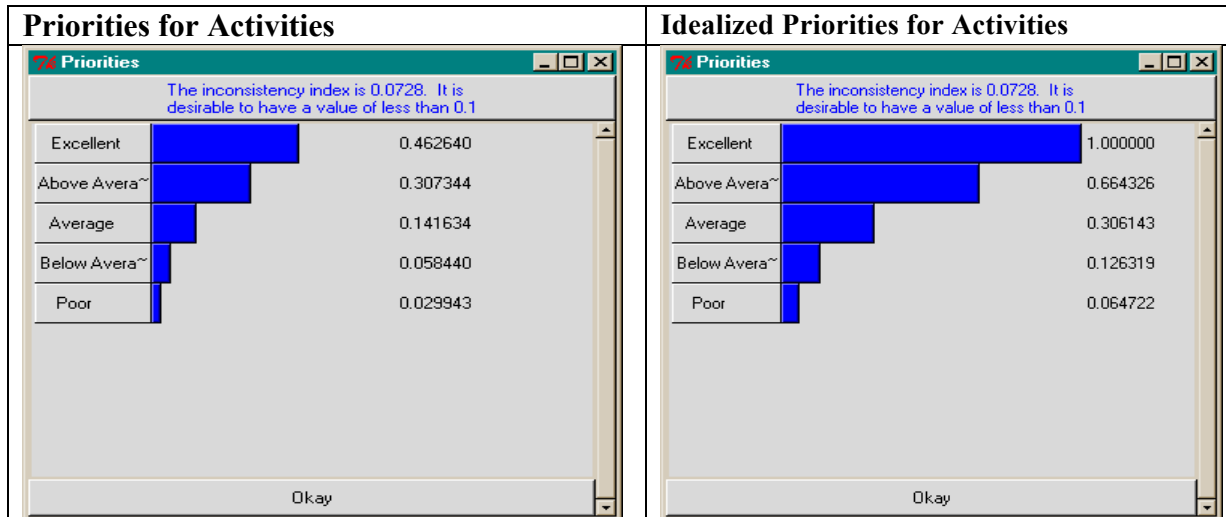
Comparisons for "" wrt "Criteria Compares for 1Activities"

File Computations Misc. Help

Graphic Verbal Matrix Questionnaire

Excellent is equally to moderately more important than Above Average

1. Excellent	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	Above Avera~
2. Excellent	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	Average
3. Excellent	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	Below Avera~
4. Excellent	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	Poor
5. Above Avera~	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	Average
6. Above Avera~	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	Below Avera~
7. Above Avera~	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	Poor
8. Average	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	Below Avera~
9. Average	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	Poor
10. Below Avera~	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	No comp.	Poor



The idealized priorities shown above are obtained from the priorities in the first column above by dividing each by the largest (0.462 in this case) and are used in the Ratings spreadsheet. For example, an Excellent rating means place the number 1.000 in the cell, for each cell multiply the cell idealized value times the column priority listed at the top of the column and add across to get the total for that row.

Close all open windows to return to the Ratings spreadsheet. Right or left click on the (Orlando, Activities) cell to get the dropdown menu for selecting the appropriate category.

## TUTORIAL

Create categories for the rest of the criteria and prioritize them. The rest of the categories that were established in this model and their priorities are shown in the table below. It is not necessary to have the same number of rating categories for each column (there are 3 for Prestige).

Activities	Nightlife	Sightseeing	Cost
Excellent 1.000	Excellent 1.000	Exceptional 1.000	\$500-\$1000 0.511
Above Average 0.664	Above Average 0.664	Above Average 0.337	\$1000-\$1800 1.000
Average 0.306	Average 0.306	Average 0.148	\$1800-\$2500 0.393
Below Average 0.126	Below Average 0.126	Poor 0.0652	> \$2500 0.098
Poor 0.06	Poor 0.06		

### VIEWING THE RESULTS IN RATINGS

- Select the Calculations/Totals command to see the evaluation scores before normalizing. The Total for each row is obtained by multiplying the values for the ratings in the cells times the column priorities and summing.
- Select the Calculations/Priorities command to see the results as priorities that sum to 1.

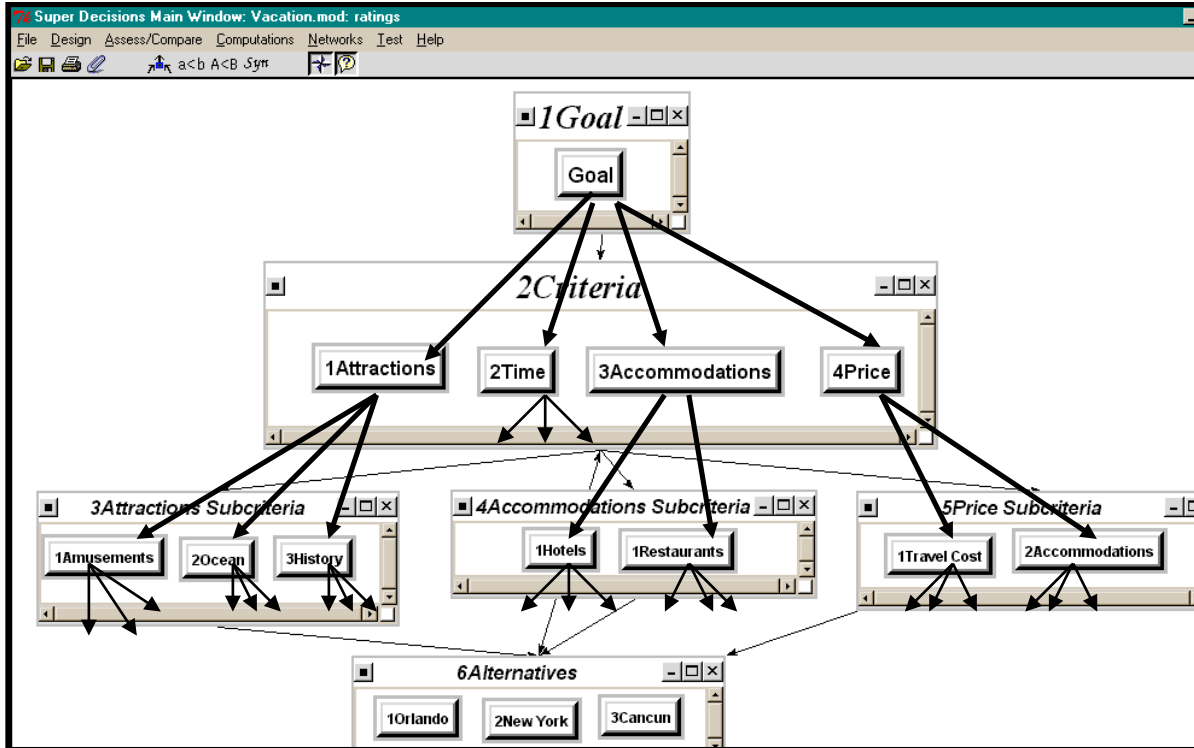
RESULTS SHOWN AS TOTALS IN THE RATINGS SPREADSHEET	TOTALS CONVERTED TO PRIORITIES IN THE RATINGS SPREADSHEET

- Select the Calculations/Matrix Priorities command to see the ideal priority values in each cell that correspond to the verbal ratings. These values can be blocked, copied with Ctrl C and pasted with Ctrl V into an Excel Spreadsheet for further processing.

	0.232605 1Activities	0.075985 2Nightlife	0.513961 3Sightseeing	0.177449 4Cost
Orlando	1.000000	0.306142	0.306142	0.511411
San Francis~	0.664326	0.664326	1.000000	1.000000
New York	0.664326	1.000000	1.000000	0.392636

## HIERARCHICAL MODELS WITH SUB-CRITERIA

When the criteria in a hierarchical model are broken down into sub-criteria one way to handle it, though not the only one is to put the criteria in a cluster, then create a cluster for the subcriteria of each criterion. A second way would be to put all the subcriteria in a level into the same cluster, but then it would be difficult to see at a glance the subcriteria that belong to a criterion.



In the figure above, one main criterion node, Time, connects directly to the alternatives. The other criteria connect to subcriteria that then connect to the alternatives. The lowest level of criteria that connect to the alternatives are called the “covering criteria”. Here the covering criteria are the main criterion Time plus the subcriteria: Amusements, Oceans, History, Hotels, Restaurants, Travel Cost, Accommodations. The pairwise comparisons are done in the usual way for this model. It can also be done as a Ratings model by selecting the bottom level or “covering criteria” as the criteria in Ratings.

## COMPLETE HIERARCHICAL MODELS

In a complete hierarchical model, all the nodes in a level connect to all the nodes in the next lower level. The model shown in Figure 8 below has a “complete hierarchy” structure except for the next to last level between “Groups Affected” and “Objectives”. The Farmers were interested only in Irrigation and Flood Control on the next level, the Recreationists only in Flat Dam (dam full of water) and White Dam (low water level in dam), the Power Users only in power and the Environmentalists only in the Environment. The clusters in the ANP model shown in Figure 9 correspond to the levels in hierarchic drawing in Figure 8.

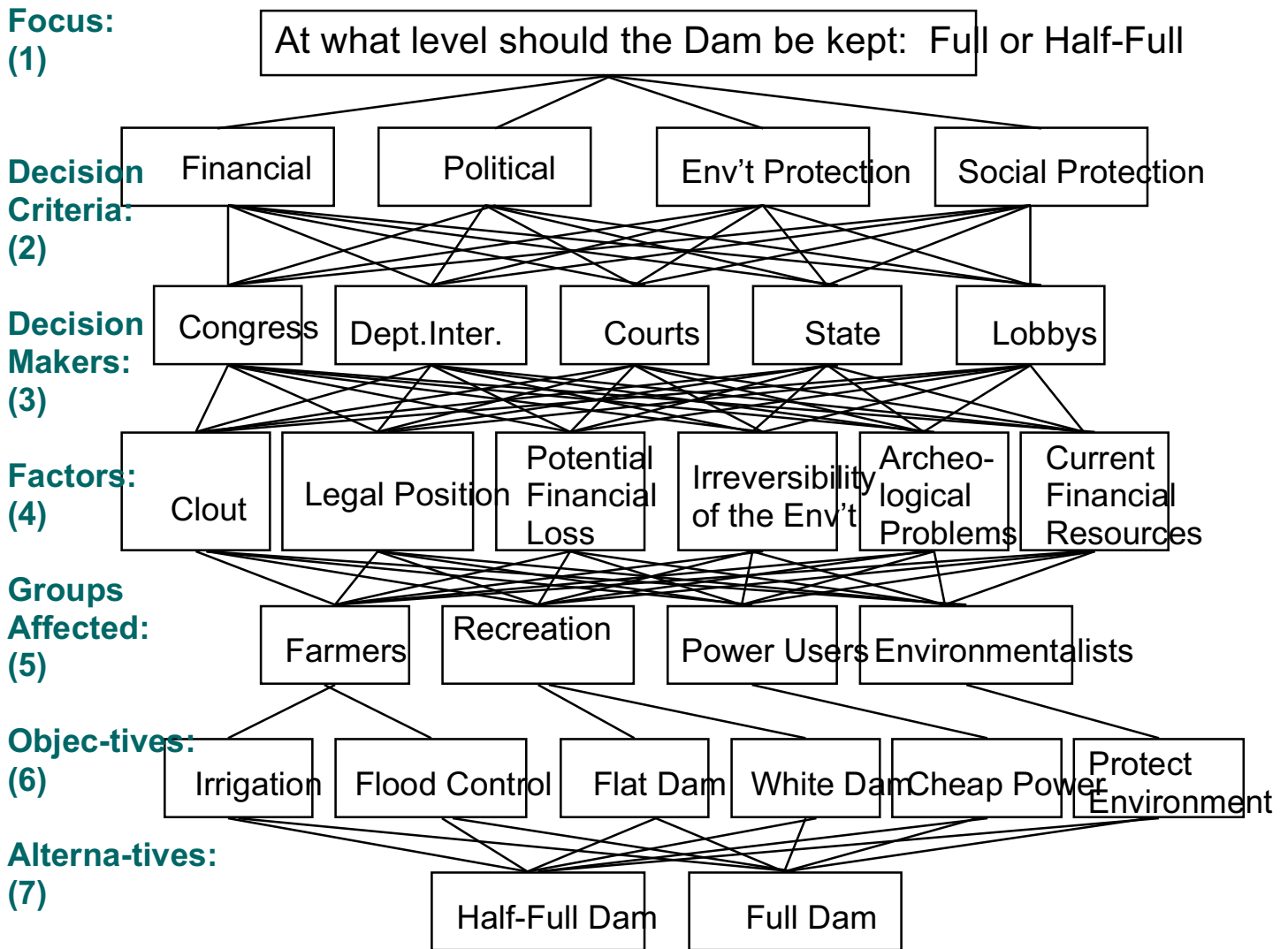


Figure 8. Hierarchy for Deciding on Water Level in a Dam

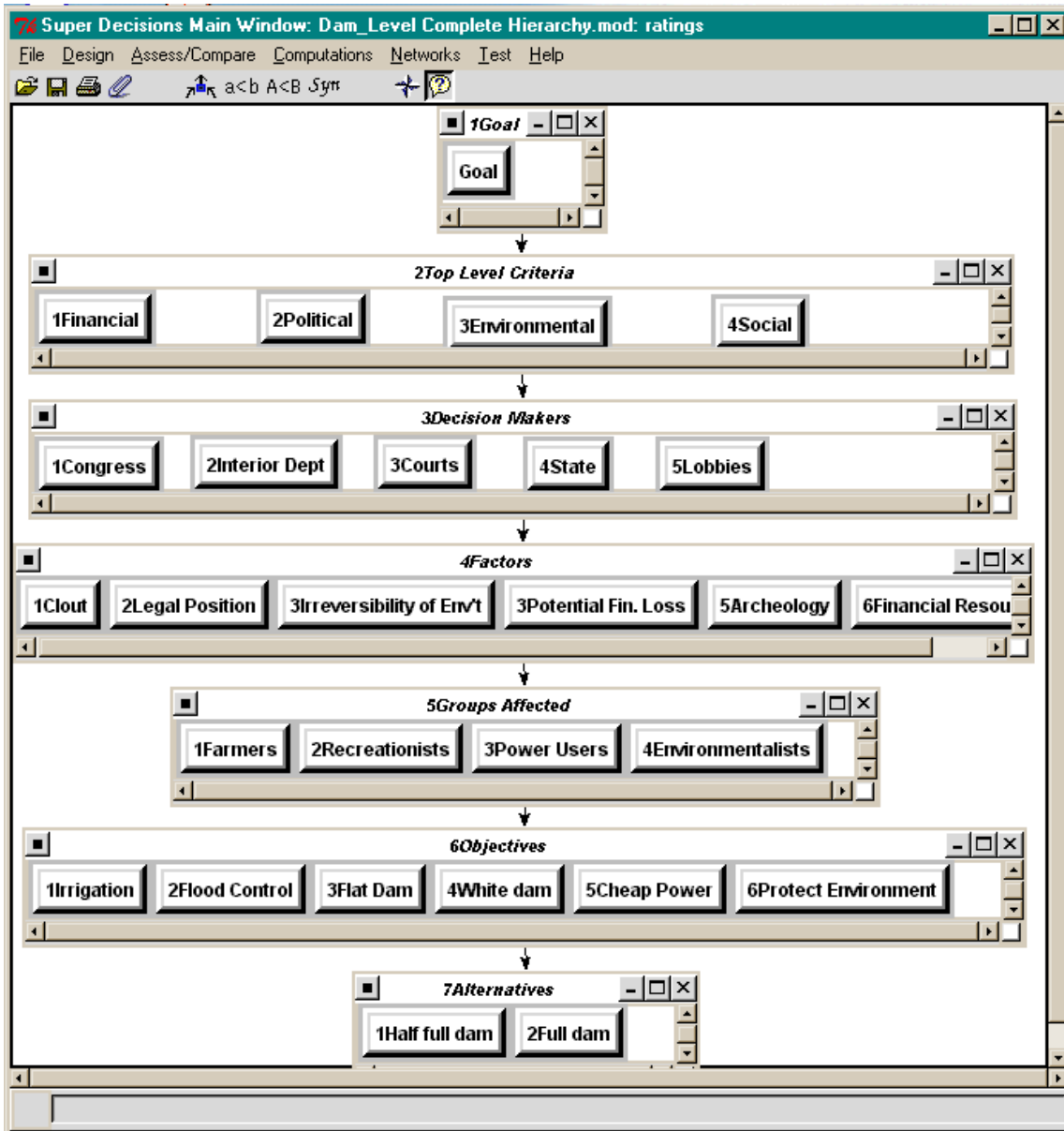



Figure 9. The ANP Model that Corresponds to the Dam Problem shown in Figure 8

In the *SuperDecisions* software, a connection from one cluster to another means at least one node in the source cluster is connected to one node in the target cluster. To see exactly which nodes are connected in the software click on the icon  to show the node connections.