ORA User's Guide 2007

ORA | Organizational Risk Analyzer

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Abstract

ORA is a network analysis tool that detects risks or vulnerabilities of an organization's design structure. The design structure of an organization is the relationship among its personnel, knowledge, resources, and tasks entities. These entities and relationships are represented by the Meta-Matrix. Measures that take as input a Meta-Matrix are used to analyze the structural properties of an organization for potential risk. ORA contains over 100 measures which are categorized by which type of risk they detect. Measures are also organized by input requirements and by output. ORA generates formatted reports viewable on screen or in log files, and reads and writes networks in multiple data formats to be interoperable with existing network analysis packages. In addition, it has tools for graphically visualizing Meta-Matrix data and for optimizing a network's design structure. ORA uses a Java interface for ease of use, and a C++ computational backend. The current version ORA1.2 software is available on the CASOS website: http://www.casos.ece.cmu.edu/projects/ORA/index.html.

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Key Words: DNA, ORA, Dynamic Network Analysis, MetaNetwork, Social Network Analysis

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Getting Started

Welcome to ORA's Help File system. The ORA help set is organized into the following top-level folders:

The Main Interface

The Main Interface is the area for working with MetaMatrices. This includes loading & merging, performing various math on the Matrices, generating different networks, and running reports.

The Visualizer

This are is for visualizing the MetaMatrices you worked with in the Main Interface. Contains tools for hiding and revealing sets or individual entities and edges. It also allows you to group the entities in various ways.

ORA Measures

Explanation of the specific rules to place on MetaMatrices for viewing data.

Lessons

Lessons designed to teach specific material

What Is ORA?

An Overview

The Organizational Risk Analyzer (ORA) is a statistical analysis package for analyzing complex systems as dynamic social networks. Many complex systems such as organizations, intra-state alliances, food webs, etc. can be represented as an ecology of interlinked networks. Within ORA any complex system is represented as a MetaMatrix.

What follows is a general description of ORA's primary capabilities. Specific instruction is provided under the correlating folders in this help system.

The ORA Visualizer

The ORA Visualizer renders conceptual images of social networks. Entities such as Agents, Task, Knowledge and Organizations are represented as Entities. Entities which share the same attributes can be further grouped together creating metaentities. Links, also called ties or edges, connect entities that share a direct relationship. Such relationships are derived from the MetaMatrix ORA's single unit of data input, and are referred to as graphs. The ORA Visualizer is interactive. You can zoom, rotate, isolate, add and remove entitysets, and much more.

See Basic Terms for additional definitions relating to Social Networks.

Reports

ORA can run many reports: Risk, Intelligence, and Sphere of Influence to name a few. Multiple organizations can be compared against each other, network structure can be optimized, subgroups within a network can be identified, and scenarios involving the removal of agents, links, or nodes can be examined. Reporting capabilities are constantly being refined and updated.

See Report for detailed instruction and an explanation of each of ORA's current reports.

Charts

Four chart types are available: Bar Chart, Scatter Plot, Histogram, and Heat Map. Each one in turn presents a different statistical profile of a selected nodeset. Examples of these reports and how to access them can be found under Basic Usages.

See Charts for detailed description of the measures and alogoriths that drive ORA Charts.

System Requirements

ORA performs best on machines that meet or exceed the following specifications:

Windows XP, 256 MB RAM, Pentium 4 processor (or equivalent) running at 1.0 GHz.

When working with extremely large data sets, increasing processing speed and RAM is highly recommended.

Basic Terms

Adjacency Matrix – A Matrix that is a square actor-by-actor (i=j) matrix where the presence of pair wise edges are recorded as elements. The main diagonal, or self-tie of an adjacency matrix is often ignored in network analysis.

Aggregation – Combining statistics from different entities to higher entities.

Attribute – Indicates the presence, absence, or strength of a particular connection between entities in a Matrix.

Centrality – The nearness of an entity to all other entities in a network. It displays the ability to access information through edges connecting other entities. The closeness is the inverse of the sum of the shortest distances between each entity and every other entity in the network.

Classic SNA density – The number of edges divided by the number of possible edges not including self-reference. For a square matrix, this algorithm first converts the diagonal to 0, thereby ignoring self-reference (a node connecting to itself) and then calculates the density. When there are N nodes, the denominator is (N*(N-1)). To consider the self-referential information use general density.

Clique – A sub-structure that is defined as a set of entities where every entity is connected to every other entity.

Clustering coefficient – Used to determine whether or not a graph is a small-world network.

Congruence – The match between a particular organizational design and the organization's ability to carry out a task.

Degree – The number of edges to other entities in the network.

Density –

- **Binary Network:** The proportion of all possible edges actually present in the Matrix.
- **Value Network:** The sum of the edges divided by the number of possible edges. (i.e. the ratio of the total edge strength that is actually present to the total number of possible edges).

Dyad – Two entities and the connection between them.

Dyadic Analysis – Statistical analysis where the data is in the form of ordered pairs or dyads. The dyads in such an analysis may or may not be for a network.

Dynamic Social Network – Dynamic Network Analysis (DNA) is an emergent scientific field that brings together traditional social network analysis (SNA), link analysis (LA) and multi-agent systems (MAS).

Edge – A specific relation among two entities. Other terms also used are tie and link.

Entities – General things within an entity class (e.g. a set of actors such as employees).

Entity – A specific entity (e.g., Joe, Martha, Bob; or, airplanes, buses, bicycles).

Entity Class – The type of items we care about (knowledge, tasks, resources, agents).

Entity Set – A collection of entities that group together for some reason.

FOG – (F)uzzy (O)verlapping (G)roups.

General density – The number of edges divided by the number of possible edges including self-reference. For a square matrix, this algorithm includes self-reference (an entity connecting to itself) when it calculates the density. When there are N entities, the denominator is (N*N). To ignore self-referential information use classic SNA density.

Gini coefficient – The measure of inequality of a distribution of income. Uses a ratio with values between 0 and 1: the numerator is the area between the Lorenz curve of the distribution and the uniform (perfect) distribution line; the denominator is the area under the uniform distribution line.

In-Degree – The sum of the connections leading to an entity from other entities.

Isolate – any entity which has no connections to any other entity

Link – see Edge

Main Diagonal – in a square matrix

Math Terms

These mathematical terms and symbols are used: Let S be any set:

- card(S) = |S| = the cardinality of S (the cardinality of the entity-sets is represented as |A|, |K|, |R|, |T|)
- $\Re$ denotes a real number
- Z denotes an integer

Matrix Algebra – The part of algebra that deals with the theory of matrices.

Measure – A measure is a function that maps one or more networks to R^n. Measures are often scalar (n=1) or vector valued with n=|V| or n=|U|.

MetaMatrix – A statistical graph of correlating factors of personnel, knowledge, resources and tasks. These measures are based on work in social networks, operations research, organization theory, knowledge management, and task management.

Monte Carlo – A random optimization of your organization

Multiplex – Network where the links are from two or more relation classes.

Multimode Network – Where the entities are in two or more entity classes.

Neighbors – Entities that share an immediate edge to the entity selected.

Network – Set of links among entities. Entities may be drawn from one or more entity classes and links may be of one or more relation classes.

A network N is a triple consisting of two sets of entities, called U and V, and a set of edges E□UxV. Thus, we write N=(U,V,E). An element e = (i,j) in E indicates a relationship or tie between entities i□U and j□V. A network where U=V and therefore E□VxV is called unimodal; otherwise the network is bimodal. We write G=(V,E) for unimodal networks. For our purposes, unimodal networks will not contain self loops, which means that (i,i)∉E for i□V.

Network Types:

- Unimodal networks are also called square networks because their adjacency matrix is square; the diagonal is zero diagonal because there are no self-loops.

Node: – see Entity

Notation:

The following matrix notation is used throughout the document for an arbitrary matrix X:

- X(i,j) = the entry in the i^{th} row and j^{th} column of X
- X(i,:) = i^{th} row vector of X
- X(:,j) = j^{th} column vector of X
- sum(X) = sum of the elements in X (also, X can be a row or column vector of a matrix)
- dich(X) = dichotomize (make binary) X, so that dich(X)(i,j) = 1 iff X(i,j) > 0
- X' = the transpose of X
- ~X = for binary X, ~X(i,j) = 1 iff X(i,j) = 0
- X@X = element-wise multiplication of two matrices (e.g. Z=X@Y => Z(i,j) = X(i,j)*Y(i,j))

ODBC – (O)pen (D)ata (B)ase (C)onnectivity

An access method developed by the SQL Access group in 1992 whose goal was to make it possible to access any data from any application, regardless of which database management system (DBMS) is handling the data.

Ontology – A branch of Metaphysics dealing with the nature of being.

Organization – An organization is a collection of networks.

Out-Degree – The sum of the connections leading out from an entity to other entities. This is a measure of how influential the entity may be.

Pendant – Any entity which is only connected by one edge. They appear to dangle off the main group.

Relation – The way in which entities in one class relate to entities in another class.

Simulated Annealing – The term Simulated Annealing draws its inspiration from metallurgy, where essentially atoms within a metal are heated thereby dislodging them from a metal's internal structure transforming the metal into another atomic state. In this way, your organization is heated changing its components in the attempt to arrive at an optimized state.

Sphere of Influence – One entity's direct relationship with one of it's neighbors as a function of specified path length.

Social Network Analysis – The term Social Network Analysis (or SNA) is used to refer to the analysis of any network such that all the entities are of one type (e.g., all people, or all roles, or all organizations), or at most two types (e.g., people and the groups they belong to).

Tie – see Edge

Trails – Analyzes the trails that an entity class makes through another entity class; for example, how vessels pass through ports.

Social Network Analysis (SNA)

Social Network Analysis is a scientific area focused on the study of relations, often defined as social networks. In its basic form, a social network is a network where the entities are people and the relations (also called links or ties) are a form of connection such as friendship. Social Network Analysis takes graph theoretic ideas and applies them to the social world. The term social network was first coined in 1954 by J. A. Barnes (see: Class and Committees in a Norwegian Island Parish). Social network analysis is also called network analysis, structural analysis, and the study of human relations. SNA is often referred to as the science of connecting the dots.

Today, the term Social Network Analysis (or SNA) is used to refer to the analysis of any network such that all the entities are of one type (e.g., all people, or all roles, or all organizations), or at most two types (e.g., people and the groups they belong to). The metrics and tools in this area, since they are based on the mathematics of graph theory, are applicable regardless of the type of nodes in the network or the reason for the connections.

For most researchers, the entities are actors. As such, a network can be a cell of terrorists, employees of global company or simply a group of friends. However, entities are not limited to actors. A series of computers that interact with each other or a group of interconnected libraries can comprise a network also.

Where to find out more on SNA

- *Scott, John*, 2000, Social Networks, Sage (2nd edition)
- *Wasserman, S. & K. Faust*, 1994, Social Network Analysis: Methods and Applications

Dynamic Network Analysis

Dynamic Network Analysis (DNA) is an emergent scientific field that brings together traditional social network analysis (SNA), link analysis (LA) and multi-agent systems (MAS). There are two aspects of this field. The first is the statistical analysis of DNA data. The second is the utilization of simulation to address issues of network dynamics. DNA networks vary from traditional social networks in that are larger dynamic multi-mode, multi-plex networks, and may contain varying levels of uncertainty.

DNA statistical tools are generally optimized for large-scale networks and admit the analysis of multiple networks simultaneously in which, there are multiple types of entities (multi-entities) and multiple types of links (multi-plex). In contrast, SNA statistical tools focus on single or at most two mode data and facilitate the analysis of only one type of link at a time.

DNA statistical tools tend to provide more measures to the user, because they have measures that use data drawn from multiple networks simultaneously. From a computer simulation perspective, entities in DNA are like atoms in quantum theory, entities can be, though need not be, treated as probabilistic. Whereas entities in a traditional SNA model are static, entities in a DNA model have the ability to learn. Properties change over time; entities can adapt: A company's employees can learn new skills and increase their value to the network; Or, kill one terrorist and three more are forced to improvise. Change propagates from one entity to the next and so on. DNA adds the critical element of a network's evolution and considers the circumstances under which change is likely to occur.

Where to learn to more:

- Kathleen M. Carley, 2003, " Dynamic Network Analysis" in Dynamic Social Network Modeling and Analysis: Workshop Summary and Papers, Ronald Breiger, Kathleen Carley, and Philippa Pattison, (Eds.) Committee on Human Factors, National Research Council, National Research Council. Pp. 133-145, Washington, DC.

- Kathleen M. Carley, 2002, " Smart Agents and Organizations of the Future" The Handbook of New Media. Edited by Leah Lievrouw and Sonia Livingstone, Ch. 12, pp. 206-220, Thousand Oaks, CA, Sage.
- Kathleen M. Carley, Jana Diesner, Jeffrey Reminga, Maksim Tsvetovat, 2005-forthcoming, Toward an Interoperable Dynamic Network Analysis Toolkit, DSS Special Issue on Cyberinfrastructure for Homeland Security: Advances in Information Sharing, Data Mining, and Collaboration Systems.

ORA and DNA

In general, you may want to use ORA in conjunction with other computational tools to advance DNA theory. The CMU CASOS tools that work with ORA to form tool chains are AutoMap (extracts networks from texts) and various DNA simulators including both Construct and DyNet. These tools have been used in a number of real world applications:

- Designing adaptive teams for Command and Control Networks
- Estimating the impact of organizational downsizing
- Estimating the effectiveness of new structures
- Evaluating risk in organizational designs
- Examine impact of IT effectiveness
- Impact analysis of actions in asymmetric warfare simulation
- Impact analysis of weaponized biological attacks on cities

ORA is interoperable with a number of other SNA and link-analysis tools: UCINET, KeyPlayer, and Analyst Notebook. Additional information is listed under data import and export.

Where to learn more about CASOS tools and this tool chain:

Kathleen M. Carley, Jana Diesner, Jeffrey Reminga, Maksim Tsvetovat, 2004, An Integrated Approach to the Collection and Analysis of Network Data, In Proceedings of the NAACSOS 2004 Conference, Pittsburgh, PA

Kathleen M.Carley, 2004, Estimating Vulnerabilities in Large Covert Networks Using Multi-Level Data, In Proceedings of the NAACSOS 2004 Conference, Pittsburgh, PA

Kathleen M. Carley, 2003, Dynamic Network Analysis in Dynamic Social Network Modeling and Analysis: Workshop Summary and Papers, Ronald Breiger, Kathleen Carley, and Philippa Pattison, (Eds.) Committee on Human Factors, National Research Council, National Research Council. Pp. 133-145, Washington, DC.

Kathleen M. Carley, Jana Diesner, Jeffrey Reminga, Maksim Tsvetovat, 2005-forthcoming, Toward an Interoperable Dynamic Network Analysis Toolkit, DSS Special Issue on Cyberinfrastructure for Homeland Security: Advances in Information Sharing, Data Mining, and Collaboration Systems.

CASOS: Center for Computational Analysis of Social and Organizational Systems (http://www.casos.cs.cmu.edu/index.html)

Where To Begin

To begin, you must load a Meta-Matrix into ORA. Your Meta-Matrix file can be of the following file formats: DyNetML (a specially defined markup language for representing dynamic networks), CSV, GraphML, and the text (DL) and binary data formats of UCINET.

Other methods to load a Metamatrix include building your own graph from an excel spreadsheet and cutting and pasting the information directly into ORA. For now, we will assume you have a MetaMatrix in one of the commonly defined formats above. There are two ways to load a MetaMatrix:

Select the folder icon from the tool bar. The navigate to the directory where the Metamatrix data set is saved

OR

From the Main Menu select: File > Open Metamatrix. Then navigate to the directory which contains the Metamatrix you want.

ORA can work with multiple MetaMatrices. Whether you load a MetaMatrix for the first time or if you had been working with a MetaMatrix from a previous session, a pop-up window displays the following button options:

Choose Replace Selected Org to remove the previous Metamatrix and replace it with the current one;

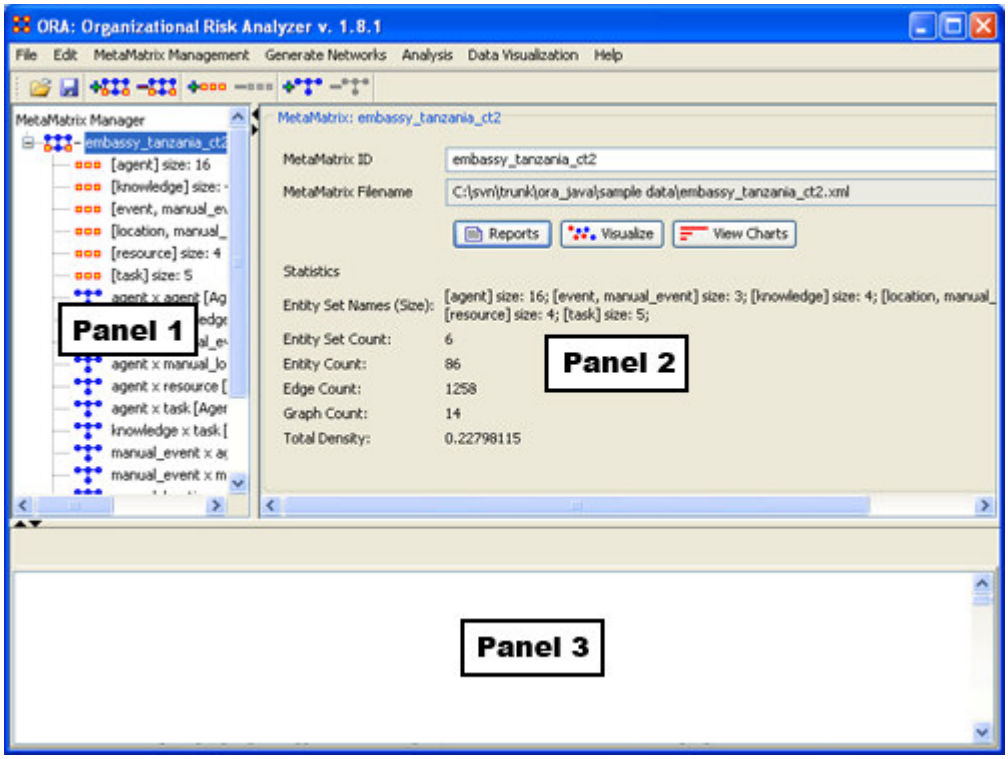
Choose Append As Additional Org to add it to any MetaMatrices already loaded in the ORA session;

Choose Replace all Orgs to remove any Metamatrices loaded into ORA and start over with the current Metamatrix only.

ORA's Main Interface

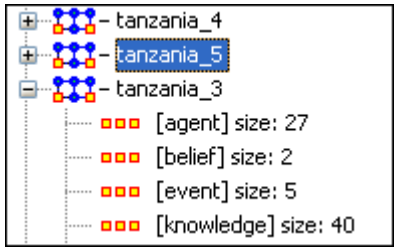
The ORA interface is organized into three resizable window panes. In the left corner appears a tree directory of the current MetaMatrix or MetaMatrices loaded into ORA. On the right, appears a pane that tells you basic information about the MetaMatrix you loaded, such as how many entities are represented. This pane also allows quick access to ORA's Visualizer, Reports and Chart tools. By selecting the Visualize button, the currently loaded MetaMatrix will render in the ORA Visualizer, which will load in a separate window.

Note the considerable amount of empty space in the ORA interface's bottom pane. This area will be used for report data generation. For now, it can be resized to one's preferences.

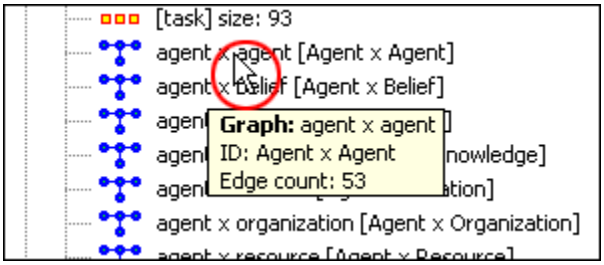


Panel 1

Panel 1 contains all the MetaMatrices you currently have active. Clicking on the plus icon will expand the MetaMatrix showing all the Entities and Graphs.



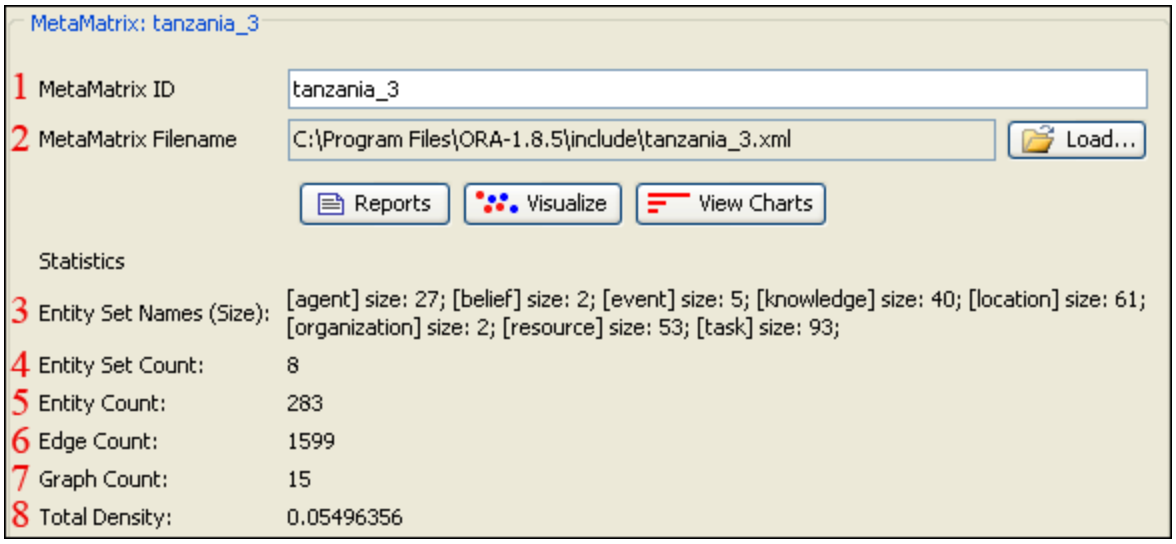
And if you hover the pointer over a graph it will display information about that graph.



Panel 2

Panel 2 displays the information regarding the

1. Name of the active MetaMatrix;
2. Currently selected metaMatrix showing it's pathway;
3. Entity Set Names (Size);
4. Entity Set Count;
5. Entity Count;
6. Edge Count;
7. Graph Count; and
8. Total Density.



Panel 3

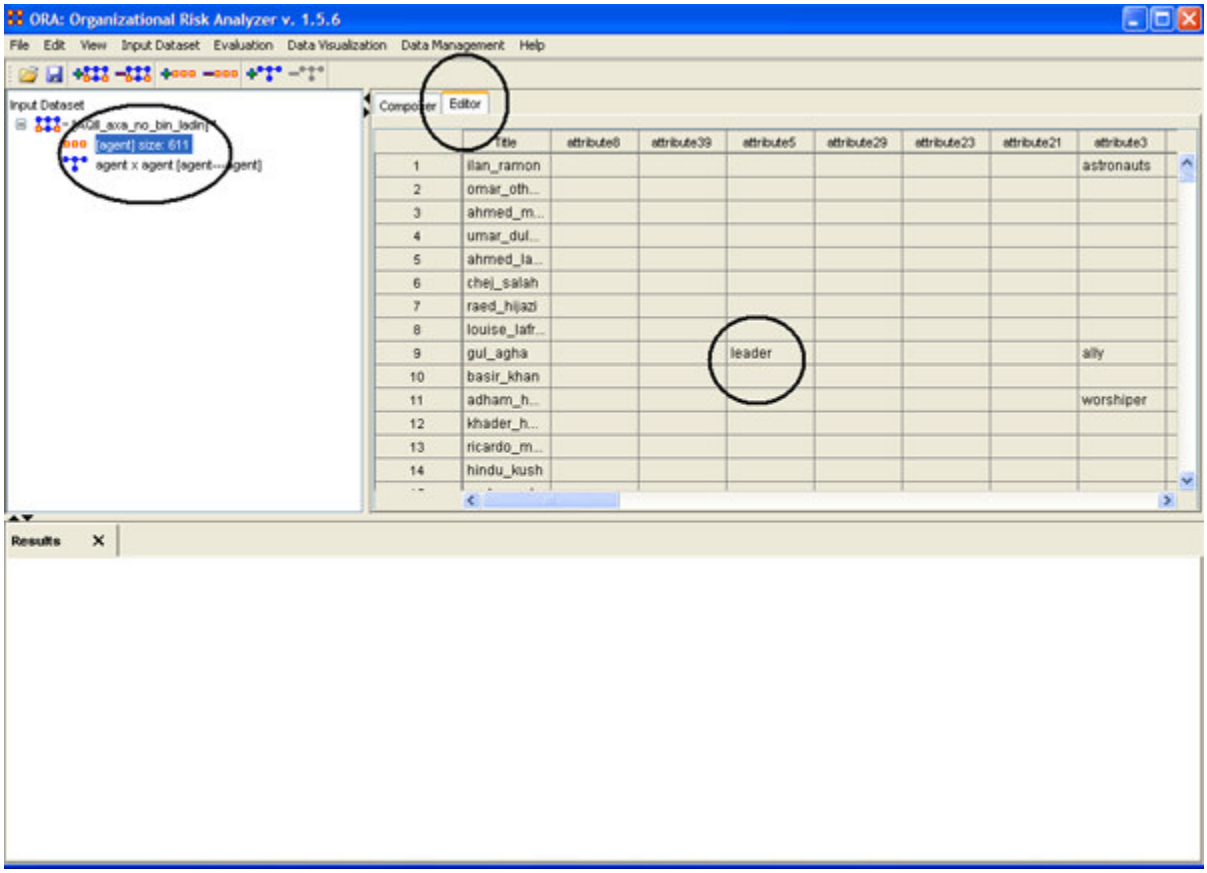
Panel 3, which at the start is blank, will contain any reports that are run on the MetaMatrices.

Adding and Removing Entities In The Editor

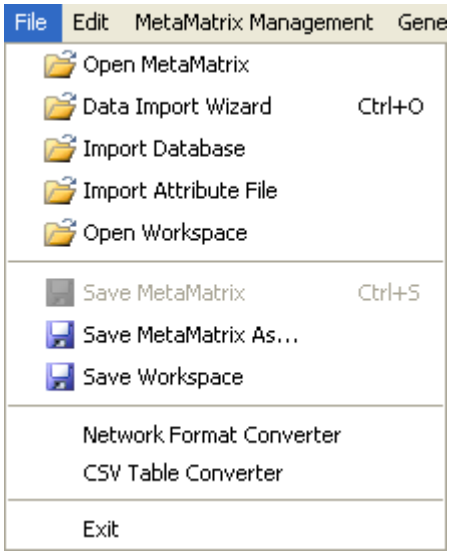
The MetaMatrix Composer is accessed through ORA's main interface and allows you to add or remove entities and entitysets by creating or removing attributes you wish to associate with your MetaMatrix. An attribute is a label that you wish to give a particular entity and can literally be anything you wish (worker, leader, Africa, March, 1989, etc.) Attributes can be used to define entities and entitysets according to your specific descriptions. For example, if you wanted to add the attribute leader to describe several entities, you can go directly inside the MetaMatrix Editor and give attributes to those entities which you attribute the description leader.

From ORA's main interface > "Editor" tab > Enter desired attribute under selected row and column for appropriate entity.

The black ellipses below highlight how to access the MetaMatrix Editor from ORA's main interface.



File Menu



Open MetaMatrix

This item opens up a single MetaMatrix with the following formats:

Dynetml (the native ORA xml format), .dl, .##h (UCINet), .CSV (comma separated values, Excel spreadsheet out), .txt (text files), .raw, .net (Pajek), .graphml, .stl (GMU model), .lo (pathfinder)

Data Import Wizard

This item contains additional options for importing MetaMatrices such as multiple file importing.

Import Database

An advanced feature for importing a database.

Import Attribute File

It is used to add an attribute into a file. The file selected must be in the CSV format.

Open Workspace

You may open an entire workspace that you were previously using. A workspace consists of a set of MetaMatricx files that were all open at the same time, and saved as a workspace.

Save MetaMatrix As…

Save the changes you've made in a MetaMatrix under a new filename.

Save Workspace

Save all active MetaMatrices into a Workspace which can be opened up at a later date.

Network Format Converter

The Network Format Converter takes files from one format and convert it to an ORA format.

CSV Table Converter

Convert a .csv file into an ORA format.

Exit

Close the program and leave

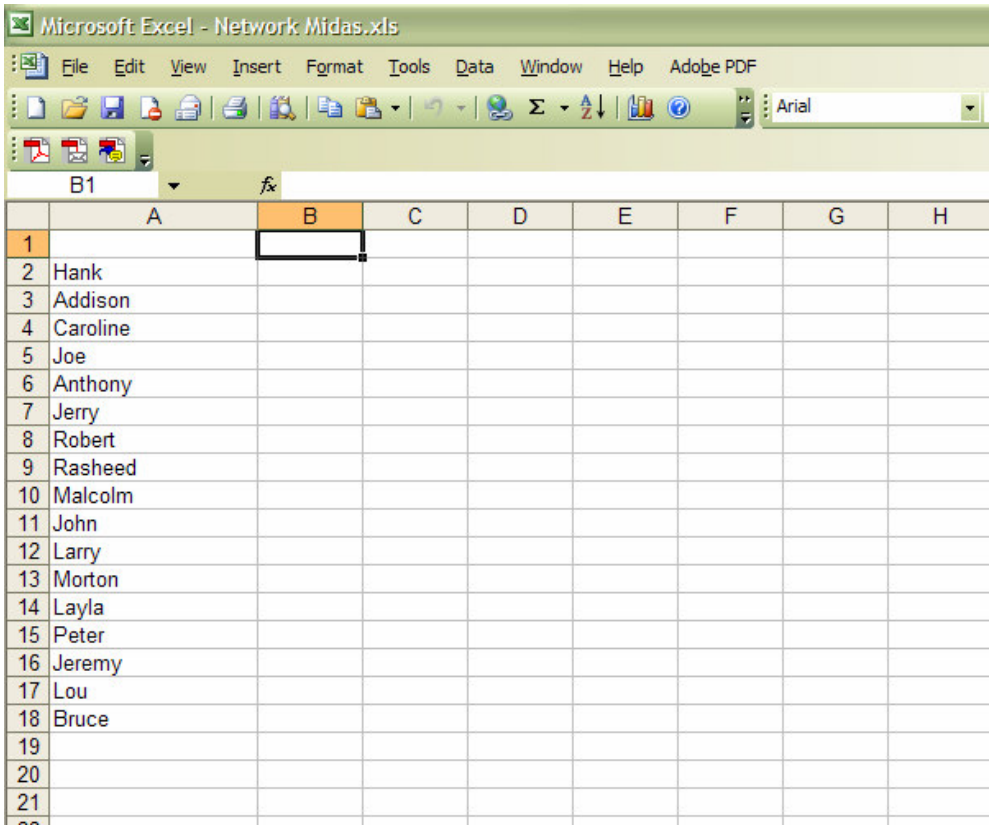
Creating A MetaMatrix From An Excel Spreadsheet

If you don't have a MetaMatrix, you can create one from scratch. Below is step-by-step instruction on how to do this.

We will create "Network Midas" an agent-by-agent square MetaMatrix. We say it is "square" because all row headings correspond directly to column headings. This is important as it relates to specific measures ORA can run on a graph. If the graph is not square, some measures will not work (See Measures for additional instruction).

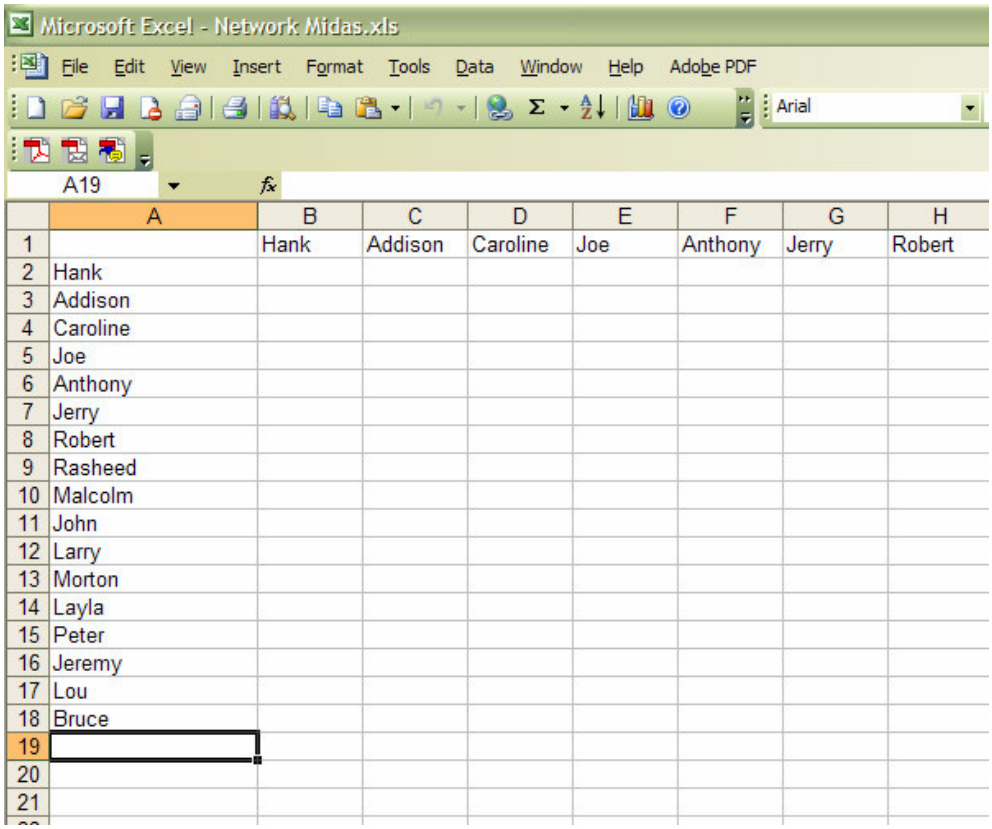
Begin by opening a blank Microsoft Excel work book. In "column A" we will enter the name of all agents that make up our social network or organization.

Note: When creating your spreadsheet, do not add any additional titles, notes, or other headings, which will interfere with the "square" properties of the MetaMatrix.



	A	B	C	D	E	F	G	H
1								
2	Hank							
3	Addison							
4	Caroline							
5	Joe							
6	Anthony							
7	Jerry							
8	Robert							
9	Rasheed							
10	Malcolm							
11	John							
12	Larry							
13	Morton							
14	Layla							
15	Peter							
16	Jeremy							
17	Lou							
18	Bruce							
19								
20								
21								

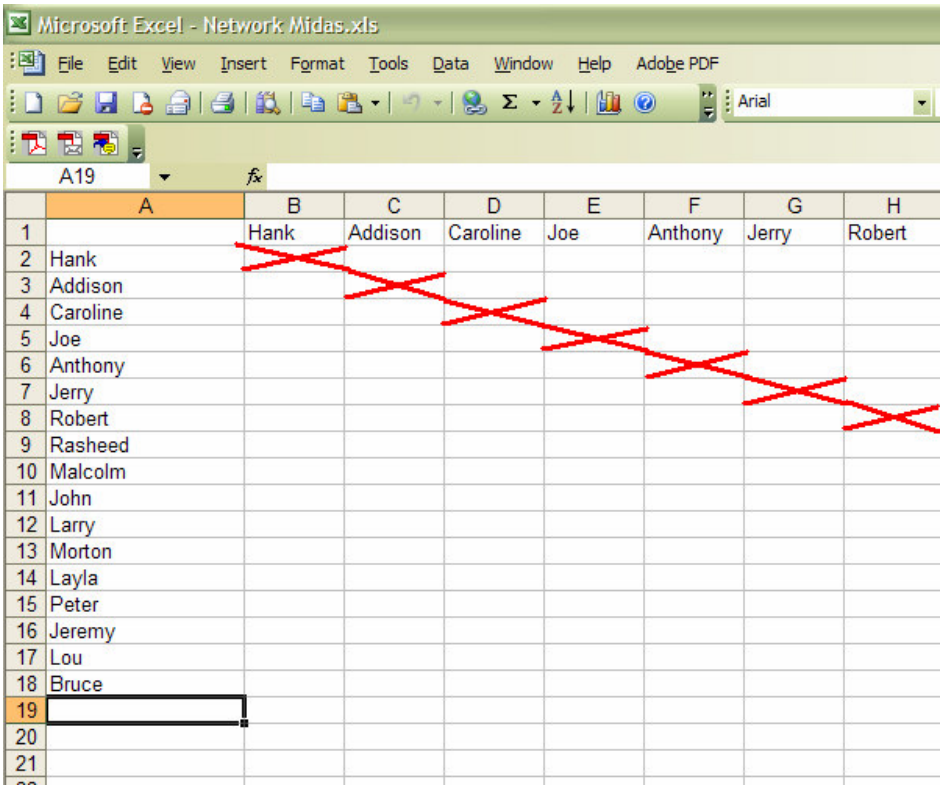
Next, create column headings using the correlating names as they appear in row headings. Again, this will ensure that our MetaMatrix will be square.



	A	B	C	D	E	F	G	H
1		Hank	Addison	Caroline	Joe	Anthony	Jerry	Robert
2	Hank							
3	Addison							
4	Caroline							
5	Joe							
6	Anthony							
7	Jerry							
8	Robert							
9	Rasheed							
10	Malcolm							
11	John							
12	Larry							
13	Morton							
14	Layla							
15	Peter							
16	Jeremy							
17	Lou							
18	Bruce							
19								
20								
21								

Here we will create "links (aka edges, and ties)" between each agent. We do this by entering a "1" if a direct connection or relationship exists and a "0" if it does not. Please note that headings that cross-reference themselves are considered redundant and thus are left blank or "0." For instance, in cell "B2" it is assumed "agent Hank" has a tie to himself.

In the example below, "Red Xs" are used to illustrate the redundant ties. This redundancy should continue as a smooth diagonal line from the top left corner of your MetaMatrix to the bottom right.

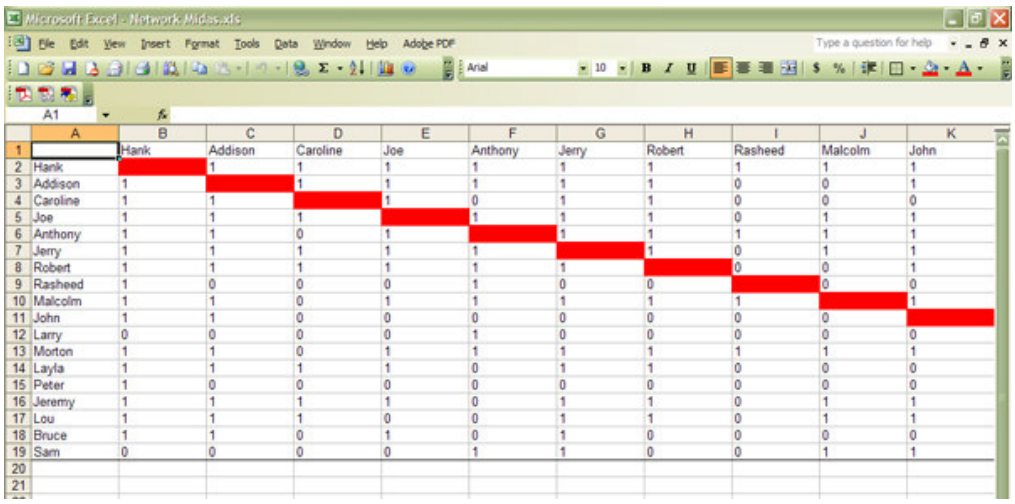


Tip! If you can't make this smooth diagonal line, you graph is not square.

Using *1s* and *0s* to establish linkages, complete your spreadsheet.

In the "Network Midas" example, we have assigned relationships randomly. Within your organization or network, however, you can describe any direct connections or relationships you are interested in analyzing. For instance, you may determine that a "direct connection" exits if agents within your network consult with each other at least once a month; literally, it can be anything you decide.

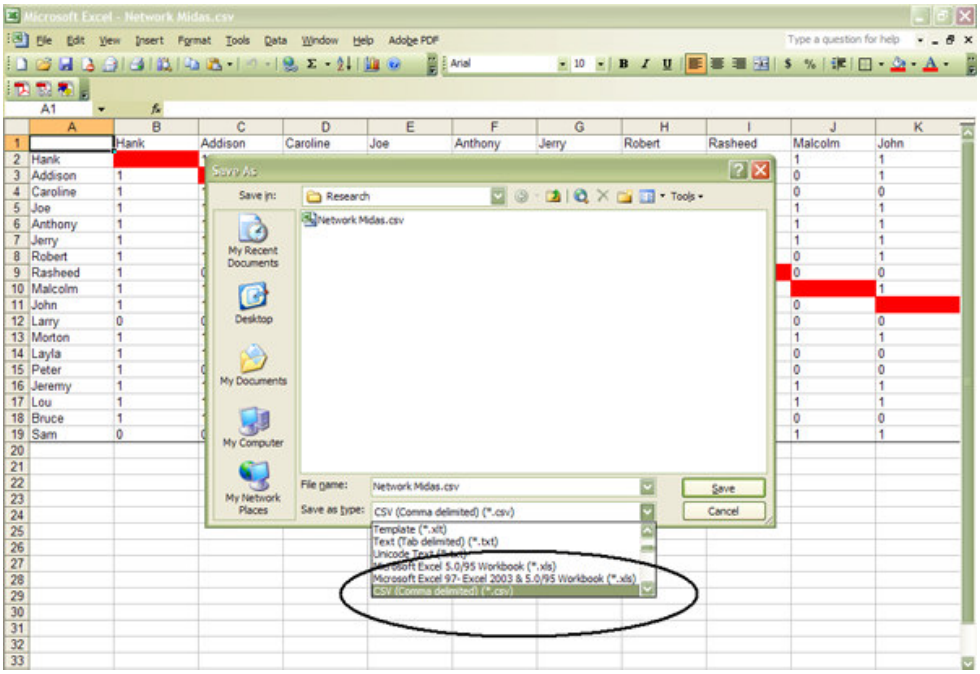
Below is our completed MetaMatrix, Network Midas (The red fill illustrates cells that do not require input due to their redundancy).

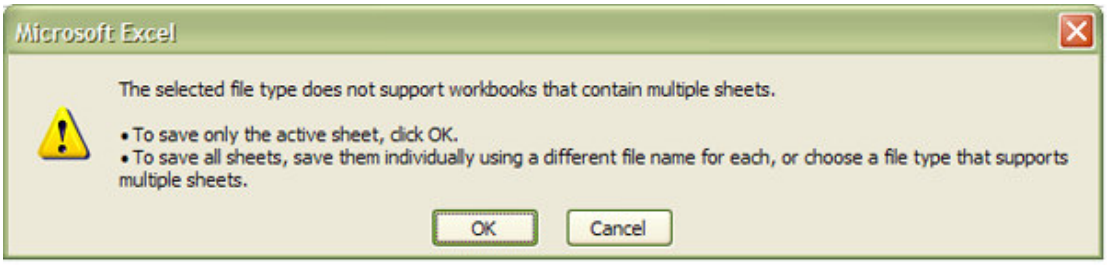


	A	B	C	D	E	F	G	H	I	J	K
1		Hank	Addison	Caroline	Joe	Anthony	Jerry	Robert	Rasheed	Malcolm	John
2	Hank		1	1	1	1	1	1	1	1	1
3	Addison	1		1	1	1	1	1	0	0	1
4	Caroline	1	1		1	0	1	1	0	0	0
5	Joe	1	1	1		1	1	1	0	1	1
6	Anthony	1	1	0	1		1	1	1	1	1
7	Jerry	1	1	1	1	1		1	0	1	1
8	Robert	1	1	1	1	1	1		0	0	1
9	Rasheed	1	0	0	0	1	0	0		0	0
10	Malcolm	1	1	0	1	1	1	1	1		1
11	John	1	1	0	0	0	0	0	0	0	
12	Larry	0	0	0	0	1	0	0	0	0	0
13	Morton	1	1	0	1	1	1	1	1	1	1
14	Layla	1	1	1	1	0	1	1	0	0	0
15	Peter	1	0	0	0	0	0	0	0	0	0
16	Jeremy	1	1	1	1	0	1	1	0	1	1
17	Lou	1	1	1	0	0	1	1	0	1	1
18	Bruce	1	1	0	1	0	1	0	0	0	0
19	Sam	0	0	0	0	1	1	0	0	1	1

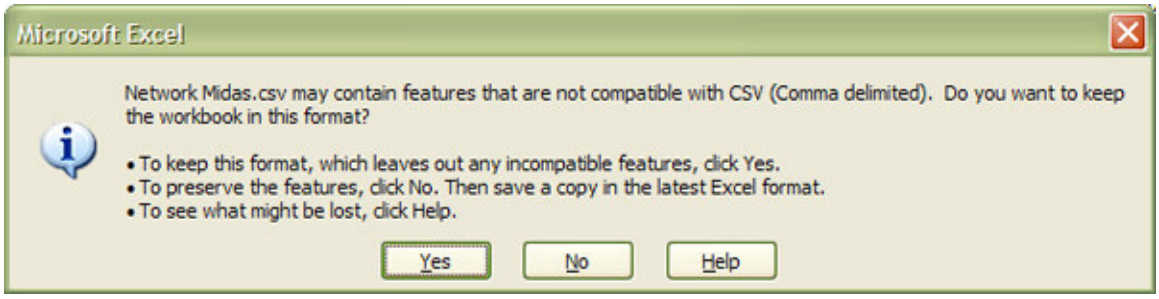
Now that we have essentially built a MetaMatrix from scratch using Excel, the next step is to save it in a compatible file format ORA can interpret. For Excel spreadsheets, in all likelihood, this will be the "CSV" (comma separate values) file format.

From the drop down menu: File > Save As > Save As Type > CSV (comma delimited) (*.csv)





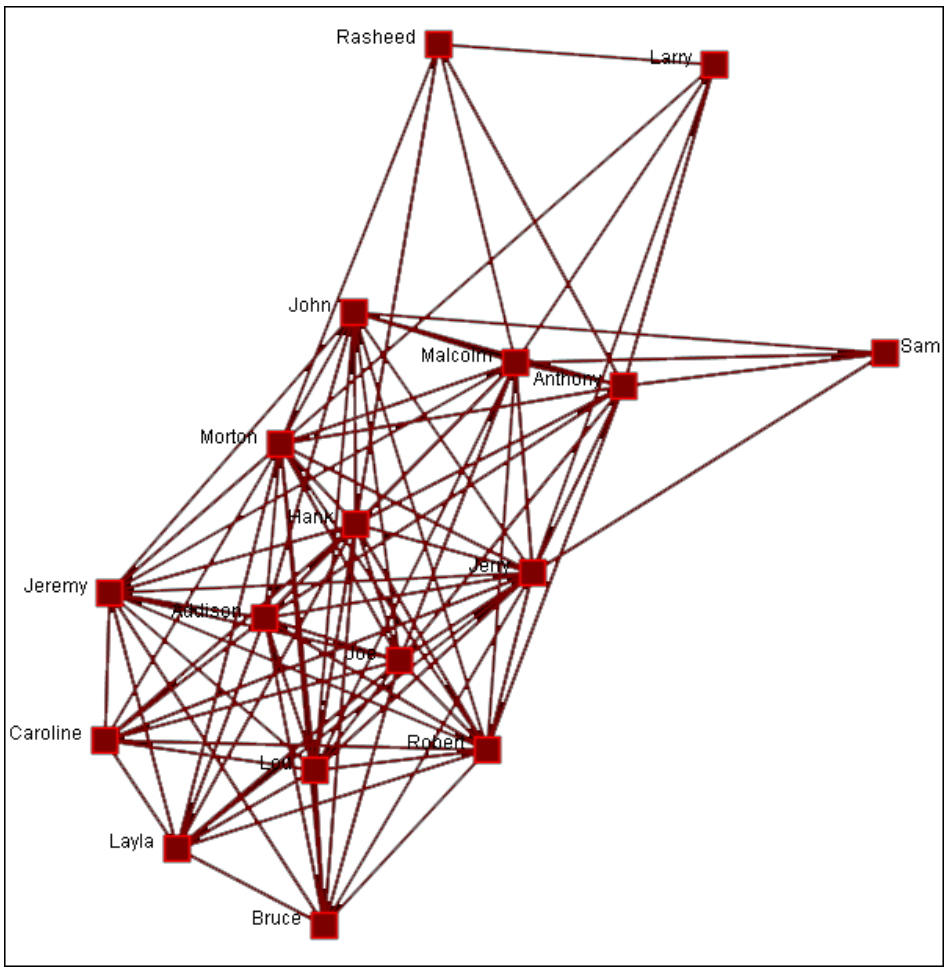
Click "OK"



Click "Yes"

Congratulations! You have now created your own MetaMatrix from scratch. Now, simply load your saved CSV file as you would any DynetML file, and work with your data the same way.

Below is a our MetaMatrix Network Midas rendered in the ORA Visualizer



ORA Charts

Charts

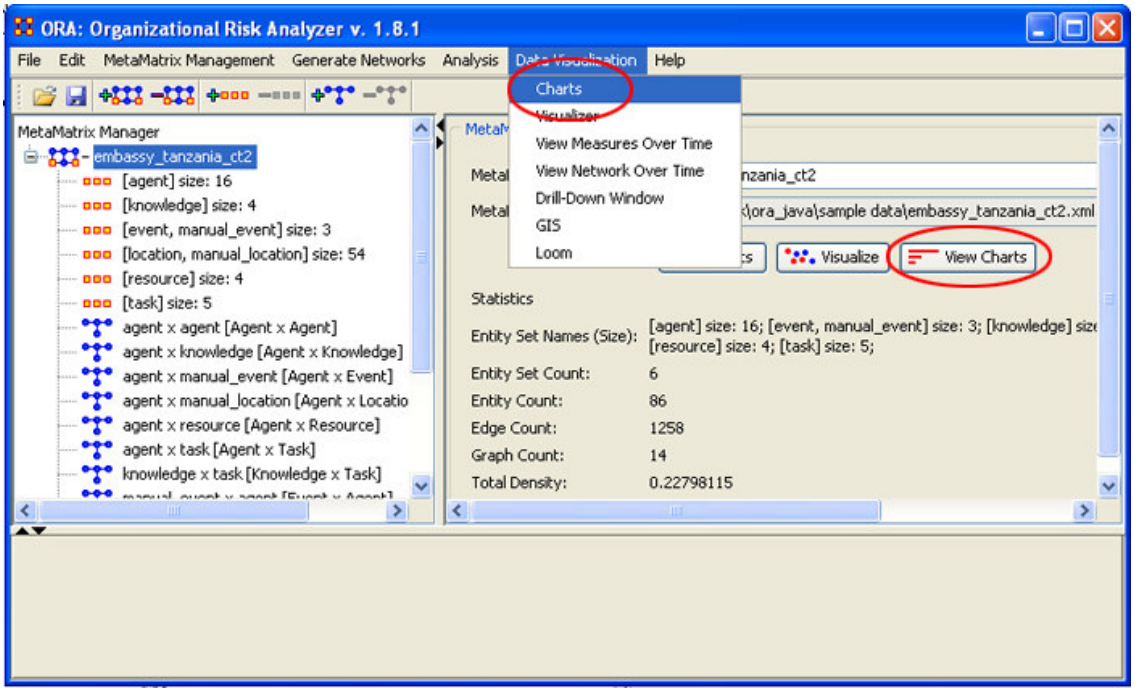
Charts – Charts Explained – Bar Chart – Scatter Chart – Histogram

Three charts are available: The Bar chart, Scatter Plot, Histogram, and Heat Map. ORA Charts can be accessed through the Main Interface by clicking the View Charts For This MetaMatrix button in the MetaMatrix Composer window pane or from the Main Interface drop down menu.

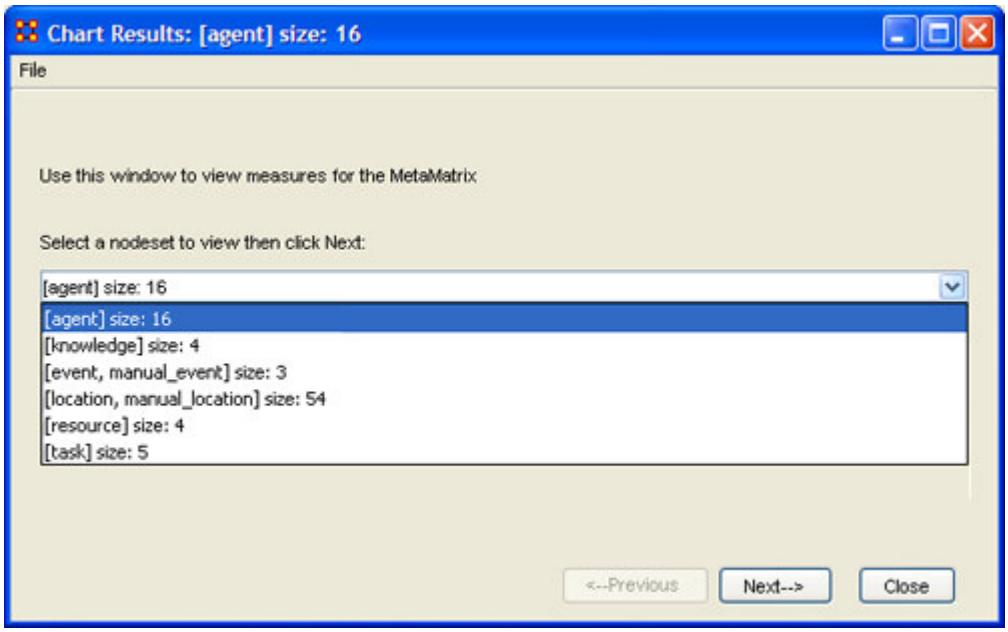
From the Main Menu select Data Visualization > Charts; OR

Select the [Charts] button.

In the screen shot below, ellipses highlight both methods to access ORA Charts.



After choosing Reports, the following pop-up window will appear. Select the entityset you are interested in Charting and select the [Next] button. For this example, we will simply select the currently loaded entityset Agents. ORA produces the following Bar Chart, displayed in the screen shot below.



By now, you should be able to access ORA Charts by loading a MetaMatrix by either using the [Charts] button in the MetaMatrix Composer window pane or from the Main Menu of the main interface. See Chart Types Explained for more detailed information about the four chart types.

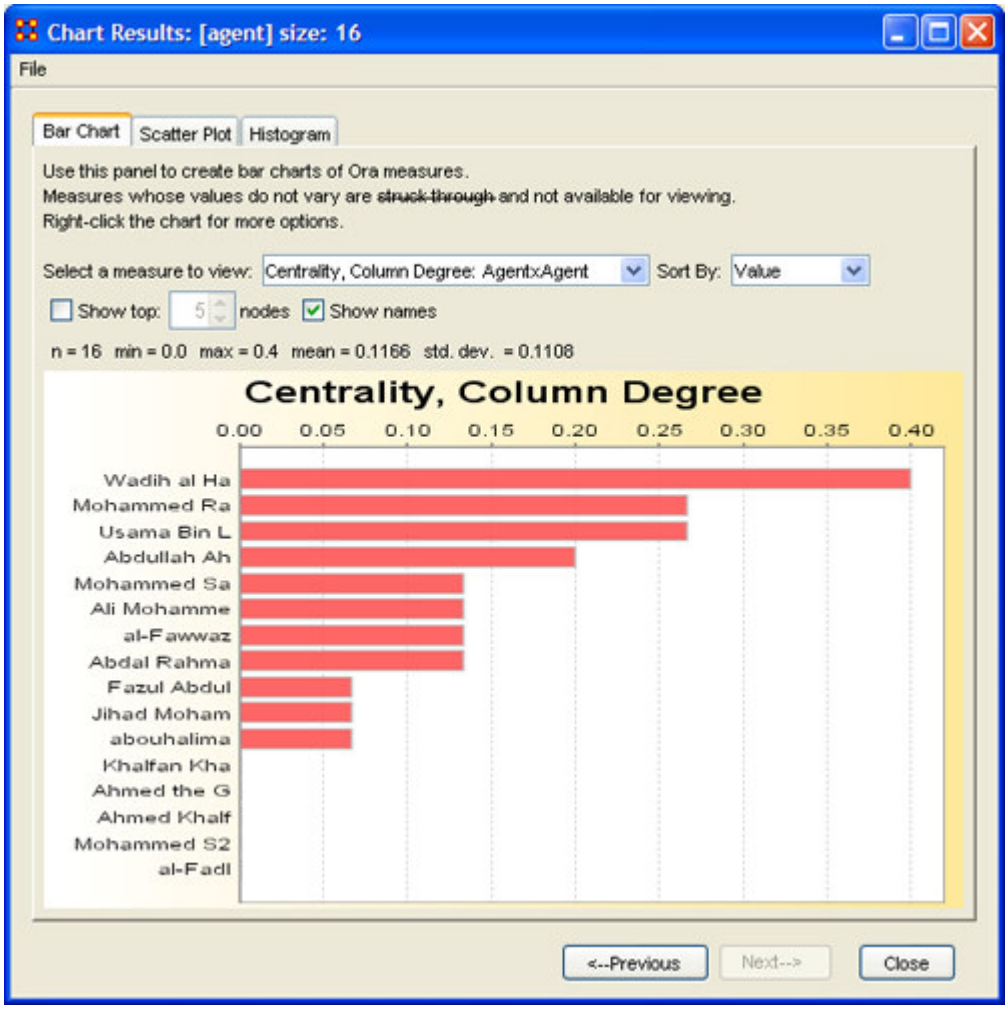


Chart Types Explained

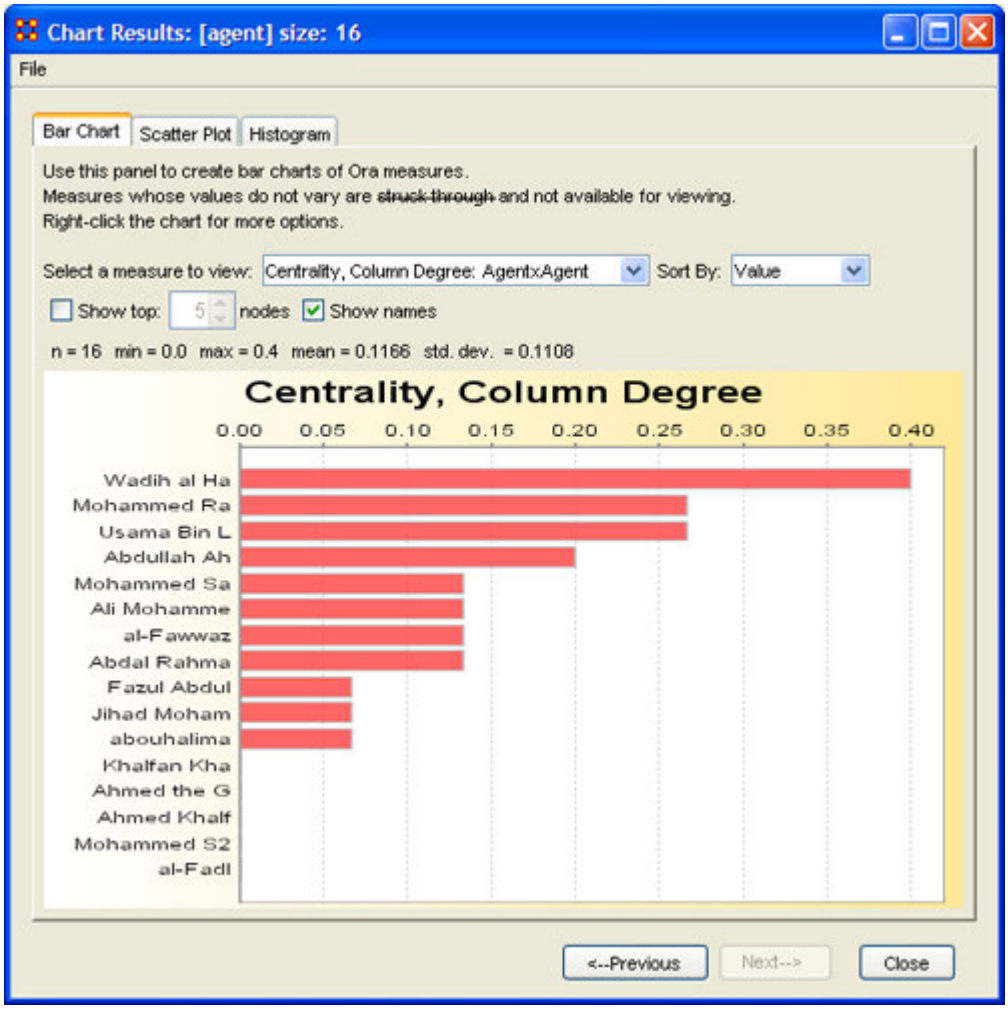
Charts – Charts Explained – Bar Chart – Scatter Chart – Histogram

Below are examples of each type of ORA charts: Bar Chart, Scatter Plot, and Histogram.

ORA Bar Chart

Charts – Charts Explained – Bar Chart – Scatter Chart – Histogram

A bar chart, also known as a bar graph, is a chart with rectangular bars of lengths usually proportional to the magnitudes or frequencies of what they represent. Bar charts are used for comparing two or more values. The bars can be horizontally or vertically oriented. Sometimes a stretched graphic is used instead of a solid bar.



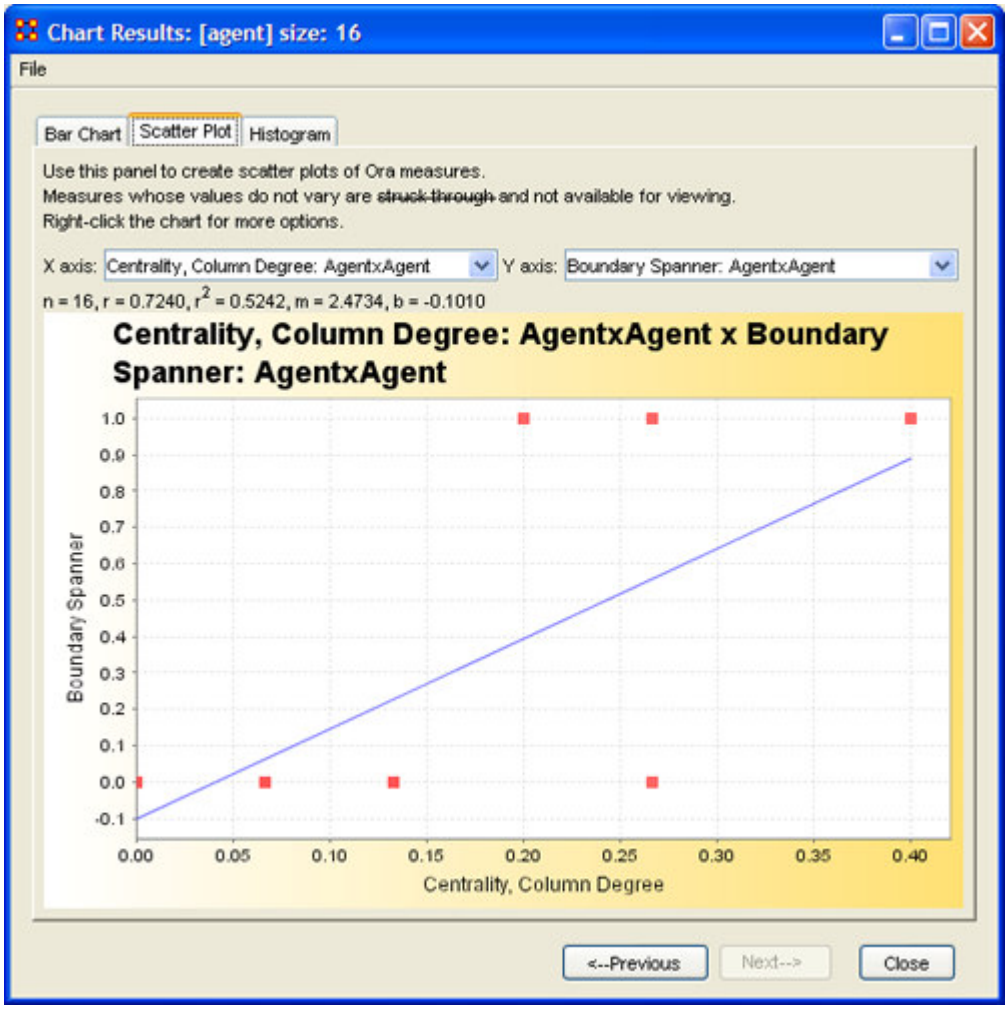
Scatter Plot

Charts – Charts Explained – Bar Chart – Scatter Chart – Histogram

A scatterplot, scatter diagram or scatter graph is a chart that uses Cartesian coordinates to display values for two variables. The data is displayed as a collection of points, each having one coordinate on the horizontal axis and one on the vertical axis.

A scatterplot does not specify dependent or independent variables. Either type of variable can be plotted on either axis. Scatterplots represent the association (not causation) between two variables.

A scatterplot can show various kinds of relationships, including positive (rising), negative (falling), and no relationship. If the pattern of dots slopes from lower left to upper right, it suggests a positive correlation between the variables being studied. If the pattern of dots slopes from upper left to lower right, it suggests a negative correlation. A line of best fit can be drawn in order to study the correlation between the variables. An equation for the line of best fit can be computed using the method of linear regression.

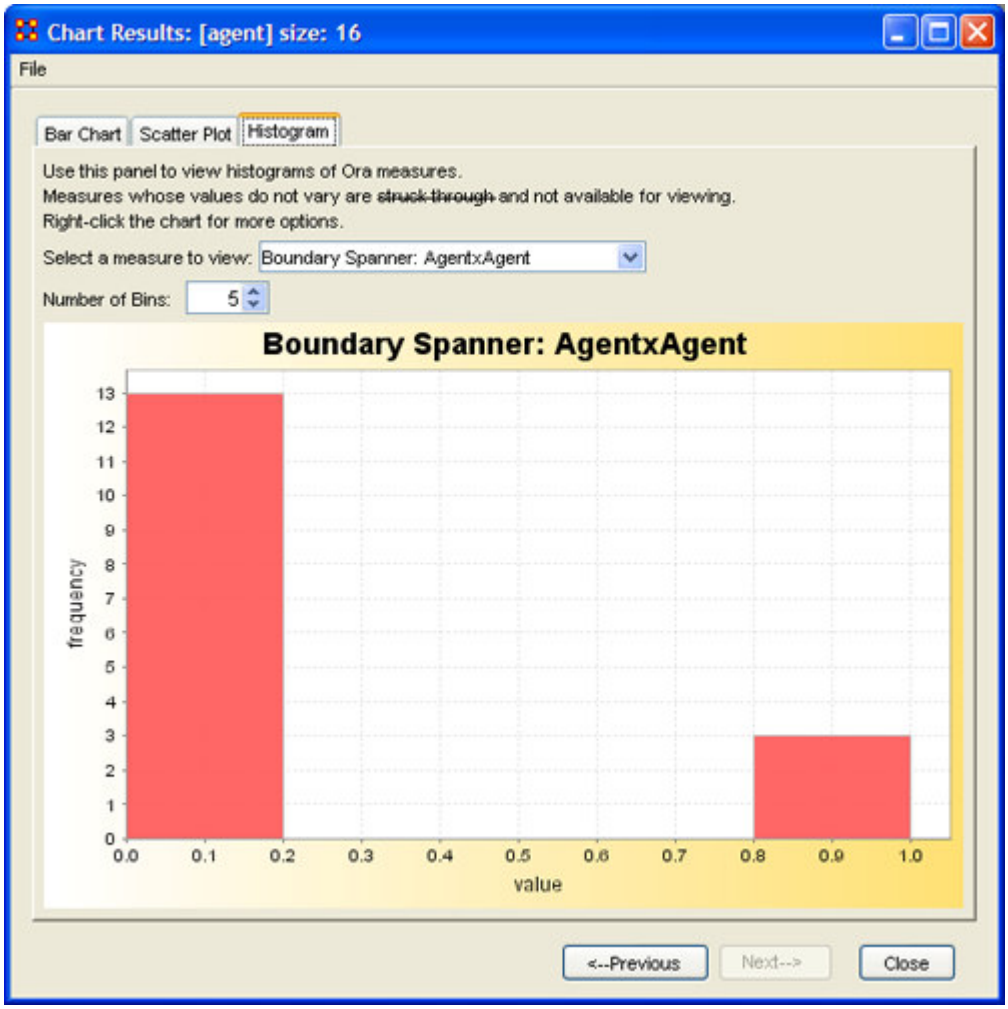


Histogram

Charts – Charts Explained – Bar Chart – Scatter Chart – Histogram

In statistics, a histogram is a graphical display of tabulated frequencies. A histogram is the graphical version of a table which shows what proportion of cases fall into each of several or many specified categories. The histogram differs from a bar chart in that it is the area of the bar that denotes the value, not the height, a crucial distinction when the categories are not of uniform width *(Lancaster, 1974)*. The categories are usually specified as non-overlapping intervals of some variable. The categories (bars) must be adjacent.

The word histogram is derived from histos and gramma in Greek, the first meaning web or mast and the second meaning drawing, record or writing. A histogram of something is thus, etymologically speaking, a drawing of the web of this something.



Over-Time Viewer

The Over-Time Viewer enables you to study changes within your organization or network over a time period. For instance, the overall centrality value of your network can be analyzed as it relates to network data compiled over the years, say, 2000, 2001, 2002. The time interval is dependent only on your data collection samples. Such an analysis can then be compared to external or internal events.

As an example, let us say you are interested in learning how the events of September 11, 2001 affected a terrorist organization or how the passing of anti-terrorism legislation impacted the same network. In either case, you can run measures in the Over Time Viewer on your network samples (loaded as multiple MetaMatrices) then compare the results against such external events.

There are three lessons showing the functions of the Overtime Viewer.

1. Lesson 5: Overtime Viewer

2. Lesson 6: Immediate Impact
3. Lesson 7: Near Term Impact Analysis

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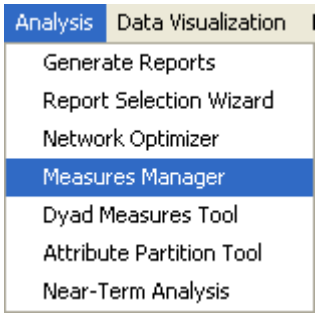
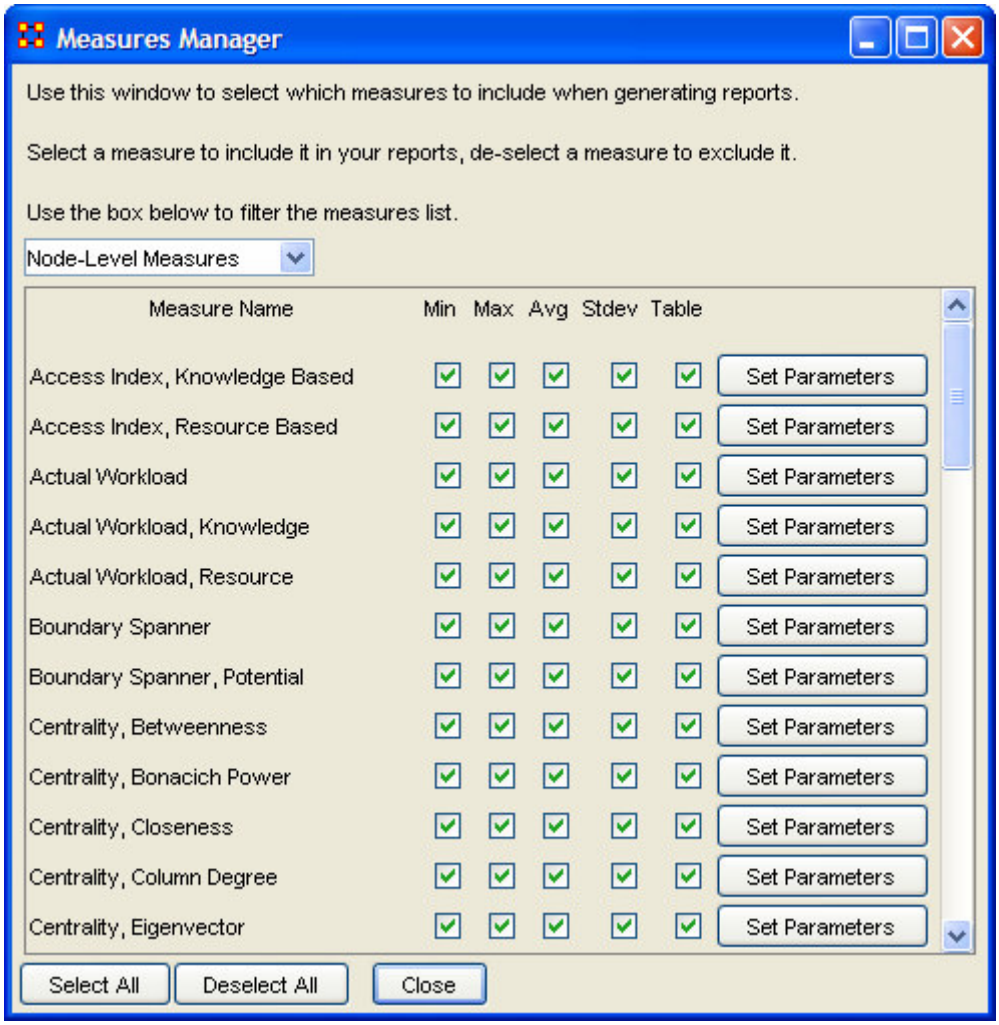
ORA Measures

ORA contains over 100 measures. A measure is a function that takes as input a MetaMatrix and outputs a single value or a vector of values. Consider the measure Density. The output for this measure is a single number used to analyze an organization. By default, all measures are run on a MetaMatrix. To view which measures are available, go to the Tools menu and select the Measures Manager.



The Measures Manager dialog box will appear. A drop down box displays the measures in ORA.



The Measures Manager categorizes measures in the following ways: Entity Level, Graph Level, and Risk Category.

An Entity Level measure produces vector output, a single value per entity. For example, Betweenness Centrality run on the Agent x Agent network outputs a value for each agent entity. A Graph Level measure outputs a single value. For example, Density run on any network outputs a single number. Additionally, seven risk categories include measures describing certain aspects of your organization's structure. All of the measures can be selected and de-selected using the buttons at the bottom of the dialog box. When a measure is deselected, it will not be used when generating certain reports.

Some reports use a predefined set of measures, and these are not affected by the Measure Manager selections (for example, the *Intel, Context, Located SubGroups, Sphere of Influence, and Immediate Impact reports*). The Risk Report, however, uses only the measures selected in the Measure Manager.

The following sets of entities (with their abbreviated symbol) are used throughout the document: Agent (**A**), Knowledge (**K**), Resource (**R**), and Task (**T**). The following networks defined on these entity sets are used throughout the documentation.

Symbol	Entity Sets		Name
	U	**V**	
AA	Agent	Agent	Communication Network
AK	Agent	Knowledge	Knowledge Network
AR	Agent	Resource	Capabilities Network
AT	Agent	Task	Assignment Network
KK	Knowledge	Knowledge	Information Network
KR	Knowledge	Resource	Training Network
KT	Knowledge	Task	Knowledge Requirement Network
RR	Resource	Resource	Resource Substitute Network
RT	Resource	Task	Resource Requirement Network
TT	Task	Task	Precedence Network

Input:

This lists each of the matrices that are required as input to the measure. If a measure takes as input a specific matrix from the Meta-Matrix, such as the Agent x Knowledge (AK) matrix, then it is listed. If the measure runs on any square (unimodal) network then N is given. A measure can require more than one input matrix.

a. Each input matrix can have one or more of the following requirements:
    i. square: the matrix must have the same number of rows as columns
    ii. binary: it must be binary data (i.e. any edges in the matrix are assumed to have a weight of one)
    iii. symmetric: the matrix must be undirected
b. ORA does the following when a matrix does not meet one or more of the above requirements:
    i. square: measure is not computed
    ii. binary: measure is computed, and edge weights are ignored (all edges are given value one)
    iii. symmetric: measure is computed, and the matrix is first symmetrized using the union method

A complete list of all measures available in ORA, along with references, input and output specifications, can be found in the following Ora Measures sections.

Access Index: Knowledge and Resource

The Boolean value is true if a particular agent is the only agent who knows a piece of knowledge and who is known by exactly one other agent. The one agent known also has its KAI set to one.

The average shortest path length between entities, excluding infinite distances.

Ashworth, 2003

TYPE: Entity Level

INPUT:

Knowledge: AK: binary; AA: binary

Resource: AR: binary; AA: binary

OUTPUT: Binary

The Knowledge Access Index (KAI) for agent i is defined as follows:

let

$$S_i = \{s \mid AK(i,s) \wedge (sum(AK(:,s)) = 1) \wedge (sum(A(i,:)) = 1)\}$$

for Resource replace AK with AR

Then

$$KAI_i = ((S_i \neq \varnothing) \vee (\exists j \mid S_j \neq \varnothing \wedge A(j,i) = 1))$$

for Resource replace KAI with RAI

Actual Workload, Knowledge and Resource Based

The knowledge an agent uses to perform the tasks to which it is assigned.

Carley, 2002

TYPE: Entity Level

INPUT:

Knowledge: AK: binary; KT: binary; AT: binary

Resource: AR: binary; RT: binary; AT: binary

OUTPUT: $\Re \in [0,1]$

Actual Workload for agent i is defined as follows:

$$[AK * KT * AT'](i,i) / sum(KT)$$

for Resource replace AK with AR and KT with RT

Note how Potential Workload is the first matrix product.

Measure: Average Distance

The average shortest path length between entities, excluding infinite distances.

Netstat

TYPE: Agent Level

INPUT: N: square, binary

OUTPUT: Graph Level:

$$\Re \in [0, N]$$

Let G=(V,E) represent a square network. Define a set S of all pairs (i,j) of entities such that i can reach j. Then average the shortest paths.

let S = {(i,j) | j is reachable in G from j }

Then,

$$\text{Average Distance} = \frac{\sum_{(i,j)\in S} d_G(i,j)}{|S|}$$

Boundary Spanner

An entity which, if removed from a network, creates a new component. This is often called a Gate Keeper entity.

Cormen, Leiserson, Riverest, Stein, 2001 p.558

TYPE: Agent Level

INPUT: N: square, binary, symmetric

OUTPUT: Entity level: Binary

A Boundary Spanner is an articulation point of N, as defined in the referenced book.

Centrality, Betweenness

The Betweenness Centrality of entity v in a network is defined as: across all entity pairs that have a shortest path containing v, the percentage that pass through v. This is defined for directed networks.

Freeman, 1979

TYPE: Entity Level

INPUT: N: square

OUTPUT: $\Re \in [0,1]$

Let G=(V,E) be the graph representation for the network. Let **n=|V|**, and fix an entity $v \in V$.

For $(u,w) \in VxV$, let $n_G(u,w)$ be the number of geodesics in G from u to w.

If $(u,w) \in E$, then set $n_G(u,w) = 1$.

Define the following:

let

$$S = \{(u,w) \in VxV \mid d_G(u,w) = d_G(u,v) + d_G(v,w)\}$$

let

$$\text{between} = \sum_{(u,w)\in S} (n_G(u,v) * n_G(v,w)) / n_G(u,w)$$

Then Betweenness Centrality of the entity $v = \text{between} / ((n-1)(n-2)/2)$.

Note: if G is not symmetric, then between is normalized by (n-1)(n-2).

Centrality, Bonacich Power

The Bonacich Power Centrality computes the centrality of each entity based on the centrality of its neighbors. Beta should be chosen such that its absolute value is less than the reciprocal of the larges eigenvalue of N.

Bonacich P, 1987

TYPE: Entity Level

INPUT: N: square

$\text{beta} \in \Re$

OUTPUT: $\Re \in [0,1]$

Let A = adjacency representation of the network N. Then Bonacich Power Centrality for the network is the solution c to the following system of linear equations:

$(I - \beta A)^{-1} c = Ae$, where I is the identity matrix, and e a vector of ones.

Note that if beta is 0, then c is simply equal to the row degree of each entity.

The values of c are not normalized.

Centrality, Closeness

The average closeness of an entity to the other entities in a network. Loosely, Closeness is the inverse of the average distance in the network between the entity and all other entities. This is defined for directed networks.

Freeman, 1979

TYPE: Entity Level

INPUT: N: square

OUTPUT: $\Re \in [0,1]$

Let G=(V,E) be the graph representation of the square network.

Fix

$v \in V$

let

$dist = \sum_{i \in V} d_G(v,i)$, if every entity is reachable from v.

Then Closeness Centrality of entity

$v = (|V|-1)/dist$.

If some entity is not reachable from v then the Closeness Centrality of v is |V|.

Centrality, Eigenvector

The centrality of a entity based on its degree and the degrees of its neighbors.

Bonacich P, 1972

TYPE: Entity Level

INPUT: N: square, symmetric

OUTPUT: $\Re \in [0,1]$

Calculates the eigenvector of the largest positive eigenvalue of the adjacency matrix representation of a square network. A Jacobi method is used to compute the eigenvalues and vectors.

Centrality, In Degree

The In Degree Centrality of a entity in a network is its normalized In-degree.

Wasserman and Faust, 1994

TYPE: Entity Level

INPUT: N

OUTPUT: $\Re \in [0,1]$

Consider the matrix representation X of a network with m rows and n columns. Each column j is assigned an in-degree centrality based on the sum of entries in its column.

The In-Degree Centrality for column j

$$\text{column j} = \frac{1}{m} \sum_{i=1}^{m} X(i, j)$$

This measure is also called Column Degree Centrality.

Centrality, Information

Calculates the Stephenson and Zelen information centrality measure for each entity.

Wasserman and Faust, 1994 (pg. 195)

TYPE: Entity Level

INPUT: N: square

OUTPUT: Entity Level:

$\Re \in [0,1]$

Calculates the measure described on pg 195-6 of Wasserman and Faust. Isolates (entities with no edges) are first removed from the network, and the measure computed on the resulting sub-graph. The isolates are given centrality value 0.

Centrality, Inverse Closeness

The average closeness of a entity to the other entities in a network. Inverse Closeness is the sum of the inverse distances between an entity and all other entities. This is defined for directed networks.

Wasserman and Faust, 1994 (pg 195)

TYPE: Node Level

INPUT: N: square, binary

OUTPUT: $\Re \in [0,1]$

Let G=(V,E) be the graph representation of the square network.

Fix $v \in V$

let

$$\text{dist} = \sum_{i \in V} \frac{1}{d_G(v,i)}, \text{ where } \frac{1}{d_G(i,i)} = 0 \text{ and } \frac{1}{d_G(v,i)} = 0$$

if i is not reachable from v.

Then, Inverse Closeness Centrality of entity v = dist/(|V|-1).

Centrality, Out Degree

The Out Degree Centrality of a entity in a square network is its normalized out-degree.

Wasserman and Faust, 1994

TYPE: Entity Level

INPUT: N: square

OUTPUT: $\Re \in [0,1]$ (If N is binary)

Consider the matrix representation X of a network with m rows and n columns. Each row i is assigned an out-degree centrality based on the sum of entries in its row.

The Out-Degree Centrality

$$\text{row i} = \frac{1}{n}\sum_{j=1}^{n} X(i,j)$$

This measure is also called Row Degree Centrality.

Centrality, Total Degree

The Total Degree Centrality of an entity in a square network is its normalized in plus out degree. The Total Degree Centrality of an entity is the normalized sum of its row and column degrees.

Wasserman and Faust, 1994 (pg 199)

TYPE: Entity Level

INPUT: N:square

OUTPUT: $\Re \in [0,1]$

Consider the matrix representation X of a square network with n entities. Each entity is assigned a value based on the sum of its row and columns.

The Total Degree Centrality for

$$\text{entity i} = \frac{1}{2(n-1)} \sum_{i=1}^{n} \sum_{\substack{j=1 \\ i \neq j}}^{n} X(i, j)$$

Note that the diagonal values are ignored.

Clique Count

Computes the number of distinct cliques to which each entity in a square, undirected network belongs.

Wasserman and Faust, 1994 (pg 254)

TYPE: Node Level

INPUT: N:square, symmetric

OUTPUT: Z (not scaled)

A clique of an undirected, square network is defined in Wasserman and Faust as a maximal complete subgraph of three or more nodes. The clique detection algorithm employed is the Bron-Kerbosch maximal clique algorithm, which is Algorithm 457 of the Collected Algorithms from CACM.

Clustering Coefficient, Watts-Strogatz

Measures the degree of clustering in a network by averaging the clustering coefficient of each entity. The clustering coefficient of a entity is the density of its ego network which is the sub graph induced by its immediate neighbors.

Watts and Strogatz, 1998

TYPE: Graph Level, Entity Level

INPUT: N: square, binary

OUTPUT:

Graph Level: $\Re \in [0,1]$

Entity Level: $\Re \in [0,1]$

let G=(V,E) be the graph representation of a square network.

Define for each node $v \in V$ its Clustering Coefficient cc_v:

let Gv = ego network of entity v

Then Clustering Coefficient for

$$\text{entity } v = cc_v = \text{density}(Gv)$$

Cognitive Demand

Measures the total amount of effort expended by each agent to do its tasks. Measures the total cognitive effort expended by an agent to do its tasks.

Individuals who are high in cognitive demand are emergent leaders. Removal of these individuals is quite disruptive to networks.

Note: The minimum input requirement is the AA network. All other networks are optional.

Carley, 2002

TYPE: Agent Level

INPUT: AA:binary; [AT:binary]; [AR:binary]; [RT:binary]; [AK:binary]; [KT:binary]; [TT:binary]

OUTPUT: Agent Level:

$\Re \in [0,1]$

The Cognitive Demand for an agent i is an average of terms, each of which measures an aspect of its cognitive demand. Each term is normalized to be in [0,1]. The number of terms depends on the input networks. The computation of each term for agent i is detailed below:

let x1 = # of agents with which i interacts

= sum(AA(i,:)) / (|A|-1)

let x2 = # of tasks to which i is assigned

= sum(AT(i,:)) / |T|

let x3 = sum of the # of agents assigned to the same tasks as i

= sum(ATA(i,:)-ATA(i,i)) / (|T|(|A|-1)), where ATA = AT*AT'

let x4 = # of resources i manages

= sum(AR(i,:)) / |R|

let x5 = # of knowledge i manages

= sum(AK(i,:)) / |K|

let x6 = sum of # resources i needs for all its tasks

= sum(ATR(i,:)) / (|T|*|R|), where ATR = AT*RT'

let x7 = sum of # knowledge i needs for all its tasks

= sum(ATK(i,:)) / (|T|*|K|), where ATK = AT*KT'

let x8 = sum of resource negotiation needs i has for its tasks

= HammingDistance(AR(i,:), [AT*RT'](i,:)) / |R|

let x9 = sum of knowledge negotiation needs i has for its tasks

= HammingDistance(AK(i,:), [AT*KT'](i,:)) / |K|

let x10 = sum of agents that i depends on or that depend on i

let w = # number of agents assigned to each task

= colsum(AT)

let s = # agents that dependent on each task

= (T+T')*w

let v = # tasks that agents are dependent on

= AT*s

Then, x10 = v(i) / (|A|*|T|*(|T|-1)).

Then Cognitive Demand for agent i is the average of the above terms.

Cognitive Distinctiveness / Cognitive Distinctiveness, Relative

Measures how distinct are two agents based on the number of knowledge bits they hold oppositely.

Carley, 2002

TYPE: Dyad Level

INPUT: AK: binary

OUTPUT: $\Re \in [0,1]$

For each pair of agents (i,j) compute the number of knowledge bits they have exactly opposite. Then normalize this sum by the total number of knowledge bits. In effect, this is the exclusive-OR of their knowledge vectors.

$$CD_{i,j} = \frac{\sum_{k=1}^{|K|} (AK_{i,k} * \sim AK_{j,k}) + (\sim AK_{i,k} * AK_{j,k})}{|K|}$$

$$CD_{i,i} = 0$$

Note that the CD output matrix is symmetric.

Relative Cognitive Distinctiveness normalizes each element of CD as follows:

$$RCD_{i,j} = \frac{CD_{i,j}}{\sum_{j=1}^{|K|} CD_{i,j}}$$

Thus, the elements of the ith row are normalized by the ith row sum.

Relative Cognitive Distinctiveness

Measures how distinct are two agents based on the number of knowledge bits they hold oppositely.

Carley, 2002

TYPE: Dyad Level

INPUT: AK: binary

OUTPUT:

Cognitive Expertise / Cognitive Expertise, Relative

Measures the complementarity of two agents based on their knowledge.

Carley, 2002

TYPE: Dyad Level

INPUT: AK: binary

OUTPUT: $\Re \in [0,1]$

For each pair of agents (i,j) compute the number of knowledge bits that j knows that i does not know. Then normalize this sum by the total number of knowledge bits that agent i does not know.

$$CE_{i,j} = \frac{\sum_{k=1}^{|K|} (\sim AK_{i,k} * AK_{j,k})}{(|K| - \sum_{k=1}^{|K|} AK_{i,k})}$$

$$CE_{i,i} = 0$$

Note that the CD output matrix is NOT-symmetric.

Relative Cognitive Expertise normalizes each element of CE as follows:

$$RCE_{i,j} = \frac{CE_{i,j}}{\sum_{j=1}^{|K|} CE_{i,j}}$$

Thus, the elements of the i*th* row are normalized by the i*th* row sum.

Cognitive Resemblance / Cognitive Resemblance, Relative

Measures the degree of resemblance between agents based on the number of knowledge bits they both have or both do not have.

Carley, 2002

TYPE: Dyad Level

INPUT: AK: binary

OUTPUT: $\Re \in [0,1]$

For each pair of agents (i,j) compute the number of knowledge bits they have in common - whether known or unknown. Then normalize this sum by the total number of knowledge bits.

$$CR_{i,j} = \frac{\sum_{k=1}^{|K|}(AK_{i,k} * AK_{j,k}) + (\sim AK_{i,k} * \sim AK_{j,k})}{|K|}$$

$$CR_{i,i} = 1$$

Note that the CR output matrix is symmetric.

Relative Cognitive Resemblance normalizes each element of CR as follows:

$$RCR_{i,j} = \frac{CR_{i,j}}{\sum_{j=1}^{|K|} CR_{i,j}}$$

Thus, the elements of the ith row are normalized by the ith row sum.

Cognitive Similarity / Cognitive Similarity, Relative

Measures the degree of similarity between agents based on the number of knowledge bits they both have.

Carley, 2002

TYPE: Dyad Level

INPUT: AK: binary

OUTPUT: $\Re \in [0,1]$

For each pair of agents (i,j) compute the number of knowledge bits they have in common. Then normalize this sum by the total knowledge between them.

$$CS_{i,j} = \frac{\sum_{k=1}^{|K|}(AK_{i,k} * AK_{j,k})}{\sum_{k=1}^{|K|}(AK_{i,k} + AK_{j,k})}|$$

$$CS_{i,i} = 1$$

Note that the CS output matrix is symmetric.

Relative Cognitive Similarity normalizes each element of CS as follows:

$$RCS_{i,j} = \frac{CS_{i,j}}{\sum_{j=1}^{|K|} CS_{i,j}}$$

Thus, the elements of the ith row are normalized by the ith row sum.

Communication

Measures the degree of similarity between agents based on the number of knowledge bits they both have.

Carley, 2003

TYPE: Agent Level

INPUT: AA:binary; AT:binary; AR:binary; RT:binary, TT:binary

OUTPUT: $\Re \in [0,1]$

Communication uses the concepts from Communication Congruence:

Handoff, Co-Assignment, and Negotiation.

let H, C, and N be defined as in Communication Congruence.

let M(i,j) = [AA + (H+H') + C + (N+N')](i,j) > 0, and M(i,i) = 0

Note that the transpose of H and N is used to make the communication reciprocal.

let d = sum(M(i,:))

let d = d / (|A|-1), normalizing d to be in [0,1]

Then Communication for agent i is d.

Component Count, Strong

The number of strongly connected components in a network.

Wasserman and Faust, 1994 (pg 109)

TYPE: Graph Level

INPUT: N:square, binary

OUTPUT: $Z \in [0,|V|]$

Given a square, symmetric network G=(V,E), the Strong Component Count is the number of strongly connected components in G. This is computed directly on G, whether or not G is directed.

Component Count, Weak

The number of weakly connected components in a network.

Wasserman and Faust, 1994 (pg 109)

TYPE: Graph Level

INPUT: N:square, binary, symmetric

OUTPUT: $Z \in [0,|V|]$

Given a square, symmetric network G=(V,E), the Weak Component Count is the number of connected components in G. Such components are called weak because the graph G is undirected.

Component Members, Weak

Assigns each entity an integer which corresponds to the weak component in the network to which it belongs.

Wasserman and Faust,1994

TYPE: Node Level

INPUT: N:square, binary, symmetric

OUTPUT: $Z \in [0,|V|]$

Given a square, symmetric network G=(V,E), the Weak Component Member for a entity is the weak component to which the entity belongs. The components are numbered from 1 to the number of weak components (Weak Component Count).

Congruence, Agent Knowledge Needs / Congruence, Agent Resource Needs

The number of skills that an agent lacks to complete its assigned tasks expressed as a percentage of the total skills required for the assigned tasks.

Lee, 2004

TYPE: Agent Level

INPUT: AK/AR:binary; KT/RT:binary; AT:binary

OUTPUT: $\Re \in [0,1]$

Agent Knowledge Needs compares the knowledge needs of the agent to do its assigned tasks, with the actual knowledge of the agent.

Let N = AT*KT' = knowledge needed by agents to do assigned tasks.

for Resource replace KT with RT

We need to sum the knowledge needed but not available.

Then, Agent Knowledge Needs for

$$\text{agent i} = \frac{\sum_{j=1}^{|\mathbb{K}|} N_{i,j} * (\sim AK_{i,j})}{\sum_{j=1}^{|\mathbb{R}|} N_{i,j}}$$

Agent Resource Needs is analogous, replacing AK with AR, and KT with RT.

Congruence, Agent Knowledge Waste / Congruence, Agent Resource Waste

The number of skills that an agent has that are not needed by any of its tasks expressed as a percentage of the total skills of the agent.

Lee, 2004

TYPE: Agent Level

INPUT: AK/AR:binary; KT/RT:binary; AT:binary

OUTPUT: $\Re \in [0,1]$

Agent Knowledge Waste compares the knowledge of the agent with the knowledge it actually needs to do its tasks. Any unused knowledge is considered wasted.

Let N = AT*KT' = knowledge needed by an agent to do its assigned tasks.

for Resource replace KT with RT

We need to sum the knowledge the agent has but which is not needed.

Then, Agent Knowledge Waste for

$$\text{agent i} = \frac{\sum_{j=1}^{|\mathbb{K}|} AK_{i,j} * (N_{i,j} = 0)}{\sum_{j=1}^{|\mathbb{R}|} AK_{i,j}}$$

The equation for Agent Resource Waste replaces AK with AR, and KT with RT.

Congruence, Communication

Measures to what extent the agents communicate when and only when it is needful to complete tasks. Hence, higher congrunce occurs when agents don't communicate if the tasks don't require it, and do when the tasks require it.

Communication needs to be reciprocal.

Carley, 2002

TYPE: Graph Level

INPUT: AA: binary, AT: binary, [AR/RT]: binary, [AK/KT]: binary, TT: binary

OUTPUT: $\Re \in [0,1]$

One of the following pairs of matrices must exist: AK/KT, AR/RT. If both exist, then the measure first concatenates them into [AK AR], [KT RT] and uses them.

Communication Congruence = 1 iif agents communicate when and only when it is needful to complete their tasks. There are three task related reasons when agents i and j need to communicate:

(a) Handoff: if i is assigned to a task s and j is assigned to a task t and s directly precedes task t.

(b) Co-Assignment: if i is assigned to a task s and j is also assigned to s.

(c) Negotiation: if i is assigned to a task s and j is not, and there is a resource r to which agents assigned to s have no access but j does.

The three cases are computed as follows:

(a) let H = AT*TT*AT'

(b) let C = AT*AT'

(c) let N = AT*Z*AR', where Z(t,r) = [AT'*AR - RT'](t,r)<0

Note that C is always symmetric, but not necessarily H and N.

let Q(i,j) = [(H+H') + C + (N+N')](i,j) > 0.

Communication Congruence requires reciprocal communication, explaining the transposes of H and N to make them symmetric.

let d = hamming distance between Q and AA, which measures the degree to which communication differs from that which is needed to do tasks.

The maximum value for d is d_max = |A|*(|A|-1)

Then Communication Congruence = 1 - (d /d_max), which is in [0,1].

Congruence, Organization Agent Knowledge Needs / Organization Agent Resource Needs

Across all agents, the skills that agents lack to do their assigned tasks expressed as a percentage of the total skills needed by all agents.

Lee, 2004

TYPE: Graph Level

INPUT: AK/AR:binary; KT/RT:binary; AT:binary

OUTPUT: $\Re \in [0,1]$

As in Agent Needs, let N = AT*KT'

for Resource replace KT with RT

Then

$$\text{Organization Agent Needs} = \frac{\sum_{i=1}^{|A|} \sum_{j=1}^{|K|} N_{i,j} * (\sim AK_{i,j})}{\text{sum}(N)}$$

Organization Agent Resource Needs is analogous, replacing AK with AR, and KT with RT.

Congruence,
Organization Agent Knowledge Waste /
Organization Agent Resource Waste

Across all agents, the skills that agents have that are not required to do their assigned tasks.

Lee, 2004

TYPE: Graph Level

INPUT: AK/AR:binary; KT/RT:binary; AT:binary

OUTPUT: $\Re \in [0,1]$

As in Agent Waste, let N = AT*KT'

for Resource replace KT with RT

Then

$$\text{Organization Agent Needs} = \frac{\sum_{i=1}^{|A|} \sum_{j=1}^{|K|} AK_{i,j} * (N_{i,j} = 0)}{\text{sum}(AK)}$$

The equation for Organization Agent Resource Needs replaces AK with AR, and KT with RT.

Congruence,
Organization Task Knowledge Needs /
Organization Task Resource Needs

Across all tasks, the skills that tasks lack expressed as a percentage of the total skills needed by all tasks.

Lee, 2004

TYPE: Graph Level

INPUT: AK/AR:binary; KT/RT:binary; AT:binary

OUTPUT: $\Re \in [0,1]$

As in Task Needs, let S = AT'*AK

for Respource replace AK with AR

Then

$$\text{Organization Task Needs} = \frac{\sum_{i=1}^{|T|} \sum_{j=1}^{|K|} KT^{t}_{i,j} * (S_{i,j} = 0)}{\text{sum}(KT)}$$

The equation for Organization Task Resource Needs replaces AK with AR, and KT with RT.

Congruence
Organization Task Knowledge Waste / Organization Task Resource Waste

Across all tasks, the skills supplied to tasks via agents that are not required by them, expressed as a percentage of the total skills needed by all tasks.

Lee, 2004

TYPE: Graph Level

INPUT: AK/AR:binary; KT/RT:binary; AT:binary

OUTPUT: Graph Level:

$\Re \in [0,1]$

As in Task Waste, let S = AT'*AK

for Resource replace AK with AR

Then

$$\text{Organization Task Waste} = \frac{\sum_{i=1}^{|T|} \sum_{j=1}^{|K|} S_{i,j} * (\sim KT_{i,j})}{\text{sum}(S)}$$

The equation for Organization Task Resource Waste replaces AK with AR, and KT with RT.

Congruence, Strict Knowledge/Strict Resource

Measures the similarity between what knowledge is assigned to tasks via agents, and what knowledge is required to do tasks. Perfect congruence occurs when agents have knowledge when and only when (strictly) it is needful to complete tasks.

Carley, 2002

TYPE: Graph Level

INPUT:

Knowledge: AK:binary; AT:binary; KT:binary

Resource: AR:binary; AT:binary; RT:binary

OUTPUT: $\Re \in [0,1]$

Knowledge Congruence = 1 iff agents have knowledge when and only when it is needful to complete their tasks. Thus, we compute the knowledge assigned to tasks via agents, and compare it with the knowledge needed for tasks.

let KAT = dich(AK'*AT)

for Resource KAT becomes RAT and replace AK with AR

let

$$d = \sum_{i=1}^{|K|} \sum_{j}^{|T|} KAT(i, j) * KT(i, j)$$

for Resource replace KT with RT

let <d = d / (|K|*|T|), which normalizes d to be in [0,1]

for Resource replace |K| with |R|

Then Knowledge Congruence = 1 - d

Congruence, Task Knowledge Needs / Congruence, Task Resource Needs

The number of skills not supplied to a task, and required to do the task, expressed as a percentage of the total skills required for the task.

Carley, 2002

TYPE: Task Level

INPUT: AK/AR:binary; KT/RT:binary; AT:binary

OUTPUT:

$$\Re \in [0,1]$$

Task Knowledge Needs compares the knowledge requirements of each task with the knowledge available to the task via agents assigned to it. It is similar to Knowledge Congruence, but quantifies only the under supply of knowledge to tasks.

Let S = AT'*AK = knowledge supplied to tasks via assigned agents

We need to sum the knowledge required but not supplied.

Thus,

$$\text{Task Knowledge Needs for task i} = \frac{\sum_{j=1}^{|K|} KT^{t}_{i,j} * (S_{i,j} = 0)}{\sum_{j=1}^{|K|} KT^{t}_{i,j}}$$

The equation for Agent Resource Needs replaces AK with AR, and KT with RT.

Congruence, Task Knowledge Waste / Congruence, Task Resource Waste

The number of skills supplied to a task via agents that are not required by it expressed as a percentage of the total skills required for the task.

Carley, 2002

TYPE: Task Level

INPUT: AK/AR:binary; KT/RT:binary; AT:binary

OUTPUT: Task Level:

$$\Re \in [0,1]$$

Task Knowledge Waste compares the knowledge requirements of each task with the knowledge available to the task via agents assigned to it. It is similar to Knowledge Congruence, but quantifies only the over supply of knowledge to tasks.

Let S = AT'*AK = knowledge supplied to tasks via assigned agents

We need to sum the knowledge supplied but not required.

Thus,

$$\text{Task Knowledge Waste for task i} = \frac{\sum_{j=1}^{|K|} S_{i,j} * (\sim KT^{t}{}_{i,j})}{\sum_{j=1}^{|K|} S_{i,j}}$$

The equation for Agent Resource Waste replaces AK with AR, and KT with RT.

Connectedness, Krackhardt

Measures the degree to which a square network's underlying (undirected) network is connected.

Krackhardt, 1994

TYPE: Graph Level

INPUT: N:square, symmetric

OUTPUT: $\Re \in [0,1]$

The Connectedness of a square, symmetric network is the Density of its Reachability Network.

Constraint, Burt

The degree to which each entity in a square network is constrained from acting because of its existing links to other entities.

Burt, 1992

TYPE: Node Level

INPUT: N: square

OUTPUT: $\Re \in [0,1]$

This is the Constraint measure described by Equ. 2.4 on pg. 55 of Burt, 1992. Note that the matrix Z is the adjacency matrix representation of the network N.

Density

The ratio of the number of edges versus the maximum possible edges for a network.

Wasserman and Faust, 1994 (pg 101)

TYPE: Graph Level

INPUT: N

OUTPUT: $\Re \in [0,1]$

Let M be the adjacency matrix for the network of dimension m x n.

If the network is unimodal, then m=n and M has a zero diagonal, and therefore

Density = sum(M)/(m*(m-1)).

For rectangular networks, Density = sum(M)/(m*n).

Diameter

The maximum shortest path length between any two nodes in a unimodal network G=(V,E). If there exist i,j in V such that j is not reachable from i, then the diameter is returned as |V|.

Wasserman and Faust, 1994 (pg 111)

TYPE: Graph Level

INPUT: N:square, binary

OUTPUT: $Z \in [0, |V|]$

The diameter of G=(V,E) is defined as:

$$\max\{d_G(i,j) \mid i,j \in V\}$$

That is, the maximum shortest directed path between any two vertices in G. If there exists i and j such that j is not reachable from i, then |V| is returned.

Diversity, Knowledge/Resource

The distribution of difference in idea sharing. This is the Herfindahl-Hirshman index applied to column sums of AK.

Borgatti, 2003

TYPE: Graph Level

INPUT:

Knowledge: AK:binary

Resource: AR:binary

OUTPUT: $\Re \in [0,1]$

This is the Herfindahl-Hirshman index (economics: sum of the squares of each firm's market share) applied to the normalized column sums of AK. This measures the degree to which knowledge is equally known.

let

$$w_k = \sum_{i=1}^{|A|} AK(i,k) \text{ , for } 1 \le k \le |K|$$

let

$$W = \sum_{k=1}^{|K|} w_k$$

Then

$$\text{Knowledge Diversity } = 1 - \sum_{k=1}^{|K|} \left(w_k / W\right)^2$$

Resource Diversity is analogous, replacing AK with AR.

Edge Count, Lateral

Fixing a root entity x, a lateral edge (i,j) is one in which the distance from x to i is the same as the distance from x to j.

Carley, 2002

TYPE: Graph Level

INPUT: N:square

OUTPUT: $\Re \in [0,1]$

Let G=(V,E) be the graph representation of a network. And fix an entity x□V to be the root entity.

Let

$$\text{Let } S = \{(i,j) \in E \mid d_G(x,i) = d_G(x,j)\}$$

Then Lateral Edge Count = |S| / |E|

Edge Count, Pooled

A pooled edge in a network N=(V,E) is an edge (i,j)□ E such that there exists at least one other edge (i,k) □ E, and k ≠ j.

Carley, 2002

TYPE: Graph Level

INPUT: N

OUTPUT: $\Re \in [0,1]$

Let M be the adjacency matrix representation of a unimodal network.

Let S = { (i,j) | M(i,j)=1 □ sum(M(:,j))>1 }

In other words: edge (i,j) is a pooled edge iff the in-degree of entity j > 1.

Then Pooled Edge Count = |S| / |E|

Edge Count, Reciprocal

The percentage of edges in a network that are reciprocated (also called Reciprocity). An edge (i,j) in the network is reciprocated if edge (j,i) is also in the network. Self-loops are ignored.

Carley, 2002

TYPE: Graph Level

INPUT: N: square, binary

OUTPUT: $\Re \in [0,1]$

Let G=(V,E) be the graph representation of a network.

Let S=card{(i,j)□E|i<,(j,i)□E}

Then Reciprocral Edge Count = |S| / |E|

Edge Count, Sequential

The percentage of edges in a network that are neither Reciprocal Edges nor Pooled Edges. Note that an edge can be both a Pooled and a Reciprocal edge. Self-loops are ignored.

Carley, 2002

TYPE: Graph Level

INPUT: N: square, binary

OUTPUT: $\Re \in [0,1]$

Let G=(V,E) be the graph representation of a network, and let X = set of Pooled edges of G, and let Y = set of Reciprocal edges of G.

Then Sequential Edge Count = | E-X-Y| / |E|

Edge Count, Skip

The fraction of edges in a unimodal network that skip levels. An edge (i,j) is a skip edge if there is a path from entity i to entity j even after the edge (i,j) is removed.

Carley, 2002

TYPE: Entity Level

INPUT: N: square, binary

OUTPUT: $\Re \in [0,1]$

A skip edge in a network G=(V,E) is an edge (i,j)□E such that j is reachable from i in the graph G'=(V,E\(i,j)), that is, the graph G with edge (i,j) removed. Skip Count is simply the number of such edges in G normalized to be in [0,1] by dividing by |E|.

Effective Network Size

The effective size of an entities's communication Network based on redundancy of ties.

Burt, 1992

TYPE: Entity Level

INPUT: N: square, binary

OUTPUT: $\Re \in [0,1]$

This is the Effective Size of Network measure described by Equ. 2.2 on pg. 52 of Burt, 1992. Note that the Communciation Network is used for the matrix Z.

Efficiency, Global

Measures the closeness of the entities in the network.

Latora and Marchiori, 2001

TYPE: Graph Level

INPUT: N:square, binary, symmetric

OUTPUT: $\Re \in [0,1]$

Global Efficiency is the normalized sum of the inverse geodesic distances between all entity pairs. Let G be a square network on n entities.

Then,

$$\text{Global Efficiency} = \frac{1}{n(n-1)} \sum_{i \neq j} \frac{1}{d_G(i,j)}$$

Efficiency, Krackhardt

The degree to which each component in a network contains the minimum edges possible to keep it connected.

Krackhardt, 1994

TYPE: Graph Level

INPUT: N: square, binary, symmetric

OUTPUT: $\Re \in [0,1]$

Let G=(V,E) be the graph representation of a square, undirected network.

let

n = number of components in G

let

c_i = number of nodes in component i

let

penalty = |E| - |V| + C

let

$$\text{maxPenalty} = C - |V| + \sum_i c_i (c_i - 1) / 2$$

Then Efficiency = 1 - penalty/maxPenalty

Efficiency, Local

Measures the closeness of the entities in each ego network in the network.

Latora and Marchiori, 2001

TYPE: Graph Level

INPUT: N: square, binary, symmetric

OUTPUT: $\Re \in [0,1]$

Local Efficiency is the normalized sum of the inverse closeness of the ego networks (here, the ego network for entity i does not include entity i).

Let G = (V,E) be any square, symmetric network with |V| = N entities.

let

V_i = set of nodes adjacent to i = $\{ j \mid (i,j) \in E \}$

let

E_i = edges between nodes adjacent

to

$$i = \{ (j,k) \mid (j,k) \in E;\ i,j \in V_i \}$$

define

$$G_i = (V_i, E_i)$$

Then,

$$\text{Local Efficiency} = \frac{1}{N} \sum_{i=1}^{N} \text{GlobalEfficiency}(G_i)$$

Entity Level

The Entity Level for a entity v in a square network is the worst case shortest path from v to every entity v can reach.

Carley, 2002

TYPE: Entity Level

INPUT: N:square

OUTPUT: $Z \in [0, |V| - 1]$

Let G=(V,E) be the graph representation of a square network and fix an entity v.

Entity Level $\text{for } v = \max \{ d_G(v, j) \mid j \in V;\ j \text{ reachable from } v \text{ in } G$ if v cannot reach any entities, then its level

Exclusivity — Knowledge, Resource, Task

Detects agents who have singular knowledge or Resources.

Ashworth, 2003

TYPE: Entity Level

INPUT:

Knowledge: AK:binary

Resource: AR:binary

Task: AT:binary

OUTPUT: $\Re \in [0,1]$

The Knowledge Exclusivity Index (KEI) for agent i is defined as follows:

Resource Exclusivity Index (REI) or Task Exclusivity Index (TEI)

$$\sum_{j=1}^{|\mathbb{K}|} \mathrm{AK}(i, j) * \exp(1 - \mathrm{sum}(\mathrm{AK}(:, j)))$$

for Resource replace AK with AR

for Tasks replace AK with AT

The Resource Exclusivity Index (REI) for agent i is defined exactly as for Knowledge Based Exclusivity, but with the matrix AK replace by AR.

The Task Exclusivity Index (TEI) for agent i is defined exactly as for Knowledge Based Exclusivity, but with the matrix AK replaced by AT.

Fragmentation

The proportion of entities in a network that are disconnected.

Borgatti, 2003

TYPE: Graph Level

INPUT: N: square, binary, symmetric

OUTPUT: $\Re \in [0,1]$

Consider a square, symmetric network G=(V,E).

let

$\mathbf{n} = |\mathrm{V}|$

let

s_k be the number of nodes in the k^{th} component of G, $1 \leq k \leq n$

Then,

$$\text{Fragmentation} = 1 - \frac{\sum_k s_k(s_k - 1)}{n(n-1)}$$

Hierarchy, Krackhardt

The degree to which a square network N exhibits a pure hierarchical structure.

Krackhardt, 1994

TYPE: Graph Level

INPUT: N:square

OUTPUT: $\Re \in [0,1]$

Let N be a square network. The Hierarchy of N is the Reciprocity of the Reachability Network for N.

Interdependence and Radials

The percentage of edges in a network N that are Pooled and Reciprocal.

Carley, 2002

TYPE: Graph Level

INPUT: N:square

OUTPUT: $\Re \in [0,1]$

Let G=(V,E) be the graph representation of a square network.

Let a = Pooled Edge Count and b = Reciprocal Edge Count of the network.

Then Interdependence = (a+b)/|E|

Interlockers and Radials

Interlockers and radial entities in a square network have a high and low Triad Count, respectively.

Carley, 2002

TYPE: Entity Level

INPUT: N: square, binary

OUTPUT: Binary

Let N=(V,E) be a square network.

Let

t_i = Triad Count for node i, $1 \leq i \leq |V|$

Let

u = the mean of $\{ t_i \}$

Let

d = the variance of $\{ t_i \}$

Then,

if $t_k \geq (u+d)$, then agent k is an *interlocker*.

If $t_k \leq (u-d)$, then agent k is a *radial*.

Load, Knowledge or Resource

Average number of knowledge or resource per agent.

Carley, 2002

TYPE: Graph Level

INPUT: AK:binary

OUTPUT: $\Re \in [0, |K|]$

Knowledge Load = sum(AK)/ (|A|)

Resource Load is defined analogously, replacing AK with AR.

Negotiation, Knowledge or Resource

The extent to which personnel need to negotiate with each other because they lack the knowledge to do the tasks to which they are assigned.

Carley, 2002

TYPE: Graph Level

INPUT:

Knowledge: AT:binary; AK:binary; KT:binary

Resource: AT:binary; AR:binary; RT:binary

OUTPUT: $\Re \in [0,1]$

Compute the percentage of tasks that lack at least one knowledge *(or Resource)*:

let

$$\text{Need} = (\text{AT'}*\text{AK}) - \text{KT'}$$

for Resource replace AK with AR and KT with RT

let

$$\text{S} = \{ \text{ i } \mid 1 \le i \le |T|, \exists \text{ j} : \text{Need(i,j)} < 0 \}$$

Then Knowledge (or Resource) Negotiation = |S| / |T|

$$\text{Network Betweenness Cent.} = \left(\sum_{1 \le i \le n} \bar{d} - d_i \right) / (n-1)$$

Network Centralization, Column Degree

A centralization based on the out degree of the column vertices in a network N.

TYPE: Graph Level

INPUT: N

OUTPUT: $\Re \in [0,1]$

Let N be a network with n column entities.

let

$$d_j = \text{degree of column node j, } 1 \le j \le n$$

let

$$\bar{d} = \max\{d_j \mid 1 \le j \le n\}$$

Then

$$\text{Column Degree Network Centralization} = \left(\sum_{1 \le j \le n} \bar{d} - d_j \right) / (n)$$

Network Centralization, In Degree

A centralization of a square network based on the In-Degree Centrality of each entity.

TYPE: Graph Level

INPUT: N:square

OUTPUT: $\Re \in [0,1]$

Let N be a unimodal network with n entities.

let

$$d_i = \text{In Degree Centrality of node i}$$

let

$$\overline{d} = \max\{d_i \mid 1 \le i \le n\}$$

Then

$$\text{In Degree Network Centralization} = \left(\sum_{1 \le i \le n} \overline{d} - d_i \right) / D$$

where D = (n-2) if N is undirected, and (n-1) otherwise.

Network Centralization, Out Degree

A centralization of a square network based on the Out-Degree Centrality of each entity.

NetStat

TYPE: Graph Level

INPUT: N:square

OUTPUT: $\Re \in [0,1]$

Let N be a unimodal network with n nodes.

let

$$d_i = \text{Out Degree Centrality of entity i}$$

let

$$\overline{d} = \max\{d_i \mid 1 \le i \le n\}$$

Then

$$\text{Out Degree Network Centralization} = \left(\sum_{1 \le i \le n} \bar{d} - d_i \right) / D$$

,

where D = (n-2) if N is undirected, and (n-1) otherwise.

Network Centralization, Row Degree

A centralization based on the out degree of the row vertices in a network N.

TYPE: Graph Level

INPUT: N

OUTPUT: $\Re \in [0,1]$

Let N be a network with n row nodes.

let

$$d_j = \text{degree of row node j, } 1 \le j \le n$$

let

$$\bar{d} = \max\{d_j \mid 1 \le j \le n\}$$

Then

$$\text{Row Degree Network Centralization} = \left(\sum_{1 \le j \le n} \bar{d} - d_j \right) / (n)$$

Network Centralization, Total Degree

A centralization of a square network based on total degree centrality of each entity.

Freeman, 1979

TYPE: Graph Level

INPUT: N: square, symmetric

OUTPUT: $\Re \in [0,1]$

Let N be a unimodal network with n entities.

let

$$d_i = \text{Total Degree Centrality of entity i}$$

let

$$\bar{d} = \max\{d_i \mid 1 \le i \le n\}$$

Then

$$\text{Total Degree Network Centralization} = \left(\sum_{1 \le i \le n} \bar{d} - d_i \right) / (n-2)$$

Network Levels

An entity level metric is one that is defined for, and gives a value for, each entity in a network. If there are x entities in a network, then the metric is calculated x times, once each for each entity. Examples are Degree Centrality, Betweeness, and Cognitive Demand.

A network level metric is one that is defined for, and gives a value for, the network as a whole. The metric is calculated once for the network. Examples are Centralization, Graph Hierarchy, and the maximum or average Betweeness.

Given an entity level metric, e.g., degree centrality, then the minimum, maximum, average, and standard deviation of that metric for that network level metrics. Examples are average degree centrality, maximum betweeness, and the standard deviation in cognitive demand.

TYPE: Graph Level

INPUT: N:square, binary

OUTPUT: $Z \in [0, |V| - 1]$

Let G=(V,E) be the graph representation of a square network and fix an entity v.

Then

$$\text{the Levels of } G = \max \{ d_G(i, j) \mid i,j \in V; \text{ j reachable from i in G} \}$$

Omega, Knowledge or Resource

The degree to which an organization reuses knowledge or resource.

Carley, Dekker, and Krackhardt 2000

TYPE: Graph Level

INPUT:

Knowledge: AT:binary; KT:binary; TT:binary

Resource: AR:binary; RT:binary; TT:binary

OUTPUT: $\Re \in [0,1]$

Let TAT = TA*TA'

Let N = ((T'@TAT)*KT')@KT'

for resource replace KT with RT

Then Knowledge Based Omega = sum(N)/sum(KT)

for resource replace KT with RT

Performance as Accuracy

Measures how accurately agents can perform their assigned tasks based on their access to knowledge and resources.

Carley, 2002

TYPE: Graph Level

INPUT:

AT: binary; [AK/KT]: binary; [AR/RT]: binary

OUTPUT: $\Re \in [0,1]$

One of the following pairs of matrices must exist: AK/KT, AR/RT. If both exist, then the measure first concatenates them into [AK AR], [KT RT] and uses them.

Accuracy is computed based on the binary classification problem. It is computed in one of two ways:

(1) Knowledge based: Let b be a binary string of length |K|, let N=KT', and let S=AK. Fix a task t.

let

$$\text{answer} = \left(\sum_{1 \le k \le |K|} N_{t,k} b_k \Big/ \sum_{1 \le k \le |K|} N_{t,k} > .5 \right)$$

which is the correct classification of b with respect to task t.

Now, let I={ i | AT(i,t)=1 }.

let

$$\text{answer}(i) = \left(\sum_{1 \le k \le |K|} N_{t,k} S_{i,k} b_k \Big/ \sum_{1 \le k \le |K|} N_{t,k} S_{i,k} > .5 \right), i \in I.$$

This is agent i's classification of b with respect to t.

The group of agents classify b using majority voting.

That is,

$$\text{group_answer} = \left(\frac{1}{|I|} \sum_{i \in I} \text{answer}(i) > .5 \right).$$

Then, if group_answer = answer, then the group was accurate, otherwise not.

This is repeated multiple times for each task, and across all tasks. The percentage correct is Performance as Accuracy.

(2) Resource based: let N=RT' and S=AR in the analysis of case (1).

Personnel Cost

Total number of people reporting to an agent, plus its total knowledge, resources, and tasks.

Carley, 2003

TYPE: Agent Level

INPUT: AA:binary; AK:binary; AR:binary; AT:binary

OUTPUT: $\Re \in [0,1]$

Personnel Cost is the sum of the in-degree centrality of all AA matrices in the graph (this computes the number of agents reporting to each agent), plus the out-degree centrality of any AK, AR, and AT graphs.

This sum is scaled so that each entity gets a score in [0,1].

Potential Workload — Knowledge or Resource

Maximum knowledge or resource an agent could use to do tasks if it were assigned to all tasks.

Carley, 2002

TYPE: Entity Level

INPUT:

Knowledge: AK:binary; KT:binary

Resource: AR:binary; RT:binary

OUTPUT: $\Re \in [0,1]$

Potential Knowledge Workload for agent i = sum((AK*KT)(i,:))/sum(KT)

for Resource replace AK with AR and KT with RT

Redundancy, Access

Average number of redundant agents per resource. An agent is redundant if there is already an agent that has access to the resource.

Carley, 2002

TYPE: Graph Level

INPUT: AR:binary

OUTPUT: $\Re \in [0,(|A|-1)*|R|]$

This is the Column Redundancy of matrix AR.

Redundancy, Assignment

Average number of redundant agents assigned to tasks. An agent is redundant if there is already an agent assigned to the task.

Carley, 2002

TYPE: Graph Level

INPUT: AT

OUTPUT: $\Re \in [0,(|A|-1)*T]$

This is the Column Redundancy of matrix AT.

Redundancy, Column

The mean number of column node edges in excess of one.

TYPE: Graph Level

INPUT: N of dimension m x n

OUTPUT: $\Re \in [0,(m-1)*n]$

Let M be the matrix representation for a network N of dimension m x n.

let

$$d_j = \max\{0, \text{sum}(M(:, j)) - 1\}$$

for

$$1 \le j \le n$$

this is the number of column entries in excess of one for column j.

Then

$$\text{Column Redundancy} = \left(\sum_{j=1}^{n} d_j \right) / n$$

Redundancy, Knowledge

Average number of redundant agents per knowledge. An agent is redundant if there is already an agent that has the knowledge.

Carley, 2002

TYPE: Graph Level

INPUT: AK: Binary

OUTPUT: $\Re \in [0, (|A| - 1) * |K|]$

This is the Column Redundancy of matrix AK.

Redundancy, Resource

Average number of redundant resources assigned to tasks. A resource is redundant if there is already a resource assigned to the task.

Carley, 2002

TYPE: Graph Level

INPUT: RT:binary

OUTPUT: $\Re \in [0, (|R| - 1) * |T|]$

This is the Column Redundancy of matrix RT.

Redundancy, Row

The mean number of row entity edges in excess of one.

TYPE: Graph Level

INPUT: N of dimension m x n

OUTPUT: $\Re \in [0, (n-1) * m]$ for N dimension m x n

Let M be the matrix representation for a network N of dimension m x n.

let

$$d_i = \max\{0, \text{sum}(M(j, :)) - 1\}$$

for

$$1 \le i \le m;$$

this is the number of column entries in excess of one for row i.

Then

$$\text{Row Redundancy} = \left(\sum_{j=1}^{m} d_j \right) / m$$

Shared Situation Awareness

The similarity of actor pairs based on social interaction, physical distance, and socio-demographic data.

Graham, 2005

TYPE: Agent Level | Dyad Level

INPUT:

- AA: interaction/communication
- AA: physical proximity
- AA: socio demographic similarity

OUTPUT:

- Agent Level: $\Re$, not scaled
- Dyad Level: $\Re$, not scaled

SSA consists of weighted terms of interaction between actions.

Let

$\alpha, \beta, \gamma, \delta, \mu$ be Real number (these are weights).

Let A = Agent x Agent interaction/communication matrix

Let P = Agent x Agent physical proximity matrix

Let S = Agent x Agent social demographic similarity matrix

Let e = eigenvector centrality measure computed on A

Let G = dyadic geodesics computed on A

Then the SSA measure between agents i and j is:

$$SSA(i,\ j) = \alpha e(i)\, e(j) + \beta P(i, j) + \frac{\delta S(i, j)}{\gamma G(i, j)} + \mu A(i, j)\, A(j, i)$$

Simmelian Ties

Computes the normalized number of entities to which each node has a Simmelian tie.

Krackhardt, 1998

TYPE: Entity Level

INPUT: N: square, binary, symmetric

OUTPUT: $\Re \in [0,1]$

Let N be a square network with n entities. The Simmelian Tie value for entity i is computed as follows:

let NS = network N symmetrized using the Intersect (Minimum) method.

All cliques of size >= 3 are computed on NS and clique membership is recorded. Let c_i be the number of entities that are in a clique with entity i.

Then the Simmelian Ties value for emtity i is c_i.

Span of Control

The average number of out edges per node with non-zero out degrees.

Carley, 2002

TYPE: Graph Level

INPUT: N: square, binary

OUTPUT: $\Re \in [0, |V| - 1]$

let S = set of entities in V that have positive out-degree

let

$$K = \sum_{i \in S} \text{outDegree(i)}$$

Then

$$\text{Span of Control} = K / |S|$$

Speed, Average

The average inverse geodesic distance between all entity pairs. The highest score is achieved for a clique, and the lowest for all isolates.

Carley, 2002

TYPE: Graph Level

INPUT: N:square, binary

OUTPUT: $\Re \in [0,1]$

Average Speed is the average of the Inverse Closeness Centrality for the network entities.

Speed, Minimum

The maximum shortest path length between entity pairs (i,j) where there is a path in the network from i to j. If there are no such pairs, then Minimum Speed is zero.

Carley, 2002

TYPE: Graph Level

INPUT: N:square, binary

OUTPUT: $\Re \in [0,1]$

Minimum Speed = 1 / (Levels for the Network)

Task Completion — Knowledge Based / Resource Based

The percentage of tasks that can be completed by the agents assigned to them, based solely on whether the agents have the requisite knowledge to do the tasks.

Carley, 2002

TYPE: Graph Level

INPUT: AK:binary; AT:binary; KT:binary

OUTPUT: $\Re \in [0,1]$

Find the tasks that cannot be completed because the agents assigned to the tasks lack necessary knowledge.

let

$$Need = [(AT'*AK) - KT']$$

let

$$S = \{ i \mid 1 \le i \le |T|, \exists j : Need(i,j) < 0 \}$$

Knowledge Based Task Completion is the percentage of tasks that could be completed = (|T|-|S|) / |T|

Resource Based Task Completion is analogous, replacing AK with AR and KT with RT.

Transitivity

The percentage of edge pairs {(i,j), (j,k)} in the network such that (i,k) is also an edge in the network.

NetStat

TYPE: Graph Level

INPUT: N:square, binary

OUTPUT: $\Re \in [0,1]$

Let G = (V,E) be the graph representation of the square network.

let

$$I = \{(i,j,k) \in V^3 \mid i,j,k \text{ distinct } \}$$

let

$$Potential = \{ (i,j,k) \in I \mid (i,j) \in E, \text{ and } (j,k) \in E \}$$

let

$$Complete = \{ (i,j,k) \in Potential \mid (i,k) \in E \}$$

Then

$$Transitivity = |Complete| / |Potential|$$

Triad Count

The number of triads centered at each entity in a square network.

NetStat

TYPE: Agent Level

INPUT: N:square, binary

OUTPUT: $Z \in [0,(n-1)(n-2)]$ for N dimension n.

Let G=(V,E) represent a square network with n entities.

And let Triad be a matrix of dimension n x n.

$$\text{Triad}(i,i) = 0$$

$$\text{Triad}(i,j) = \text{card}\{\ k\ \mid k \mathrel{!}= i,\ k \mathrel{!}= j;\ AA(i,j) \wedge AA(i,k) \wedge AA(k,j)\ \},\ i \neq j$$

Then

$$\text{the Triad count for agent } i = \text{sum}(\text{Triad}(i,:))$$

Under Supply — Knowledge / Resource

The extent to which the knowledge/Resource needed to do tasks are unavailable in the entire organization.

Carley, 2002

TYPE: Graph Level

INPUT: AK:binary; AT:binary; KT:binary

OUTPUT: $\Re \in [0,1]$

This is the number of required knowledge not available to tasks based on the current agent task assignments normalized by the number of tasks.

Knowledge Under Supply = sum(dich(KT - AK'*KT)) / |T|

Under Resource Supply is analogous, replacing AK with AR, and KT with RT.

Upper Boundedness, Krackhardt

The degree to which pairs of agents have a common ancestor.

Krackhardt, 1994

TYPE: Graph Level

INPUT: N: square, binary

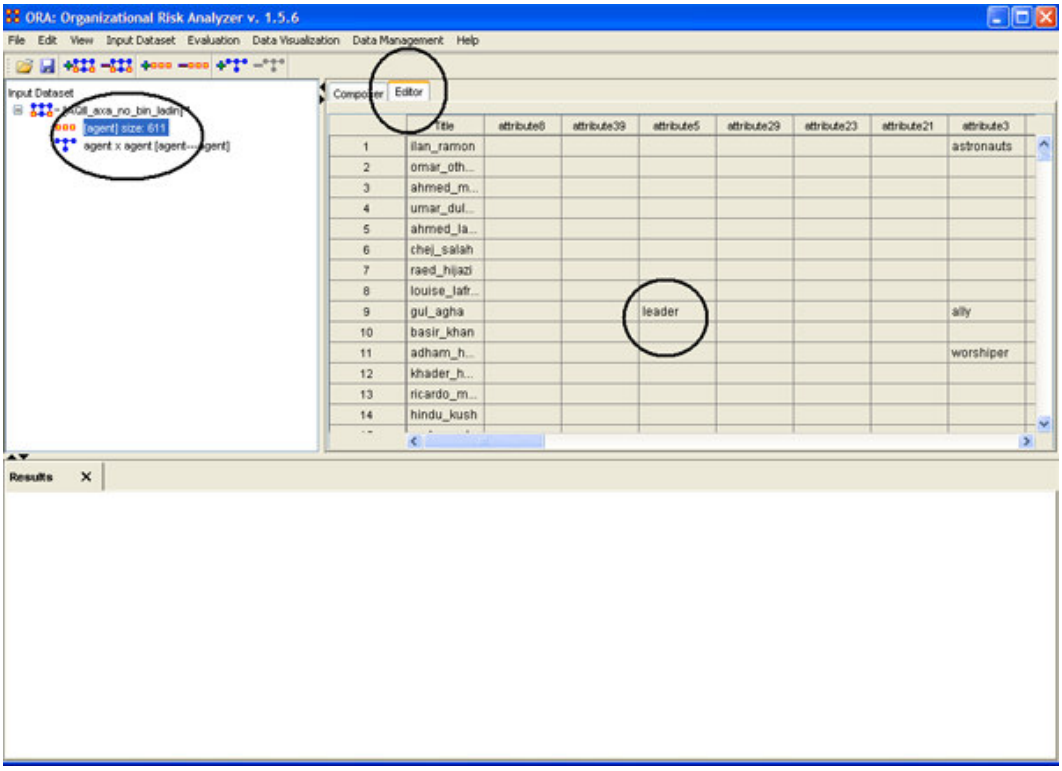
OUTPUT: $\Re \in [0,1]$

Adding and Removing Entities In The Editor

The MetaMatrix Composer is accessed through ORA's main interface and allows you to add or remove entities and entitysets by creating or removing attributes you wish to associate with your MetaMatrix. An attribute is a label that you wish to give a particular entity and can literally be anything you wish (worker, leader, Africa, March, 1989, etc.) Attributes can be used to define entities and entitysets according to your specific descriptions. For example, if you wanted to add the attribute leader to describe several entities, you can go directly inside the MetaMatrix Editor and give attributes to those entities which you attribute the description leader.

From ORA's main interface > "Editor" tab > Enter desired attribute under selected row and column for appropriate entity.

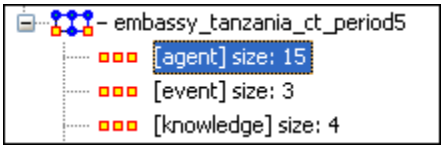
The black ellipses below highlight how to access the MetaMatrix Editor from ORA's main interface.



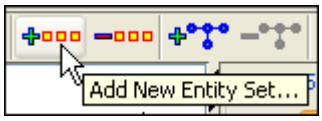
Copy / Paste Editor Values

Creating a new Entity Set

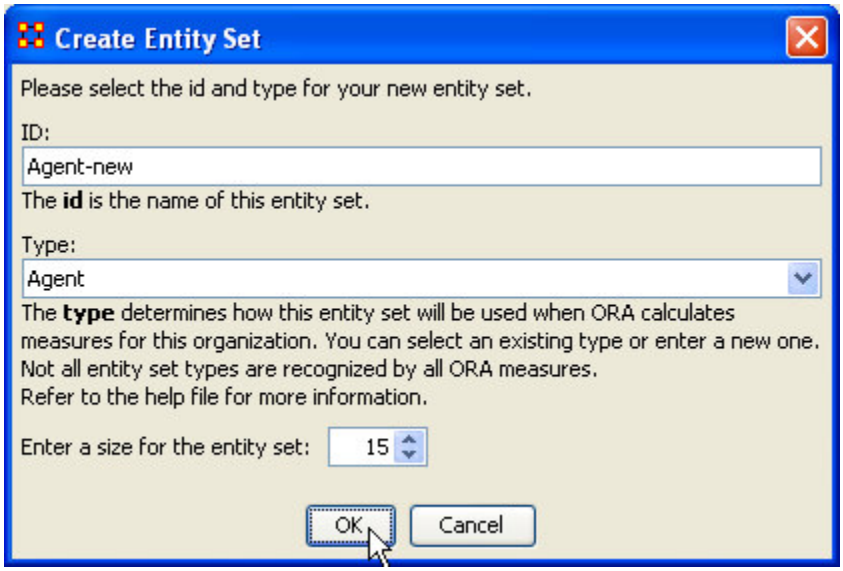
There are times you need to create a new Entity Set with existing values from another Entity Set. For example, I will create a second Entity from the set [agent] size: 15.



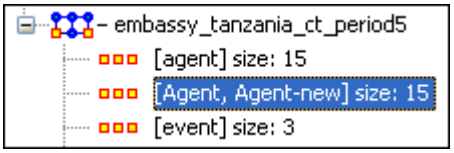
Select the Add New Entity Set… button.



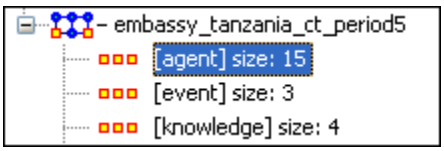
This will bring up the Create Entity Set dialog box. I give it a new name, Agent-new, leave the type as Agent, and set the Enter a size for the entity set to 15 in order to match the existing set. The select the [OK] button.



A new Entity set will appear in the left panel, [Agent, Agent-new] size: 15.

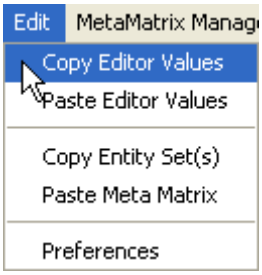


Go back to the original Entity set.

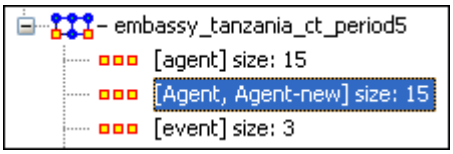


Move the pointer into the topmost cell and Left-Click. This selects the entire column of values.

From the main menu select Edit > Copy Editor Values



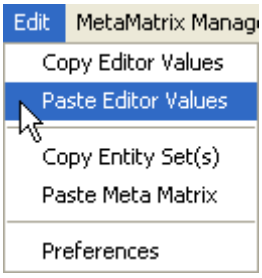
Re-Select the new Entity set.



Move the pointer into the topmost cell and Left-Click. This selects the entire column of values that you want to replace.

	Title	ID
1	Agent_1	Agent-new...
2	Agent_2	Agent-new...
3	Agent_3	Agent-new...
4	Agent_4	Agent-new...
5	Agent_5	Agent-new...
6	Agent_6	Agent-new...
7	Agent_7	Agent-new...
8	Agent_8	Agent-new...
9	Agent_9	Agent-new...
10	Agent_10	Agent-new...
11	Agent_11	Agent-new...
12	Agent_12	Agent-new...
13	Agent_13	Agent-new...
14	Agent_14	Agent-new...
15	Agent_15	Agent-new...

From the main menu select Edit > Paste Editor Values



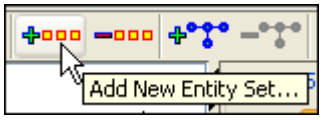
The values are now copied into the new Entity set.

	Title	ID
1	mohamed...	Agent-new...
2	khalfan_m...	Agent-new...
3	mohamm...	Agent-new...
4	ahmed_th...	Agent-new...
5	fazul_moh...	Agent-new...
6	bin_laden	Agent-new...
7	ali_moha...	Agent-new...
8	ahmed_g...	Agent-new...
9	mohamm...	Agent-new...
10	jamal_al-f...	Agent-new...
11	khalid_al-f...	Agent-new...
12	jihad_mo...	Agent-new...
13	mahmud_...	Agent-new...
14	abdullah_...	Agent-new...
15	abdal_rah...	Agent-new...

Creating a new {Partial} Entity Set

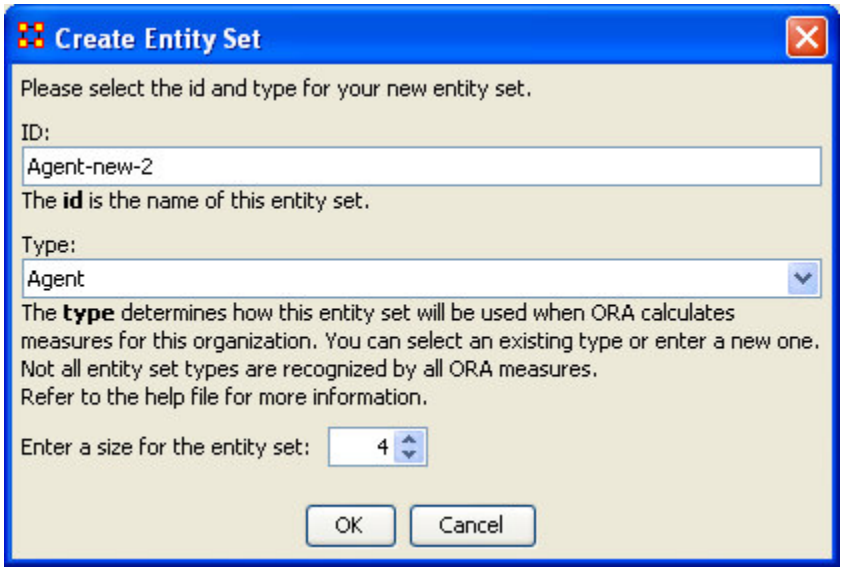
There may be times when you need to create a new Entity set but only need some of the values from an existing set. The procedure is similar to that above.

Again, Select the Add New Entity Set… button.

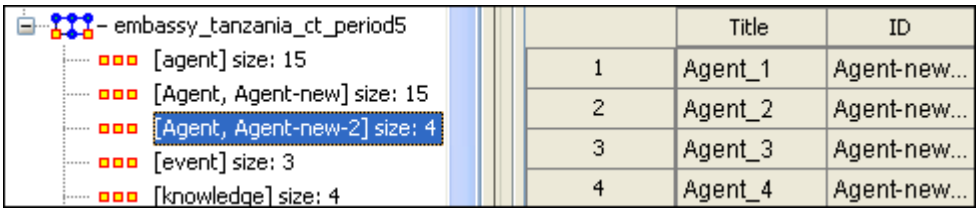


This will bring up the Create Entity Set dialog box as before. But this time we'll create a different sized Entity set from the original.

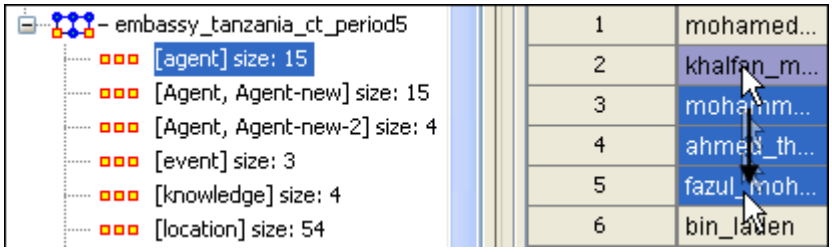
Give the set a new name, Agent-new-2, leave the type as Agent, and this time set the Enter a size for the entity set to 4 in order to match the existing set. The select the [OK] button.



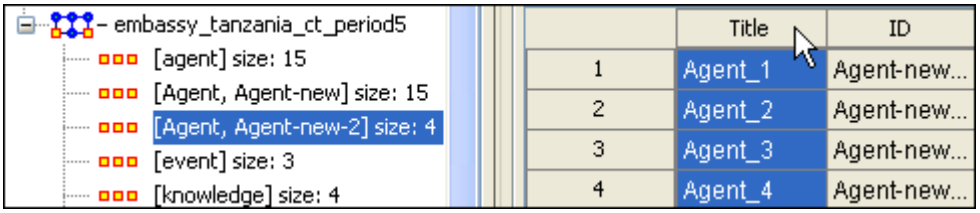
The new Entity set, [Agent, Agent-new-2] size: 4 appears in the left panel.



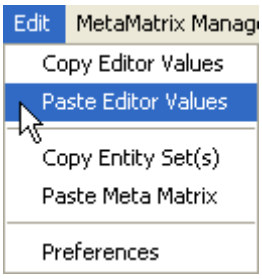
Re-Select the original Entity set. Move the pointer to the first value you want to copy. Move the pointer to the last value you want to copy. Press and hold the Shift key and Left-click the last value.



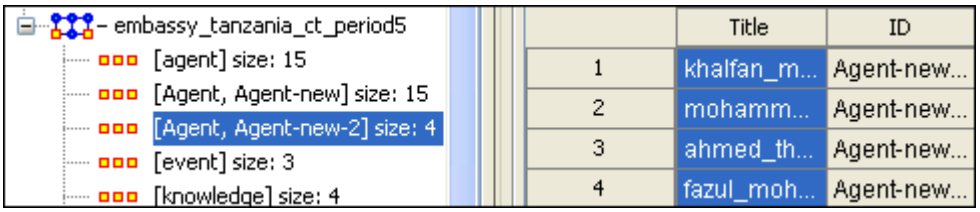
Re-Select the new Entity set and Left-Click in the top cell to select all the values.



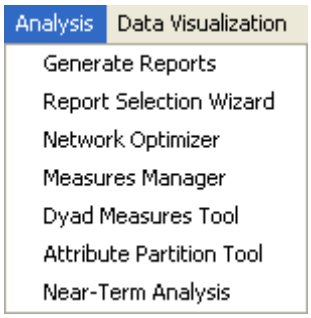
From the main menu select Edit > Paste Editor Value



The four values form the original 15 have been copied into a new, smaller, Entity set.



Analysis



Generate Reports – Brings up a dialog box that enables you to choose to run any report on any currently active MetaMatrix then select the format you want the results.

Report Selection Wizard – Assists you in selecting the best reports for the selected MetaMatrix.

Network Optimizer – Creates new MetaMatrices based on an existing MetaMatrices using a particular set of measures. Use this tool to maximize one or more measures within your organization by changing network variables and analyze your organization under various scenarios.

Measures Manager – The option allows you to choose which measures are to be used in generating reports for the selected MetaMatrices. The dropdown menu allows you to chose measures lists which divide them up into categories such as: Slow Measures, Critical Risk Employees, and Resource Allocation Risk.

Dyad Measures Tool – Use this tool to produce new graphs from existing MetaMatrices using specific measures. You can either create new MetaMatrices or append these graphs to existing MetaMatrices.

Attribute Partition Tool – Creates new MetaMatrices using an existing MetaMatrices and uses attribute values to affect the result.

Near-Term Analysis – Tool used to detect the results when a set of entities is removed from an existing circumstance. See Lesson 7 for more information.

ORA Charts

Charts

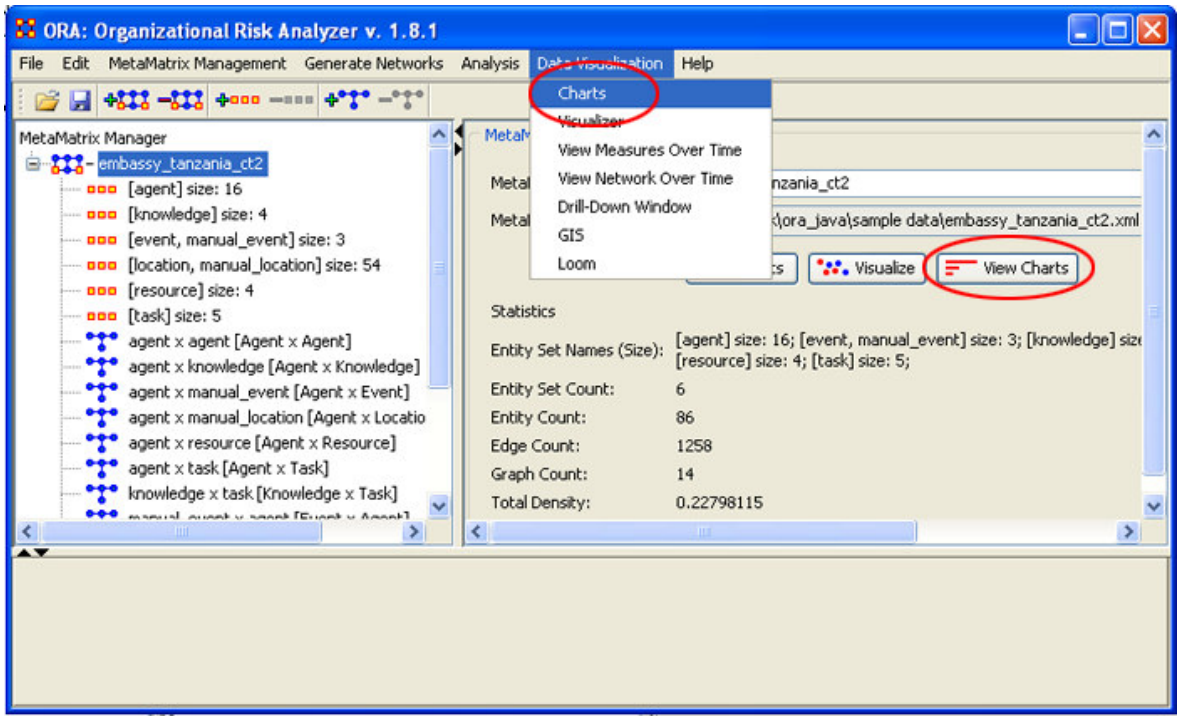
Charts – Charts Explained – Bar Chart – Scatter Chart – Histogram

Three charts are available: The Bar chart, Scatter Plot, Histogram, and Heat Map. ORA Charts can be accessed through the Main Interface by clicking the View Charts For This MetaMatrix button in the MetaMatrix Composer window pane or from the Main Interface drop down menu.

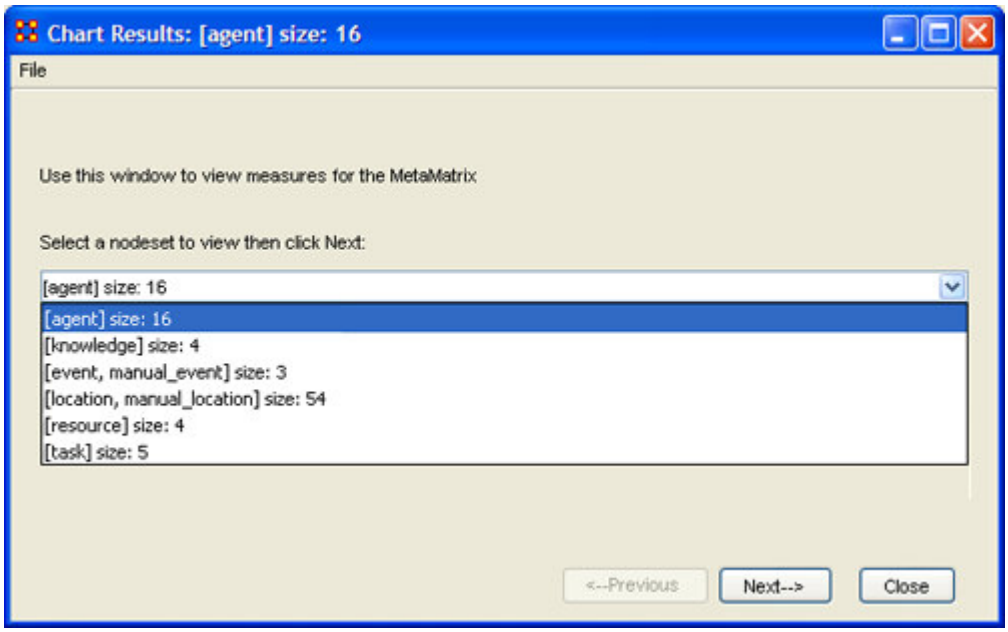
From the Main Menu select Data Visualization > Charts; OR

Select the [Charts] button.

In the screen shot below, ellipses highlight both methods to access ORA Charts.



After choosing Reports, the following pop-up window will appear. Select the entityset you are interested in Charting and select the [Next] button. For this example, we will simply select the currently loaded entityset Agents. ORA produces the following Bar Chart, displayed in the screen shot below.



By now, you should be able to access ORA Charts by loading a MetaMatrix by either using the [Charts] button in the MetaMatrix Composer window pane or from the Main Menu of the main interface. See Chart Types Explained for more detailed information about the four chart types.

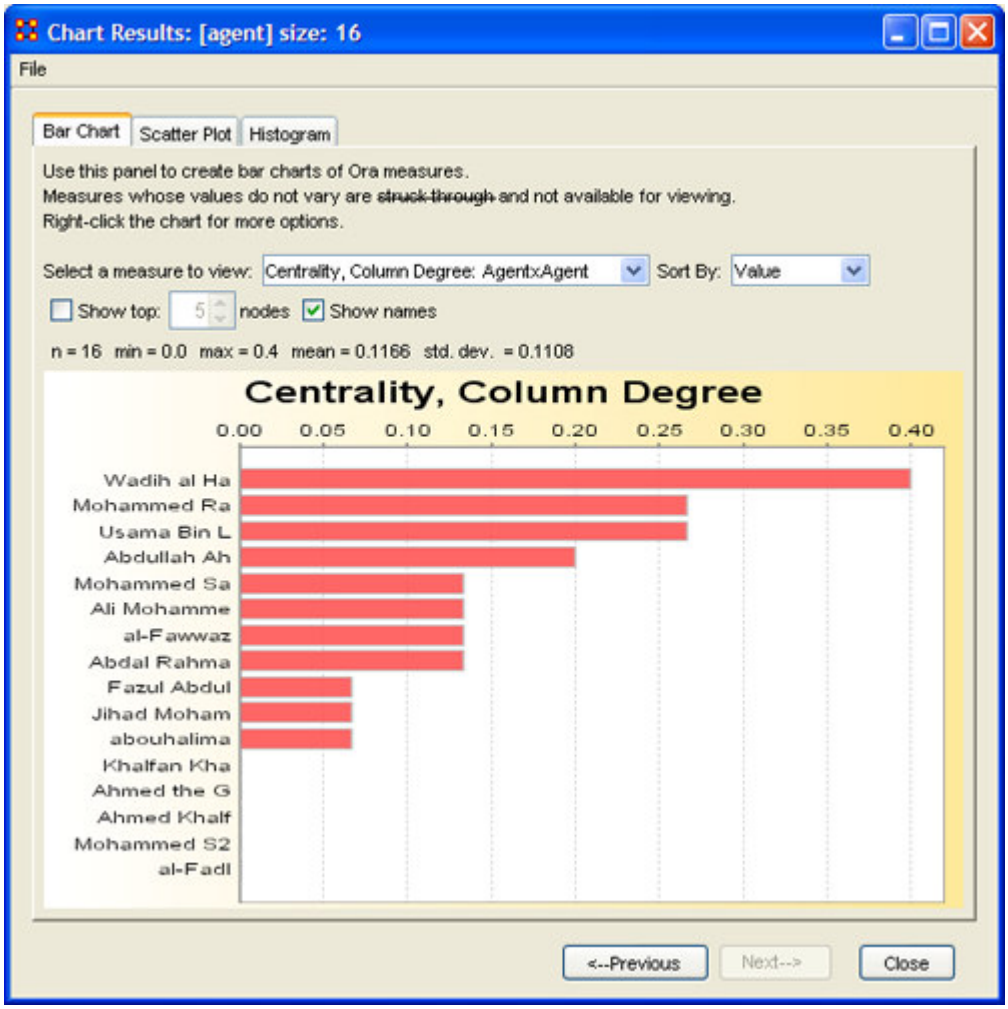


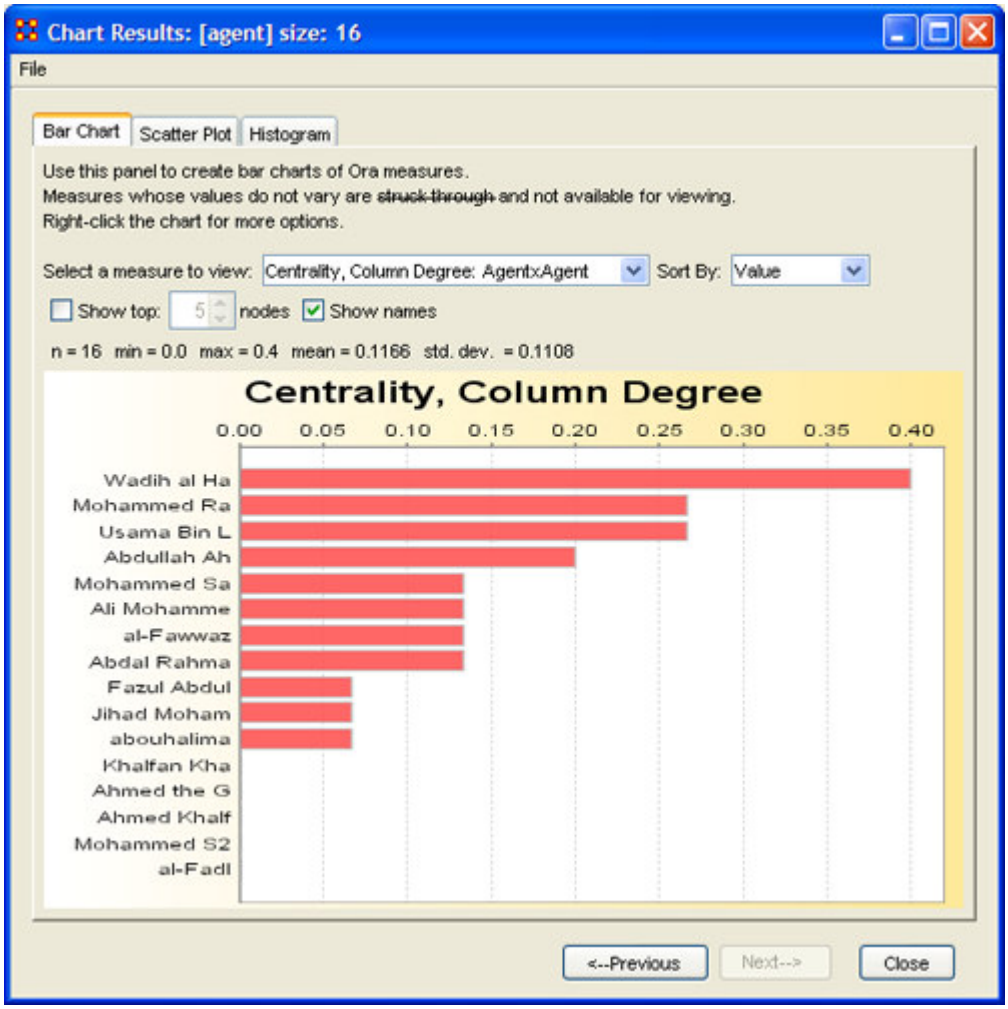
Chart Types Explained

Below are examples of each type of ORA charts: Bar Chart, Scatter Plot, and Histogram.

ORA Bar Chart

Charts – Charts Explained – Bar Chart – Scatter Chart – Histogram

A bar chart, also known as a bar graph, is a chart with rectangular bars of lengths usually proportional to the magnitudes or frequencies of what they represent. Bar charts are used for comparing two or more values. The bars can be horizontally or vertically oriented. Sometimes a stretched graphic is used instead of a solid bar.



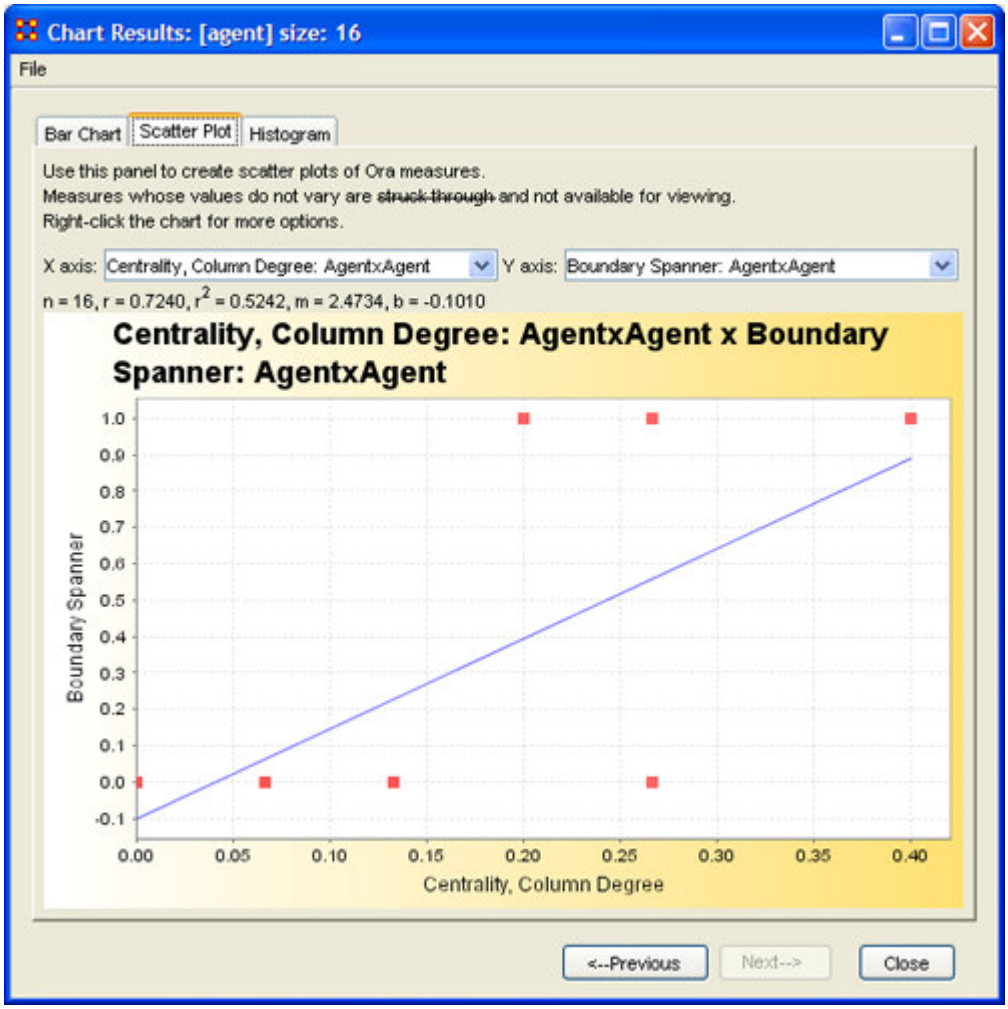
Scatter Plot

Charts – Charts Explained – Bar Chart – Scatter Chart – Histogram

A scatterplot, scatter diagram or scatter graph is a chart that uses Cartesian coordinates to display values for two variables. The data is displayed as a collection of points, each having one coordinate on the horizontal axis and one on the vertical axis.

A scatterplot does not specify dependent or independent variables. Either type of variable can be plotted on either axis. Scatterplots represent the association (not causation) between two variables.

A scatterplot can show various kinds of relationships, including positive (rising), negative (falling), and no relationship. If the pattern of dots slopes from lower left to upper right, it suggests a positive correlation between the variables being studied. If the pattern of dots slopes from upper left to lower right, it suggests a negative correlation. A line of best fit can be drawn in order to study the correlation between the variables. An equation for the line of best fit can be computed using the method of linear regression.

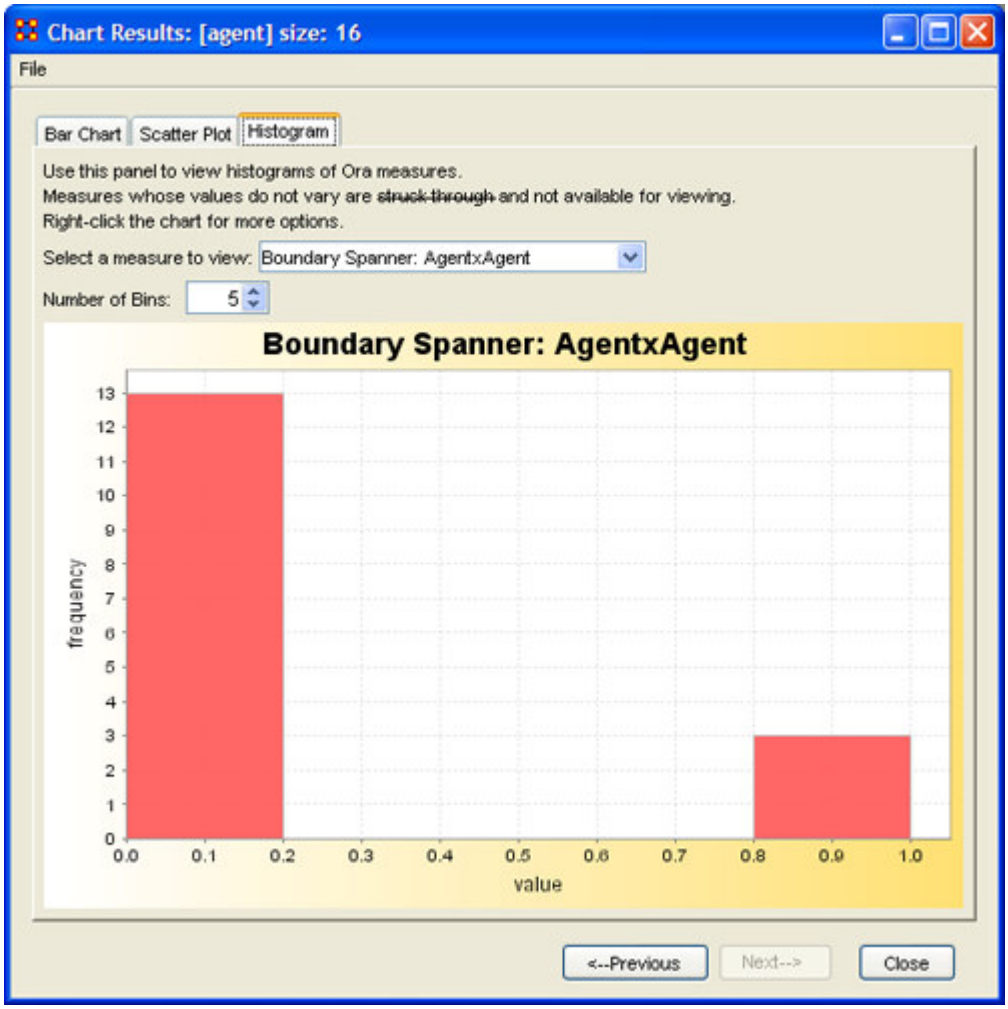


Histogram

Charts – Charts Explained – Bar Chart – Scatter Chart – Histogram

In statistics, a histogram is a graphical display of tabulated frequencies. A histogram is the graphical version of a table which shows what proportion of cases fall into each of several or many specified categories. The histogram differs from a bar chart in that it is the area of the bar that denotes the value, not the height, a crucial distinction when the categories are not of uniform width *(Lancaster, 1974)*. The categories are usually specified as non-overlapping intervals of some variable. The categories (bars) must be adjacent.

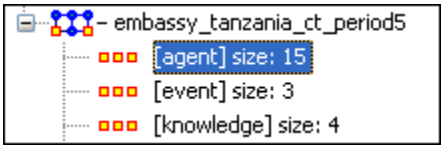
The word histogram is derived from histos and gramma in Greek, the first meaning web or mast and the second meaning drawing, record or writing. A histogram of something is thus, etymologically speaking, a drawing of the web of this something.



Copy / Paste Editor Values

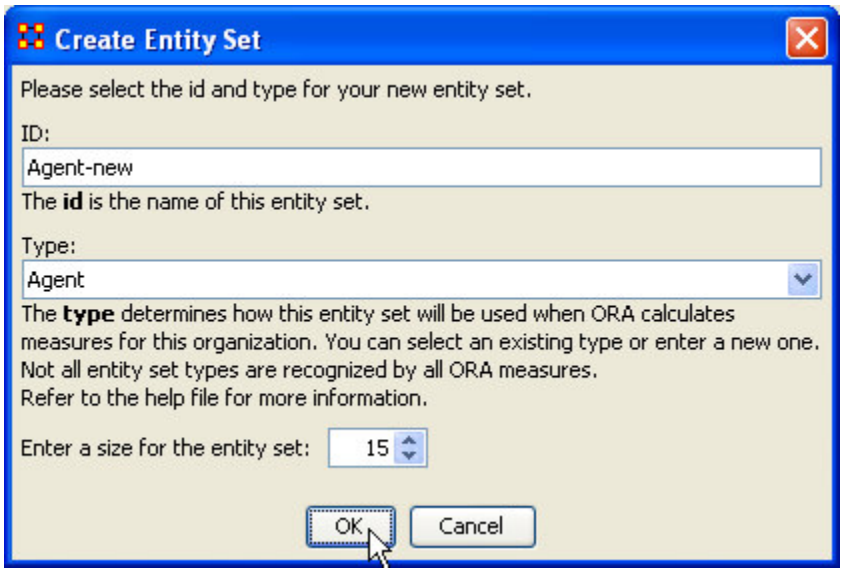
Creating a new Entity Set

There are times you need to create a new Entity Set with existing values from another Entity Set. For example, I will create a second Entity from the set [agent] size: 15.

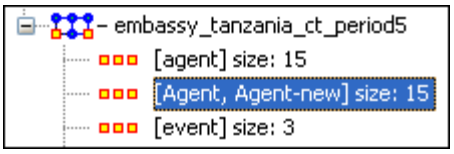


Select the Add New Entity Set… button.

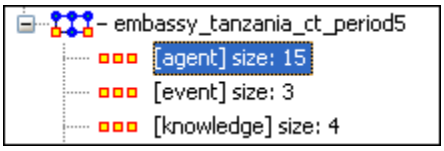
This will bring up the Create Entity Set dialog box. I give it a new name, Agent-new, leave the type as Agent, and set the Enter a size for the entity set to 15 in order to match the existing set. The select the [OK] button.



A new Entity set will appear in the left panel, [Agent, Agent-new] size: 15.

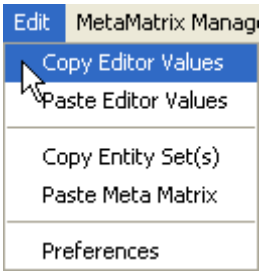


Go back to the original Entity set.

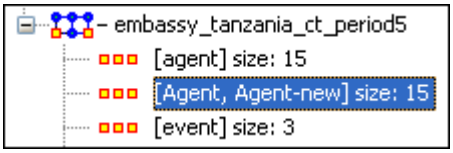


Move the pointer into the topmost cell and Left-Click. This selects the entire column of values.

From the main menu select Edit > Copy Editor Values



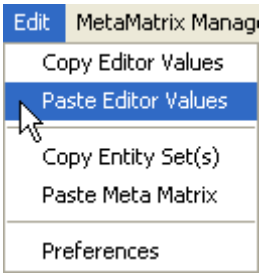
Re-Select the new Entity set.



Move the pointer into the topmost cell and Left-Click. This selects the entire column of values that you want to replace.

	Title	ID
1	Agent_1	Agent-new...
2	Agent_2	Agent-new...
3	Agent_3	Agent-new...
4	Agent_4	Agent-new...
5	Agent_5	Agent-new...
6	Agent_6	Agent-new...
7	Agent_7	Agent-new...
8	Agent_8	Agent-new...
9	Agent_9	Agent-new...
10	Agent_10	Agent-new...
11	Agent_11	Agent-new...
12	Agent_12	Agent-new...
13	Agent_13	Agent-new...
14	Agent_14	Agent-new...
15	Agent_15	Agent-new...

From the main menu select Edit > Paste Editor Values



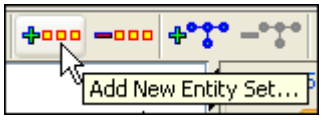
The values are now copied into the new Entity set.

	Title	ID
1	mohamed...	Agent-new...
2	khalfan_m...	Agent-new...
3	mohamm...	Agent-new...
4	ahmed_th...	Agent-new...
5	fazul_moh...	Agent-new...
6	bin_laden	Agent-new...
7	ali_moha...	Agent-new...
8	ahmed_g...	Agent-new...
9	mohamm...	Agent-new...
10	jamal_al-f...	Agent-new...
11	khalid_al-f...	Agent-new...
12	jihad_mo...	Agent-new...
13	mahmud_...	Agent-new...
14	abdullah_...	Agent-new...
15	abdal_rah...	Agent-new...

Creating a new {Partial} Entity Set

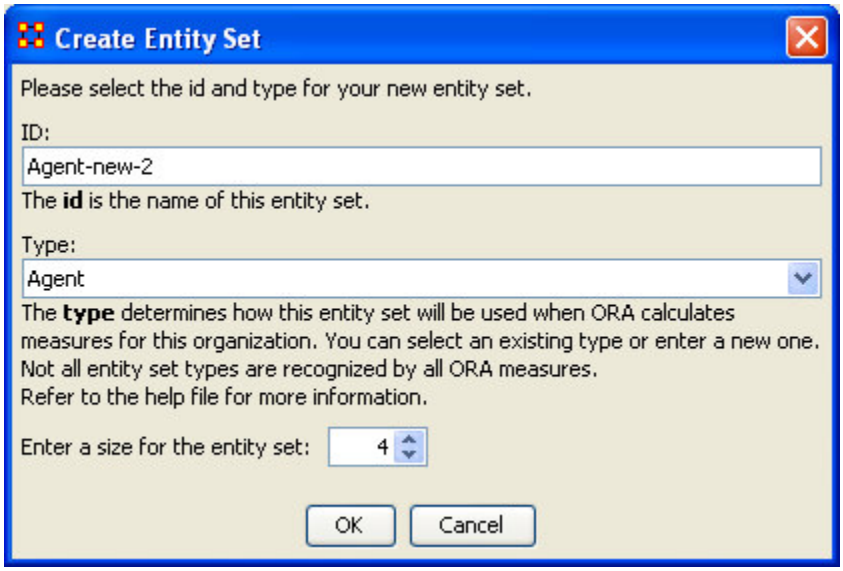
There may be times when you need to create a new Entity set but only need some of the values from an existing set. The procedure is similar to that above.

Again, Select the Add New Entity Set… button.

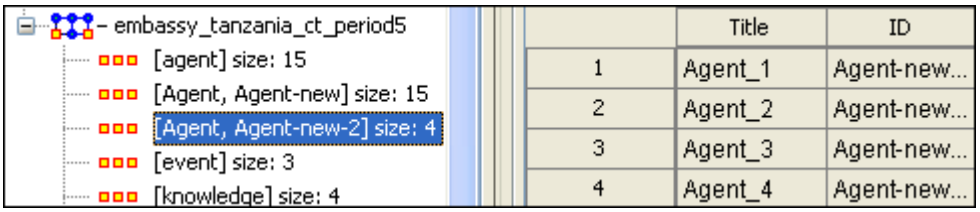


This will bring up the Create Entity Set dialog box as before. But this time we'll create a different sized Entity set from the original.

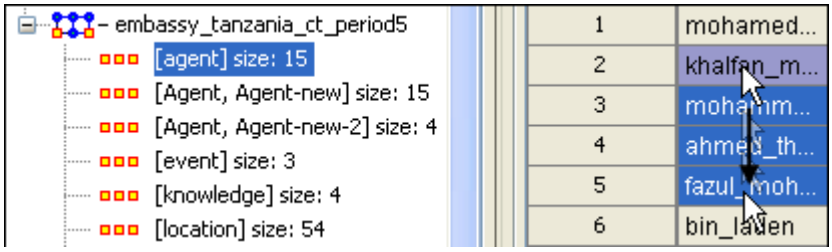
Give the set a new name, Agent-new-2, leave the type as Agent, and this time set the Enter a size for the entity set to 4 in order to match the existing set. The select the [OK] button.



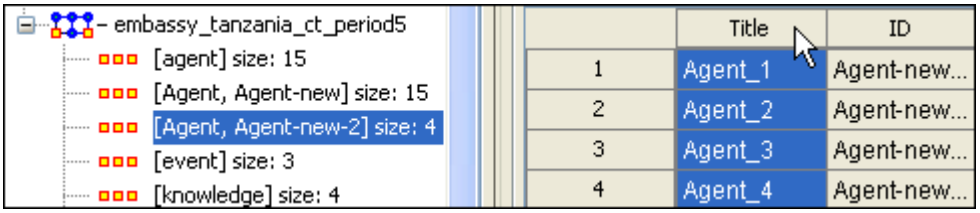
The new Entity set, [Agent, Agent-new-2] size: 4 appears in the left panel.



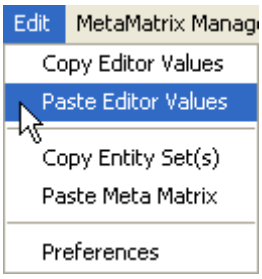
Re-Select the original Entity set. Move the pointer to the first value you want to copy. Move the pointer to the last value you want to copy. Press and hold the Shift key and Left-click the last value.



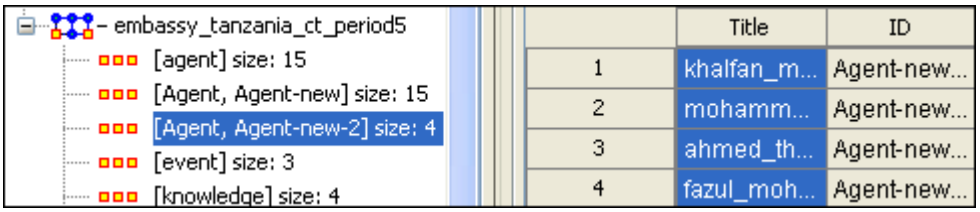
Re-Select the new Entity set and Left-Click in the top cell to select all the values.



From the main menu select Edit > Paste Editor Value



The four values form the original 15 have been copied into a new, smaller, Entity set.

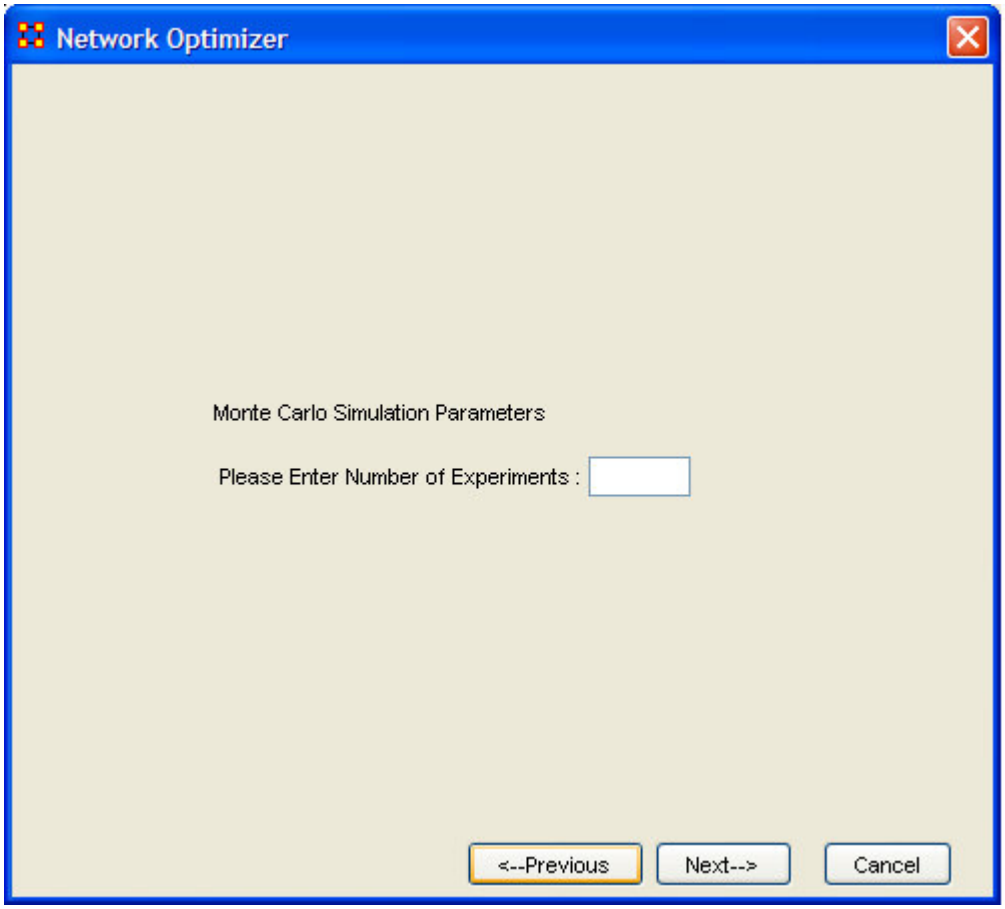


Default and Advanced Experiment Type

The Default and Advanced Experiment Type options are relevant to both the Monte Carlo and Simulated Annealing Optimization methods. If you select "Default" option in the Network Optimizer window pane, for either Monte Carlo or Simulated Annealing, no further input is necessary. Simply select the Next button. If you choose "Advanced" the following screen appears (screen shot below) requesting parameter input respective to either the Monte Carlo or Simulated Annealing optimization method.

Monte Carlo

This screen shot below requests parameter input for an "Advanced" Monte Carlo Simulation. The recommended value for the Monte Carlo Experiment is between 50,000 and 500,000.

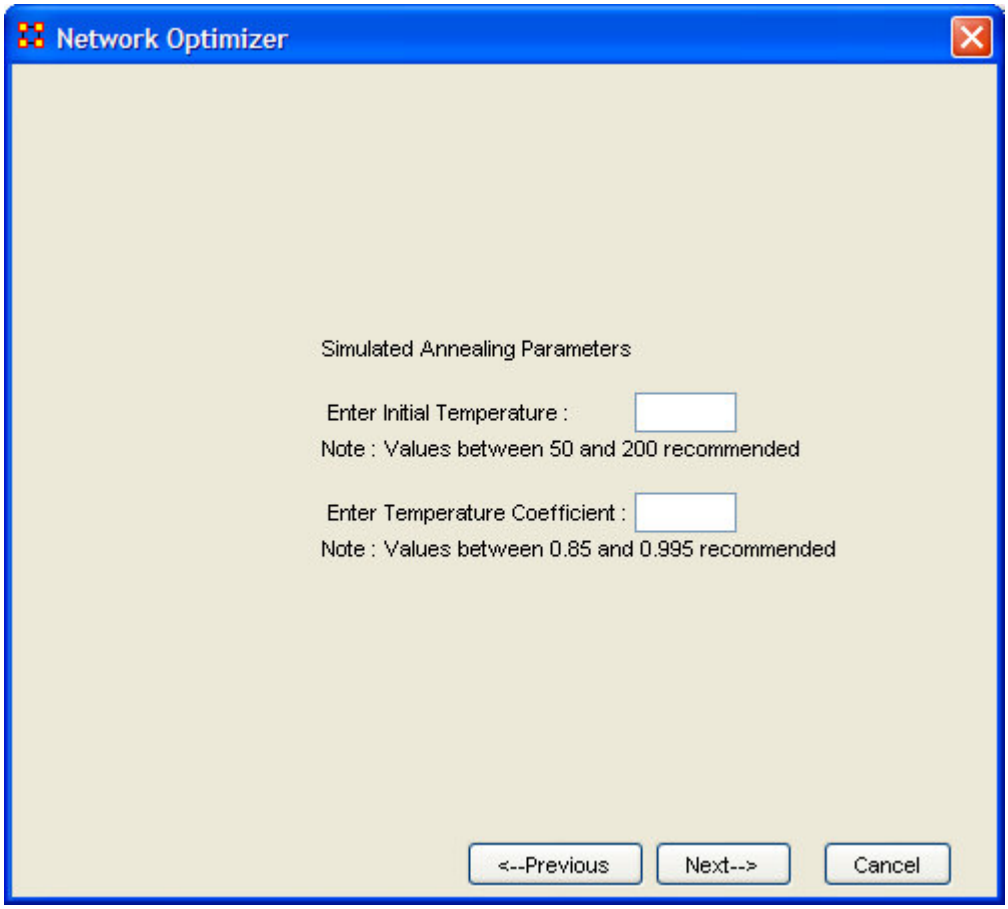


Simulated Annealing

This dialog box allows the input of the parameters for the Advanced Simulated Annealing optimization.

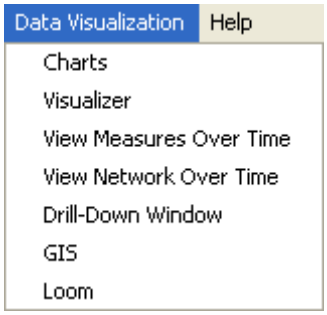
The recommended value for Initial Temperature is around 100.

recommended value for Temperature Coefficient is around 0.95.



Tip! The term "Simulated Annealing" draws its inspiration from metallurgy, where essentially atoms within a metal are heated thereby dislodging them from a metal's internal structure transforming the metal into another atomic state. In this way, your organization is "heated" changing its components in the attempt to arrive at an optimized state.

Data Visualization



Charts – When run this function will plot the three graphs, Bar Chart, Scatter Plot, and Histogram on the choosen Matrix.

Visualizer – This menu item calls up the Visualizer.

View Measures Over Time – Requires multiple MetaMatrices. First plots points for measure selected on each of the Matrices active with the option to see a direct line from the earliest to the latest point.

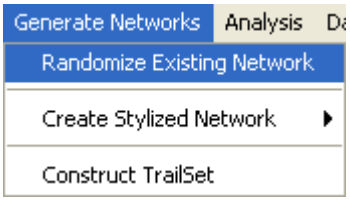
View Network Over Time – Requires multiple MetaMatrices. Displays entities and edges for each of the active MetaMatrices

Drill-Down Window – Allows for quick, plotting of entities connected to a choosen entity.

GIS (Geographical Information System) – Analyze, forecast, and visualize a wide variety of spatial interactions and networks within a global-scale.

Loom – Works with entities moving between places over time. Requires the use of a trailset.

Generate Networks



Generate Networks according to predefined algorithms

Randomize Networks

Scrambles the edges of a graph

Create Stylized Network

Generates new MetaMatrices using various Mathematical formulas.

Construct Trailset

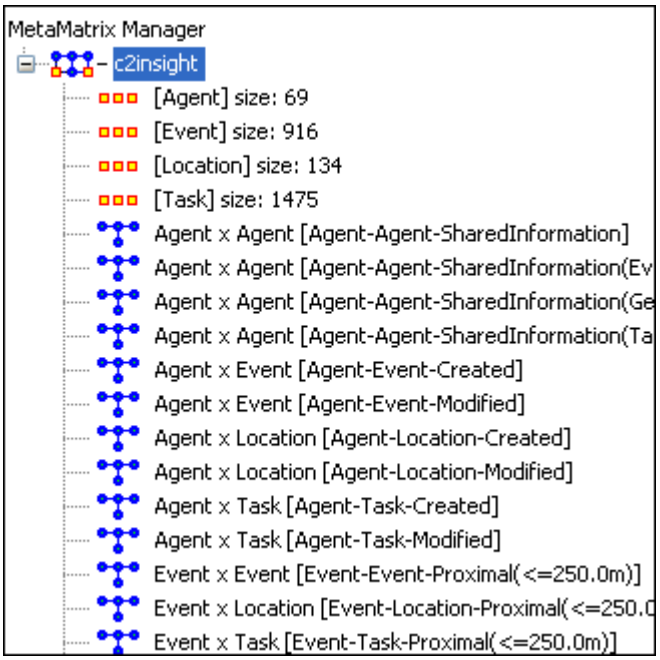
Coming soon

The GIS Visualizer

Data load in ORA main window

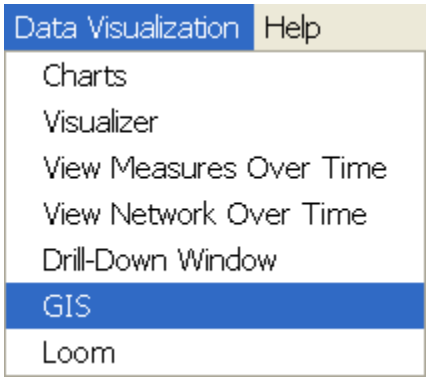
- Before running ORA GIS, a DynetML file should be loaded in the ORA main window.

  The data to visualize should be highlighted.

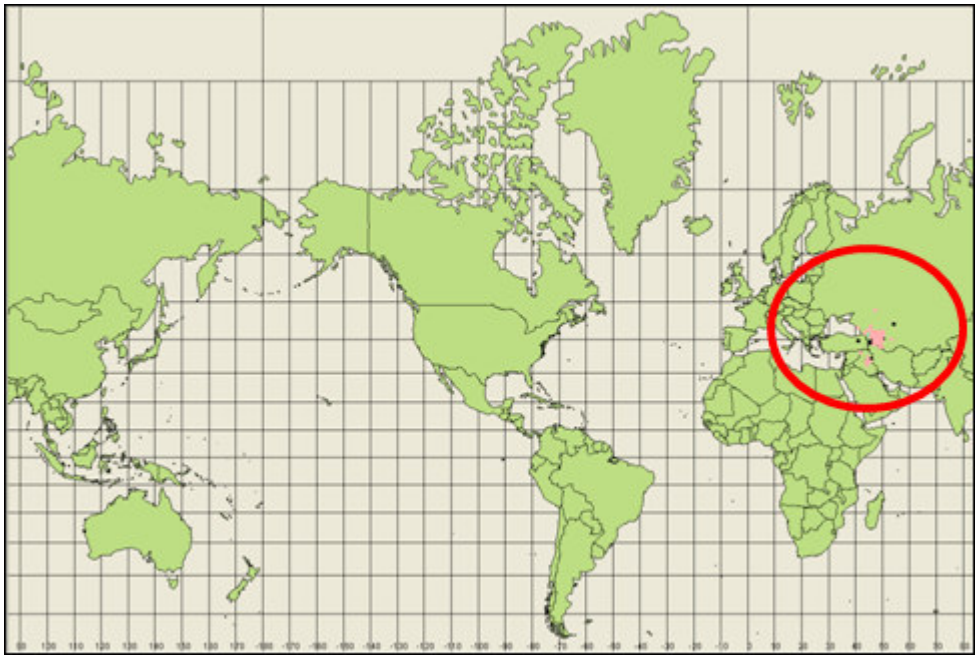


Run ORA GIS

- After loading data, select Data Visualization > GIS.



- Then, ORA will display ORA GIS window showing the geospatial distribution of the entities across the world.



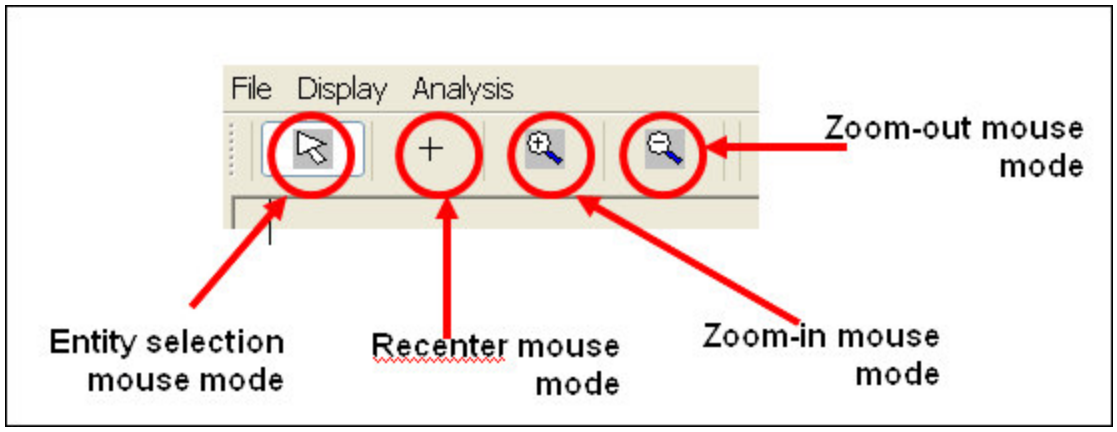
Re-center and zoom-in

You can re-center:

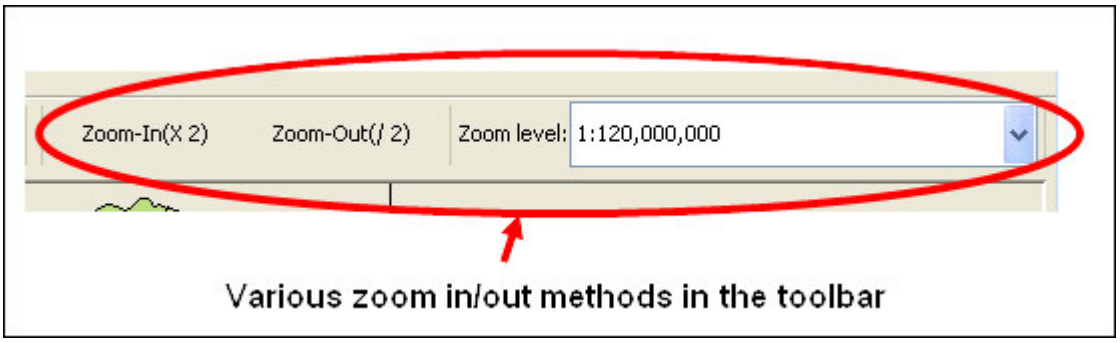
1. Changing mouse mode as a recenter mode (click the recenter mode in the toolbar)
2. Clicking a point of the map.

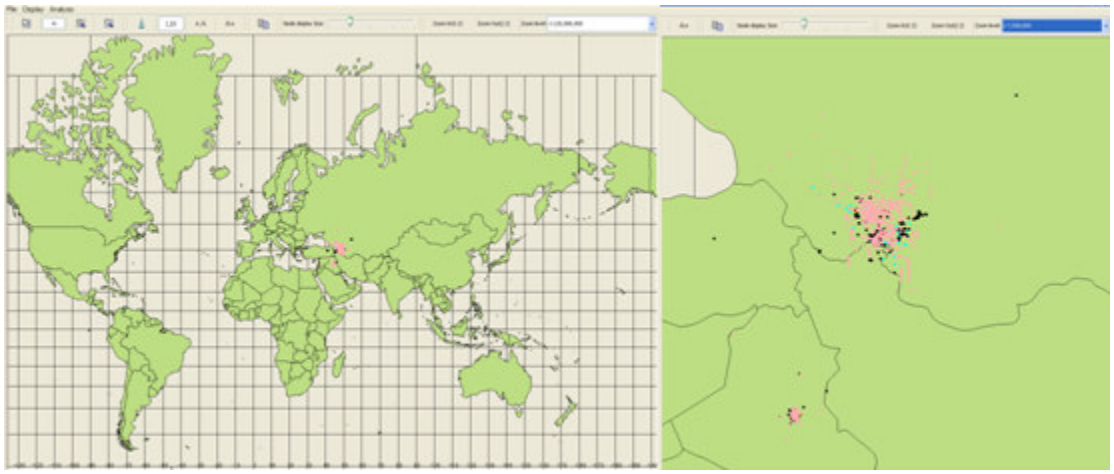
You can zoom-in and zoom-out:

1. Changing mouse mode as a zoom-in/out mode (click the zoom-in/out mode in the toolbar)
2. Clicking a point of the map.



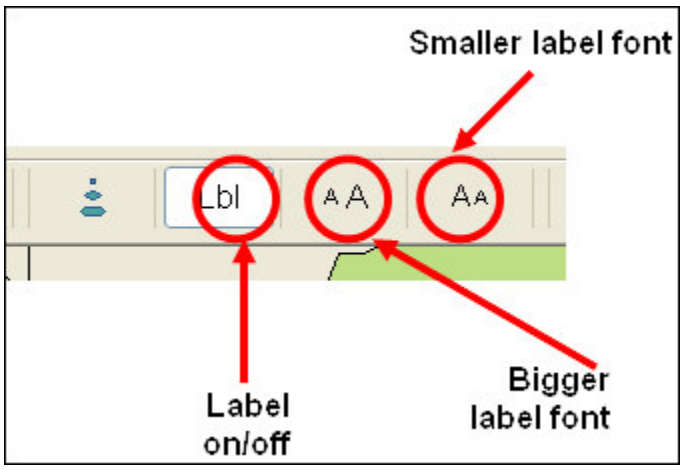
Or, you can use other zoom-in/out methods in the toolbar.

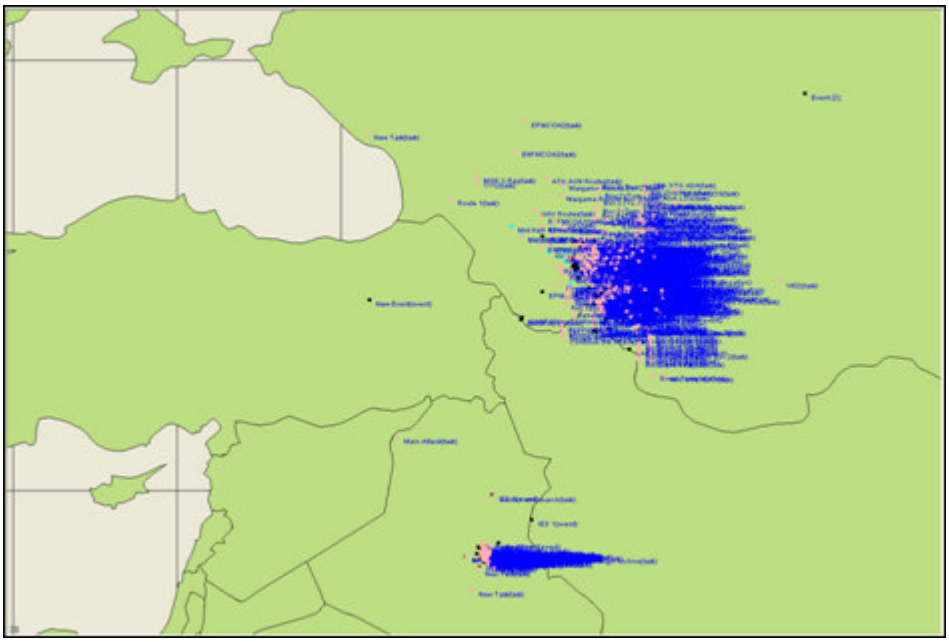




Label display and entity size

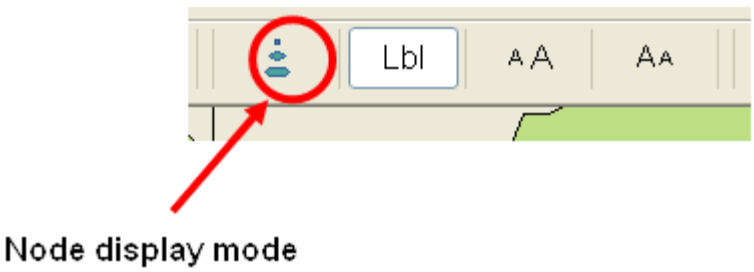
- You can display the labels of the entities by changing the label button in the toolbar.



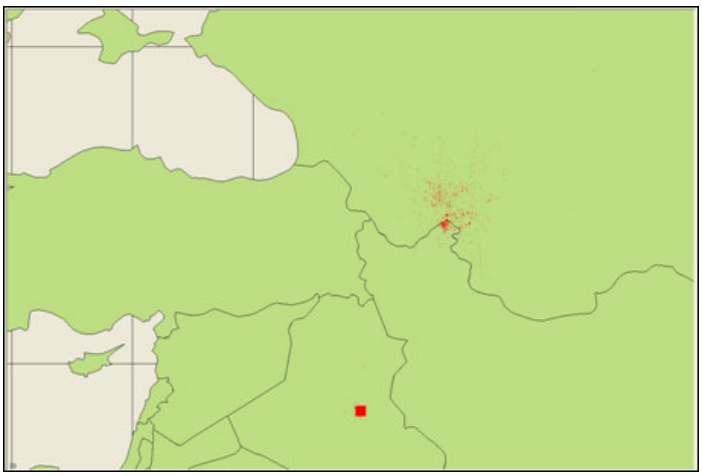


Entity size adjustment

- Also, you can adjust the size of the entity by changing the entity display mode. You can change the entity display mode by clicking the display mode change button in the tool bar.

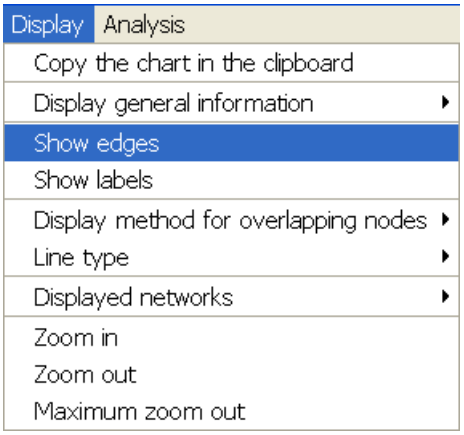


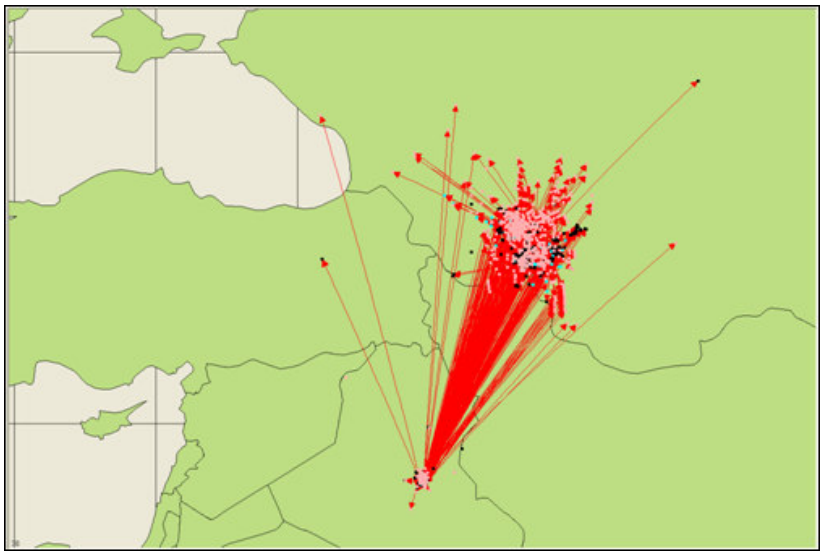
- The entity size will represent the number of the entities in the region.



Edge display

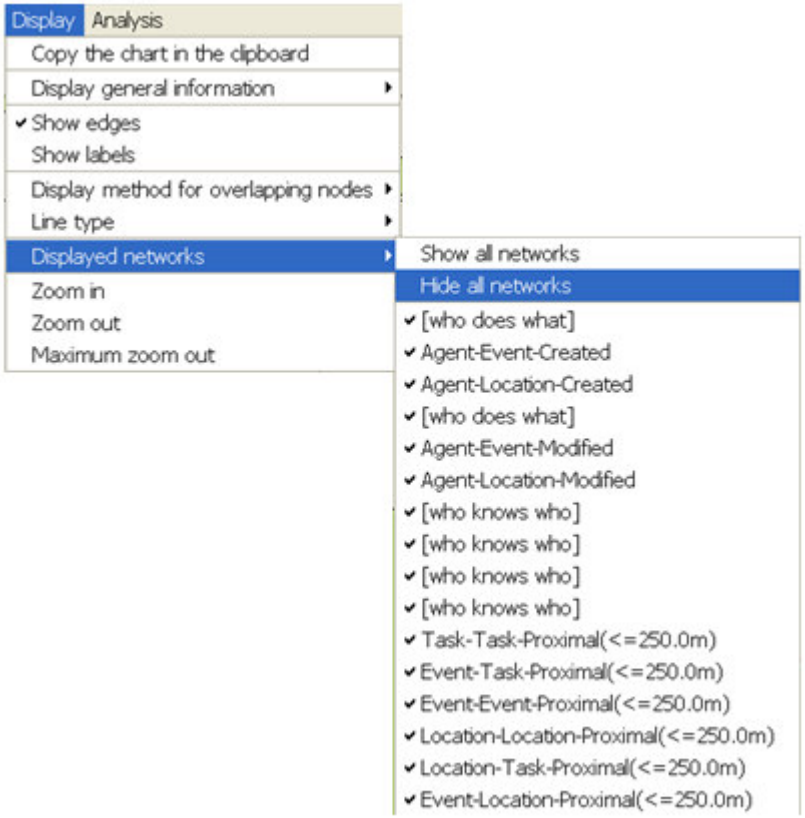
- You can turn on/off edge display by selecting form the menu Display > Show edge.



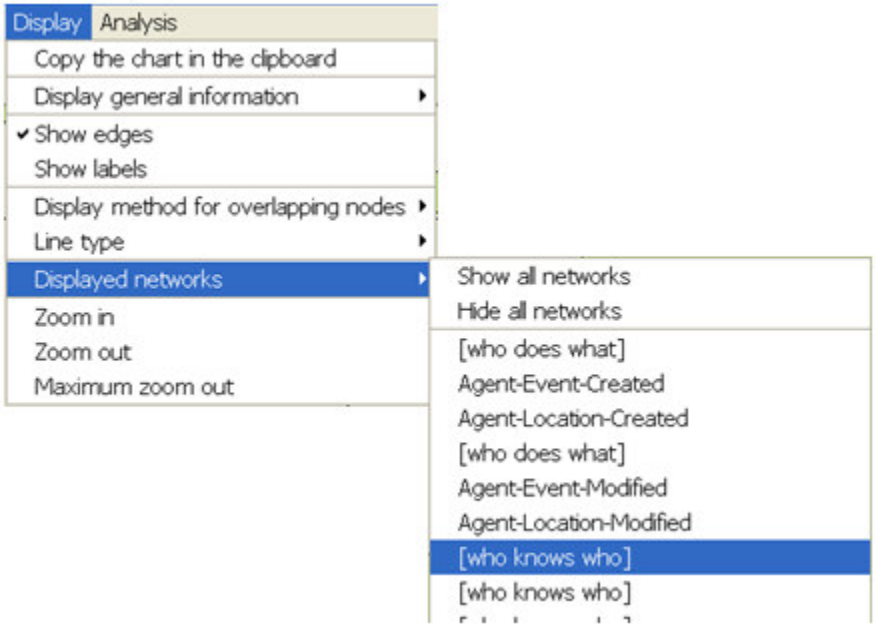


Selective network display (1)

- You can selectively display networks. First, you can hide all the displayed networks by selecting form the menu Display > Displayed Networks > Hide all networks

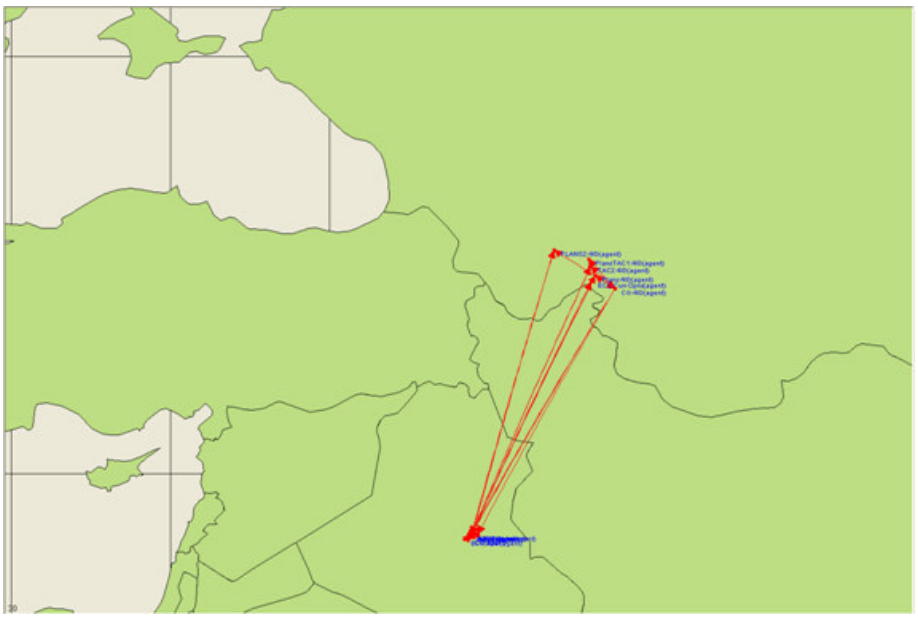


- Then, you can select the network you want to show by selecting from the menu Display > Displayed Networks > [who knows who].



Selective network display (2)

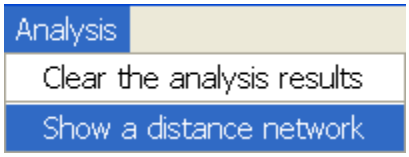
- This is the result of showing only who-knows-who network and turning on the label display.



Distance network creation

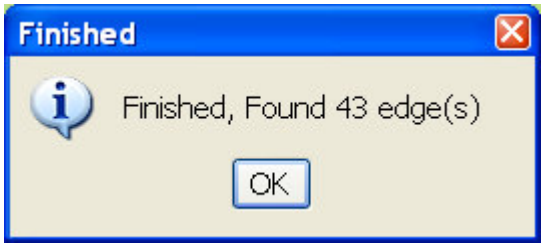
You can create a distance network among the displayed edges.

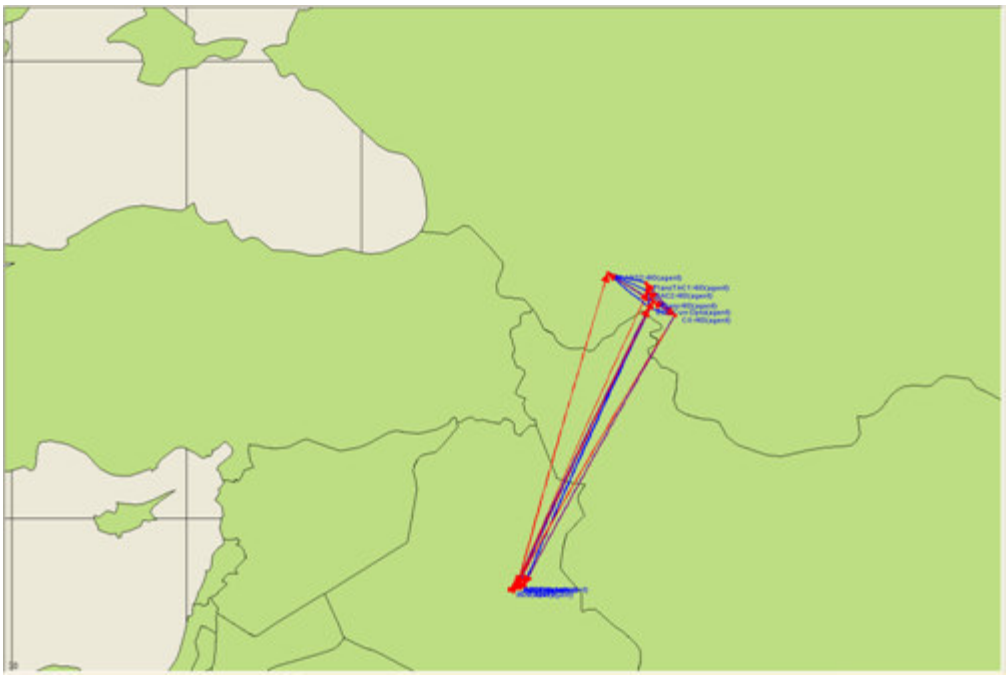
1. Select on the menu Analysis > Show a distance network



2. Set the threshold for edge generation.

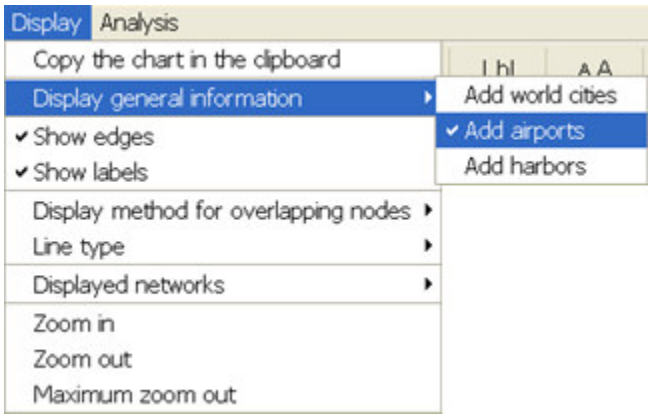
3. Then ORA GIS tells you how many edges are created and the created edges will be in the map with blue links.



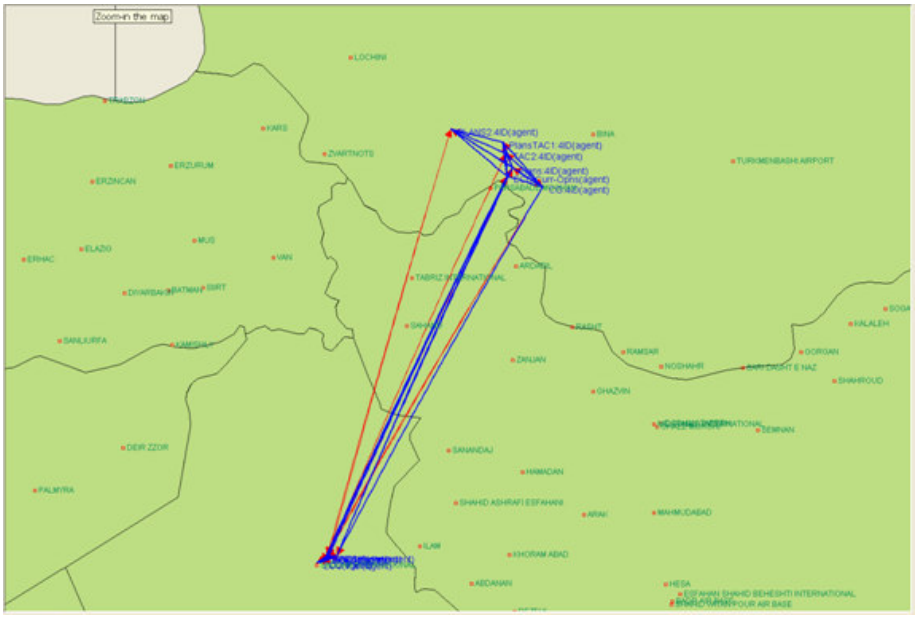


Add general locations of interest

- ORA GIS can show the world cities, airports and harbors. Select Display > Display general information > Add airports.

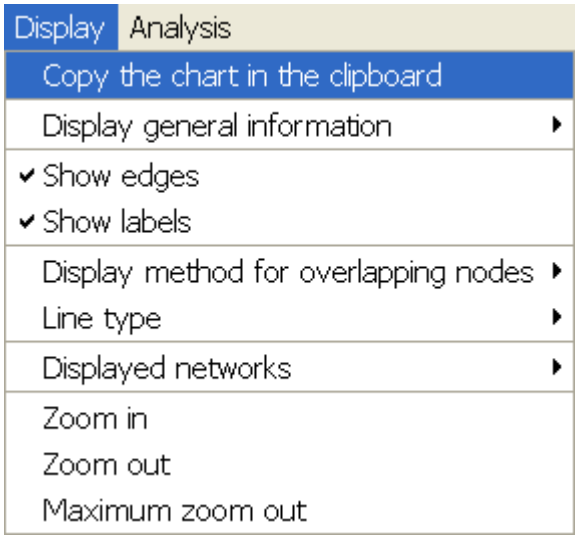


- Then, the map will show the airports. This will give you some chance to reason how closely the entities are located to the important locations of interest.

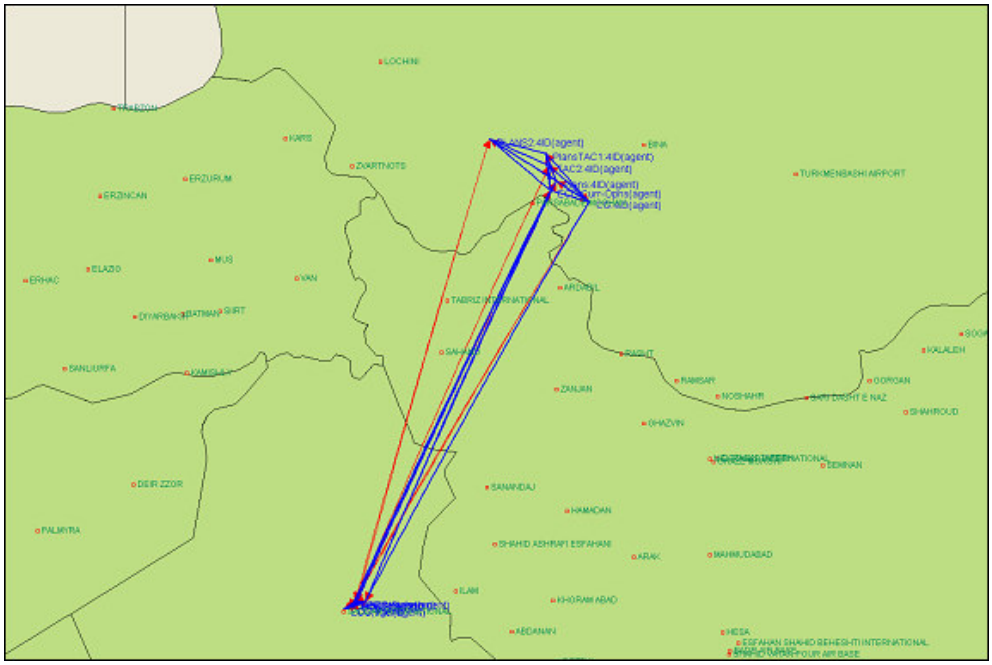


Clip board copy of the image

- From the menu select Display > Copy the chart in the clipboard

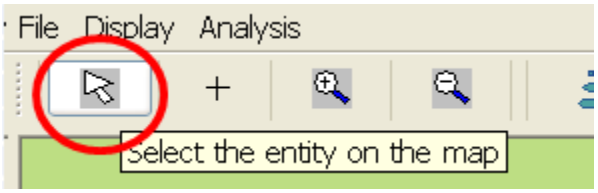


- ORA GIS will copy the image to clipboard, so you can paste the image on MS Word or MS Powerpoint.

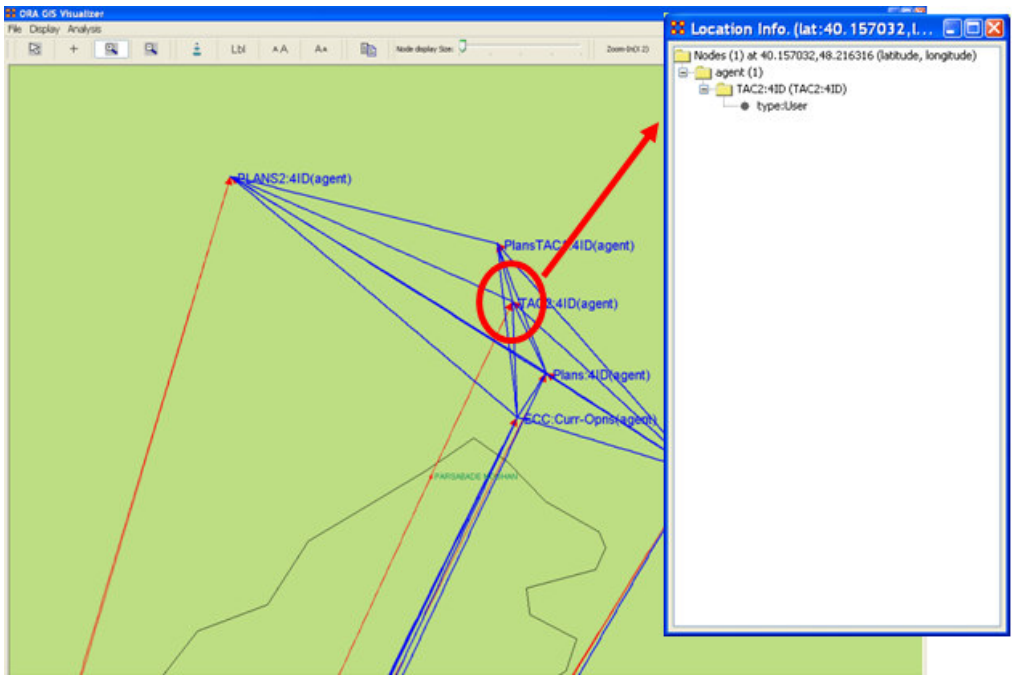


Entity selection

- Change the mouse mode to entity selection mode by clicking a button in the toolbar.



- Then, click one of the entities on the map, then you will get a popup window displaying the detailed information of the entity at the location.


ORA GIS Visualizer
File Display Analysis
Location Info. (lat:40.157032,l...
Nodes (1) at 40.157032,48.216316 (latitude, longitude)
agent (1)
TAC2:4ID (TAC2:4ID)
type:User
PLANS2:4ID(agent)
PlansTAC2:4ID(agent)
TAC2:4ID(agent)
Plans:4ID(agent)
ECC:Curr-Opns(agent)

Matrix Algebra

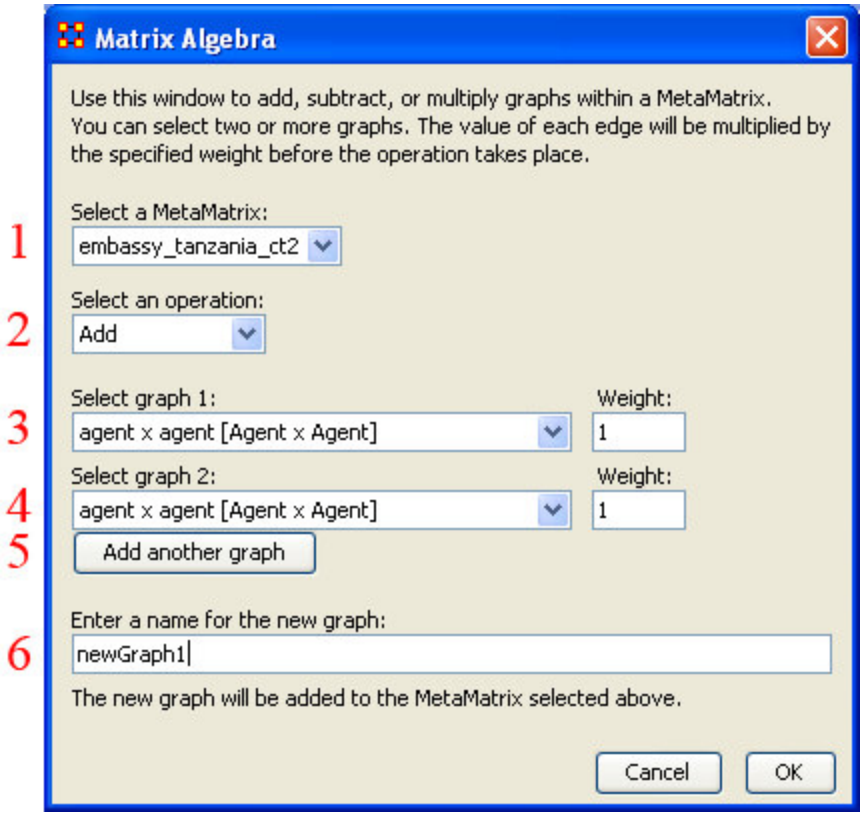
The Matrix Algebra allows you to perform mathematical operations on two matrices. The options in ORA are addition, subtraction, and multipication. These functions help spot strong and weak connections within a Matrix.

I start with one MetaMatrix loaded.

From the menu select MetaMatrix Management > Matrix Algebra…

The Matrix Algebra dialog appears. There are six areas which you can manipulate. These are each described below the dialog box.

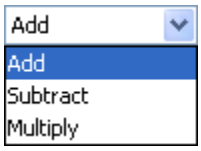
Note: Both matrices should be the same dimensions.



1. Select a MetaMatrix

This dropdown menu will show all the MetaMatrices you currently have active. To perform a math function on a matrix, highlight it in the dropdown menu.

2. Select an Operation



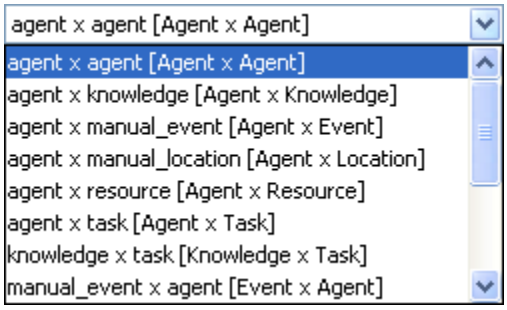
This option allows you to choose which operation, Add, Subtract, or Multiply, you want to perform on the graphs.

- Add: This function adds together corresponding cells of two different graphs.

- Substract: his function subtracts together corresponding cells of two different graphs.
- Multiply: Multiplication is slightly different than the add or subtract. The number of rows in the first Matrix must equal the number of columns in the second. A Matrix can be multipied by itself to help reveal specific strong and weak areas.

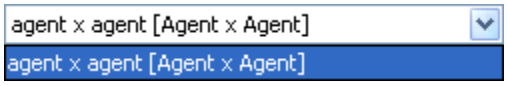
3. Select Graph 1:

   Next select the first graph you want to work with.



4. Select Graph 2:

   Then select the second graph to do the algebra on.



5. Add Graph:

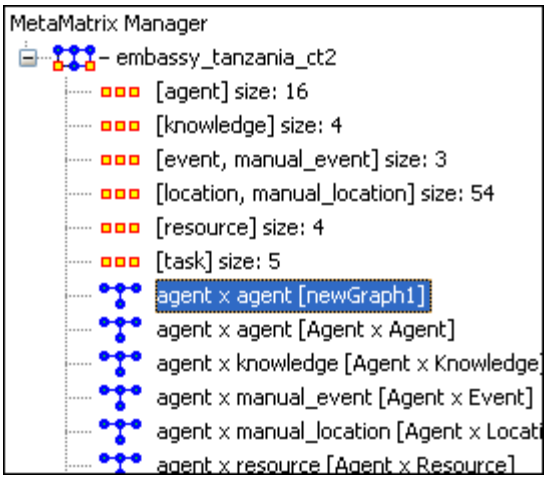
   If you wish, you can add additional graphs to the equation. Different selections in the previous choices will give you different options in each dropdown.

6. Enter a name for the new graph:

   When everything is set, type in the name for your new graph.

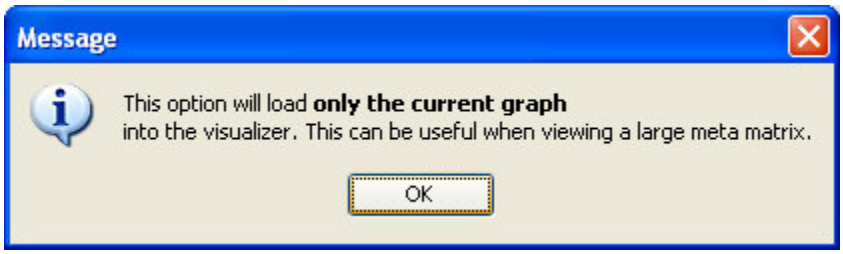
   Finally, select [OK] to create you new graph. You can then create more graphcs if desired. When you are done, Select [Cancel] to remove the dialog box from the screen.

   Your new graph will now appear in the box with your MetaMatrix. Next highlight the graph you just created.

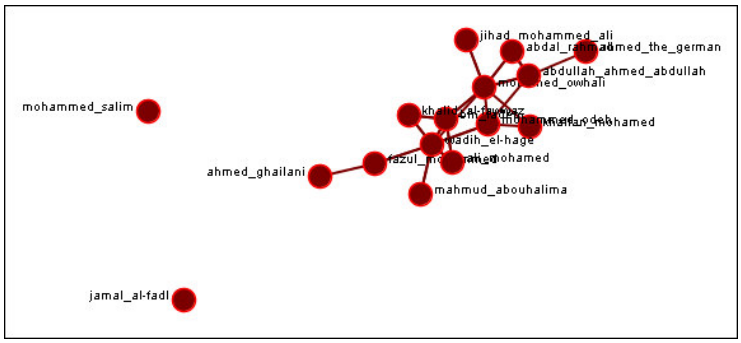


Next, select the [Visualize Only this Graph] button

You will get a warning box asking if you're sure you want to visualize only one graph. Select [OK] to run the Visualizer or press the red X to close the box.

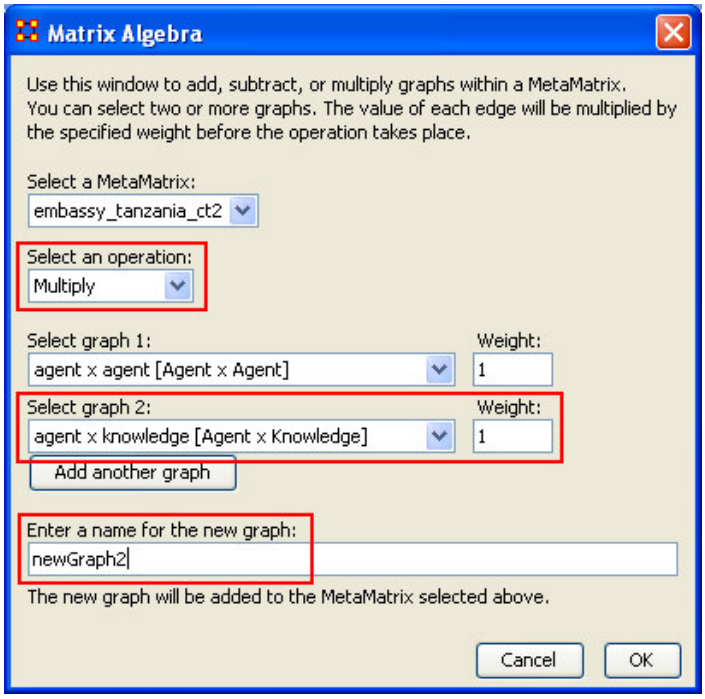


This will bring up the Visualizer displaying the graph. Your display will depend on the graph selected. In this particular example there are only Agents and Edges connecting Agents displayed in the Visualizer and the Legend.

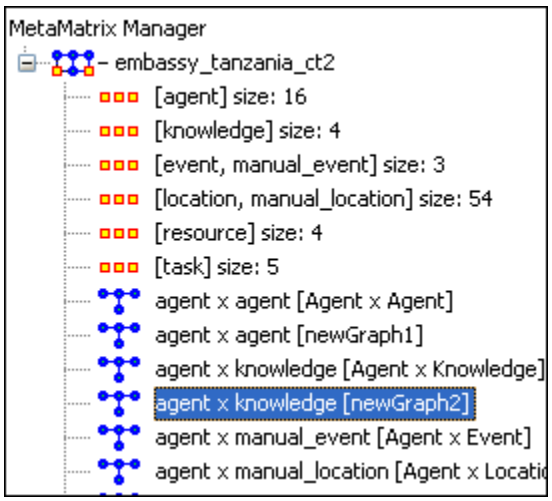


Now we'll create a second graph. This time we'll use the multiply operation, the second graph will throw knowledge into the mix.

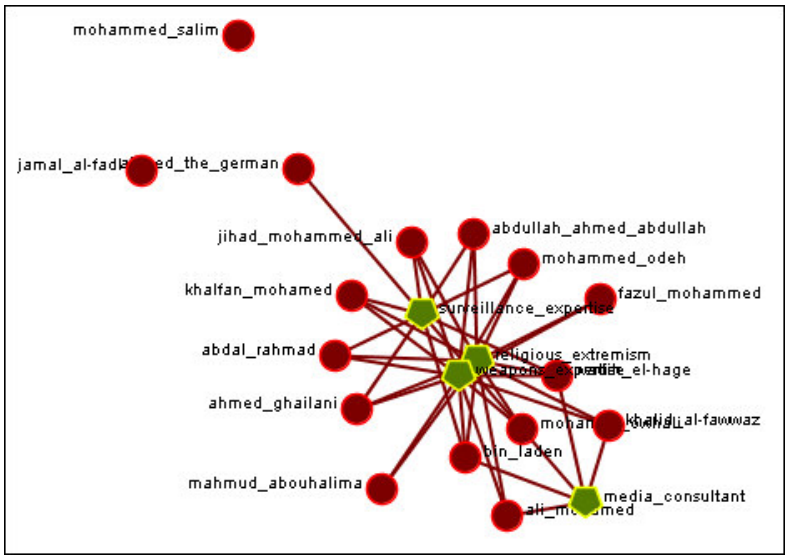
Note: Remember to name your file something different.

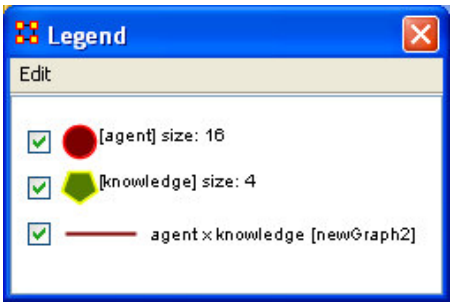


Highlight your newly created graph and select the Visualize Only this Graph once again and select OK in the dialog box.



This time, since a graph with knowledge was selected the Visualizer and Legend display both Agents and Knowledge and also the Edges connecting them all.

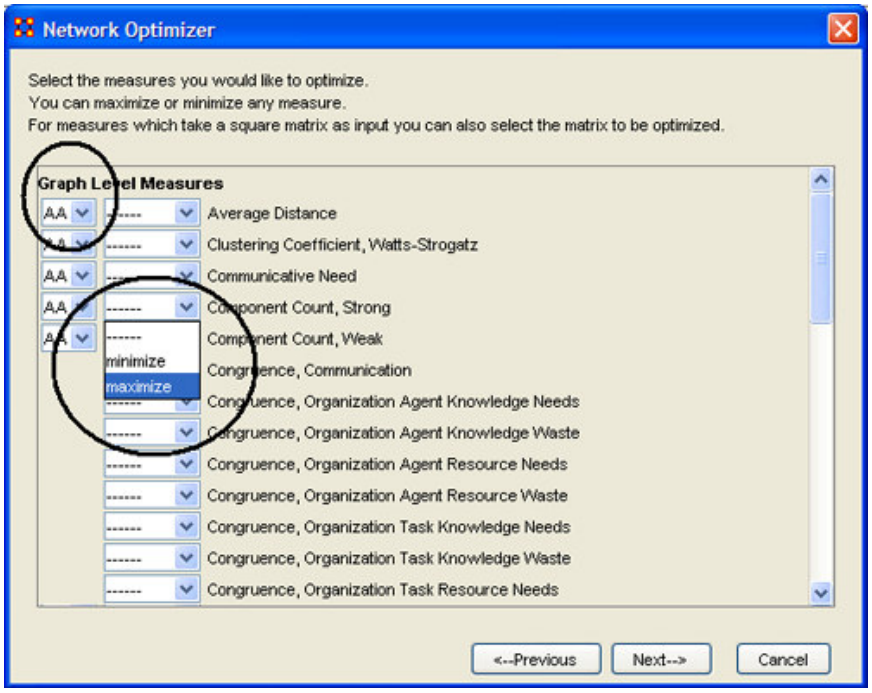




Monte Carlo Network Optimization

Monte Carlo, as the name implies, is a random optimization of your organization. To initiate a Monte Carlo Network Optimization, first select the measures you would like to optimize. Note that you can select multiple measures to be optimized simultaneously. Graph Level allows you specify the node type: Agent, Agent; knowledge, knowledge; Task, Task; Resource, Resource.

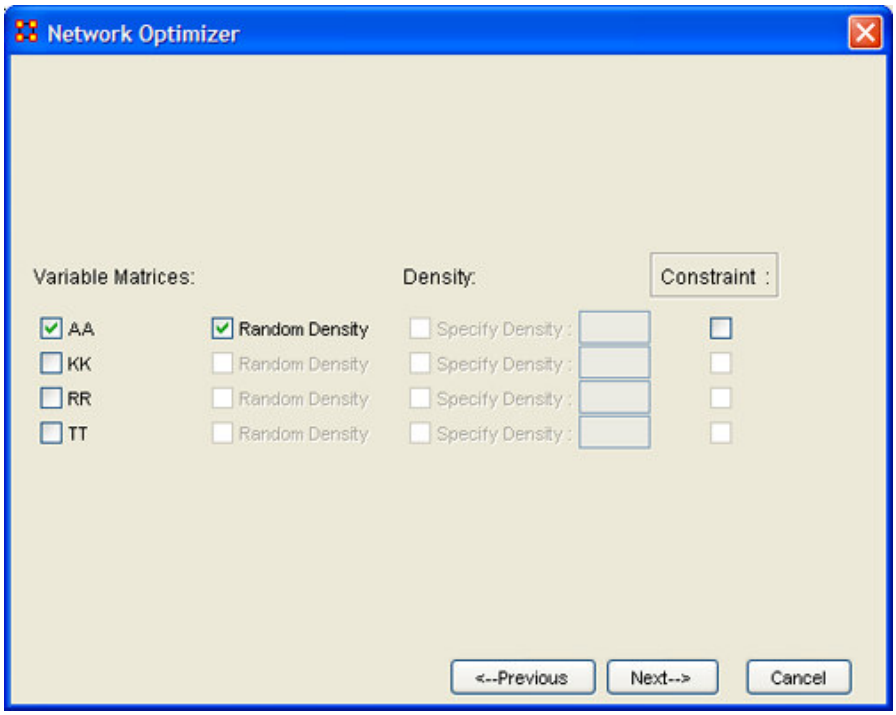
The black ellipses below highlight areas of the Network Optimizer window pane that enable you to customize your network optimization.



After selecting the measures you want, select the [Next] button.

The next screen presents you with the variables to choose along with the parameters for each.

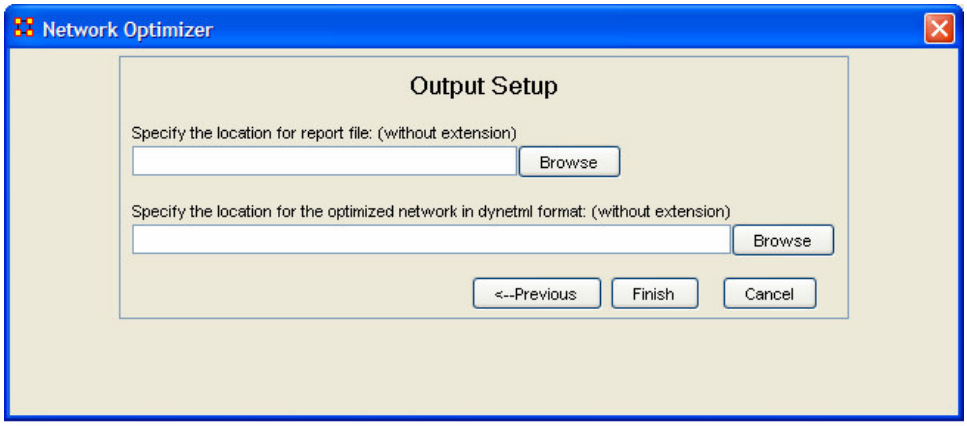
Please note: In the Monte Carlo method you can specify if you would like to run optimization with fixed or random density, and if you want to keep at least one non-zero element in every row of sub-matrices.



After making your selections select the [Next] button.

Specify the location for the data log file, without specifying an extension.

Select the [Browse] button(s) to select the directory you want to save the file(s).

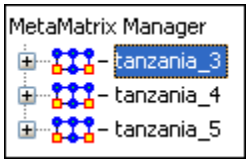


After selecting the destinations for your files select the [Finish] button.

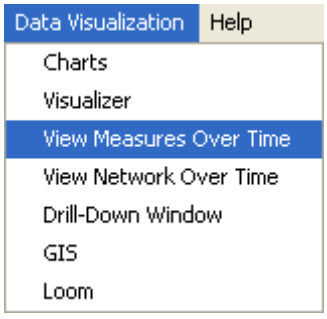
View Measures Over Time

Using the View Measures Over Time on a MetaMatrix allows you to see the affect over multiple MetaMatrices.

In this example I start out with three MetaMatrices loaded.

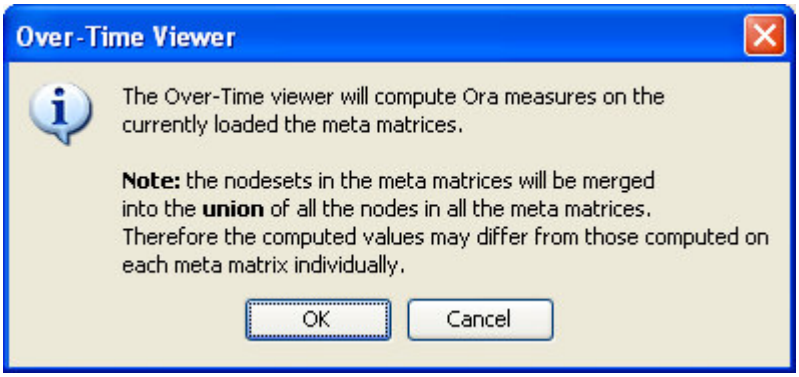


From the main menu select Data Visualization > View Measures Over Time



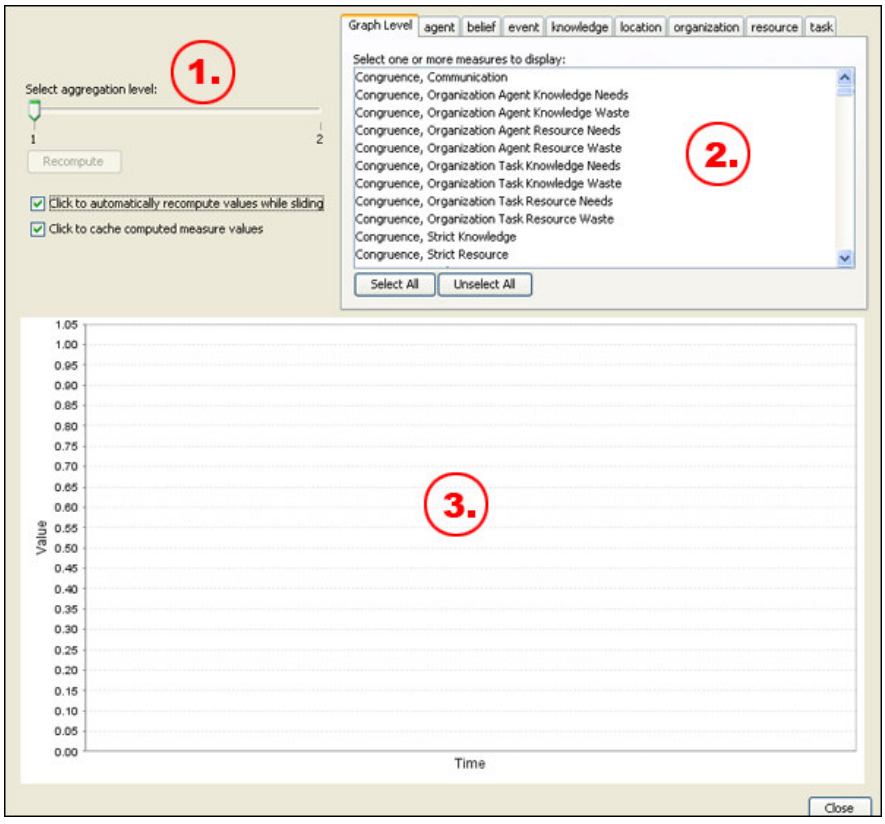
A dialog box will appear stating it will run on the currently loaded MetaMatrices. If you have any MetaMatrices you do not want in the calculation nit [Cancel] and remove them from Panel 1 before proceeding.

Once you have the MetaMatrices you wish to work with active, select [OK].



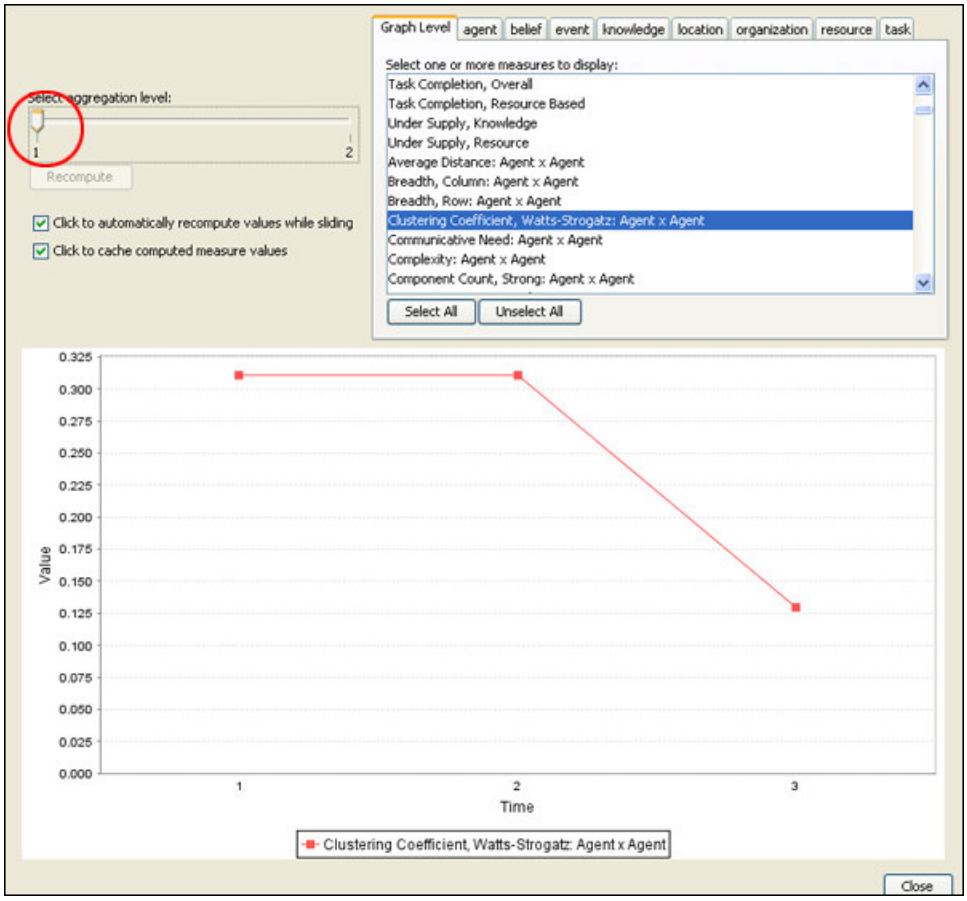
The View Measures Over Time box will appear. It consists of three sections:

1. Set Aggregation Level – A slider allowing you to choose between plotting all Matrices or just the beginning and end points.
2. The Measures selection tabs – Choosing a particular tab will reveal the measures that are capable of being run on that particular entity.
3. The Time / Value charting area – The area in which the plots will be plotted.

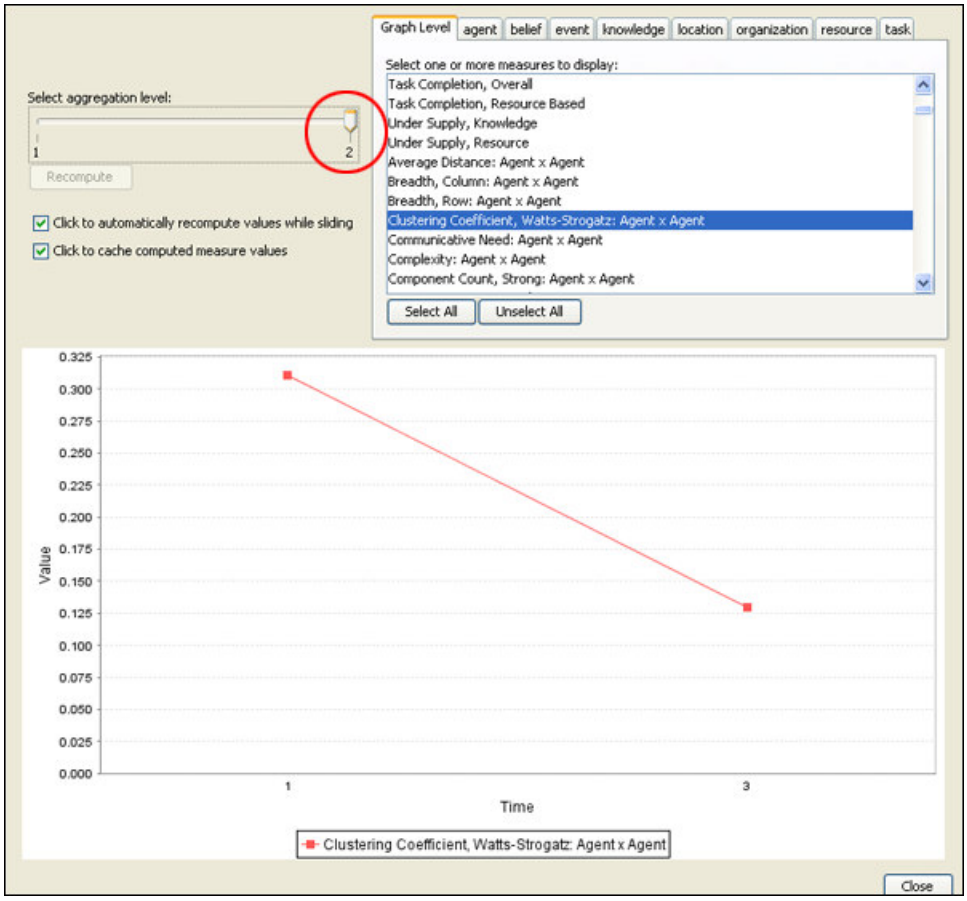


In this example I set the Aggregation Level to 1 and chose Clustering Coefficient.

The program then plotted the three points form the three MetaMatrices I had loaded, tanzaniz_3, tanzaniz_4, and tanzaniz_5.



Moving the pointer to Aggregation level 2 draws a line form the beginning value to the ending value.


Graph Level
agent
belief
event
knowledge
location
organization
resource
task
Select one or more measures to display:
Task Completion, Overall
Task Completion, Resource Based
Under Supply, Knowledge
Under Supply, Resource
Average Distance: Agent x Agent
Breadth, Column: Agent x Agent
Breadth, Row: Agent x Agent
Clustering Coefficient, Watts-Strogatz: Agent x Agent
Communicative Need: Agent x Agent
Complexity: Agent x Agent
Component Count, Strong: Agent x Agent
Select All
Unselect All
Select aggregation level:
1
2
Recompute
Click to automatically recompute values while sliding
Click to cache computed measure values
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
Value
1
3
Time
Clustering Coefficient, Watts-Strogatz: Agent x Agent
Close

Mental Model Reports

Single condensed files - per chunk, where a chunk is N days prior to or posterior to an event, excluding the day of the event

Number of concepts - Number of words (frequency count per email) *Carley and Kaufer, 1993*

Number of isolated concepts - Number of words that were coded as knowledge items, but did not get linked into statements *Carley and Kaufer, 1993*

Number of statements - Number of edges (frequency count per email) *Carley and Kaufer, 1993*

Density - Density of semantic network *Carley and Kaufer, 1993*

Set-Theoretic and qualitative (word-level) comparison of maps from before and after event

Concept Analysis - Concepts are classified according to whether they have high and low values for the measures: total degree centrality, betweenness centrality, and consensus.

Allusions - high degree, low betweenness, low consensus *Carley and Kaufer, 1993*

Buzzwords - low degree, high betweenness, low consesus *Carley and Kaufer, 1993*

Emblems - low degree, high betweenness, high consensus *Carley and Kaufer, 1993*

Factoids - low degree, low betweenness, high consensus *Carley and Kaufer, 1993*

Ordinary Words - low degree, low betweenness, low consensus *Carley and Kaufer, 1993*

Placeholders - high degree, high betweenness, low consensus *Carley and Kaufer, 1993*

Stereotypes - high degree, low betweenness, high consensus *Carley and Kaufer, 1993*

Symbols - high degree, high betweenness, high consensus *Carley and Kaufer, 1993*

Mental Model Reports Bibliography

- *Carley, Kathleen & Kaufer, David. (1993).* Semantic Connectivity: An Approach for Analyzing Symbols in Semantic Networks. Communication Theory, 3, 183-213.
- *Wasserman, S., & Faust, K.*. Social Network Analysis: Methods and Applications. New York and Cambridge, ENG: Cambridge University Press.
- Watts, D.J., Strogatz, S.H.(1998) Collective dynamics of 'small-world' networks. Nature 393:440-442.

Edit Menu

Copy Editor Values / Paste Editor Values

Used to create New Entity sets. The sets created can be identically sized (allowing you to paste an entire column in) or a smaller, subset allowing you to choose only a portion of the original set.

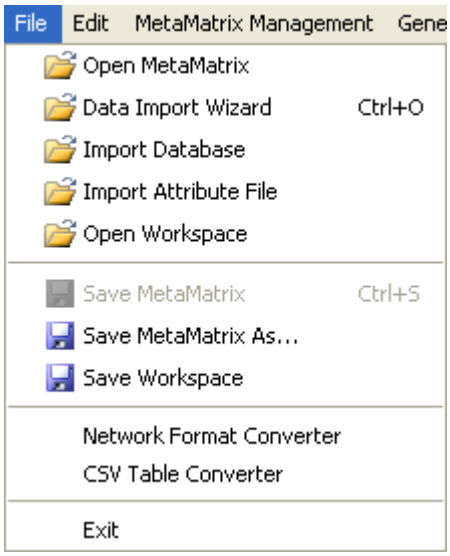
Copy MetaMatrix / Paste MetaMatrix

Used for quickly creating duplicate MetaMatrices to work with so your original Matrices remain unchanged.

Preferences

Contains settings for controlling the environment for working within ORA.

File Menu



Open MetaMatrix

This item opens up a single MetaMatrix with the following formats:

Dynetml (the native ORA xml format), .dl, .##h (UCINet), .CSV (comma separated values, Excel spreadsheet out), .txt (text files), .raw, .net (Pajek), .graphml, .stl (GMU model), .lo (pathfinder)

Data Import Wizard

This item contains additional options for importing MetaMatrices such as multiple file importing.

Import Database

An advanced feature for importing a database.

Import Attribute File

It is used to add an attribute into a file. The file selected must be in the CSV format.

Open Workspace

You may open an entire workspace that you were previously using. A workspace consists of a set of **MetaMatrix** files that were all open at the same time, and saved as a workspace.

Save MetaMatrix As…

Save the changes you've made in a MetaMatrix under a new filename.

Save Workspace

Save all active MetaMatrices into a Workspace which can be opened up at a later date.

Network Format Converter

The Network Format Converter takes files from one format and convert it to an ORA format.

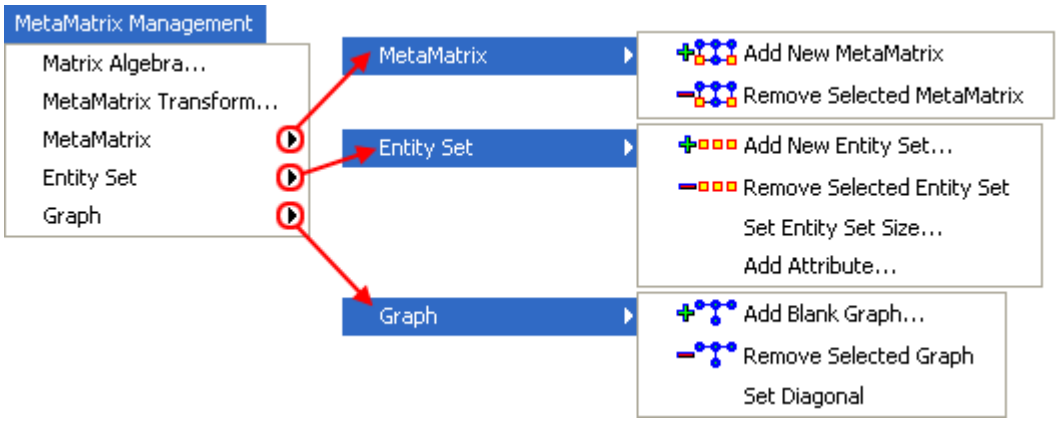
CSV Table Converter

Convert a .csv file into an ORA format.

Exit

Close the program and leave

MetaMatrix Management



These sets of menu items enable you to control the addition or removal of MetaMatrices, Entity Sets, and Graphs as well as adding Attributes to an Entity Set.

The Matrix Algebra and MetaMatrix Transform also create new Matrices, Sets, and Graphs but do it with Mathematical operations.

MetaMatrix Algebra… – Enables you to perform mathematical operations on two MetaMatrices.

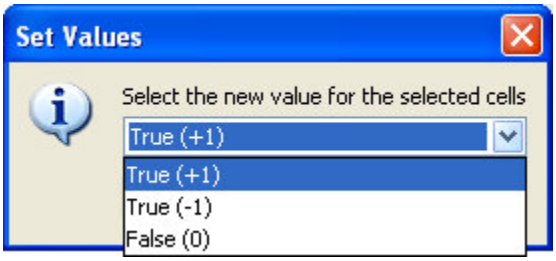
MetaMatrix Transform… – Tools which enable you to clean up a Visualizer display making it easier to read.

MetaMatrix – Used for adding or removing MetaMatrices from use.

Entity Set– Enables you to add an Entity Set, remove an Entity Set, change an Entity Set size, or Add an Attribute to an existing Entity Set. Depending on what you have selected different options may be greyed out.

Graph – Similar to Entity Set only working with Graphs. Enables you to either add or remove a graph.

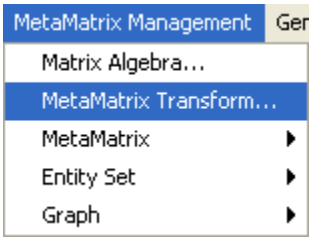
This also enables you to Set the Diagonal of a graph to either -1, 0 or +1. Useful for setting consistent values on an agent-by-agent graph.



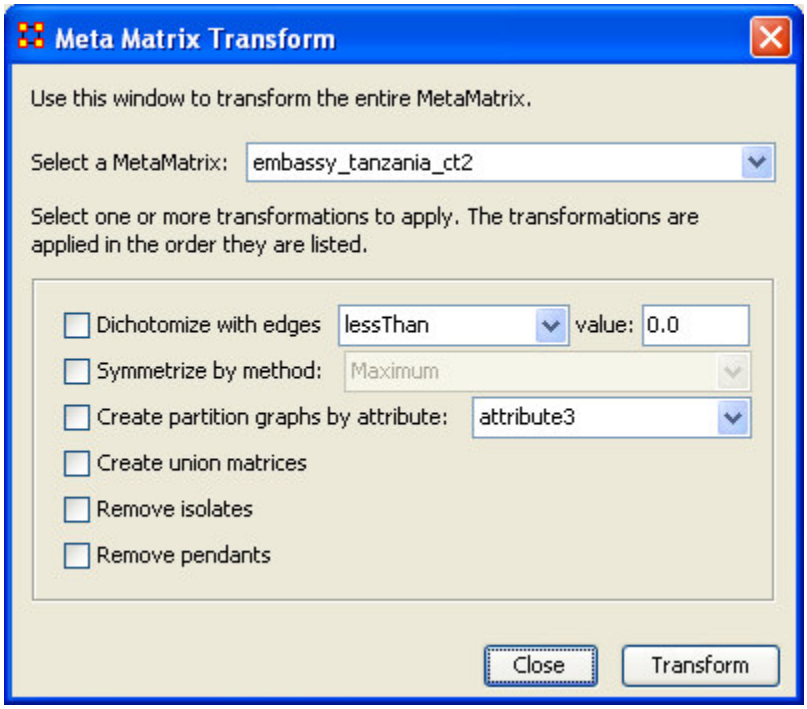
Matrix Transform

On some occasions the display in the Visualizer is too cluttered to make sense of. But there are ways to clean up the display in order to make it easier to view your data.

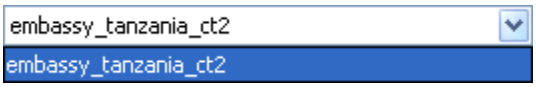
In the main menu select MetaMatrix Management > MetaMatrix Transform…



The MetaMatrix Transform dialog box will appear. It consists of two sections. The top section allows you to pick the MetaMatrix to work with. The bottom sections allows you to select how you data will be transformed.



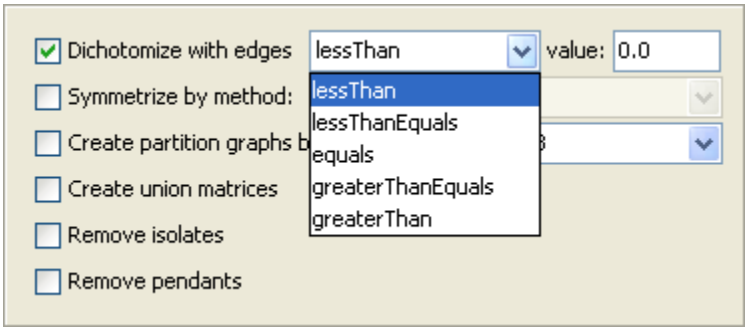
From the top section dropdown you can select which MetaMatrix you want to work with. It will list all the Matrices you currently have active.



Transformations

Dichotomize with Edges

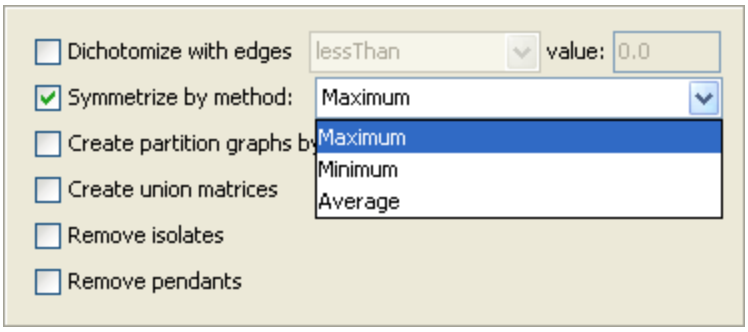
Dichotomize with Edges will turn valued data into binary data. First choose the type of measurement to determine your break point, lessThan, lessThanEquals, equals, greaterThanEquals, or greaterThan. Then input a value to use. By setting the dichotomizing value you can turn the value of the edges into a representation of the absence of presence of an edge.



Symmetrize by Method

Symmetrize is a tool that is used to turn directed or asymmetric network data into un-directed or symmetric data. All three methods use a pair of values from the upper and lower portions of the table (e.g. cell 1, 3 is compared to cell 3, 1)

- Maximum Compares the values and uses the larger of the values. This is using the strongest value
- Minimum Similar to Maximum only it uses the lower, or weaker, value.
- Average takes the two values and averages them.

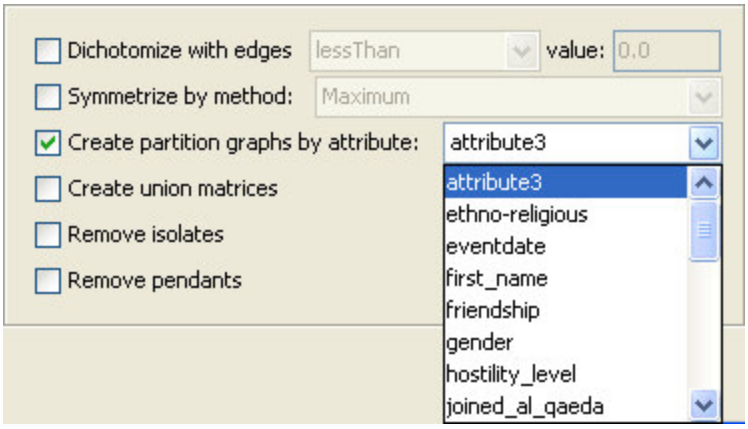


Create partition graphs by attribute:

This partitions the entity set according to the values of the specified entity attribute and then creates a collection of new graphs based on the partitioned entity set.

This kind of grouping is often done in network analysis to understand how some sets of entities are embedded in various social roles or how they interact within larger entities.

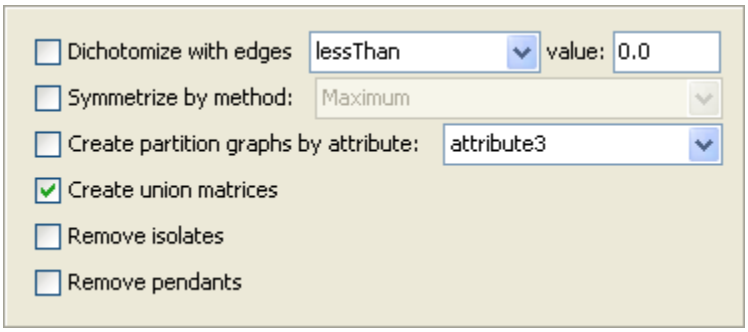
Example, if you have an Agent entity set that has a gender attribute for each entity that takes on values male and female, then using this feature four new Agent x Agent graphs would be created that contained edges from males to males, males to females, females to males, and females to females. No new entity set is created and no data is changed.



Create union matrices

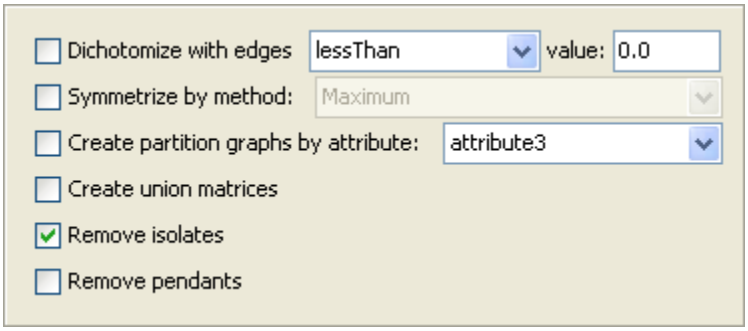
This creates new graphs that are the union of all graphs of the same type.

Example, if the meta-matrix had two Agent x Agent graphs, then using this feature a new Agent x Agent graph would be created that was the union of the two.



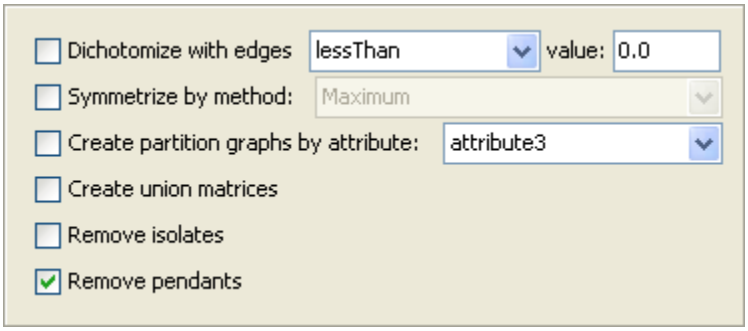
Remove Isolates

Selecting this checkbox will remove any isolates from the Visualizer.



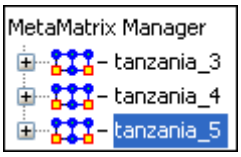
Remove Pendants

Selecting this checkbox will remove any pendants from the Visualizer.

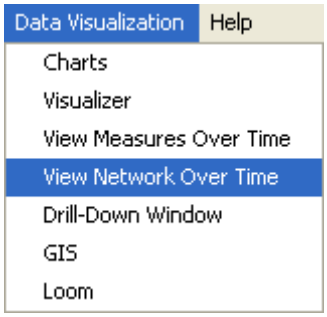


View Network Over Time

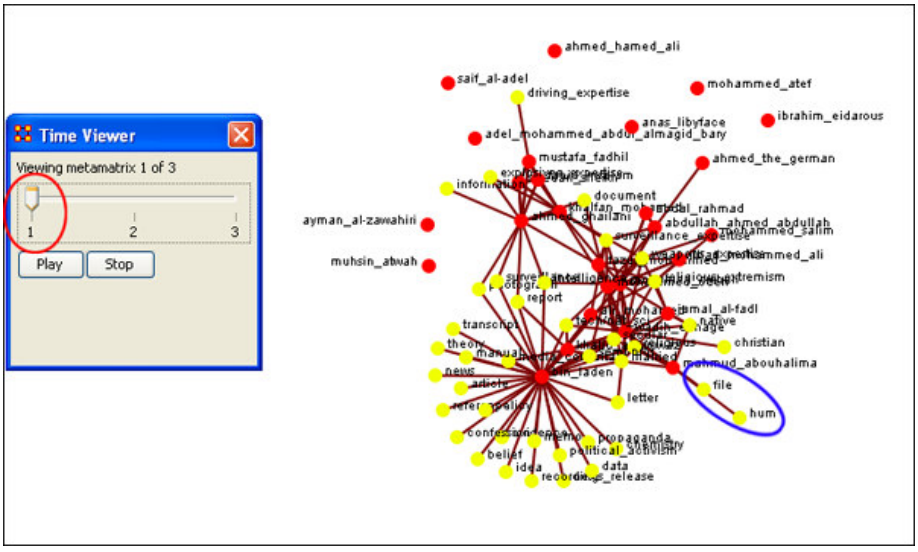
The View Network Over Time allows you to set up multiple Matrices that encompass various time frames and view them in succession. First, make sure you have two or more MetaMatrices active in the leftside panel.



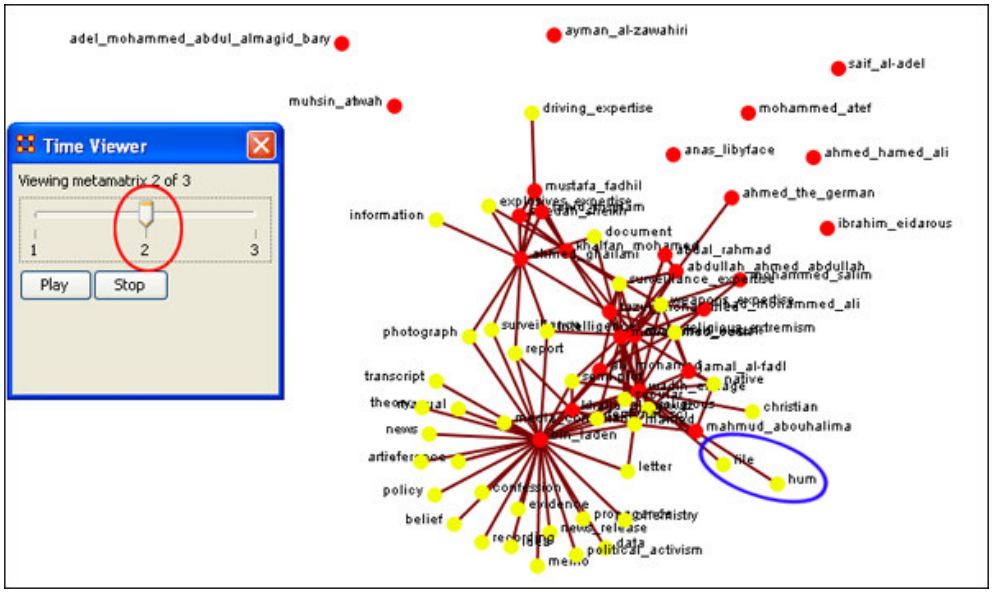
Now select form the menu Data Visualization > View Network Over Time



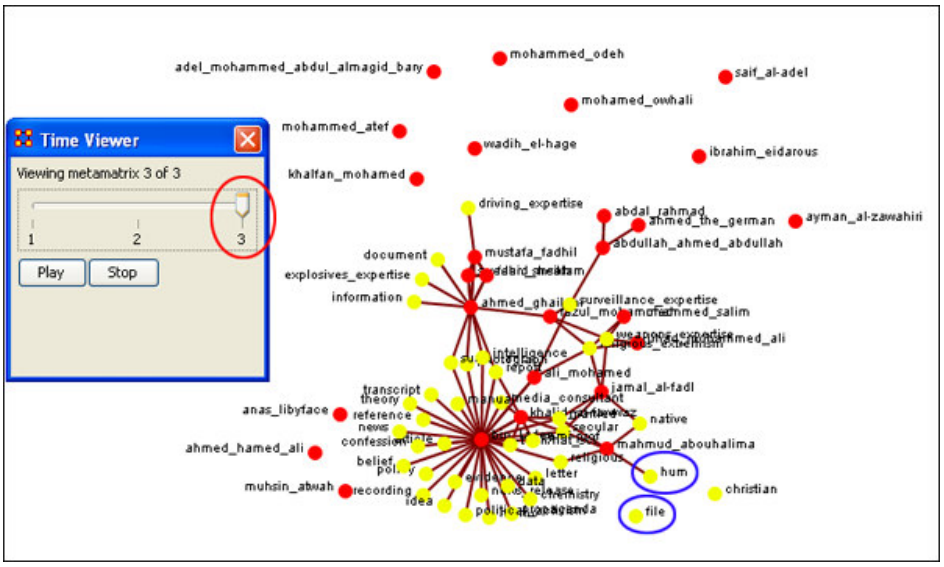
This will bring up the Visualizer along with the Time Viewer window. At the start the pointer starts at the first position. You can see in the blue ellipse that hum is connected singularly to file.



Moving the pointer to the second position you can see that hum is no longer connected to file but it still connected to another entity inside the cluster.



Moving the pointer to the third position causes hum to become a completely isolated entity. file is still connected to the cluster.

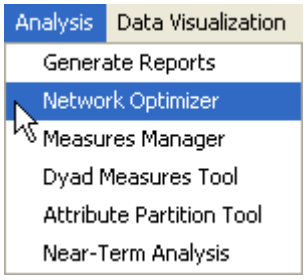


The Network Optimizer

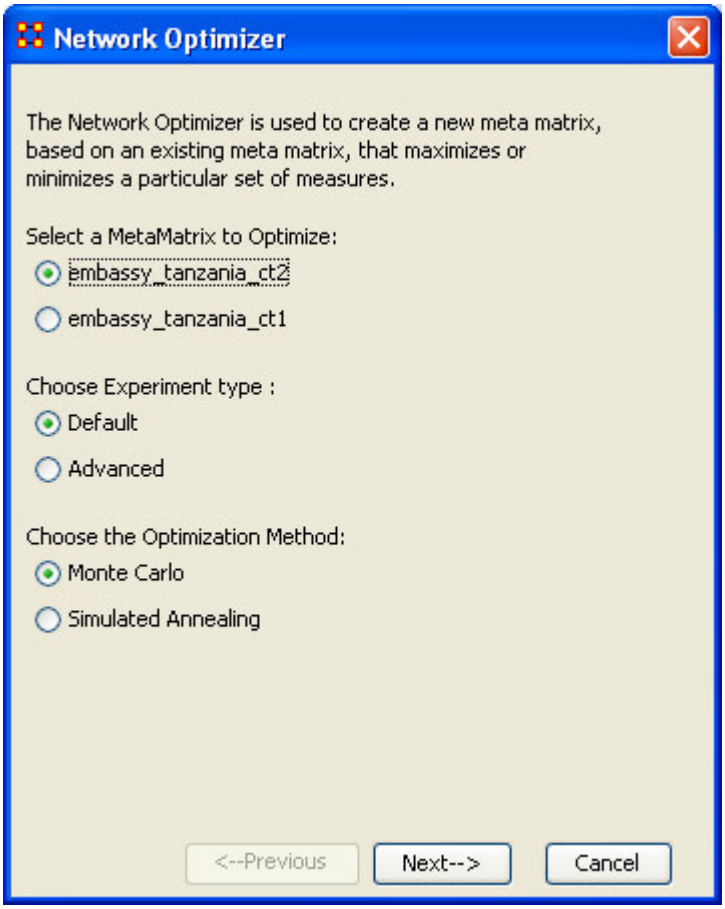
The Network Optimizer is a tool to maximize one or more measures within your organization. You can use this tool to change network variables and analyze your organization under various scenarios.

First, make sure you have a MetaMatrix loaded. Next, start up the Network Optimizer.

From the Main Menu select Analysis > Network Optimizer

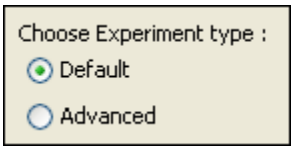


This will bring up the Network Optimizer wizard interface. Below is a screen shot of the Network Optimizer Interface.



Select the MetaMatrix you wish to optimize. You can choose from any MetaMatrix you have loaded into the MetaMatrix Manager. In this example, we will use the MetaMatrix *embassy_tanzania_ct2.xml*.

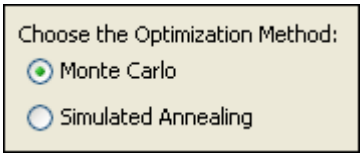
Choose Experiment Type



Default will make the optimum selections for you.

Advanced allows you to select various options.

Optimization Method



Monte Carlo creates a totally random network optimization based on a variety of variables. After selecting Monte Carlo, select the [Next] button.

Simulated Annealing allows for a more structured network optimization. Simulated Annealing requires a selection of certain variables that will run your network optimization in a more structured manner.

Preferences

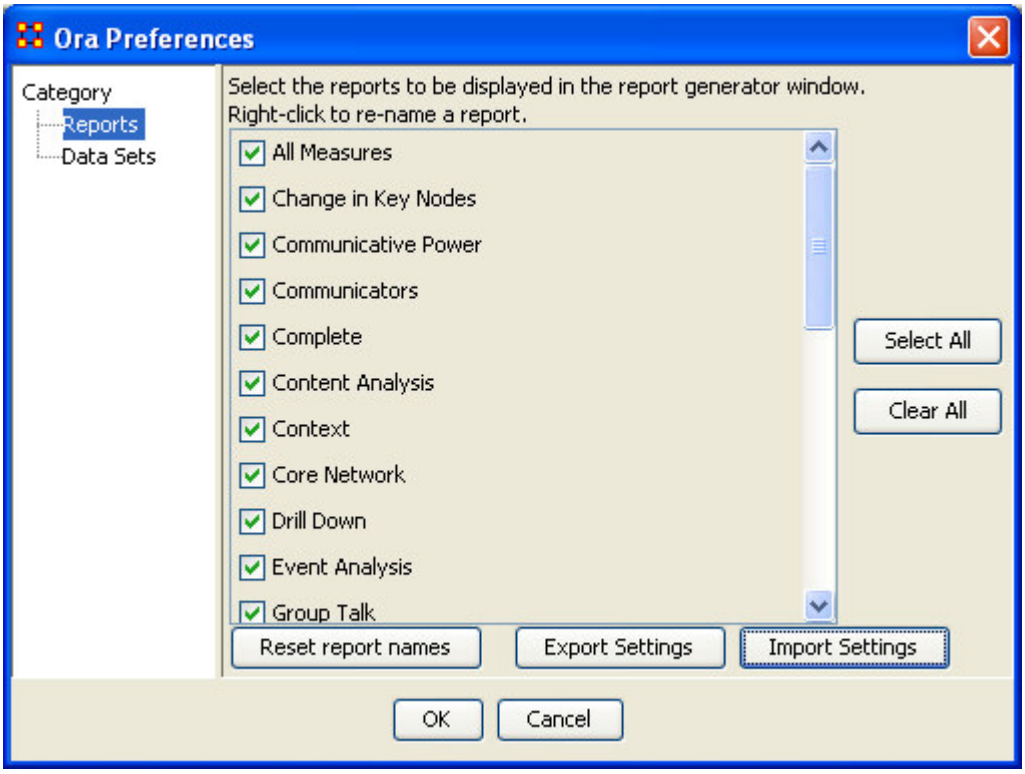
Setting up your environment

The ORA preferences allow you to group Reports and set of files to open automatically.

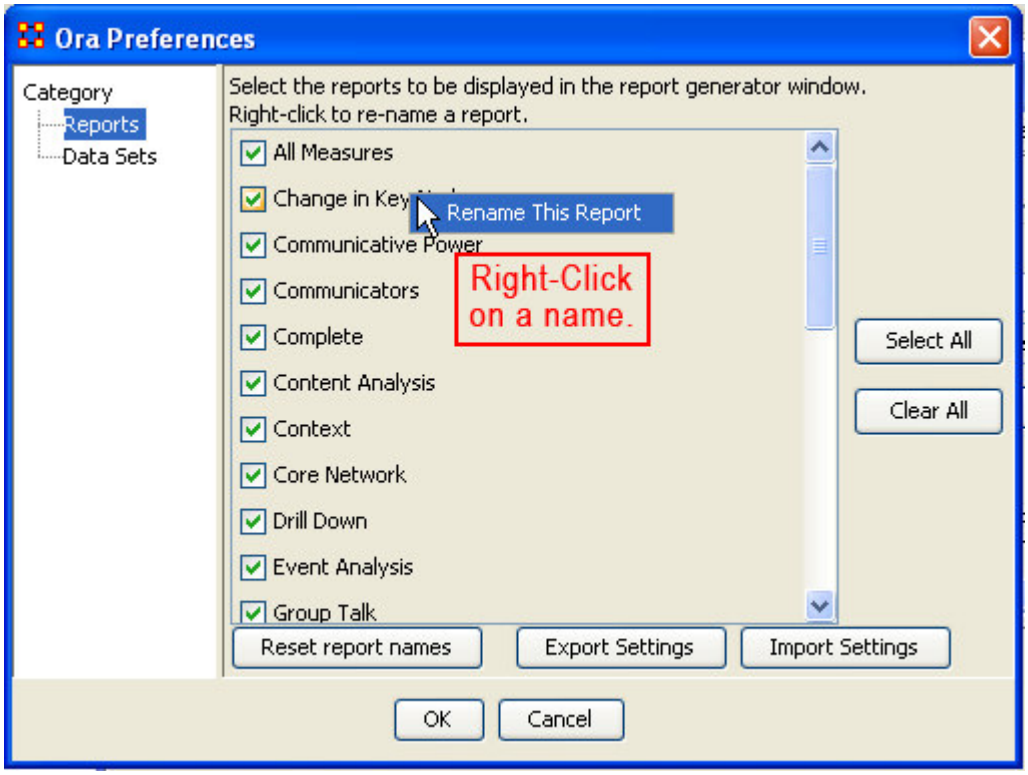
Reports

Reports – Export Settings – Datasets

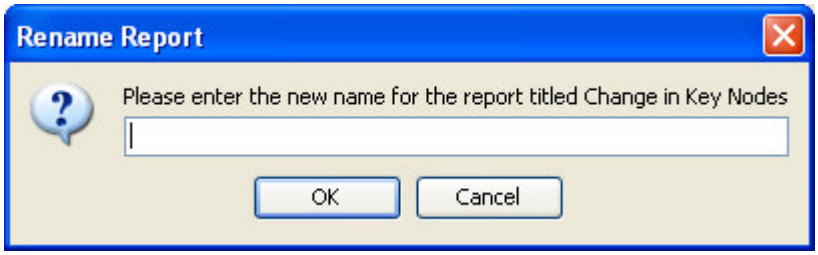
From this window you can Rename and Restore report names, Export settings for automatic loading, and Import previously created load sets. Below is the default preference window.



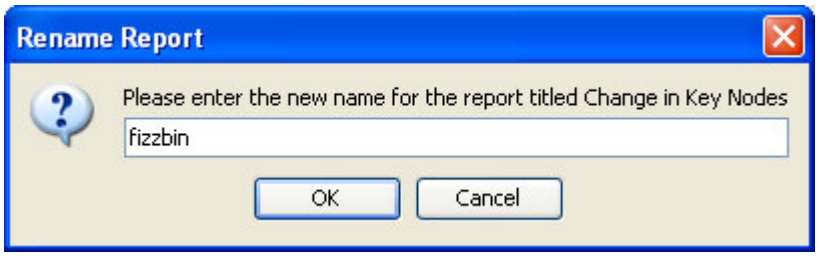
To rename a report Right-click on the name. A small box will popup, Rename this Report. If you wish to rename this report Left-click the box.



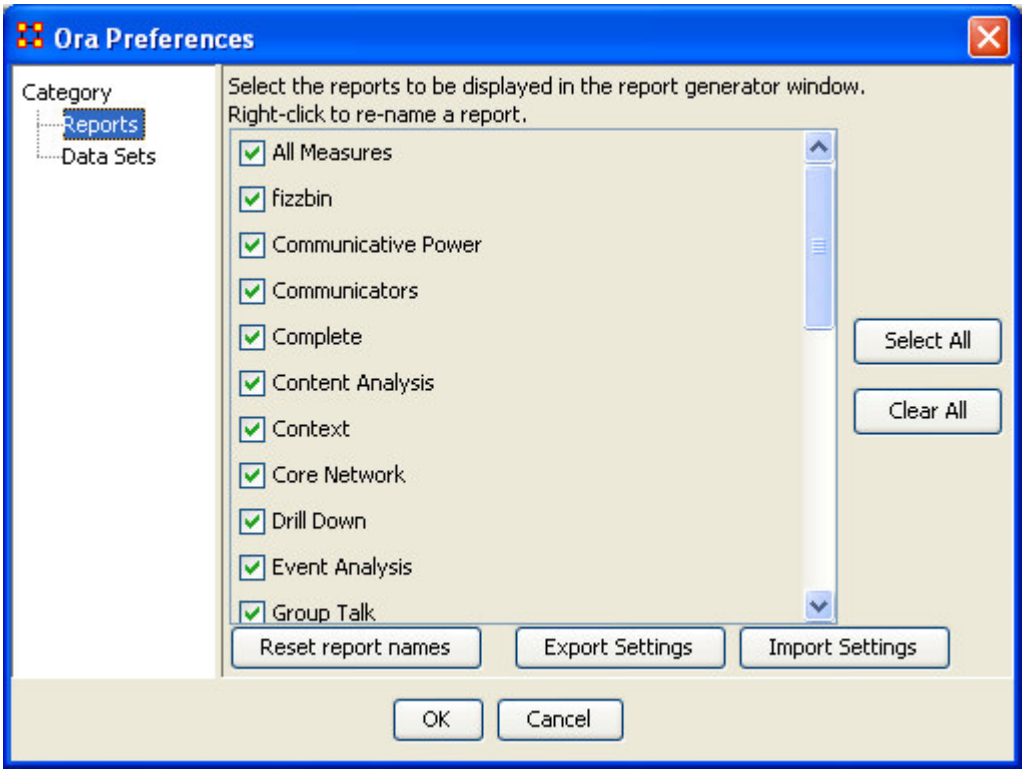
A dialog box will appear. Enter the name you want to rename the choosen report.



In this case I chose the name fizzbin.

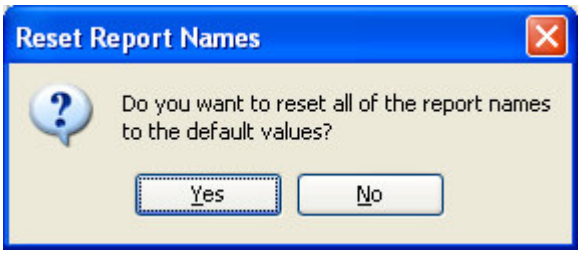


To rename the report select OK. The report formerly known as Change in Key Modes is now know as fizzbin.

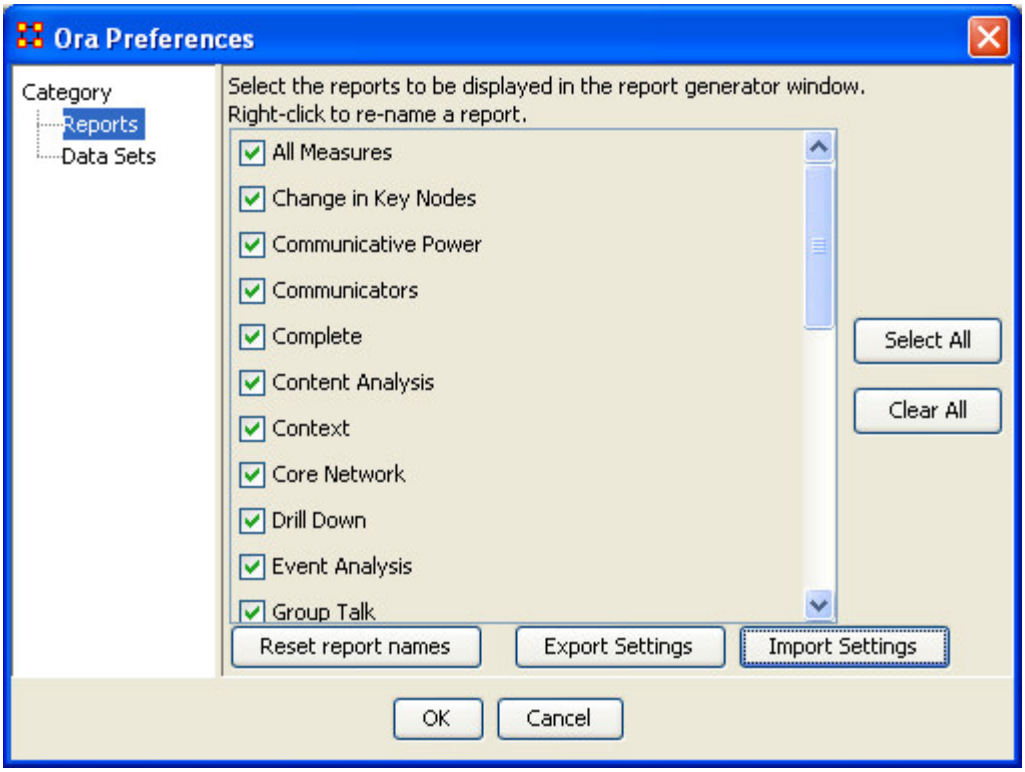


Now say you wish you hadn't renamed all those reports cause a name like fizzbin really doesn't make much sense. Select the button marker Reset report names. A dialog box will appear asking if you want to reset your report names.

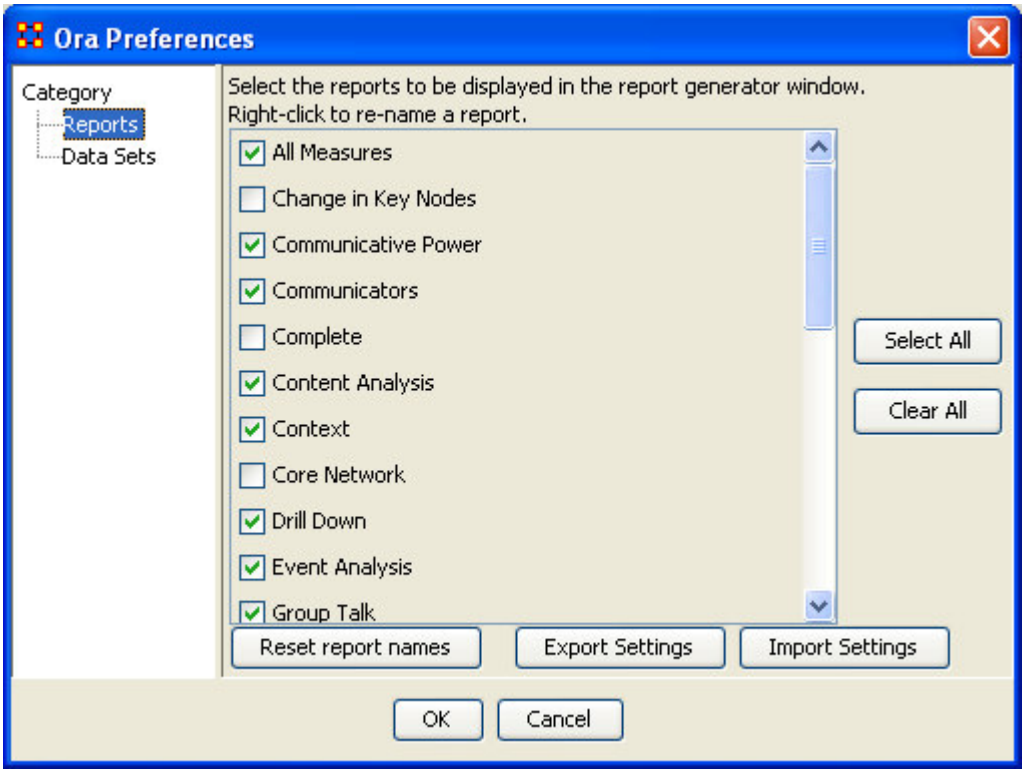
Note: Resetting report names reset ALL report names!



Now all your reports names are back to their defaults.



Now let's say that you know that you don't need ever single report to show up in the program. You can set which reports are visible and hidden. By unchecking the box to the left of the name the report will be invisible to the program.



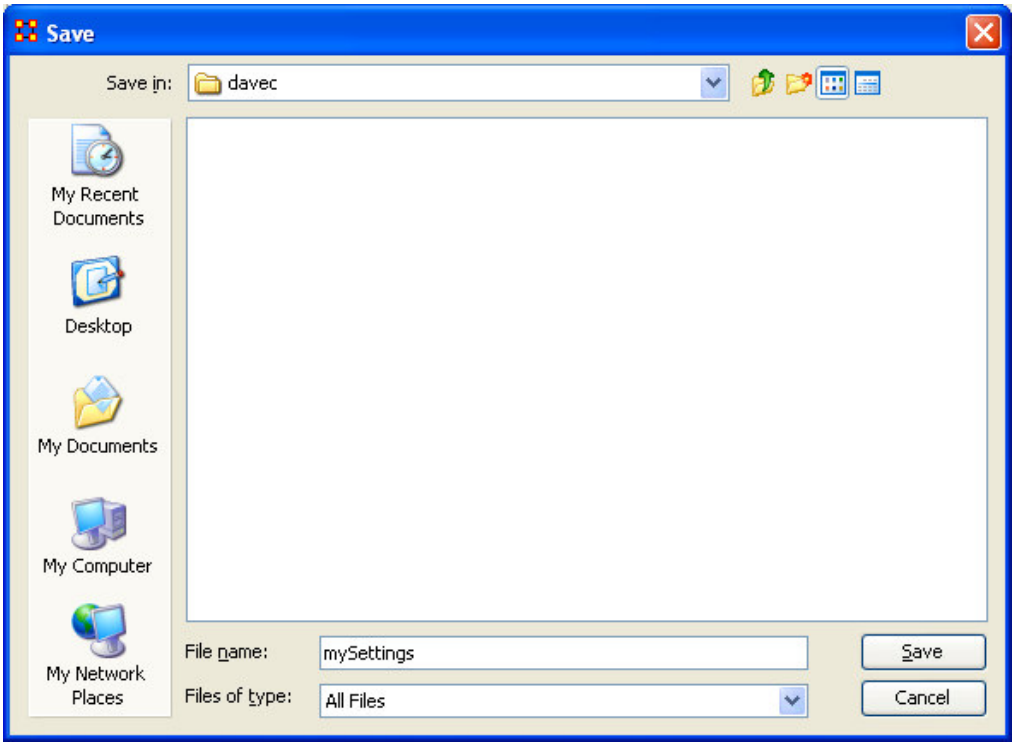
Export Settings

Reports – Export Settings – Datasets

After you've finally decided which reports you want visible (and invisible) and what you want all your reports to be called you can save this setting for future reference. So even if someone else changes report names or visibility settings you can call your personnel setting up and quickly resume your work.

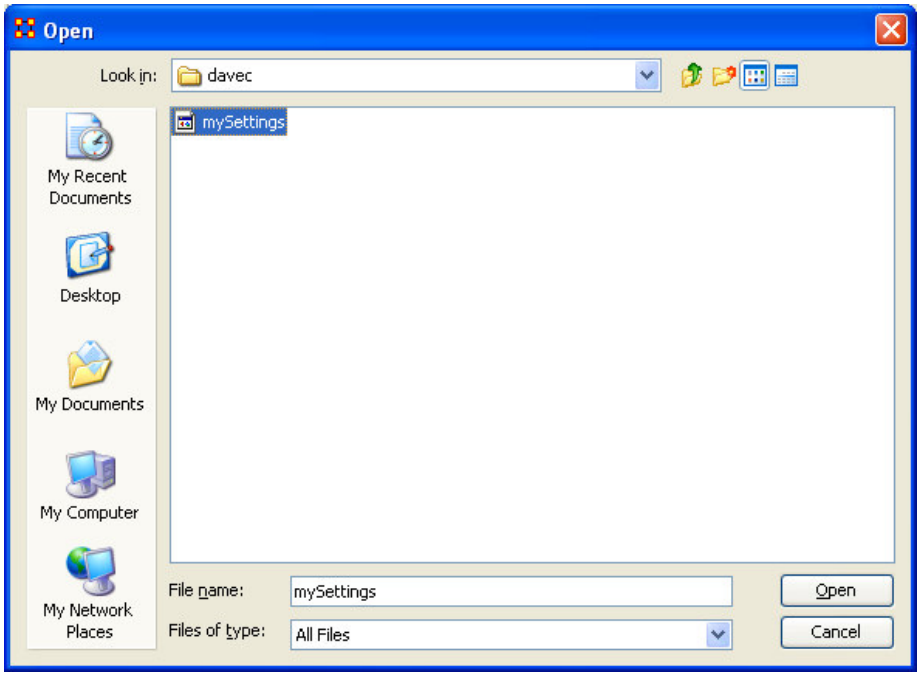
First select the Export Settings button at the bottom of the dialog box. This will bring up a second dialog box. Select OK to confirm this is the action you wish. If not, select the X in the top-right corner.

This will bring up a Save dialog box. Type in the name you want to save your settings at and select Save



So the next time you start up the program and names and settings have been changed you can select Import Settings, navigagte to the directory you saved you Settings file and have ORA reset the nanmes and visibility settings.

Save this file in a place you remember so you can call up your settings quickly.

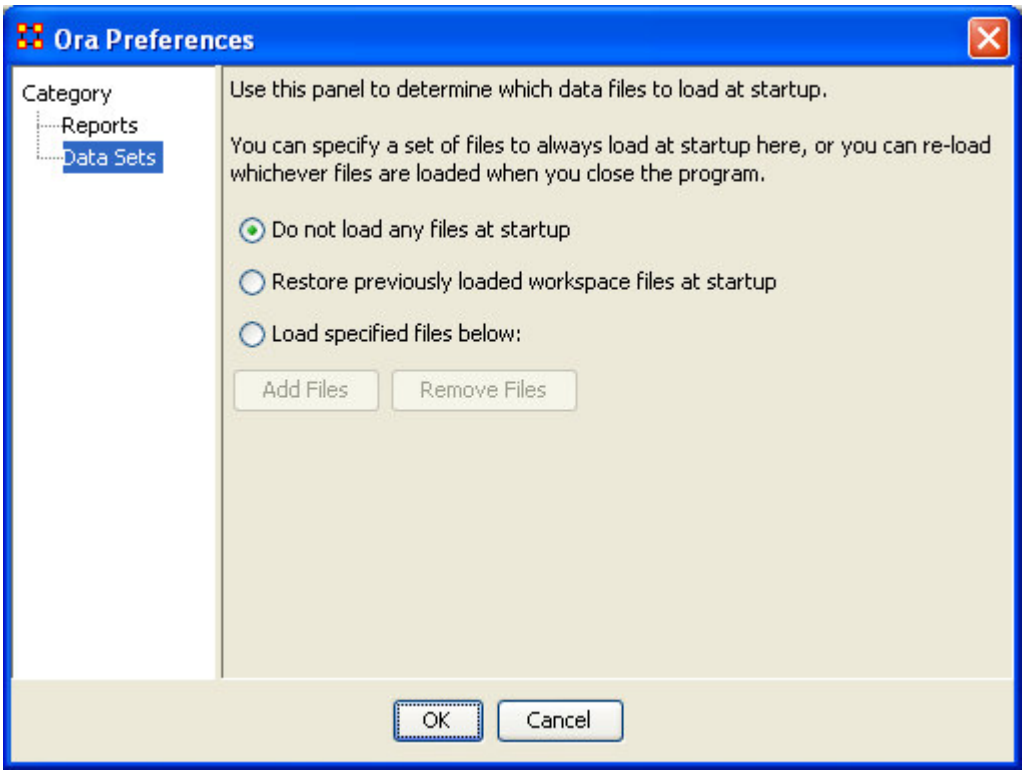


Data Sets

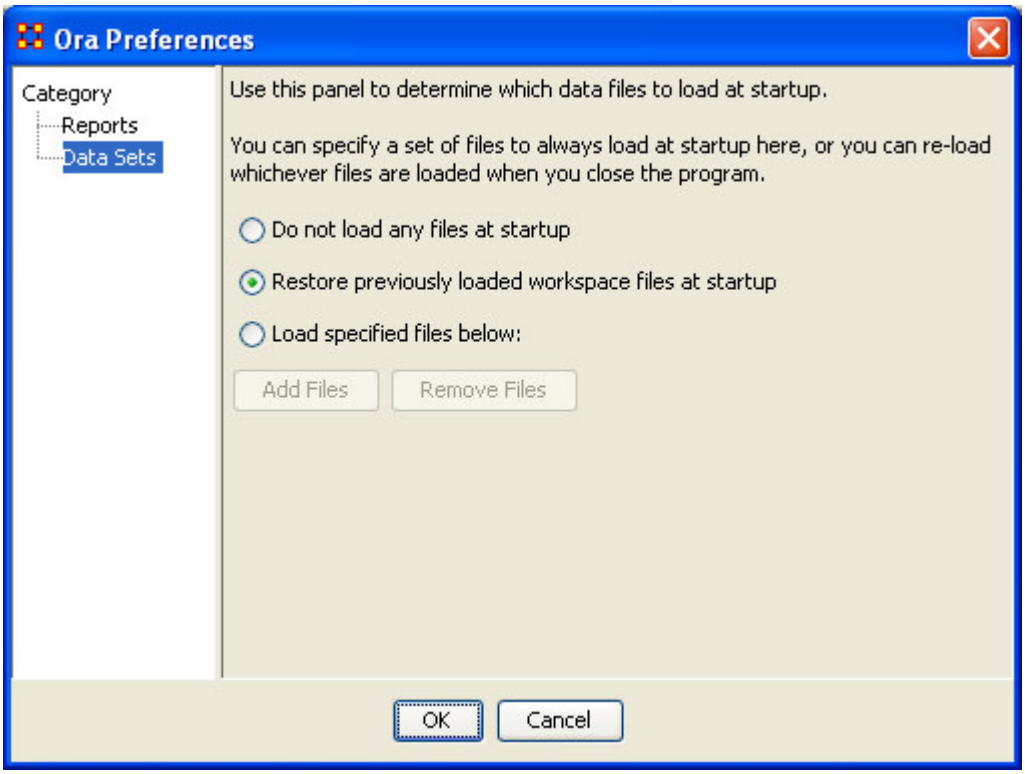
Reports – Export Settings – Datasets

This dialog box controls what MetaMatrices will load up during startup. There are three options.

1. Do not load any files at startup

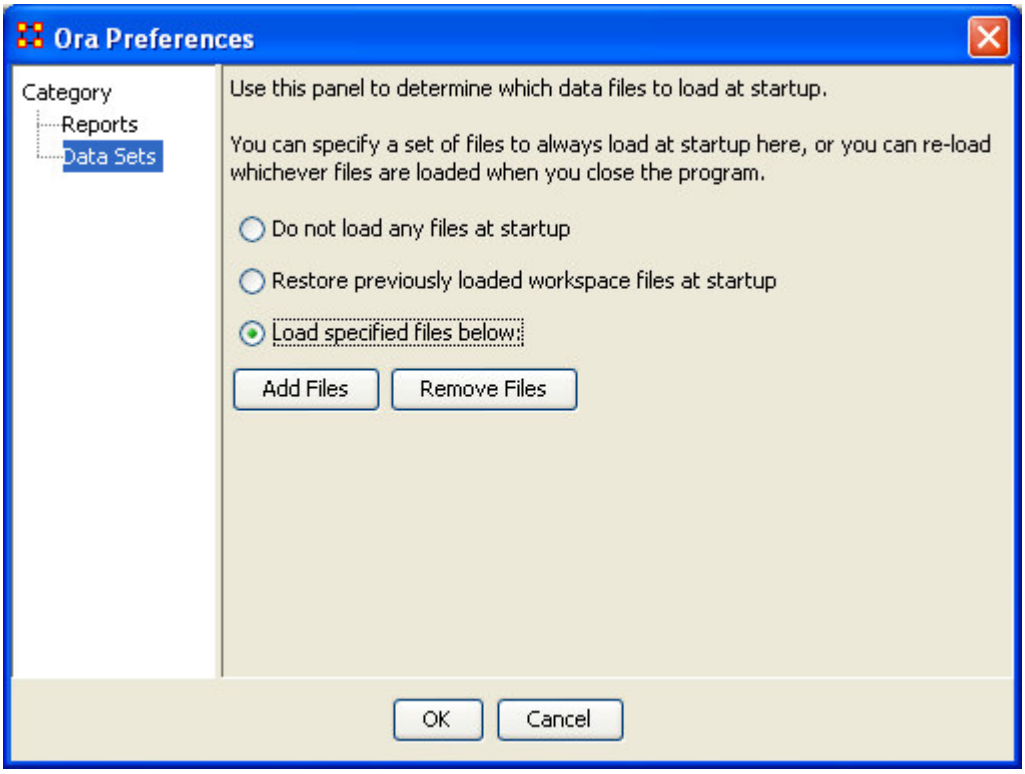


2. Restore previously loaded workspace

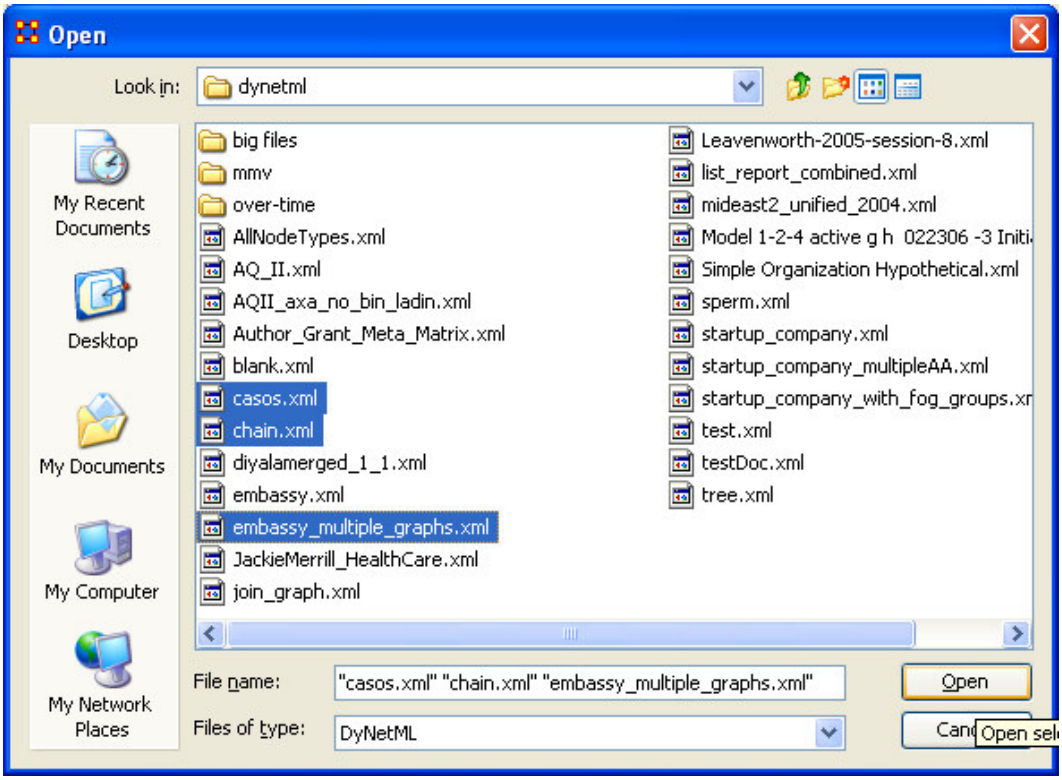


3. This option is a little more complicated.

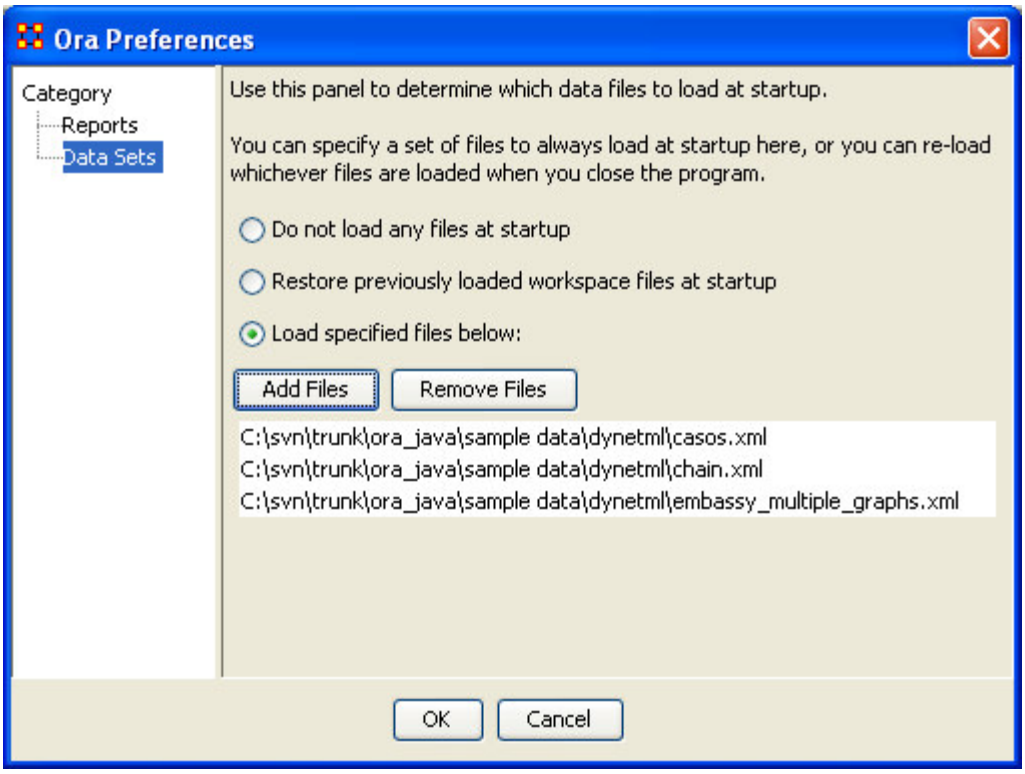
First select the Load specified files below radio button. Then select the Add Files button.



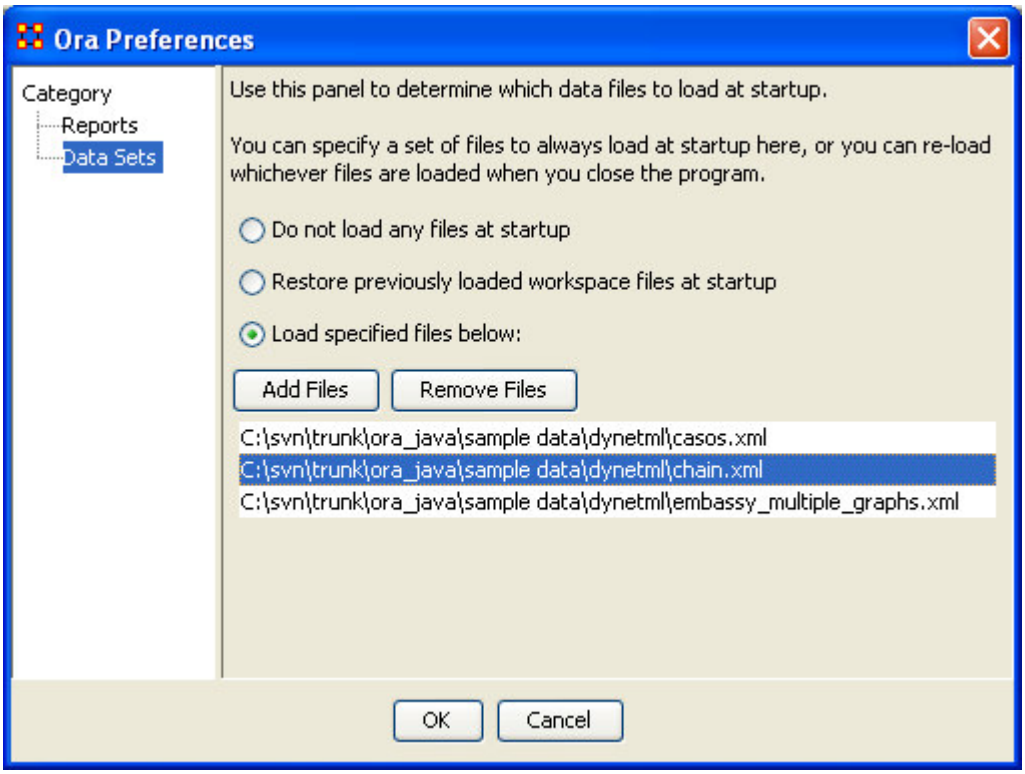
The Open dialog box will appear. Navigate to the directory of the files you want to automatically open. Select one or more files. In order to select more than one file press and hold the Ctrl key while selecting multiple files. You will see them appear in the File name text field. When you have selected all your files select the Open button.



In the Ora preference dialog box the files you selected will appear under the Add Files button.

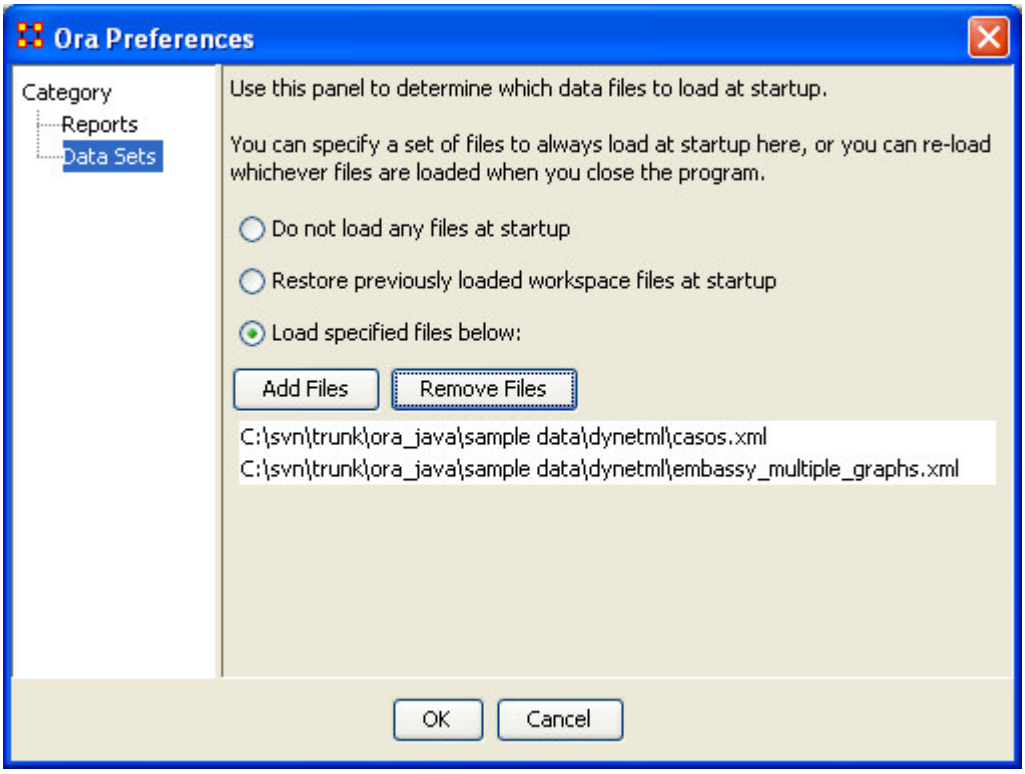


If at some time in the future you wish to delete one or more of the files you selected from automatically opening up on startup you can clear multiple files form the list. Select one or more files (pressing and holding the Ctrl key for multiple files. Then select the OK button.



You will be prompted to confirm your choice.

If you selected Yes then the selected files will be removed from the list of files to load at startup.

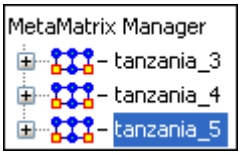

Ora Preferences
Category
Reports
Data Sets
Use this panel to determine which data files to load at startup.
You can specify a set of files to always load at startup here, or you can re-load whichever files are loaded when you close the program.
Do not load any files at startup
Restore previously loaded workspace files at startup
Load specified files below:
Add Files
Remove Files
C:\svn\trunk\ora_java\sample data\dynetml\casos.xml
C:\svn\trunk\ora_java\sample data\dynetml\embassy_multiple_graphs.xml
OK
Cancel

Randomize Existing Network

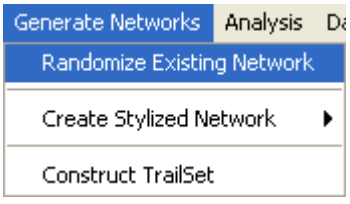
A random graph is obtained by starting with a set of n entities and adding edges between them at random. Different random graph models produce different probability distributions on graphs.

Creating a Random Graph

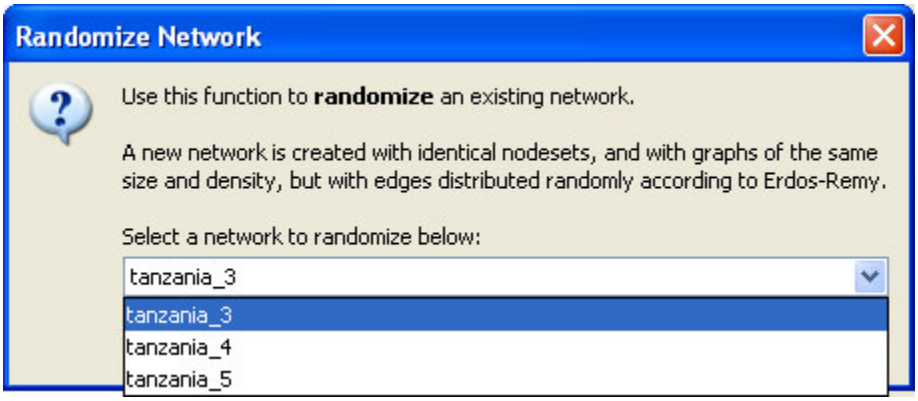
This function randomizes the edges in a MetaMatrix



From the menu select Generate networks > Randomize Existing Network

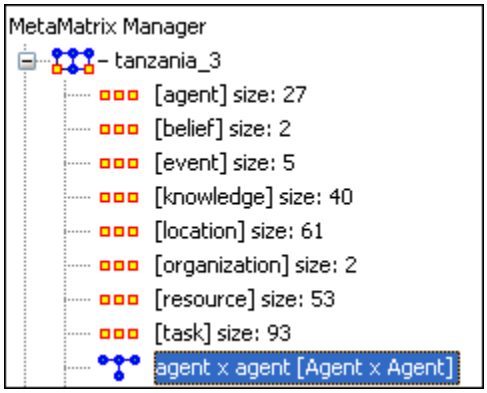


The dialog box and form the drop down menu select the MetaMatrix you want to randomize.

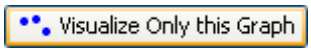


In leftside panel a new MetaMatrix will appear named after the selected Metamatrix and denoting it has been randomized.

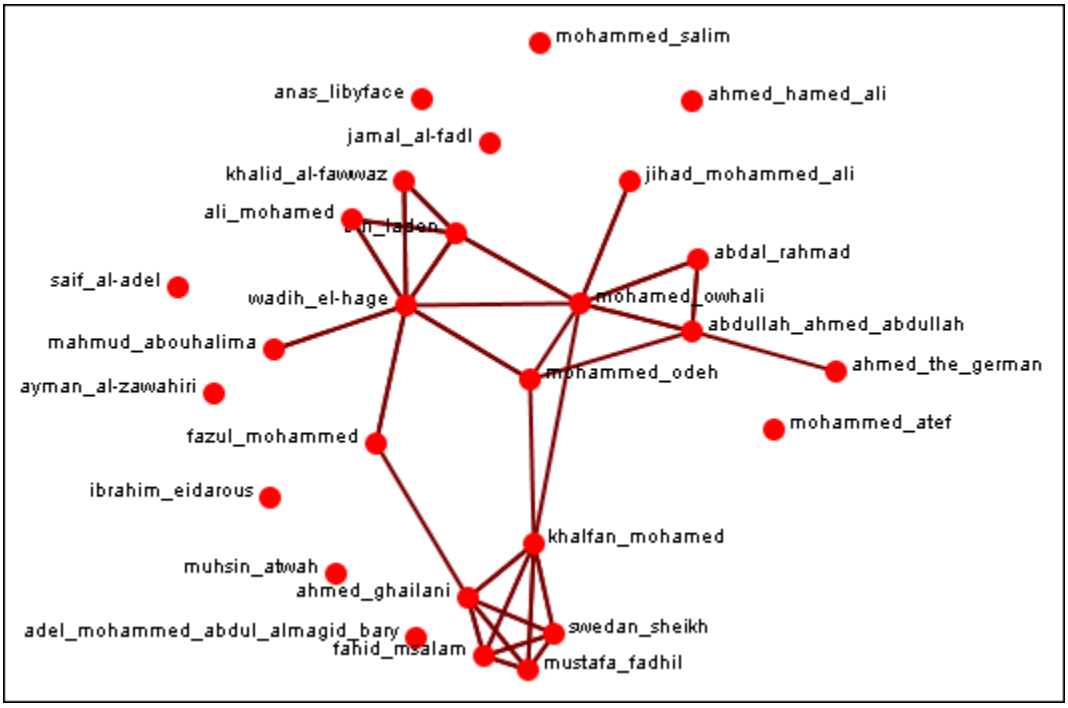
First, return to the original MetaMatrix and select a graph. Here I selected the agent x agent graph.



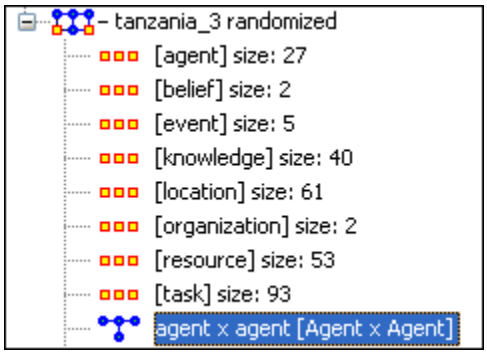
And select the Visualize Only this Graph.



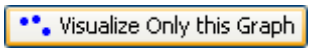
You will get a visualization of the agent x agent graph.



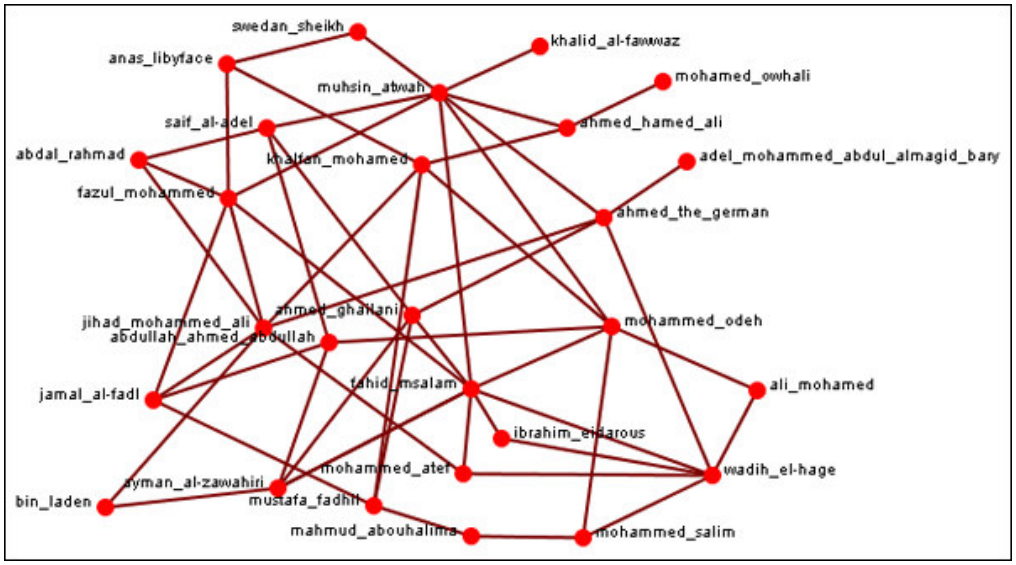
Now select the newly created randomized MetaMatrix you just created. Select the same agent x agent graph as per the original MetaMatrix.



And again, select the Visualize Only this Graph.



As shown in the Visualizer the edges have been randomized.


swedan_sheikh
khalid_al-fawwaz
anas_libyface
mohamed_owhali
muhsin_atwah
saif_al-adel
ahmed_hamed_ali
abdal_rahmad
khalfan_mohamed
adel_mohammed_abdul_almagid_bary
fazul_mohammed
ahmed_the_german
jihad_mohammed_ali
ahmed_ghailani
mohammed_odeh
abdullah_ahmed_abdullah
ali_mohamed
jamal_al-fadl
tahid_msalam
ibrahim_eidarous
wadih_el-hage
mohammed_atef
ayman_al-zawahiri
bin_laden
mustafa_fadhil
mahmud_abouhalima
mohammed_salim

ORA Reports

Reports

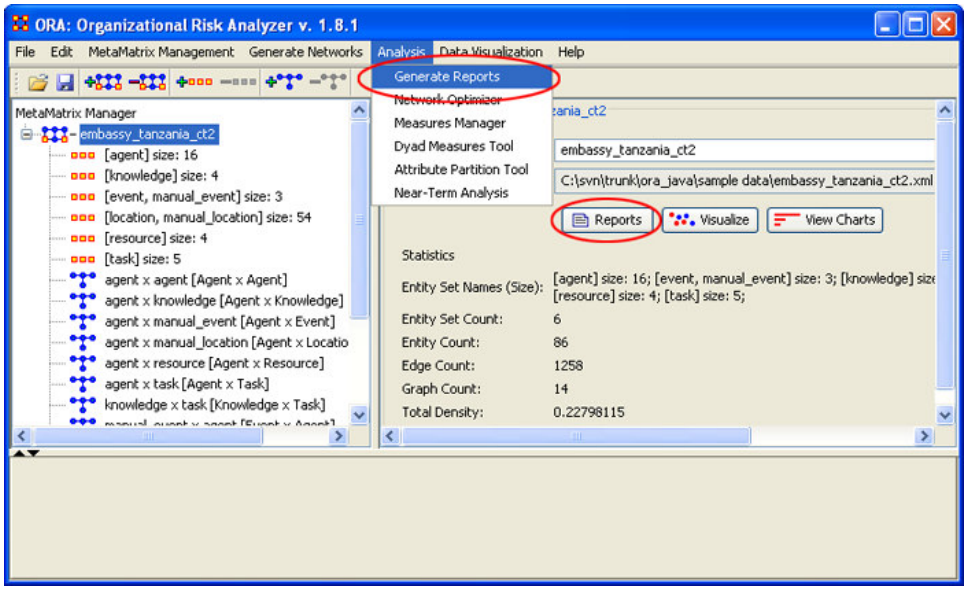
Reports – Reports Explained

Reports are one of ORA's core functions, which also include the Visualizer and Chart tools. You can access ORA reports from the main interface drop-down menu bar or from the Reports button, which should appear in the right panel of the main interface after you have loaded a MetaMatrix.

From the Main Menu select Analysis > Generate Reports; or

Select the [Reports] button

The red ellipses on the screen shot below highlight how to access ORA Reports from the main interface.



ORA Reports provide a computational tool to analyze data that comprise a network as representated by a MetaMatrix or MetaMatrices. They are driven by a variety of key measures proven useful to researchers in the analysis of networks.

Reports Explained

Reports – Reports Explained

All Measures - Runs a collection of measures and categorizes the output according to risk categories. Each category analyzes a particular aspect of the Meta-Matrix structure.

Belief - The Belief report contains the most common beliefs shared by most people, the beliefs with the highest GINI coefficient, the most strongly held beliefs, the most likely to change beliefs, the most neutral individuals, and the most opinionated individuals.

Capability - This report is used to assess an individuals' and organizations' capability to perform tasks.

Change in Key entities - Analyzes the changes over time of the agents that score the highest in measure values.

Communicative Power - Analyzes one or more mental map models, classifying concepts according to their values for selected measures.

Communicators - Analyzes the communication network (agent by agent) and gives high level statistics on its structure.

Complete - Computes all network analysis measures.

Context - Compares measured values against various stylized forms of networks in an effort to characterize the networks topology.

Core Network - Computes the core network and reports general statistics.

Drill Down - Computes the drill down from a selected organization and then to a selected agent

Event Analysis - Computes the central events with respect to other network entities.

Group Talk - Analyzes the relationships between agent and knowledge.

Immediate Impact - Computes the key actors of a network, and then isolates them individually to determine the effect on measure values.

Influence Net - Displays the influence network and gives high level statistics on its structure.

Intelligence - Identifies key entities and groups who by virtue of their position in the network are critical to its operation.

Located Subgroups - Identifies the subgroups present in the network using various grouping algorithms.

Location Analysis - Computes the central locations with respect to other network entities

Management - Identifies over and underperforming individuals and assesses the state of the network as a functioning organization.

Potential Errors - Detects potential errors in agent to agent interactions based on the expected interactions from cognitive similarity and expertise.

QAP Analysis - Computes QAP Correlation and Regression (Dekker and Y-Permutation methods) on input matrices.

Semantic Network - Analyzes one or more mental map models, computing the central graphs and key concepts and statements.

Shortest Path - Computes the shortest path between two entities and general statistics on the paths. The Sphere of Influence on each entity is also computed.

Simmelian Ties Analysis - Calculates the number of Asymmetric, Sole-Symmetric, and Simmelian ties in all Agent by Agent and Organization by Organization graphs and computes the standard measures on them.

Sphere of Influence - For each individual, identifies the set of actors, groups, knowledge, resources, etc. that influence and are influenced by that actor.

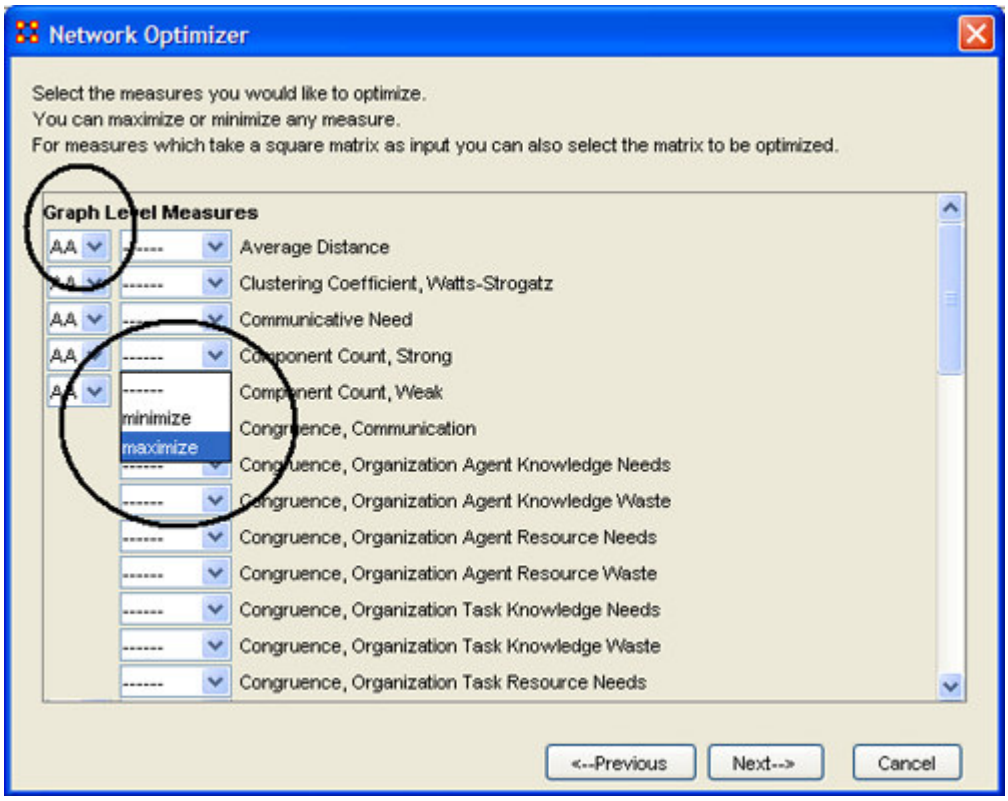
Standard Network Analysis - Calculates the standard network analysis measures (degree centrality, betweenness, centrality, etc.)

Trails - Analyzes the trails that an entity class makes through another entity class; for example, how vessels pass through ports.

Version Test - Recomputes the measures contained within the DyNetML file and compares them with the existing measures. This is a diagnostic tool.

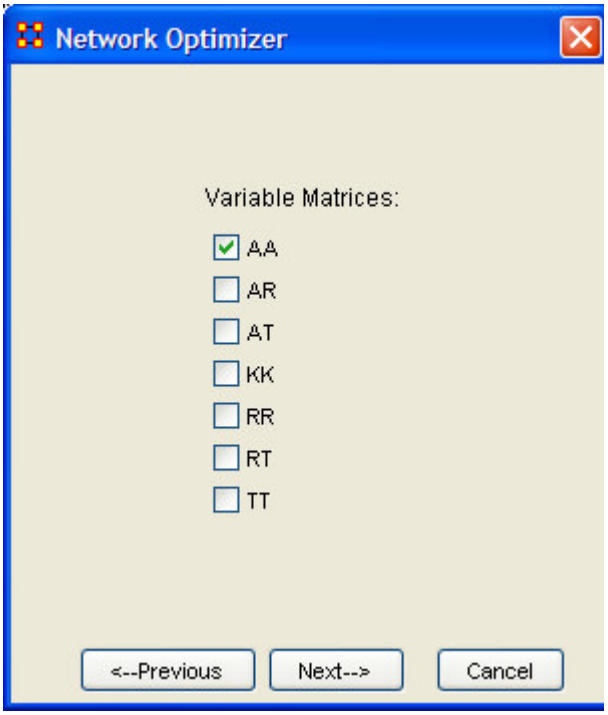
Simulated Annealing Network Optimization

Select the measures you would like to optimize. Note that you can select multiple measures to be optimized simultaneously. Graph Level allows you specify the node type (Agent, Agent; knowledge, knowledge; Task, Task; Resource, Resource). The black circles below highlight the areas of the Network Optimizer window pane that allow you to customize your network optimization.



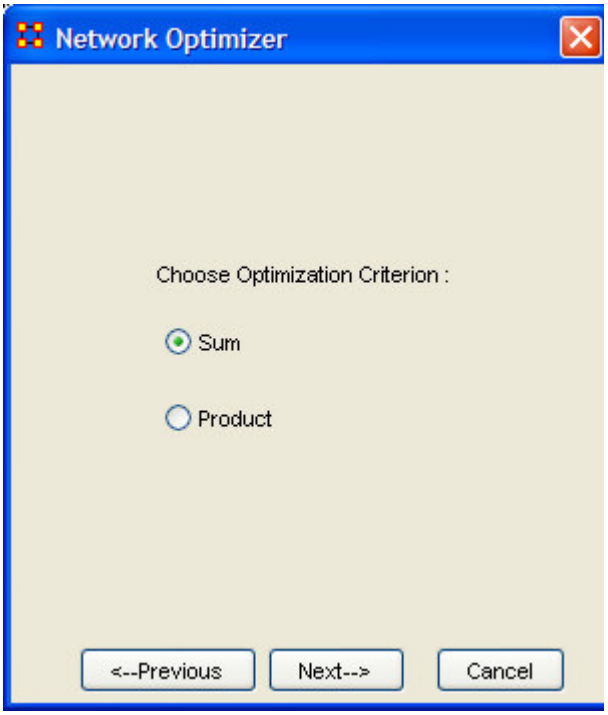
After you have selected the measures you are interested in optimizing, select the [Next] button.

Choose the sub-matrices that to be varied during the optimization process. If you chose Monte Carlo method you should also specify if you would like to run optimization with fixed or random density, and if you want to keep at least one non-zero element in every row of sub-matrices.



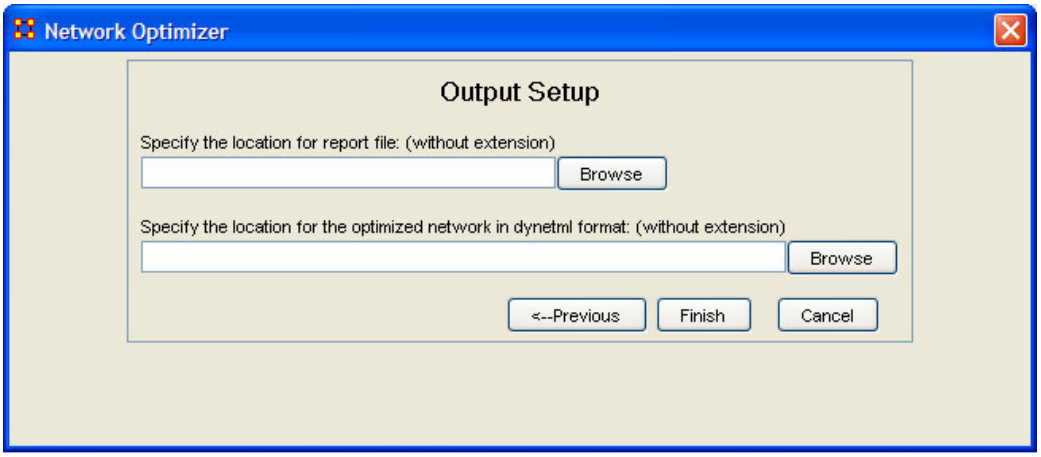
Select the [Next] button

Then choose the optimization criterion: Sum or Product.



Select the [Next] button

Specify the location for the data log file, without specifying an extension. Select Verbose if you want to analyze the whole process of optimization.



Select the [Finish] button

The data log file will be displayed in the bottom panel of the main ORA Main Interface window.

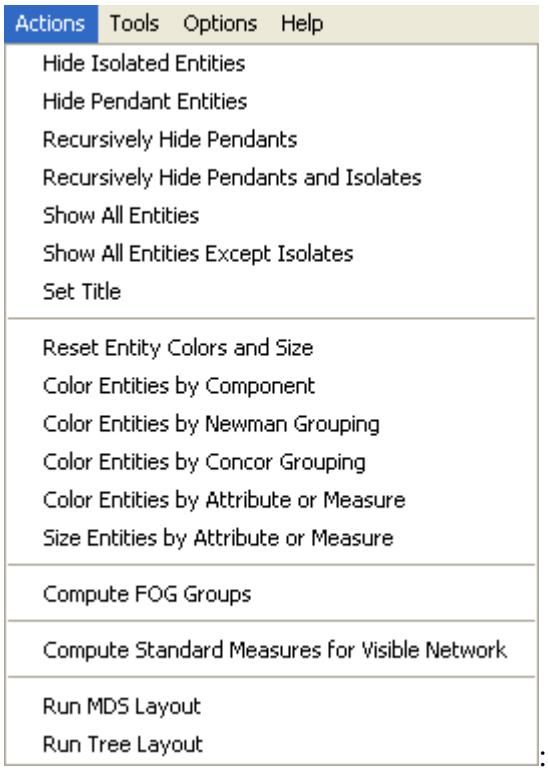
The ORA Visualizer

The ORA Visualizer renders a MetaMatrix graphically. You can interact with your data in a variety of ways: remove key actors, isolate certain links, or focus on any particular relationship by using tools such as the Path Finder and grouping algorithms.

Below is a visualized MetaMatrix of the al Qaeda terrorist network believed to behind the 1998 U.S. Embassy bombing in Dar es Salam, Tanzania. In this example, red squares denote actors; light blue triangles denote resources; green pentagons denote knowledge bases; and blue pentagons denote tasks. The shapes are called entities. The colored lines, which link entities together, represent a connection or direct relationship to each other. The terms edge, tie, and link are used interchangeably to describe these connections.

Actions

The contains a description of the functions of the Action Menu:



:

Hide Isolated Entities : Remove any entity which has zero edges connecting it to other entities.

Hide Pendant Entities : Remove any entity which has only one edge connecting it to another entity.

Recursively Hide Pendants : This function will run the both the Hide Pendant routine until there are no more Pendants.

Recursively Hide Pendants and Isolates : This function will run both the Hide Pendant and Hide Isolate routines until there are no more Pendants or Isolates.

Show All Entities : Any entities that were previously hidden will be revealed.

Show All Entities Except Isolates : Reveal any entities that were previously hidden with the exception of entities that have no edges connecting them to another entity.

Set Title : Allows the user to specify a title for the Visualizer picture. Useful for creating slides that need a labeled picture

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Reset Entities Color and Size : If colors and sizes have been changed this option will reset them to the defaults.

Color Entities by Components : This computes the components of the visible network and then color codes the entities according to which component it is in. A component is a single piece of a network whereby any two entities in a component are connected by a sequence of edges.

Color Entities by Newman Grouping : This computes the Newman algorithm on the visible network and then color codes the entities according to which Newman group it belongs.

Color Entities by CONCOR Grouping : This computes the CONCOR algorithm on the visible network and then color codes the entities according to which CONCOR group it belongs.

Each pair of actors is correlated then each row extracted and correlated with each other row. Shows how similar is the vector of similarities of actor X to the vector of similarities of actor Y? Repeat this process over and over. The elements are iterated correlation matrix converge on a value of either +1 or -1.

CONCOR then divides the data into two sets on the basis of these correlations. Then, within each set (if it has more than two actors) the process is repeated. The process continues until all actors are separated. The result is a binary branching tree that gives rise to a final partition.

Color Entities by Attribute or Measure : This allows the user to select a entity attribute and color code the entities according to its value for the attribute.

For Attribute: If each entity contained the race attribute, then entities that had an attribute value of hispanic would be one color, those with value white would have another color, etc.

For Measure: The user selects a measure to compute on the visible network and then the entities are sized according to its value for the measure.

Note: All of the operations are on the visible network, that is, whatever entities and edges are currently displayed in the Visualizer.

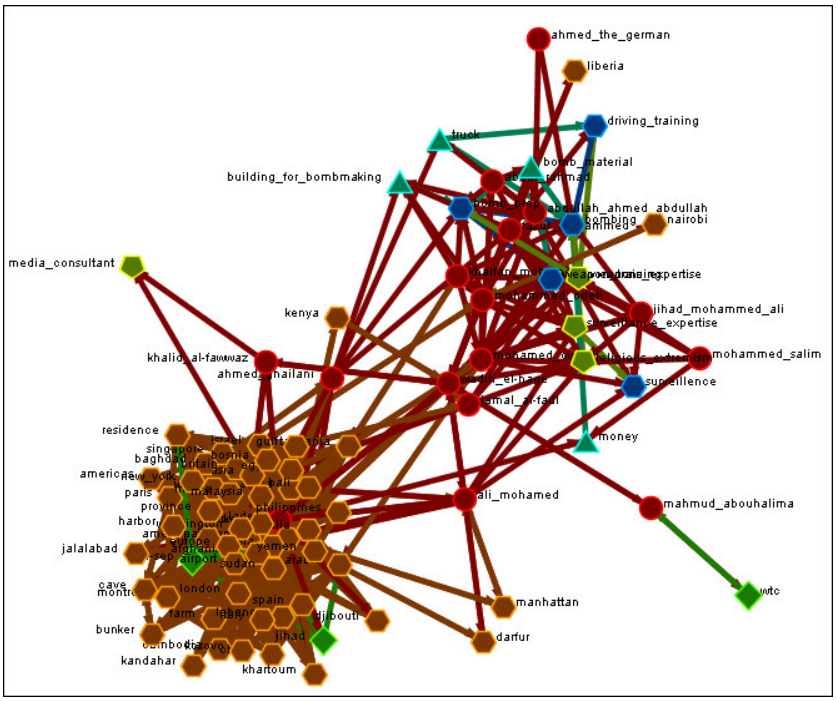
Size Entities by Attribute or Measure : Allows the user to scale entity sizes based on a measure or entity attribute. Measures are run on the visible network.

Compute FOG Groups : The ORA Visualizer can locate FOG Groups within your MetaMatrix. FOG (Fuzzy Overlapping Groups) indicates entities that can belong to groups with various strength and the likelihood those entities will participate in events associated with that group.

Compute Standard Measures for Visible Network : Computes the following collection of measures on the visible network: Total Degree Centrality, Betweenness Centrality, Eigenvector Centrality, Cognitive Demand, Resource Exclusivity, T ask Exclusivity, Knowledge Exclusivity. The measure values can then be viewed within the Entity Status Window.

Run MDS Layout : This runs an alternative layout algorithm which determines how the entities and edges are displayed on the screen. It uses a Multi-Dimensional-Scaling algorithm. This can sometimes create better layouts than the default. But it takes longer to run.

Run Tree Layout : Displays the current visible network as a Bayes Network.



Compute FOG Groups

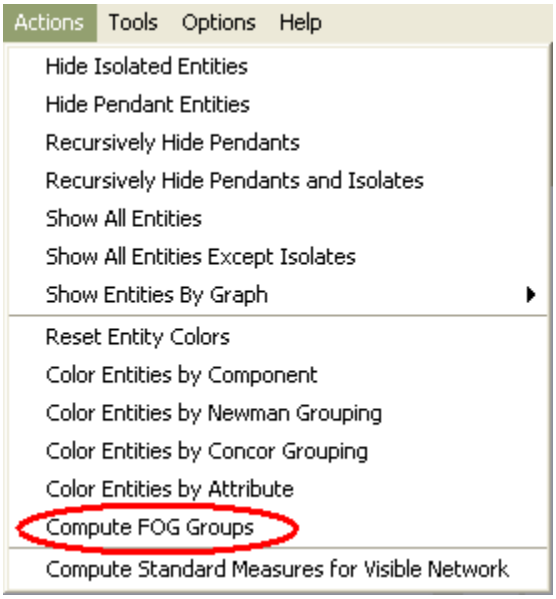
FOG Group Basics

Basics – Example

The ORA Visualizer can locate FOG Groups within your MetaMatrix. FOG (Fuzzy Overlapping Groups) indicates entities that can belong to groups with various strength and the likelihood those entities will participate in events associated with that group. Overlapping occurs when individuals belong to many groups simultaneously, so that the groups share members. To access the ORA Compute Fog Groups you must first be working in the Visualizer.

From the Visualizer drop-down tool bar: Actions > Compute FOG Groups

The red circle below highlights how to access the Compute FOG Groups function.

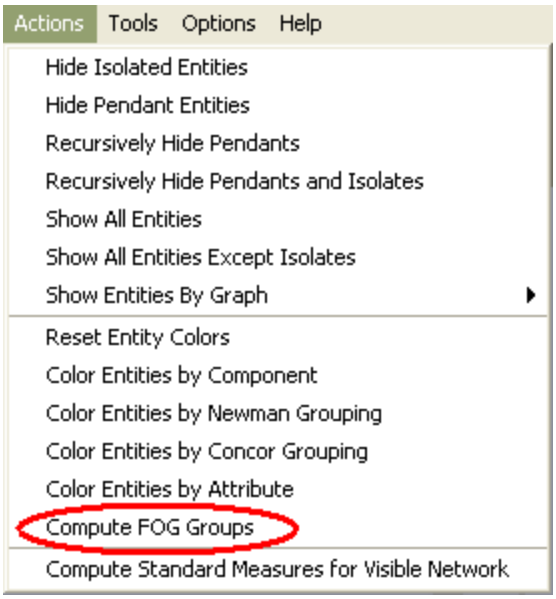


FOG Group Example

Basics – Example

Using the Embassy.xml MetaMatrix, we will use the Compute FOG Group function to determine FOG groups within our network.

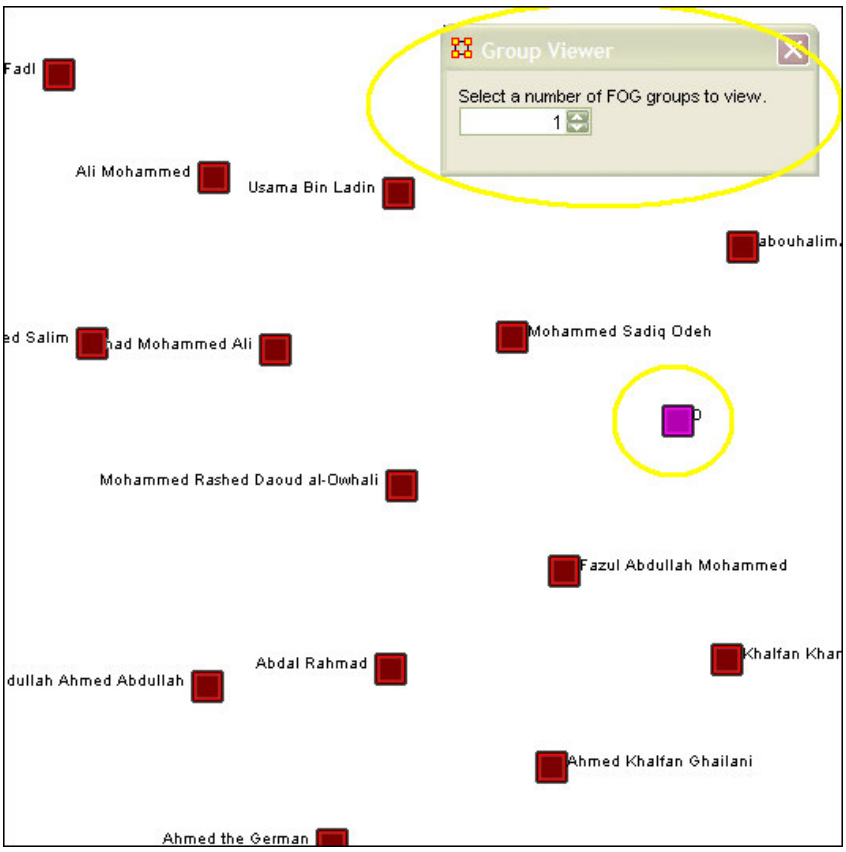
1. Load in the Embassy.xml MetaMatrix
2. Then access the Compute FOG Group function from the Visualizer drop-down tool bar. The red ellipse below highlights where to find the Compute FOG Group function.



Click Compute FOG Groups

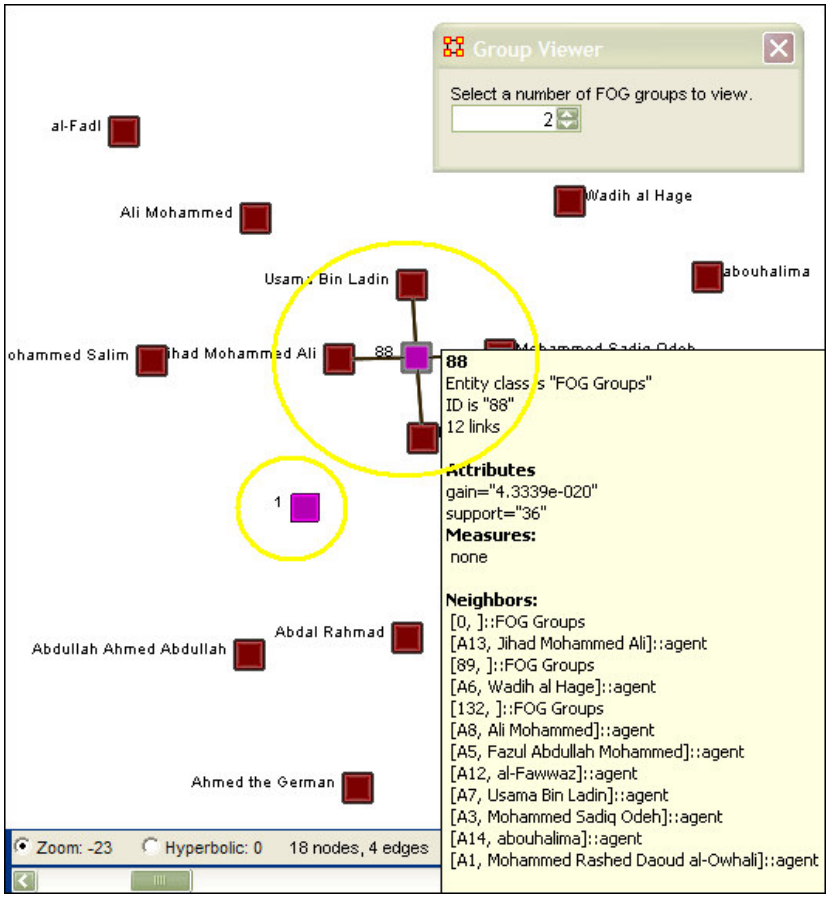
The following Group Viewer selector box will appear. The yellow ellipse show the Group Viewer box. By default, the selector box will be set to "1"

The first FOG Group will be displayed, denoted in the screen shot below as the purple square in the smaller yellow ellipse.



Select the number of FOG Groups to compute.

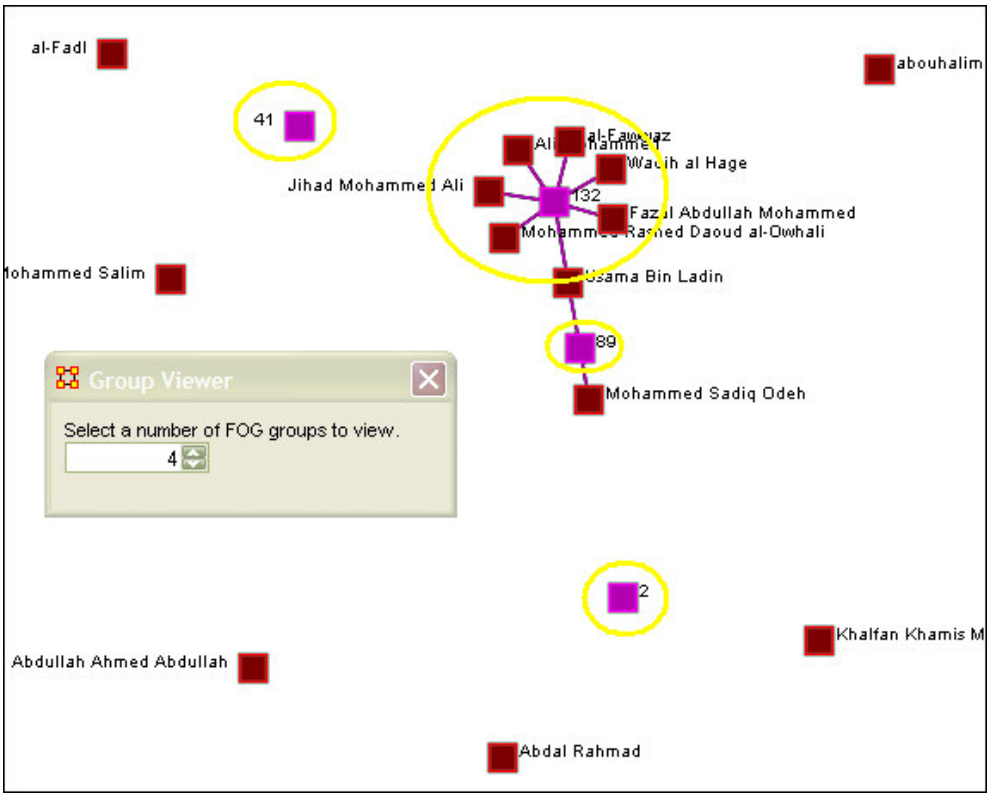
In this example, we will change the selector to "2" Notice the changes in the Visualizer. The screen shot below displays the Embassy.xml MetaMatrix with the Compute FOG Group with two groups.



Two FOG Groups are displayed, denoted in the yellow ellipses in the screen shot above.

By clicking on any individual FOG Group you can access the Entity Status Box (shown above). This will list that FOG Groups Attributes, Measures, and Neighbors.

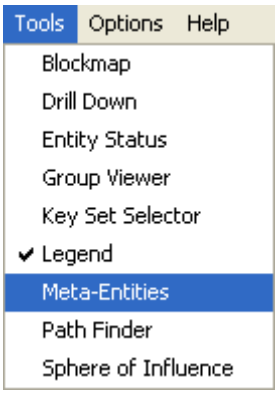
Finally, below is a screen shot with the Compute FOG Groups selector set to "4" using the Embassy.xml MetaMatrix as an example.



Creating A Meta-Entity

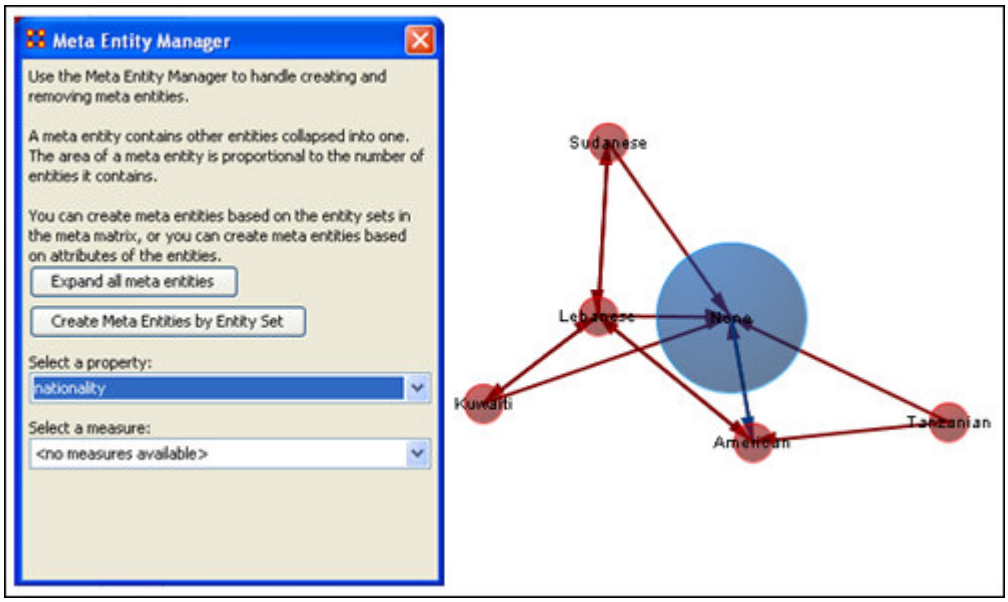
A Meta-Entity contains multiple entities collapsed into one. You can create Meta-Entities based on the entitysets in your organization, or you can create MetaN-Entities based on the attributes of the entities. To create Meta-Entities, you must access the Meta-Entity Manager. There are two ways to do this:

1. From the drop down menu > Tools > Meta-Entities

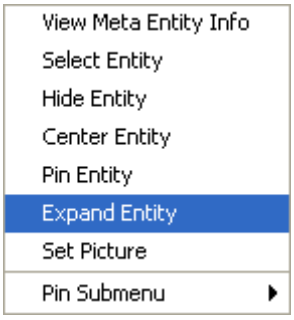


2. from the Visualizer tool bar

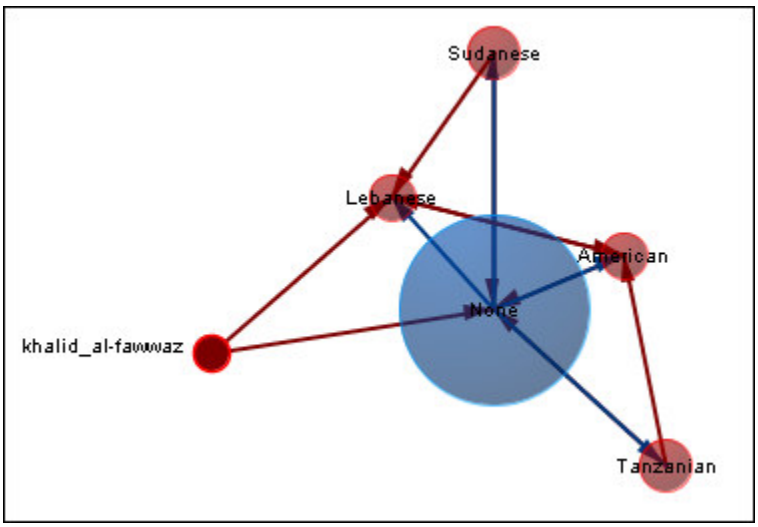
In the screen shot below Meta-Entities were created for the attribute Nationality of our Agent by Agent MetaMatrix graph. The Visualizer itself, shows your condensed visualization. All the entities, which share the same attributes, are now groped into Meta-Entites.



To view what is contained in one of the meta-entities, right-click an entity to bring up the contextual menu and highlight Expand Entity.



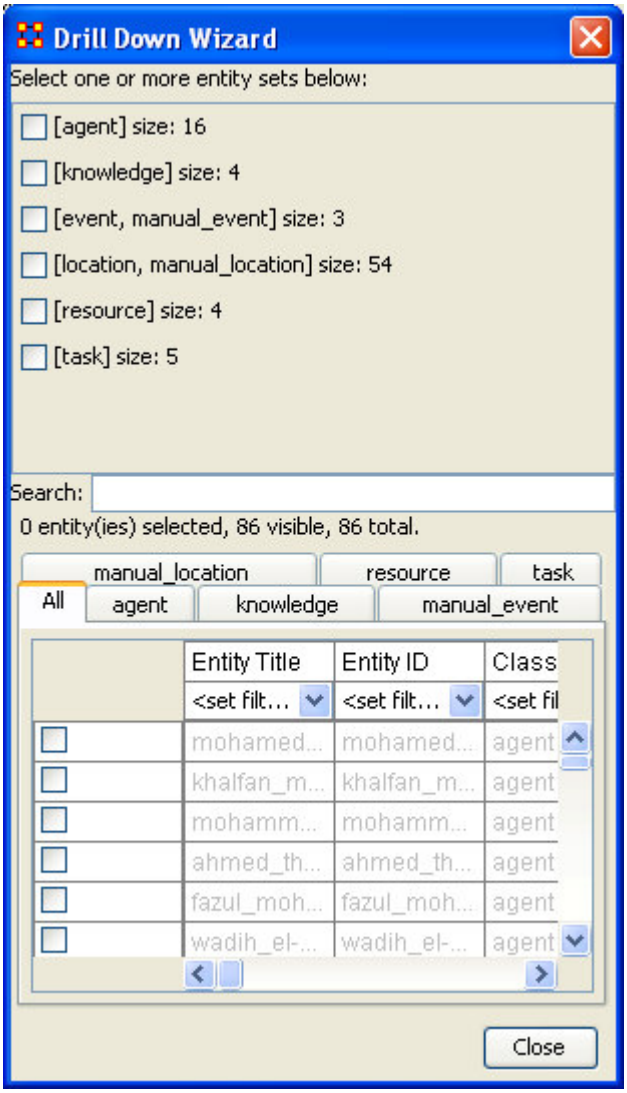
Whatever entities were contained inside the Meta-Entity will be revealed. In the example only one entity was revealed.



Drill Down Wizard

With the ORA Drill-Down Wizard you can quickly visualize ego networks by overall entity class (knowledge, tasks, resources, agents) or by choosing individual nodes from a checklist. The ORA Drill-Down Wizard is only accessible through the Visualizer: From the ORA Visualizer Main Menu select Tools > Drill Down

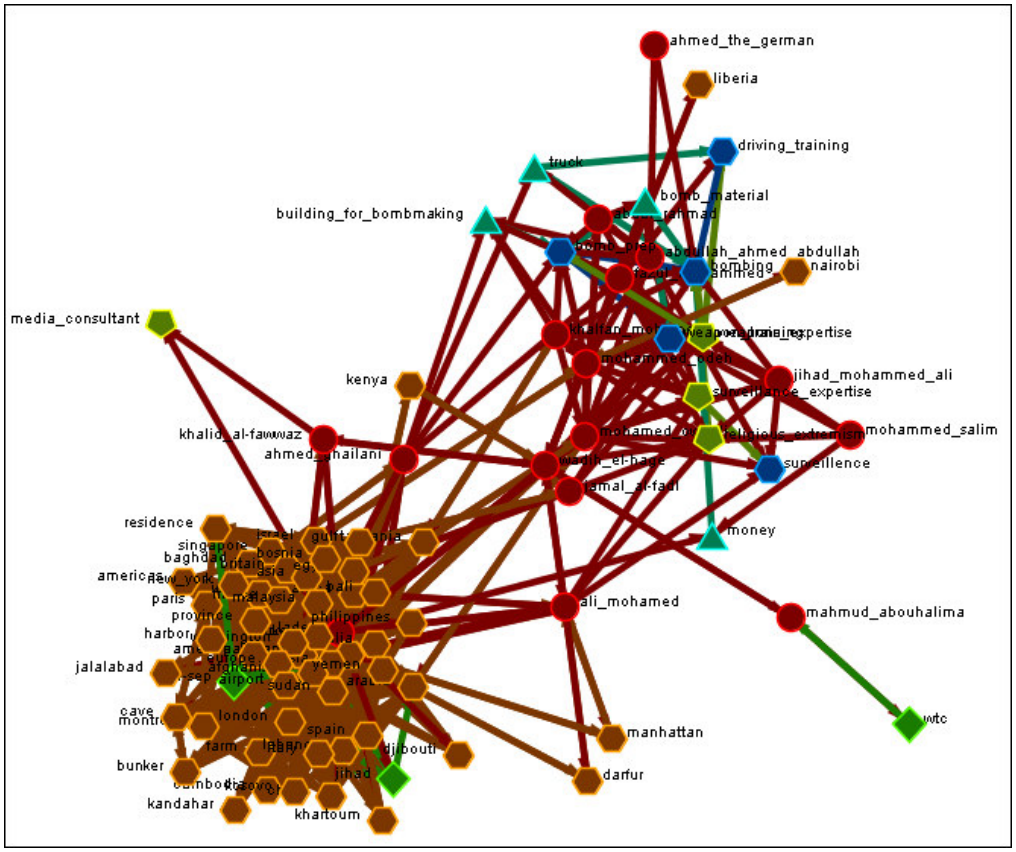
The following window box will appear.



The top sections allow you to choose the entities for use. The bottom tabs allow for choosing specific entities within a set.

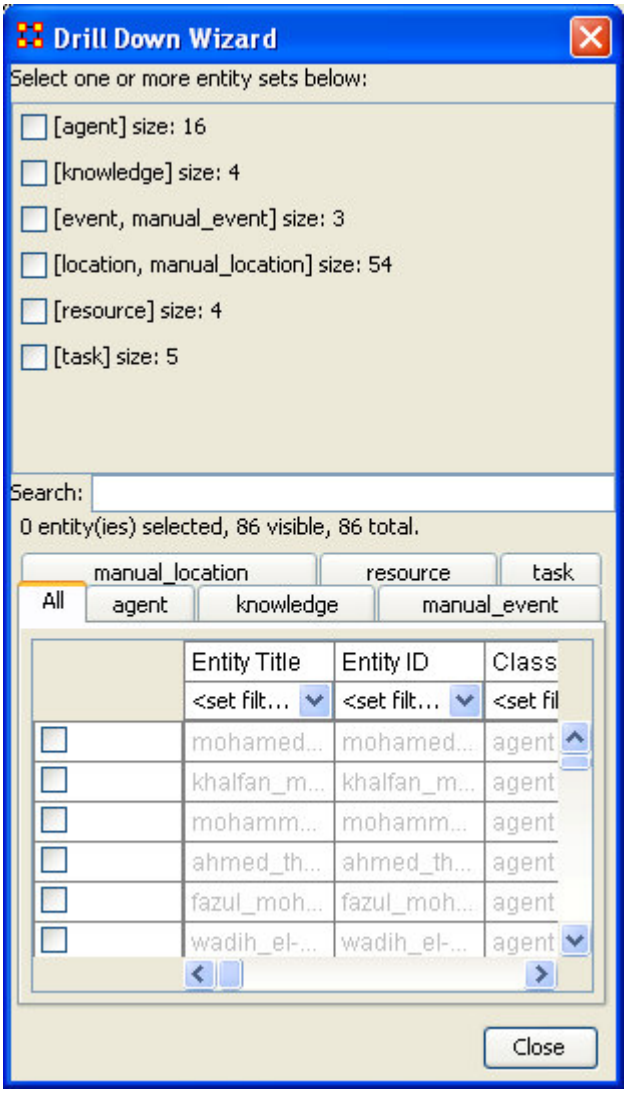
Drill Down Wizard Example

Using the Embassy MetaMatrix, we will render the various entity classes using the Drill-Down Wizard Tool. The screen shot below displays the Embassy MetaMatrix as it should first appear in the Visualizer.

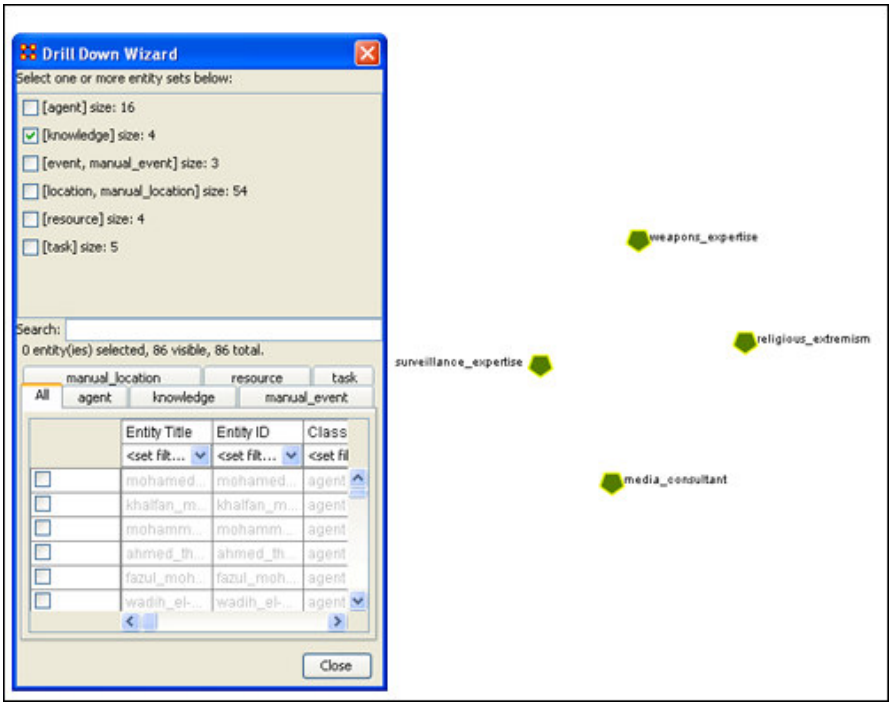


From the Main Menu select Tools > Drill Down.

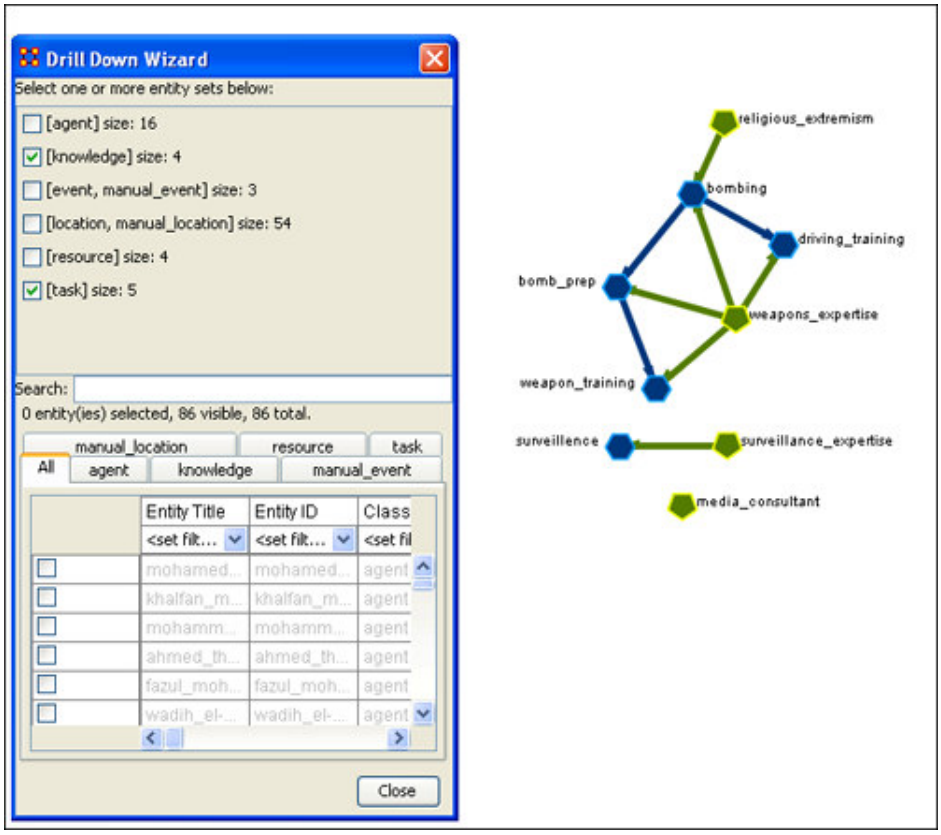
This will bring up the Drill Down dialog box as shown below).



Here, select the entity class Knowledge by selecting the Knowledge check mark box. The screen shot below, displays the end result that you should now see in the Visualizer.

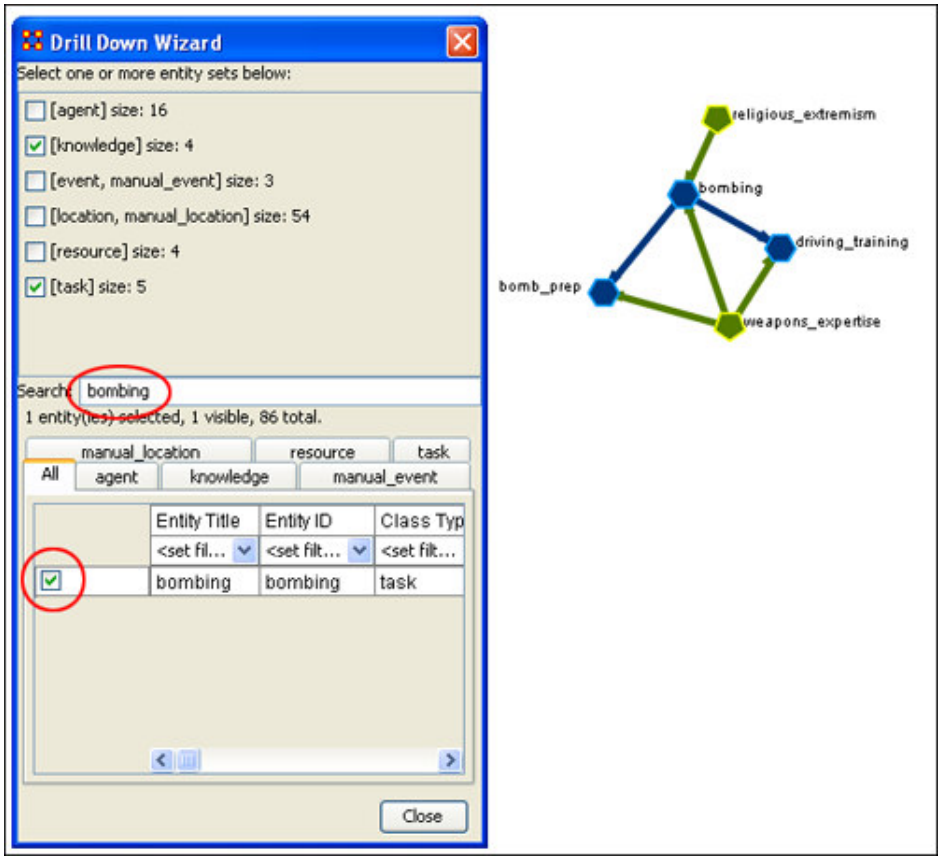


Next, with the Knowledge entity box checked, add the entity class Task. The screen shot below displays the end result.



Next use the search bar feature of the Drill-Down Wizard to narrow the search.

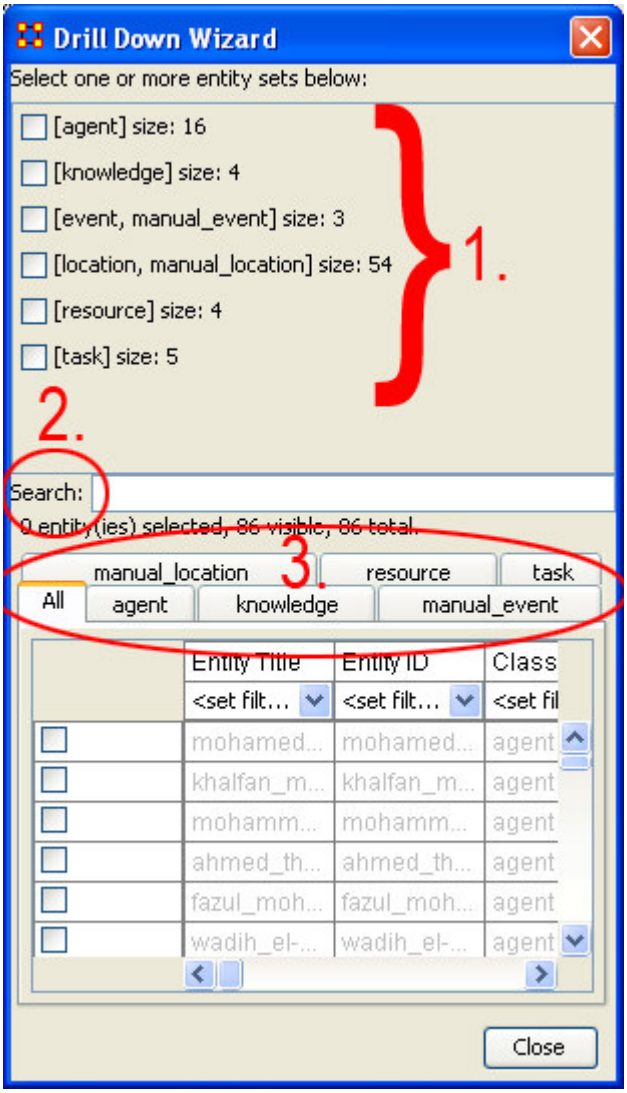
Enter the word Bombing in the Visualizer search field below. Then select the check box on the bombing row. The screen should now reflect your new search parameters. Everything not associated with bombing has been turned off.



Drill Down Wizard Explained

The ORA Drill Down Wizard can be broken down into three primary sections of input:

1. **Section 1:** enables you choose individual entity sets or combination of entity sets to display in the Visualizer.
2. **Section 2:** of the Drill Down Wizard enables you to search for a particular entity within your MetaMatix. This can be handy when you dealing with large entitysets and the one you are interested in finding is not easily located.
3. **Section 3:** enables you check mark an individual entity within your MetaMatrix by entity class if so desired.

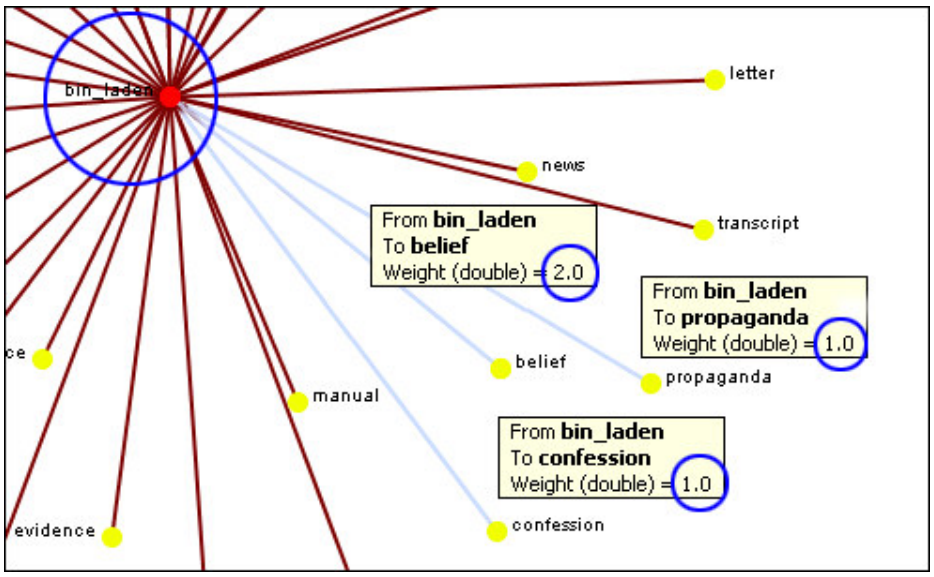


Hide Edges With Weight

At times you will want to view the Visualizer with just the more weighted edges displayed. You can select to hide edges either Less Than or Greater Than a certain value.

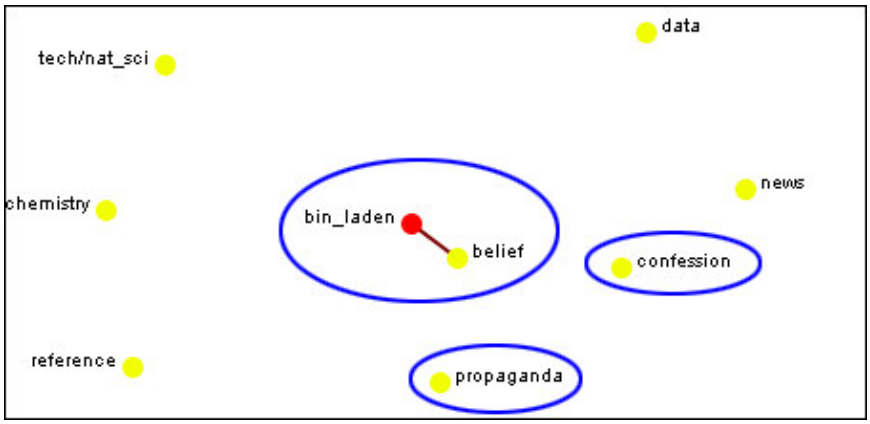
For this example we'll keep the Less Than option.

- In the example below both confession and propaganda have a connection weight to bin_laden of 1.0.
- belief has a connection weight to bin_laden of 2.0.



Increasing the edge weight to 1.1 will hide every edge less than that, namely confession and propaganda.

belief, with an edge weight of 2.0, remains connected to bin_laden but the edges for confession and propaganda are now hidden (along with most of the other edges).



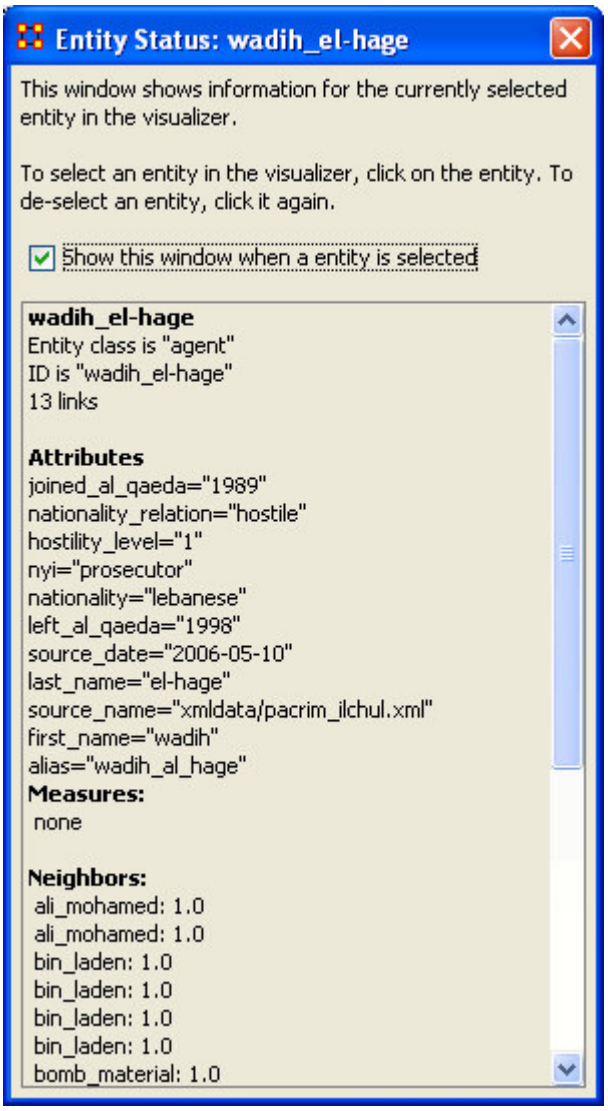
Entity Status

Entity Status Window

Window – Example

The Entity Status Window is selected by default. It first pops-up when you select any entity in the Visualizer. This window provides you with a snapshot of the currently selected entity by displaying that entities unique Attributes, Measures, and Neighbors.

Below is a screen shot of the Entity Status Window. By un-checking the box Show this window when a entity is selected, the entity Status Window will cease to appear when clicking on entities within the Visualizer.



Attributes are descriptions you may or may not have given to particular entity or entitieset in your network.

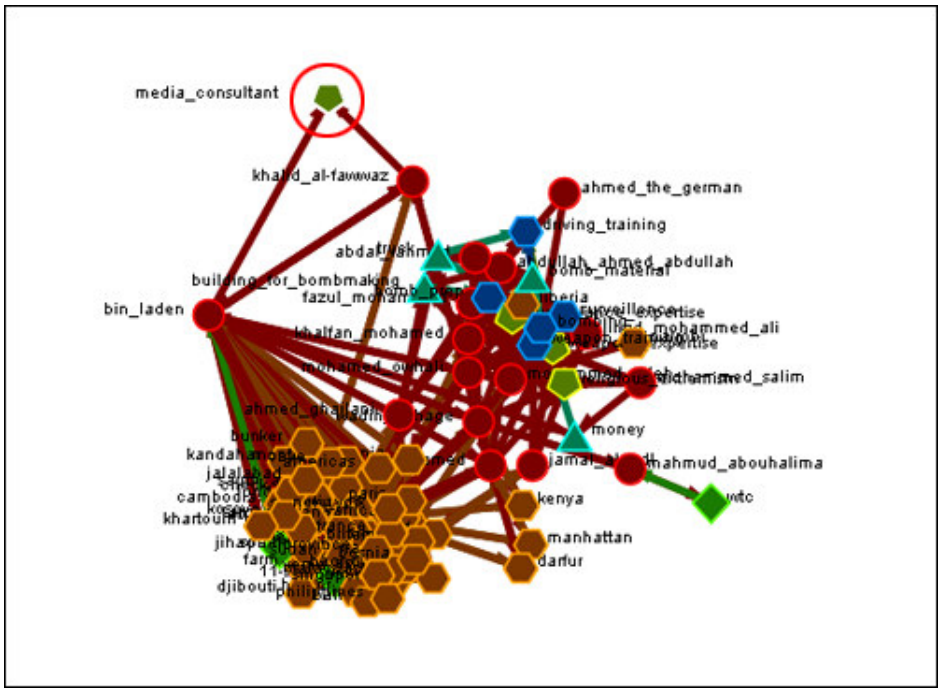
Measures describes computational functions in which the entity is directly involved. A more complete description can be founc under ORA Measure.

Neighbors are entities that share an immediate link to the entity selected.

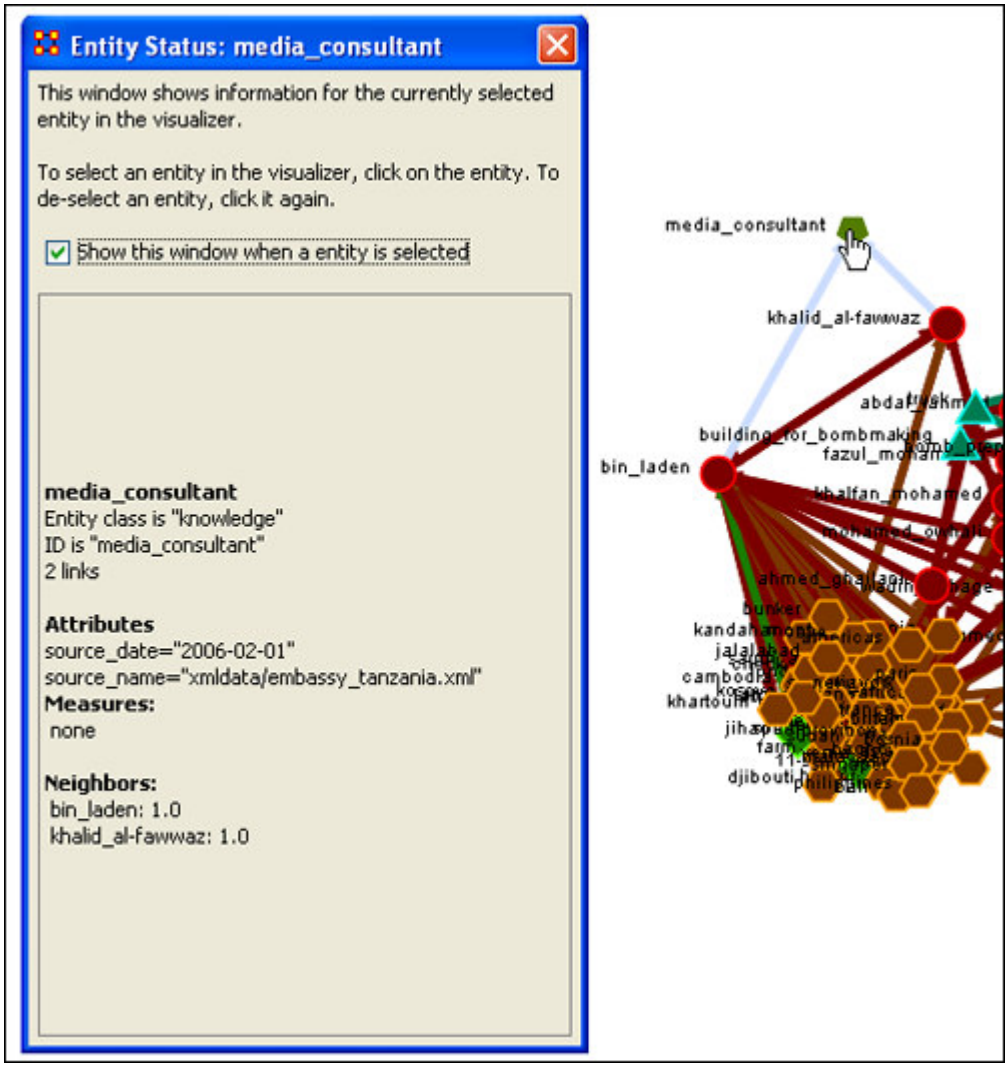
Entity Status Example

Window – Example

Using the Embassy MetaMatrix visualization, select the entity media consultant highlighted in the following screenshot with the red circle.



The screen shot below displays the result. You will see that the entity media consultant has two neighbors, Usama Bin Laden and Khalid al-Fawwaz.

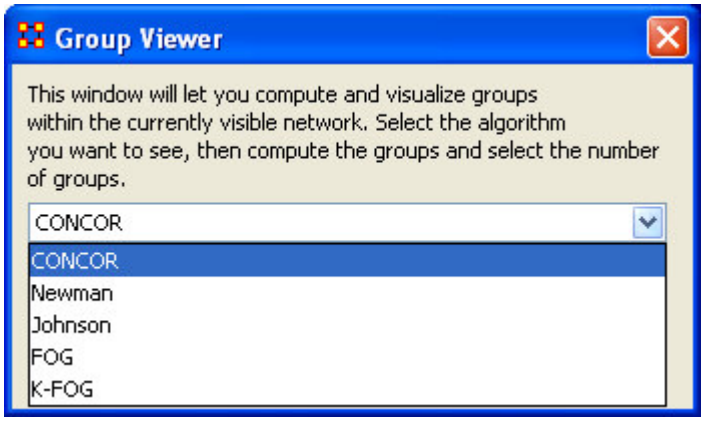


Tip! If you are more interested in using other functions within the Visualizer, such as the Path Finder, deselect the Entity Status option to un-clutter your visualization.

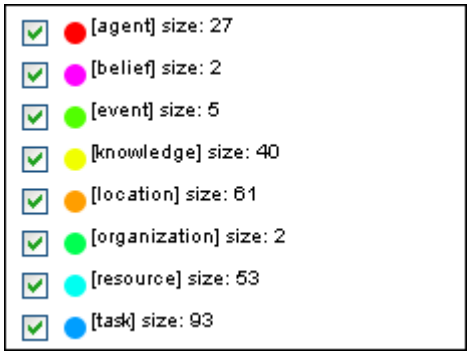
Group Viewer

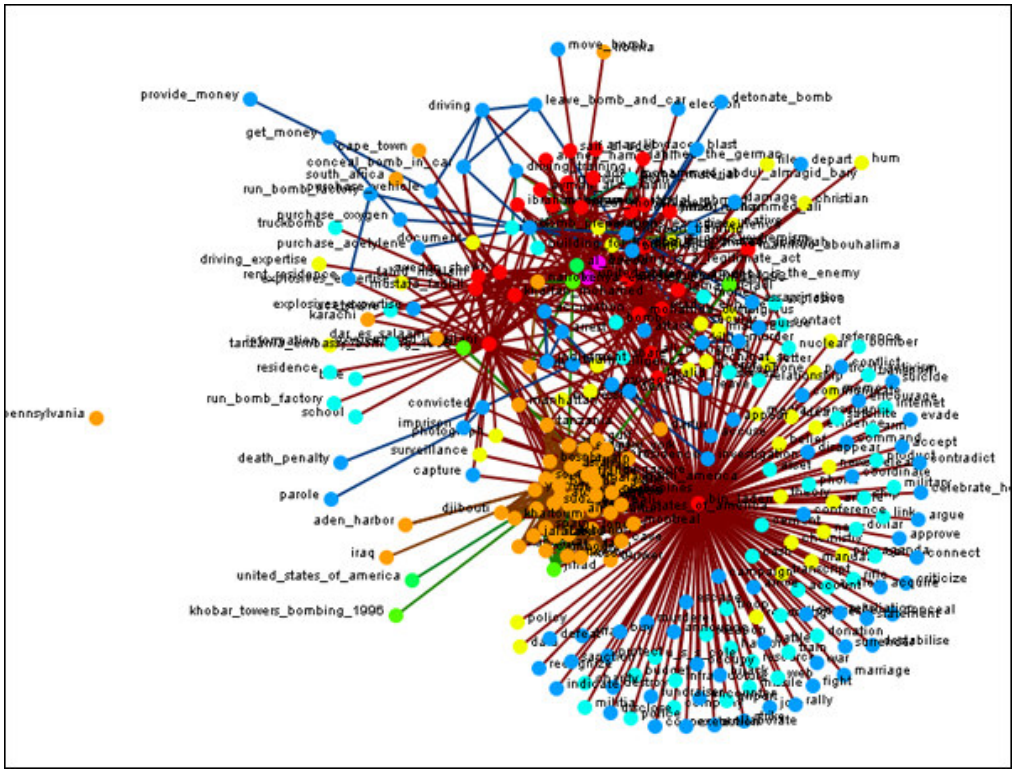
The Group Viewer helps separate entities into distinct groups. Take the starting view form the Visualizer. Not much can be discerned from this rather jumbled view with all of the entities choosen.

There are five group which can be called up: CONCOR, Newman, Johnson, FOG, and K-FOG

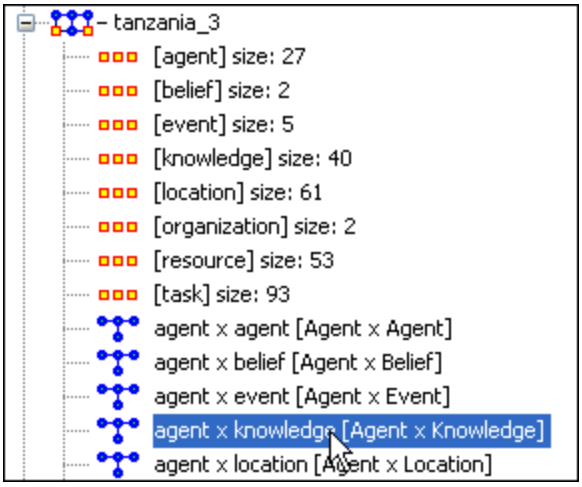


When you first call up the Visualizer every entity is listed and displayed on screen. At first glance, not much can be discerned.



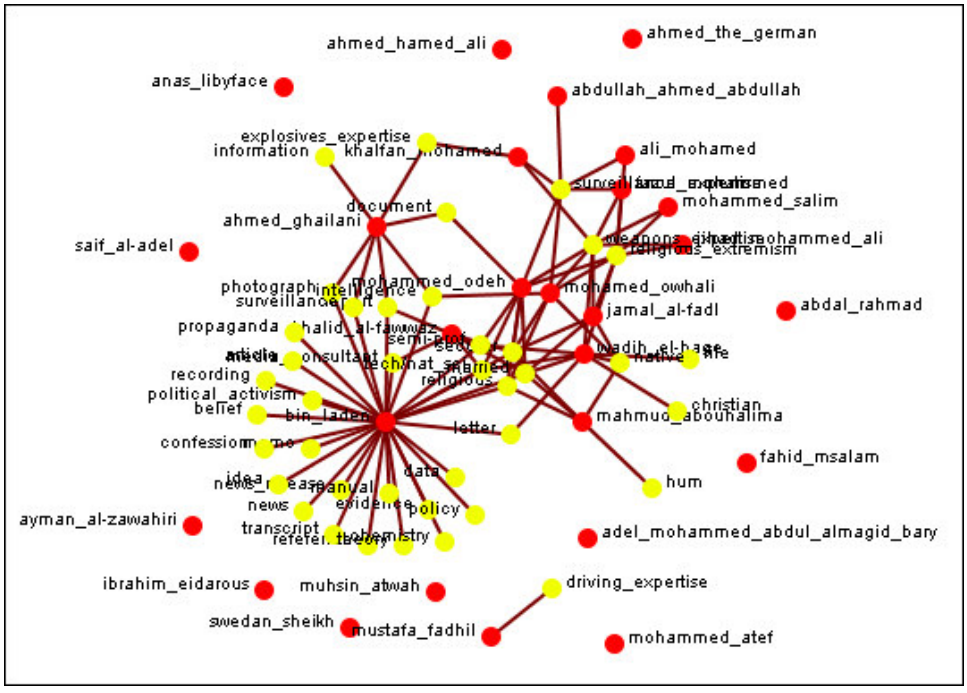


One way is to visualize one of the graphs. Highlight one of the graphs you want to view in difference groups.

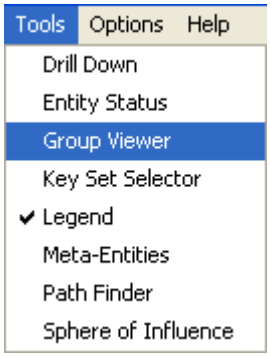


Then Select Visualize Only this Graph

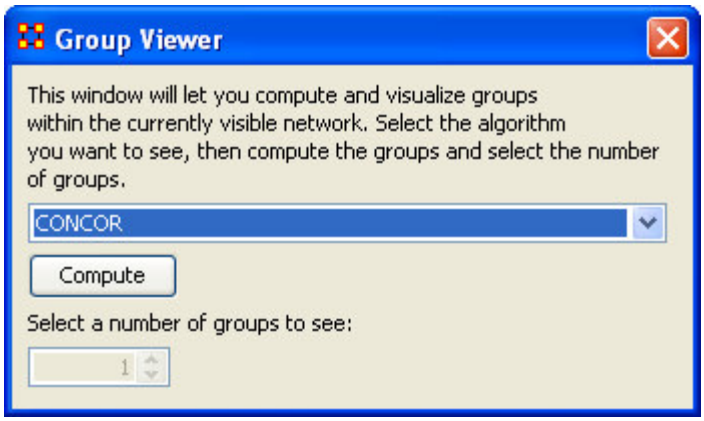
We now have a much more manageable display.



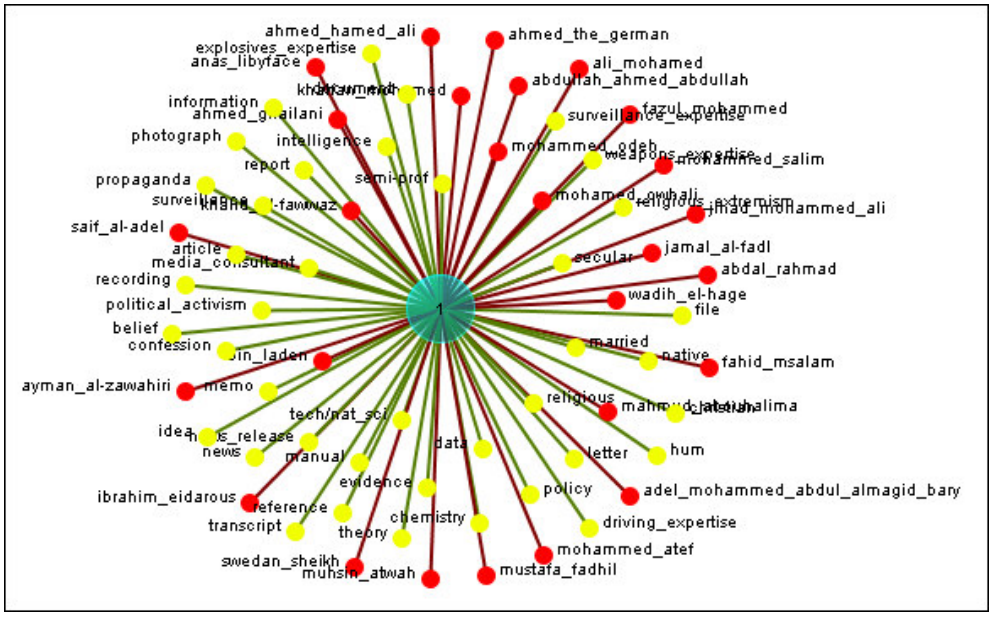
Select from the Menu Tools > Group Viewer



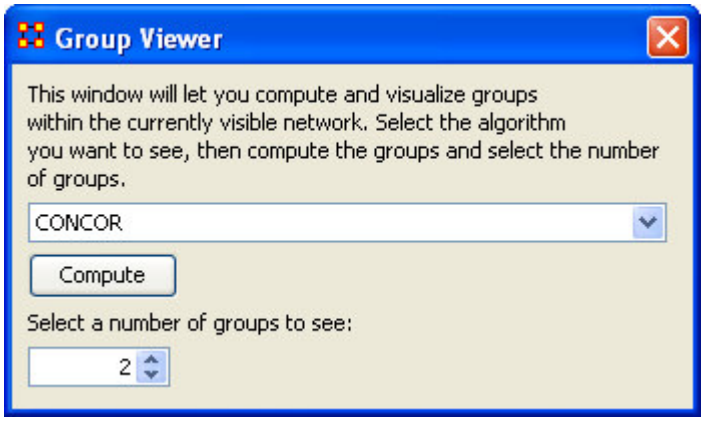
Which calls up the Group Viewer dialog box. First let's see what happens with the CONCOR options. Select [Compute] to activate the grouping.



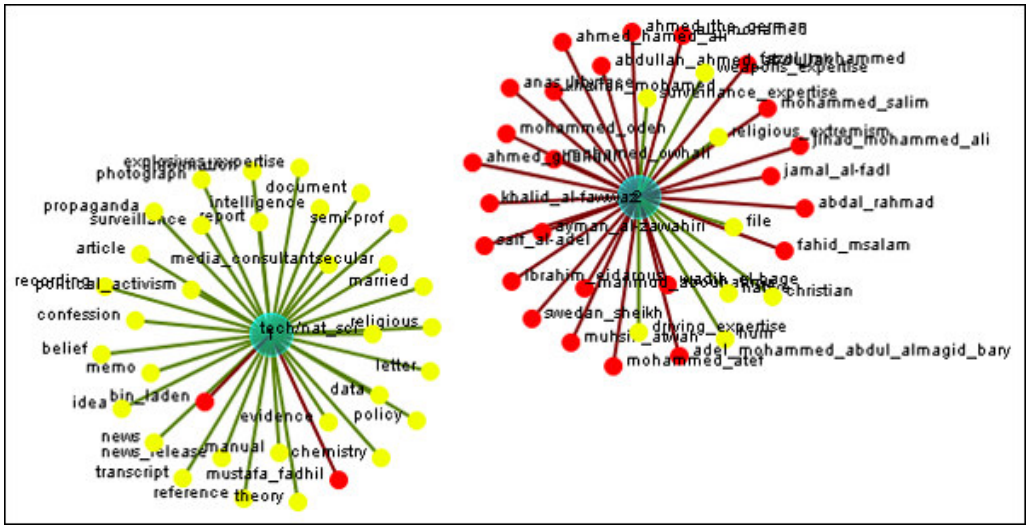
The default is one group with all visible entities connected to the center



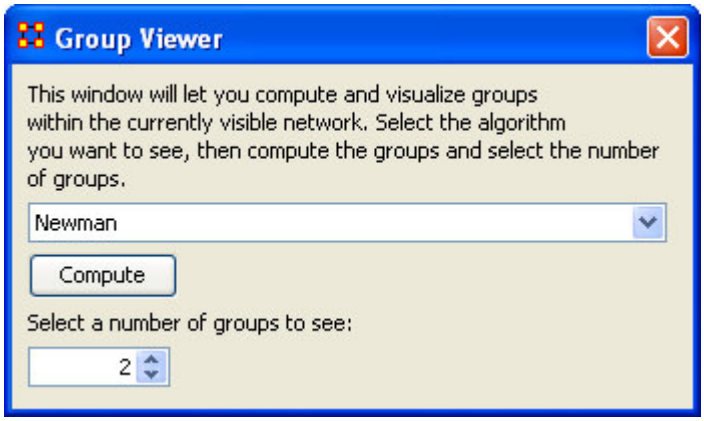
The dialog box, increase the Select a number of groups to see: to 2.



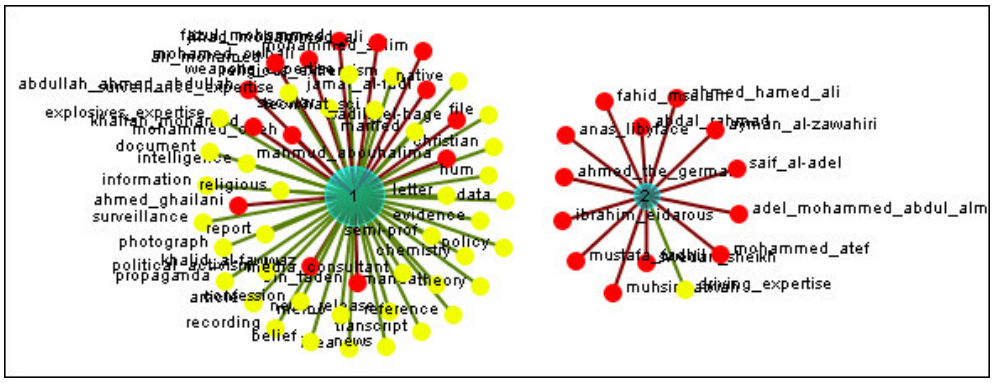
Now displayed are two groups. On the left most of the knowledge entities are connected to two agents, bin_laden and mustafa_fadhil. The group on the right consists of the remaining agents combined with a few of the knowledge entities. Notice that the knowledge driving_expertise is one of the knowledge entities on the right.



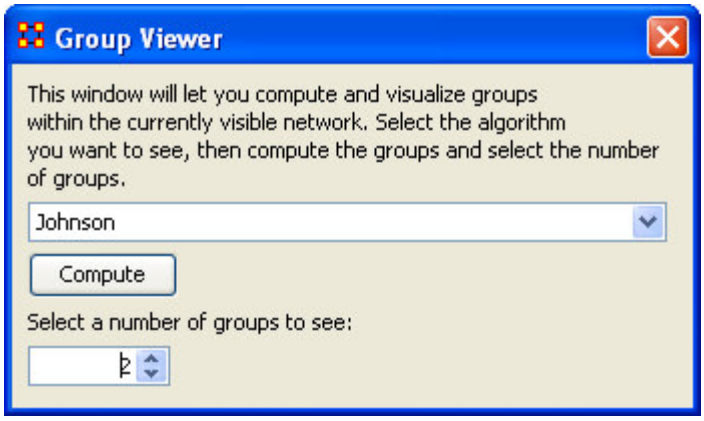
Now change the group to Newman and select [Compute] and increase the Select a number of groups to see: to 2.



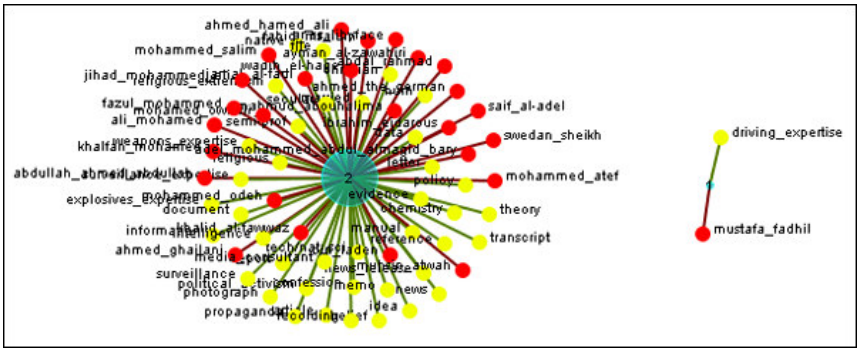
Once again we see two groups but the division is different. The left group contains all the knowledge entities except driving expertise. And now there are fewer agent entities connected to this knowledge.



Now change the group to Johnson and select [Compute] and increase the Select a number of groups to see: to 2.

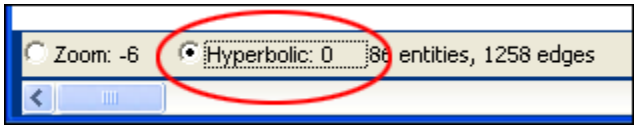


driving_expertise is still the only knowledge in the right group but notice that now there is only one agent connected to it, mustafa_fadhil. Looking back, he was connected to driving_expertise in Newman but not CONCOR.

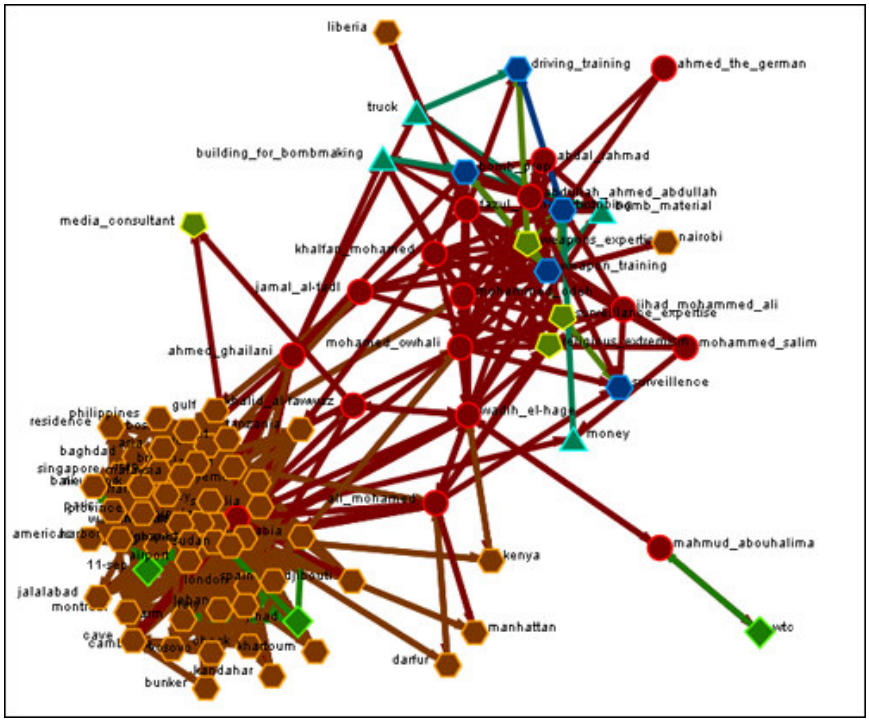


Hyperbolic View

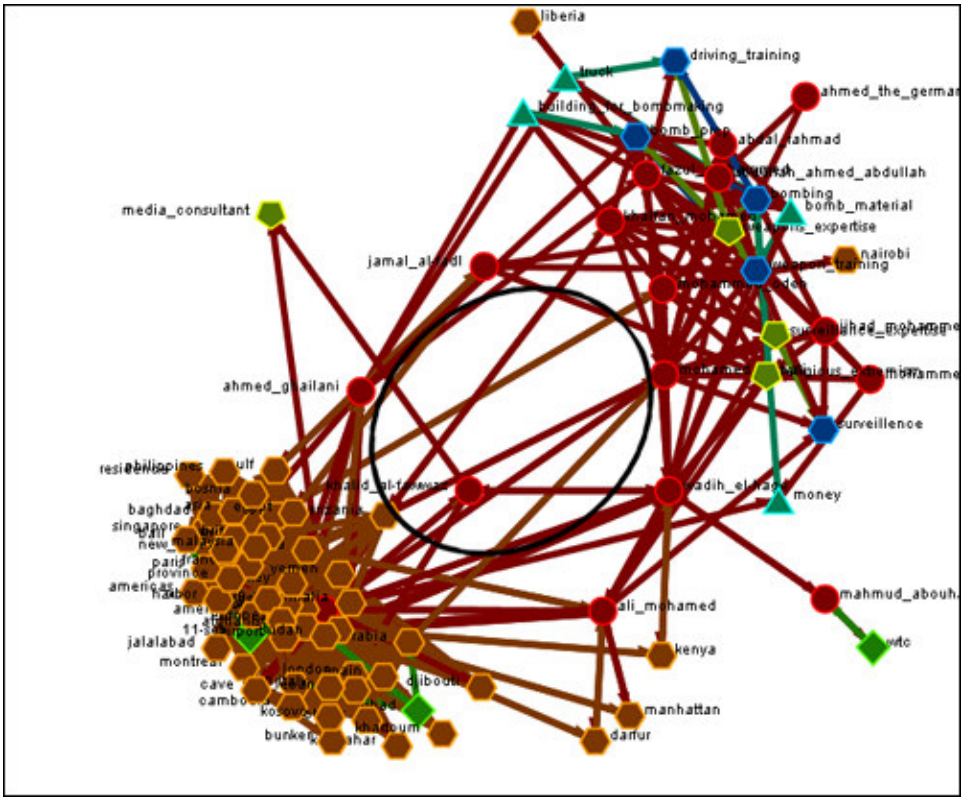
The Hyperbolic function creates a bulge within your visualization adding a sense of depth. By moving the slider from right to left, you can increase or decrease this bulge effect and create different depth-added views. The Hyperbolic radio button and slider can be found at the bottom of the window.



Note : The Hyperbolic function, when selected, converts the slider to this feature. This is also true of using the zoom and rotate functions. Use all three in conjunction to get your visualization just the way you want it. Scroll down below this screen shot for another when viewed with the Hyperbolic feature.



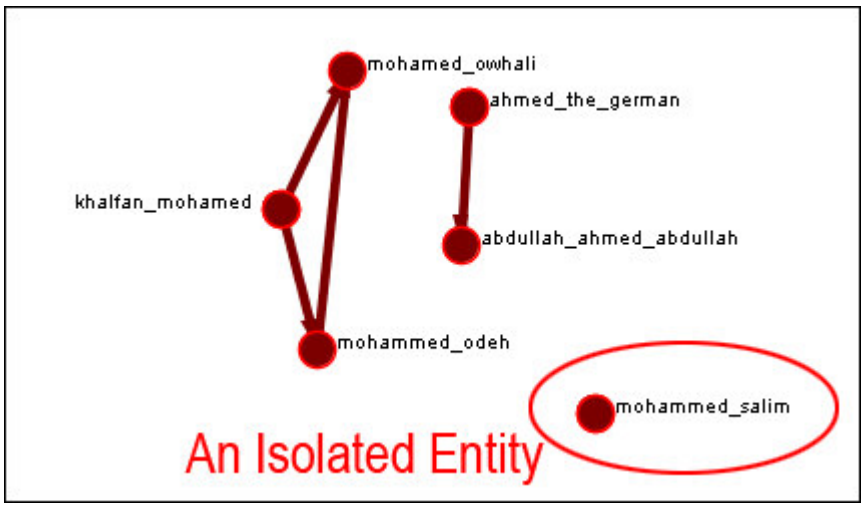
In the screen shot below, black ellipse highlights the effect of adding the Hyperbolic View to a visualization. Compare the slider positions and visualizations in both screen shots to examine this subtle effect. Of course, the best way to become familiar with the Hyperbolic view is to simply experiment within the Visualizer itself.



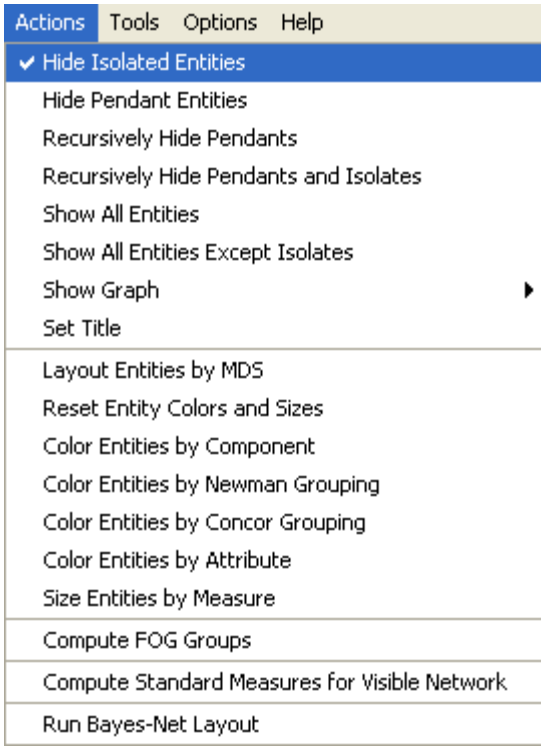
Note : It is useful to use this tool in conjunction with the Rotate and Magnify tools to obtain just the view you desire.

Removing Isolates

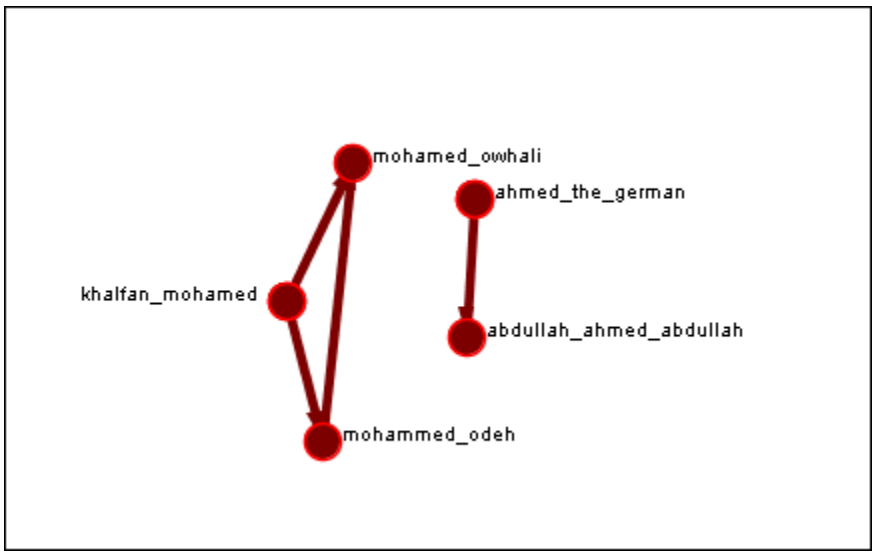
To further simply a visualization, it may prove useful to remove isolated entities from the visualization. Isolated entities are entities not directly linked or connected to other entities, which share direct ties with each other. In the screen shot below, the red ellipse highlights an isolated entity which needs removed.



Select from the Main Menu: Actions > Hide Isolated Entities.



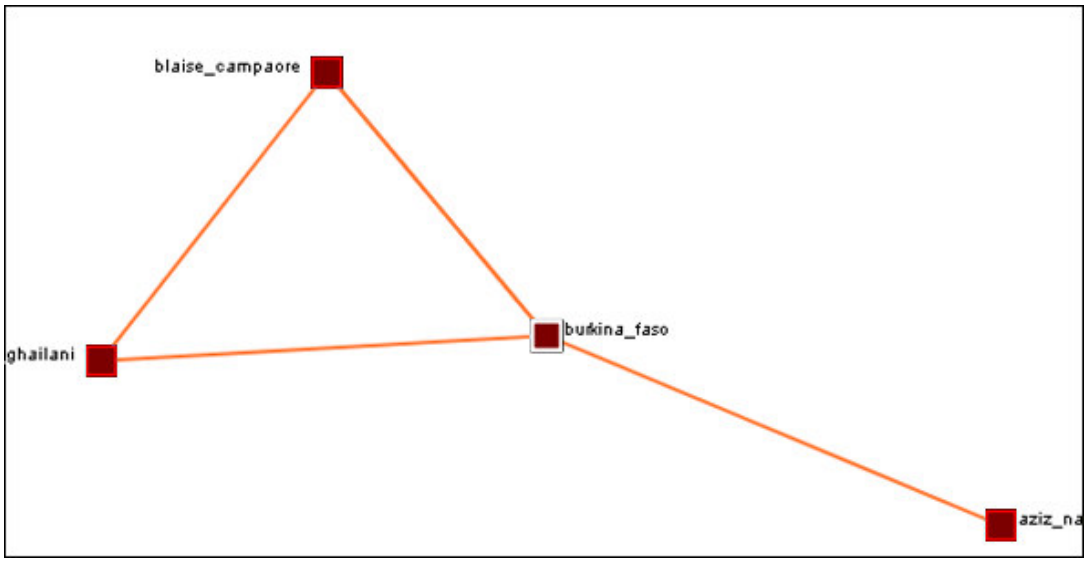
In the screen shot below, after removing isolated entities, the visualization is further simplified.



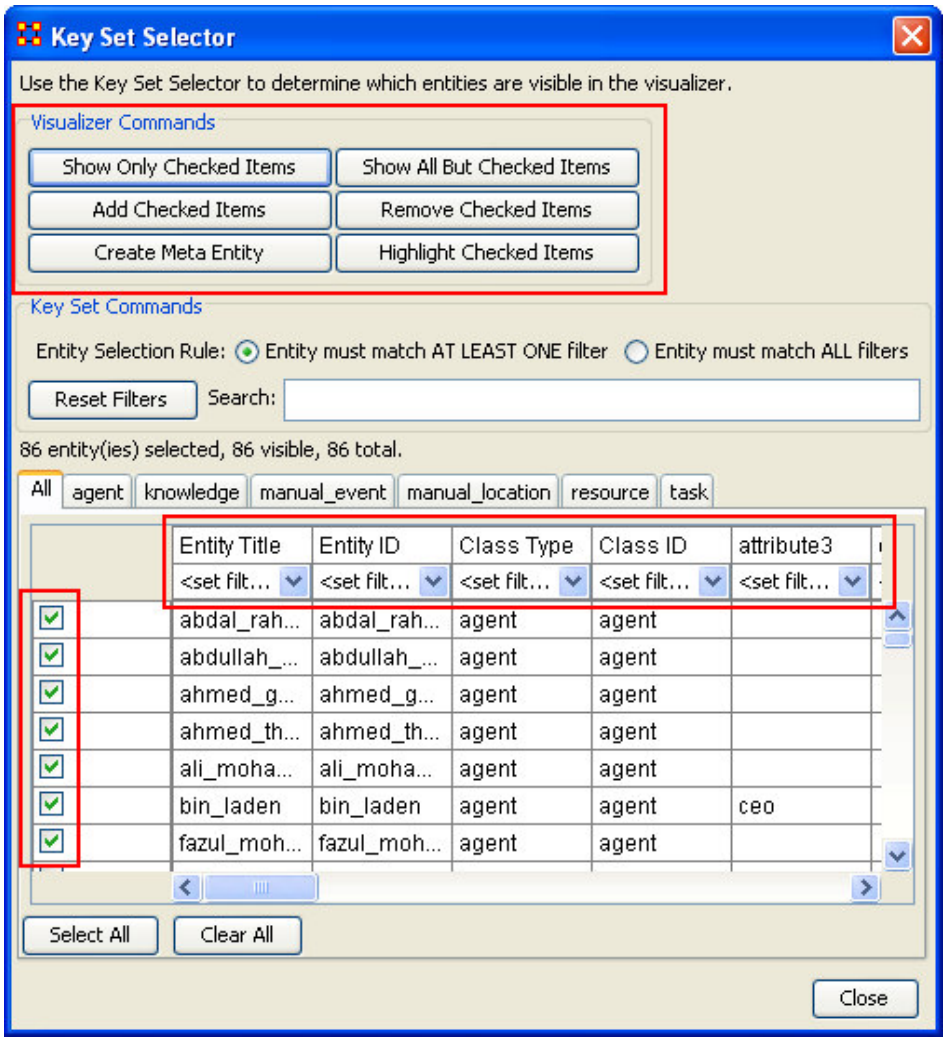
Adding And Removing entities In The Key Set

The ORA Key Set Selector allows you to determine which entities are visible in the Visualizer. The Key Set Selector is accessible through the ORA tool bar.

From the ORA menu choose Tools > Key Set Selector



This will bring up the following dialog box in which to make your selections.



Above is a screen shot of the Key Set Selector accessible through the ORA Visualizer tool bar. The red rectangles show the primary areas of the Key Set Selector, which enable you to hide and add entities to your visualization. Note the green checkmarks along the first column. These checkmarks indicate exactly which entities within your visualization are selected. The button within the Visualizer Commands section of the window pane, allow you to view your visualization by Show Only Selected or Show All But Selected.

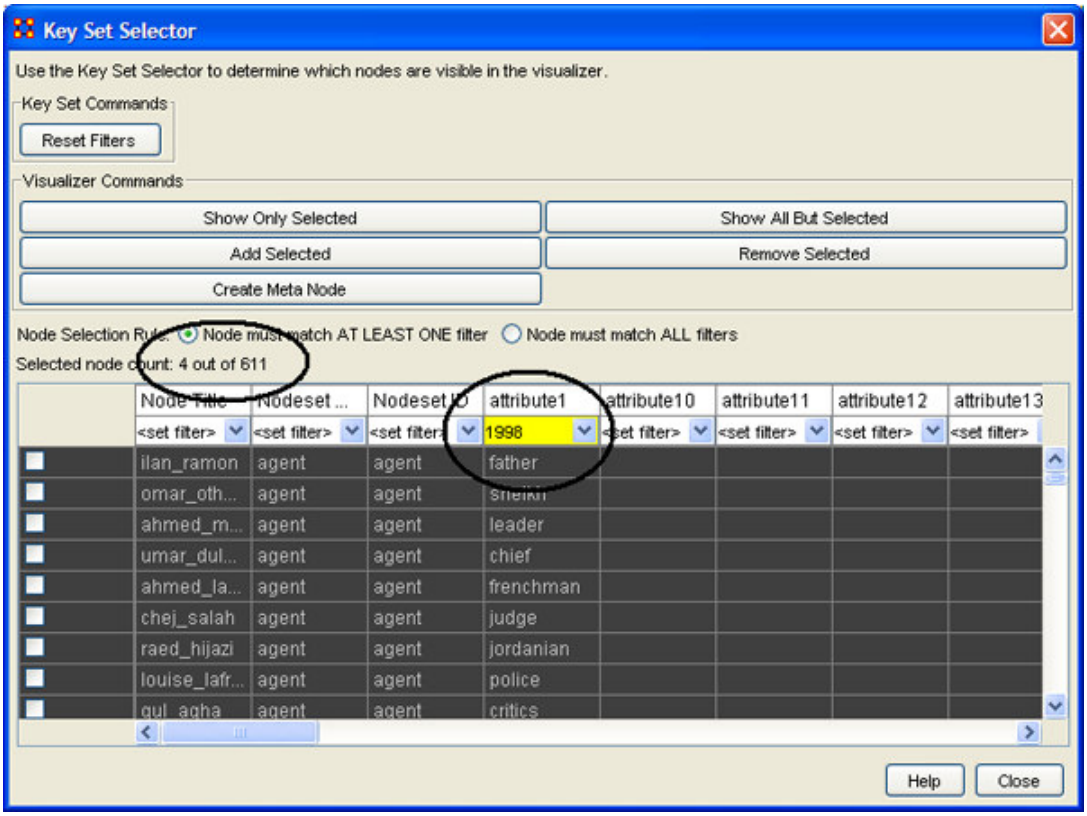
Furthermore, Visualizer Commands allows you to Add Selected, Remove Selected, and Create Meta entities.

Note: The difference between Showing and Adding and conversely Show All But Selected and Remove Selected.

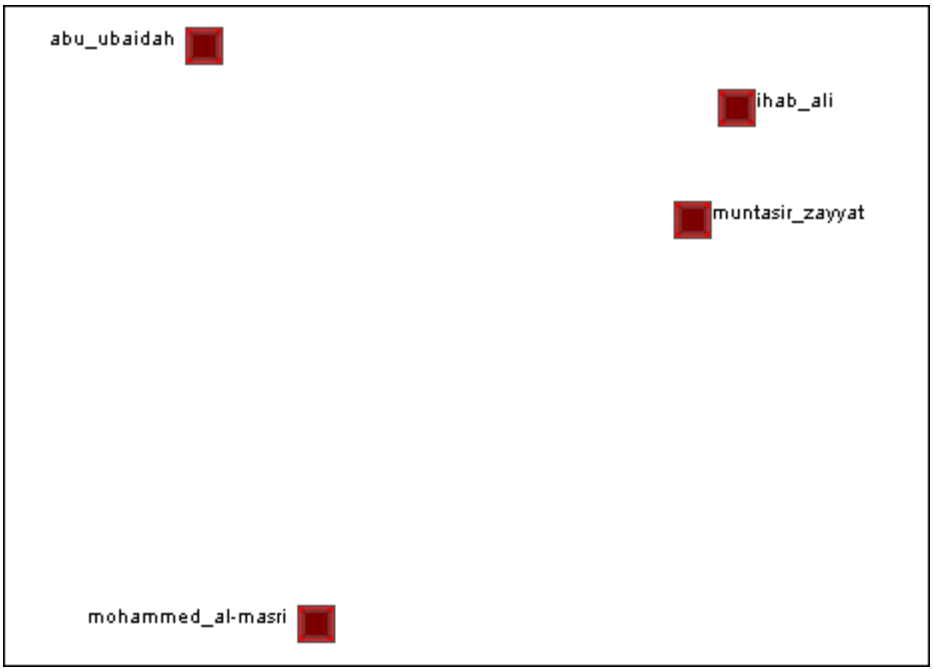
Essentially, when you add you are literally adding entities to your visualization versus showing, which is displaying entities already part of the current visualization.

The Node Title Row, highlighted by the middle red rectangle on the screen shot below, allows you filter entities in your visualization. To view only the entities in your visualization that contain a certain attribute, which you are interested in examining, you can turn the filter on by clicking the drop down tab in the row immediately following the Entity Title row (Scroll for another screen shot of filtering the current MetaMatrix using attribute 1 from the Key Set Selector column heading).

In the screen shot below, note that using the filters we selected under attribute 1 the attribute 1988 from the drop down menu. A black ellipse highlights that by selecting this attribute, 4 out of 611 entities contain that attribute. By clicking Show Only Selected the ORA Visualizer will render these four entities. Note that the green check marks in the first column have been unselected. Only the entities that shared the 1988 attribute will be selected. If you scroll down this column, those entities will turn up as selected. By clicking Show All But Selected the ORA Visualizer will render the MetaMatrix without the four entities containing the attribute 1988. Other filters can be used to create a variety of visualizations correlating any attributes that you are interested in examining. Note also that you will note be able to add attributes directly into the Key Set Selector. This must be done in the MetaMatrix Editor (See Adding and Removing entities In the Editor to add attributes).



By clicking the Show Only Selected button in the Visualizer Ket Set Commands, the four entities, which contained the attribute 1988, will appear in the Visualizer. You can see that these entities share no direct ties.



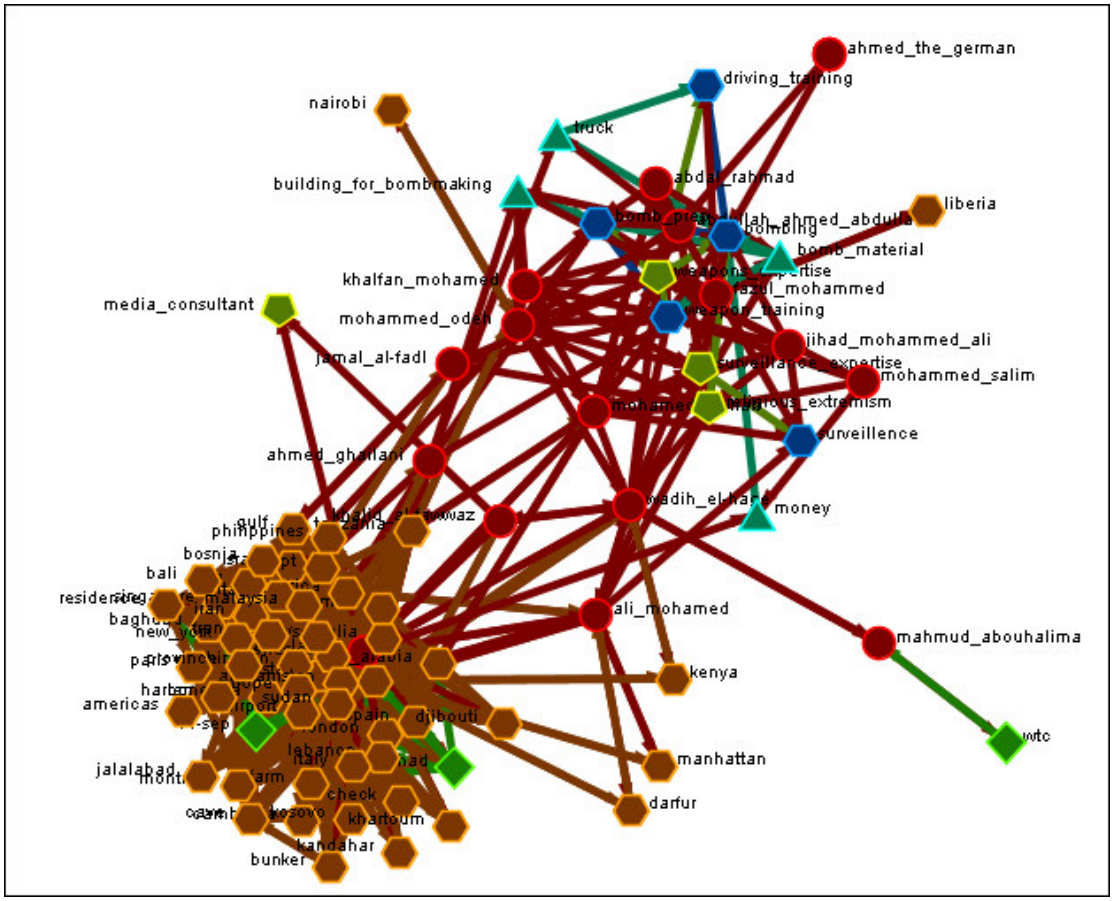
Show / Hide Labels

Entity labels, which often prove helpful in describing entity points, can sometimes clutter a visualization. Thus, it may be necessary to eliminate labels from your visualization. The following procedure will help clarify the screen when it is clouded by the many labels.

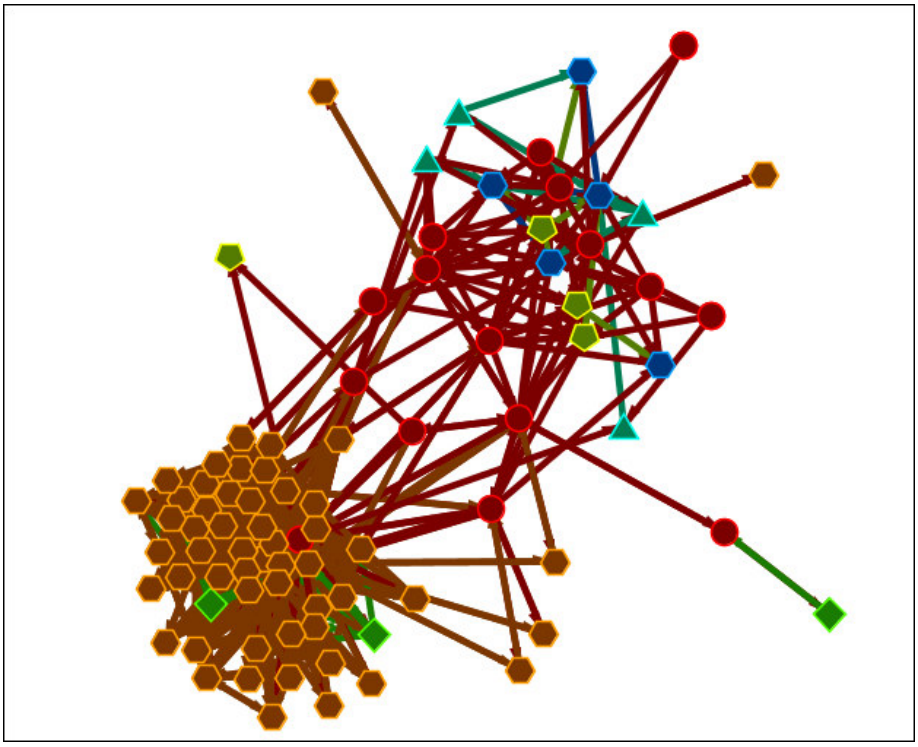
To remove labels go to Visualizer tool bar and select Show Labels button.

The red circle highlights where to find the Label Button on the Visualizer tool bar.

This initial screen shot shows the Visualizer with all the labels.



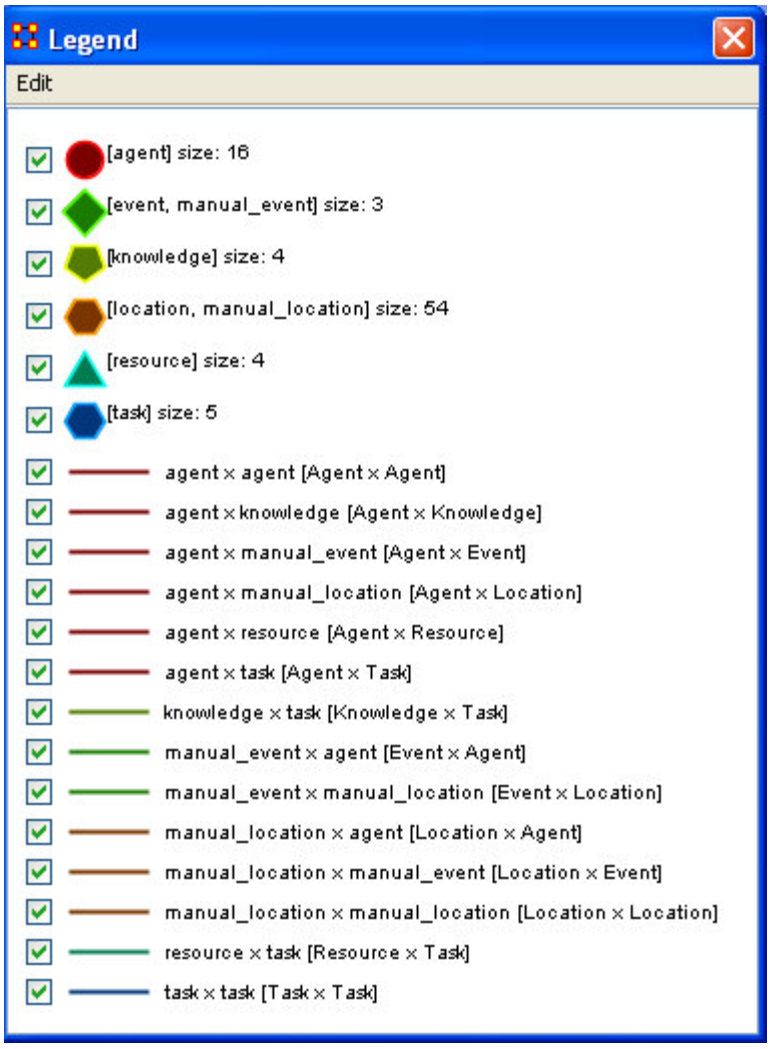
When you click the Label button on the Visualizer tool bar ORA removes all labels. In the screen shot below, our example above has the labels removed. Note that now a much more clearer conceptual picture of the network is produced.



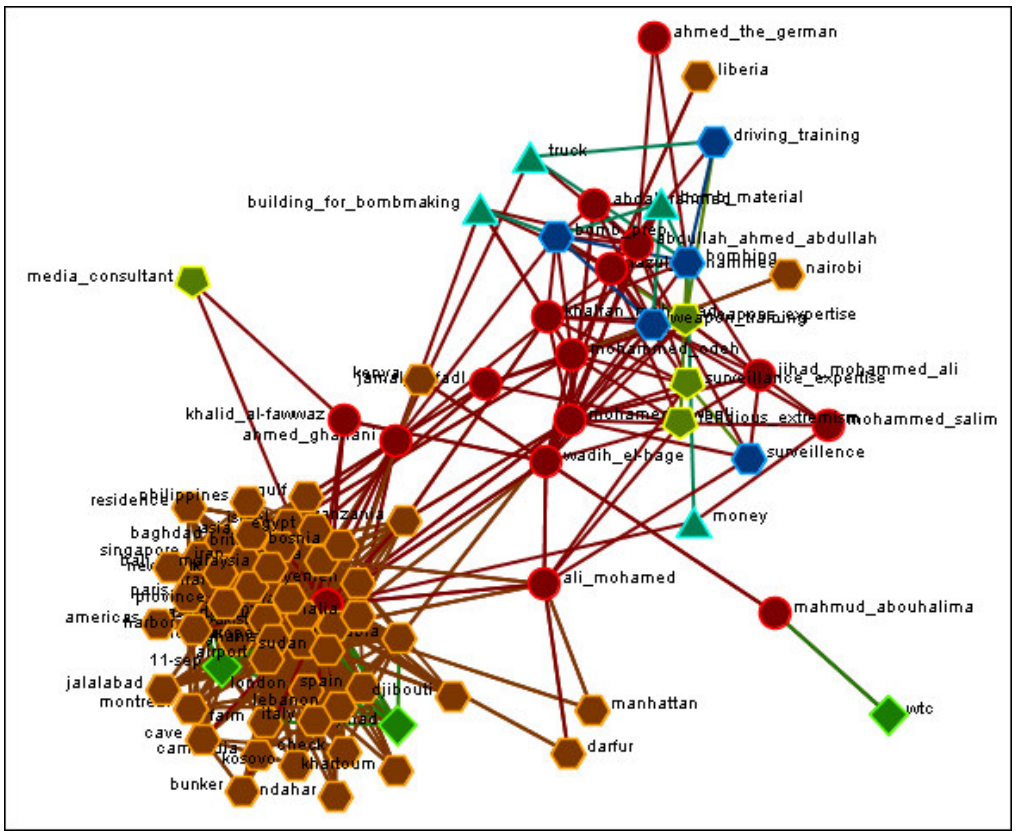
Legend

The Legend box allows you to quickly hide and reveal entities and edges in the Visualizer. Placing a mark in the checkboxe will make an element visible.

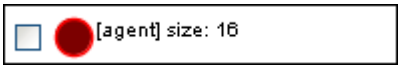
When you start the Visualizer up all the boxes will contain checkboxes.

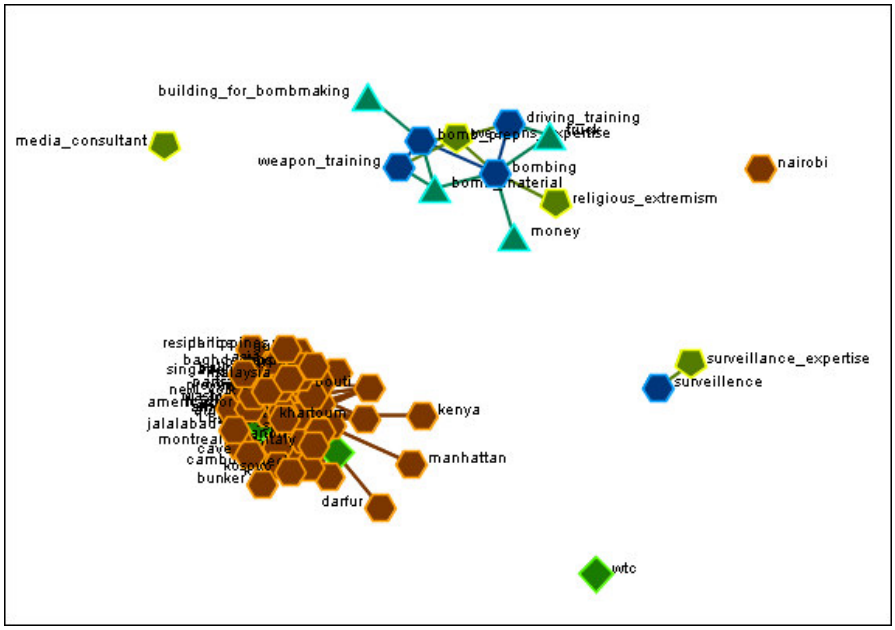


And in the Visualizer all entities and edges are revealed.

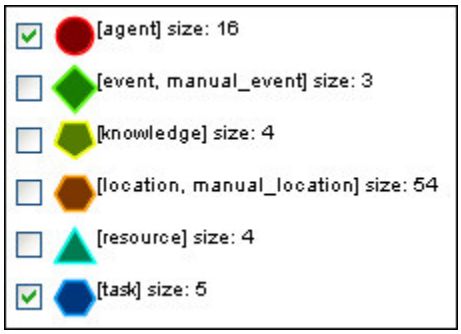


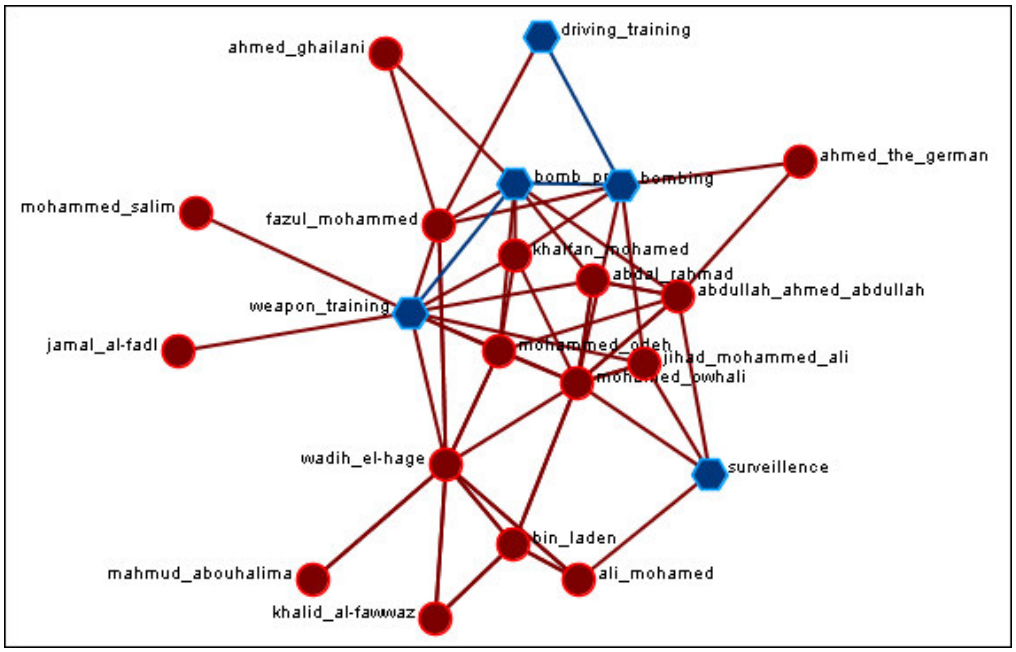
By using the Legend checkboxes you can selectively hide entities and edges. Deselect the checkbox to the left of [agent]. Notice in the Visualizer that all of the Entities marked as agents are now hidden, along with any connections they had with the rest of the entities.



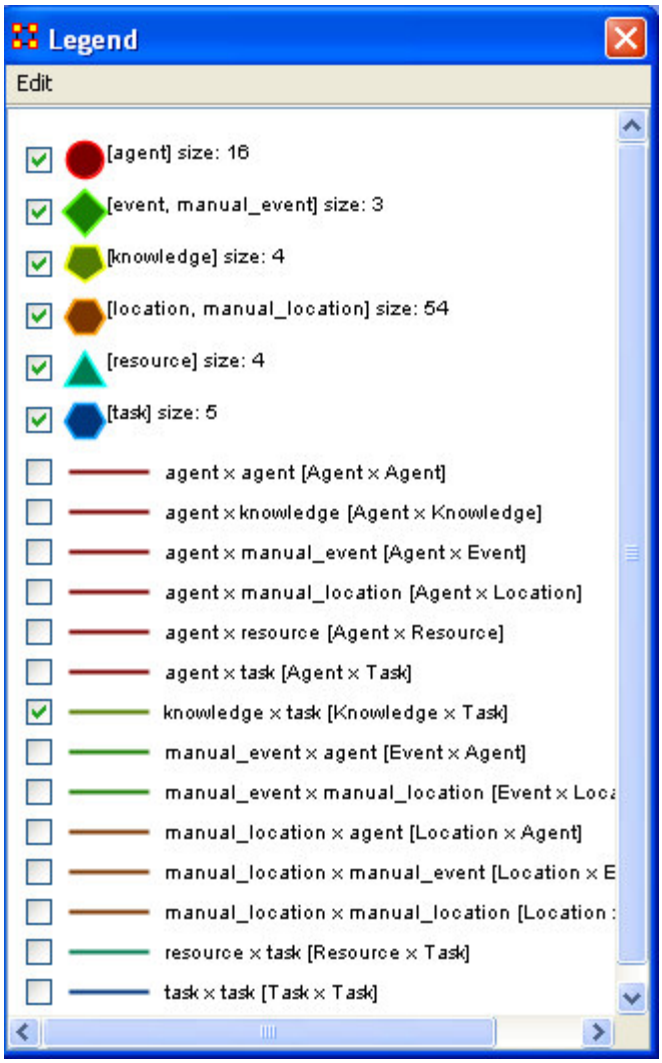


Then Selecting and Deselectin various checkboxes will affect what is displayed on the screen. Here we've reselected [agent] and deselected [event, manual_event], [knowlegde], location, manual_location], and [resource]. In the Visualizer only [agent] and [task] remain visible and connected.

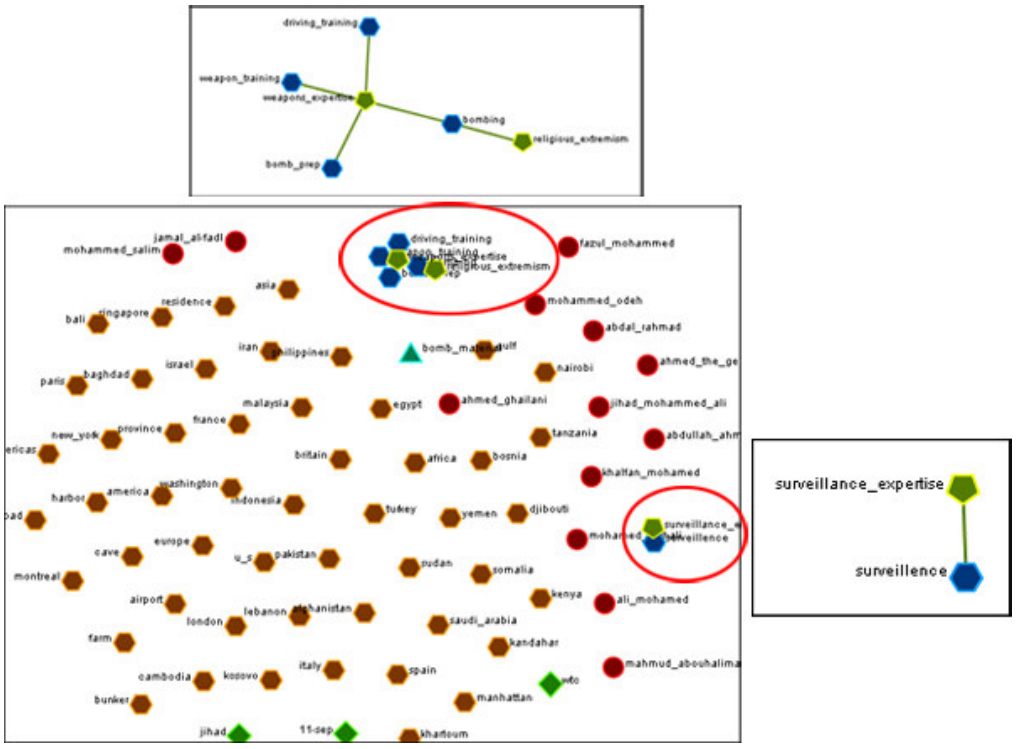




Next Reselect all the entities and Deselct all edges except knowledge x task. Most of the entities are now disconnected except the few that contain knowledge x task edges.



In the screenshot below the two red circles show the only two groups that remain connected. By removing the checkmarks from all but the knowledge x task edges only two groups remain.



Options

Show Weight Edges – Toggles whether the weight of various edges is displayed.

Show Self-Loops –

Edge Color – Options for coloring the edges.

Show Mouse Overs –

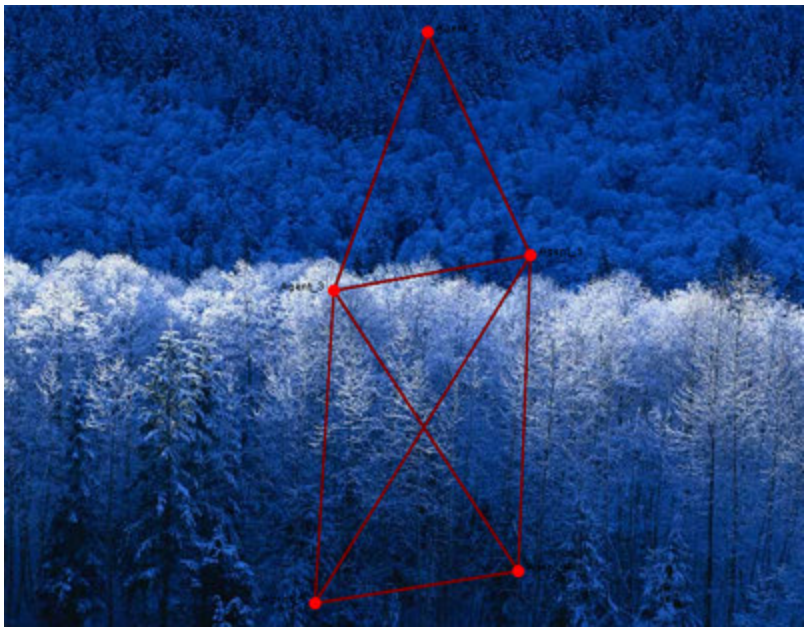
Entity Style –

Black and White Only –

Background Color – Changing the background color changes it in both the Visualizer and the Legend.

Beware: Some of the possible background colors can make it difficult to view the Visualizer. Your best choice is white.

Background Image – Allows you to chose a .jpg, .gif, or .png to use as a background.



Color Entities from Color Attribute –

The Path Finder

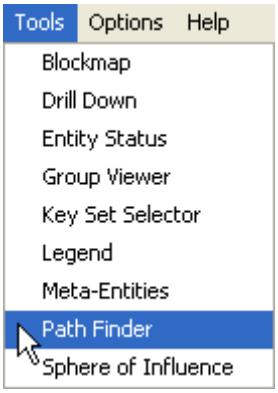
Path Finder Basic

Basics – Examples

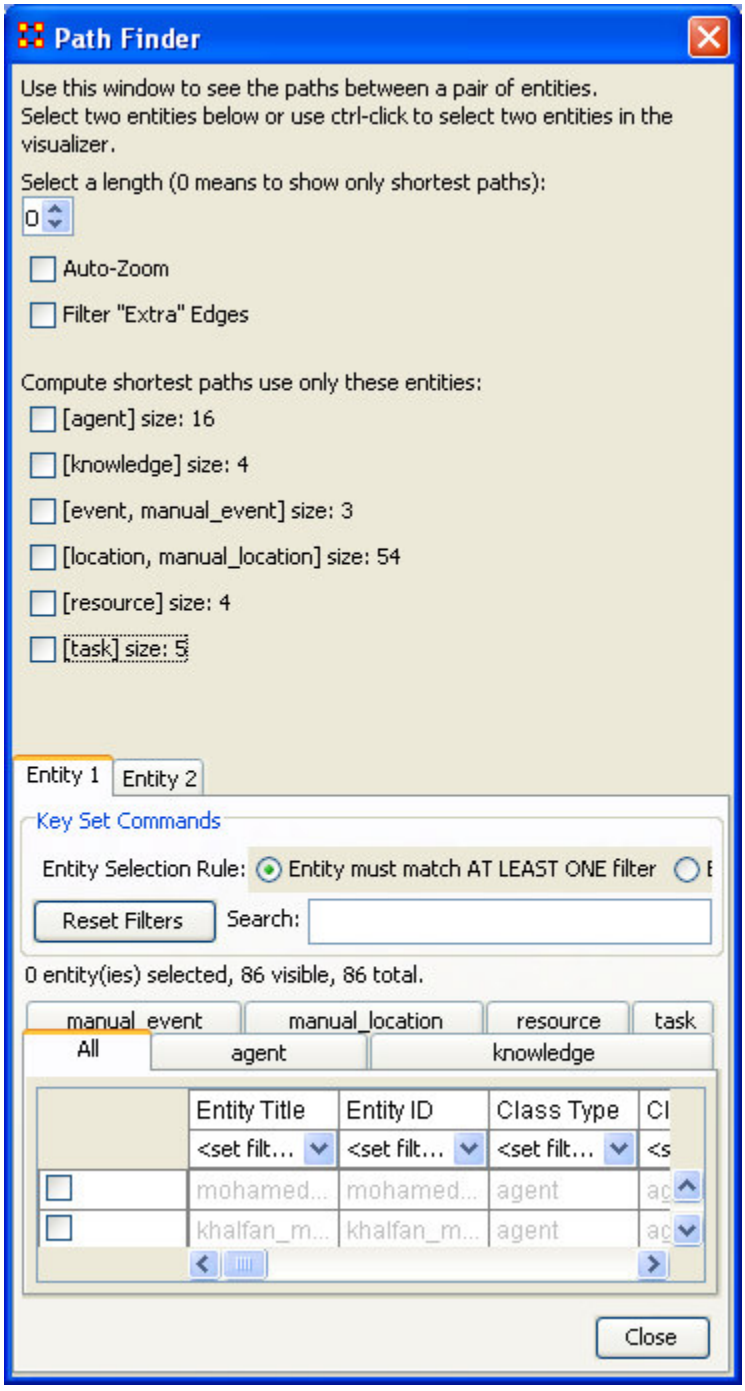
The Path Finder allows you to focus or drill down on a particular entity, or multiple entities, that you may be interested in analyzing in greater detail. This is accomplished within the ORA Visualizer by using the Path Finder tool, accessible from the Visualizer menu. The Path Finder creates an Ego Network for any particular entity or selection of entities and can show you how entities are connected.

An Ego Network, or Sphere of Influence, is essentially a visual representation of a selected entity and its relationship to its immediate neighbors, or other entities, within the network. Each direct tie between an entity and its neighboring entities in a network is referred to as a path. Path length is the number of ties that separate any two entities. Multiple entities can be used by the Path Finder for comparing Ego Networks.

From the Main Visualize Menu select Tools > Path Finder



After selecting the Path Finder, the following dialog box will appear.



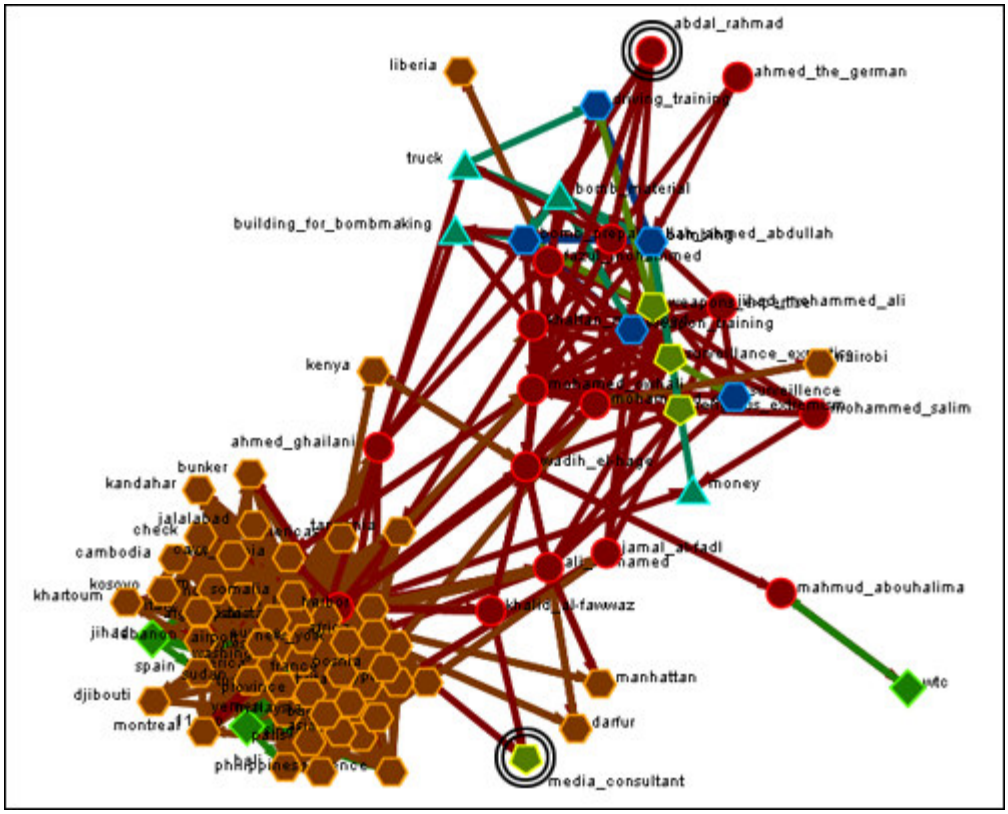
From this dialog box you select which entities you want to use, then select the two entities from the tabs at the bottom.

Path Finder Example

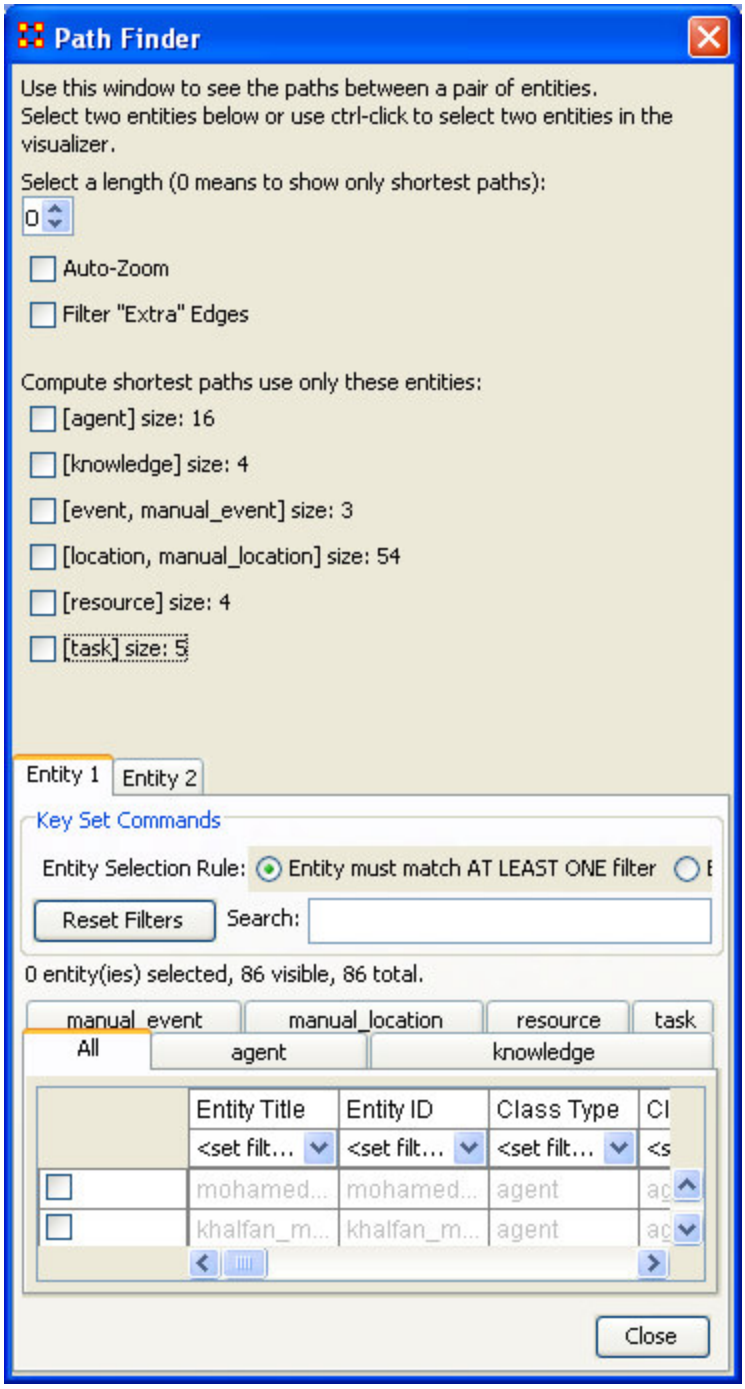
Basics – Examples

In this example, we are working with the MetaMatrix embassy_bombing. Below in an example of this MetaMatrix as it first appears in the Visualizer. We will now attempt to

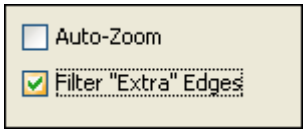
find the path between the agent entity Abdal Rahmad and the knowledge node Media Consultant. We will now connect the circled entities in the Visualizer.



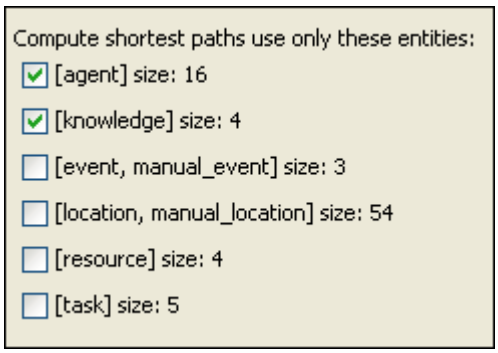
From the Main Menu select: Tools > Path Finder



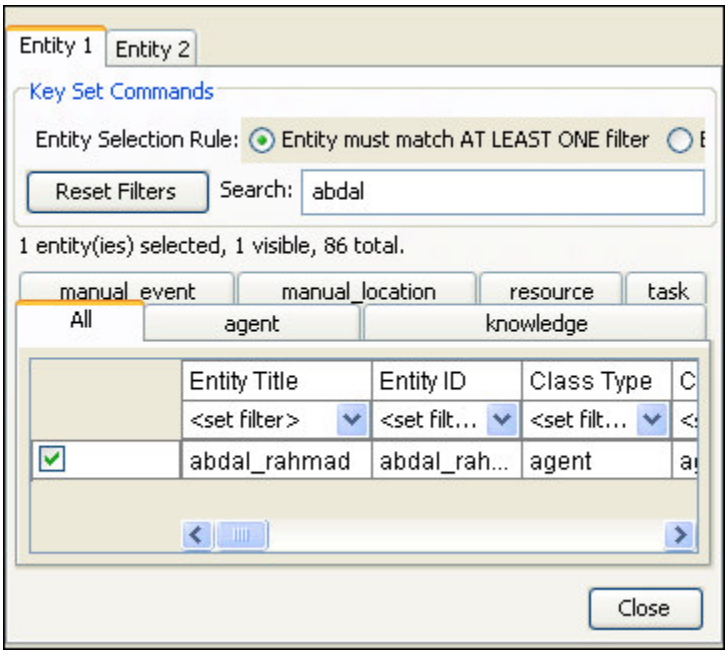
To filter out any extemporaneous edges, select the Filter "Extra" Edges



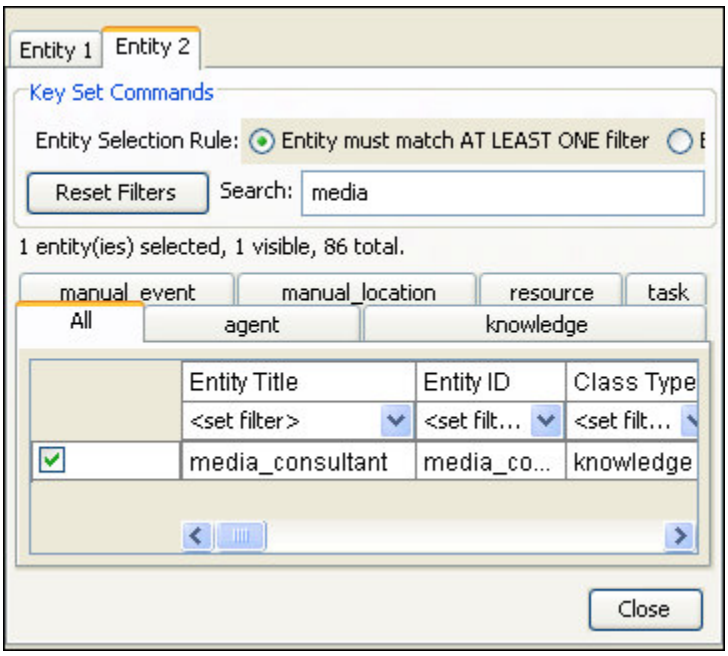
Now select the entity sets you wish to use to connect the two entities



Make sure the Entity 1 tab is active. In the search box, type abdal This will filter out all but the abdal_rahmad line. In other MetaMatrices there may be others that match. Type in as much as needed to find your choice. Select the checkbox on the left.

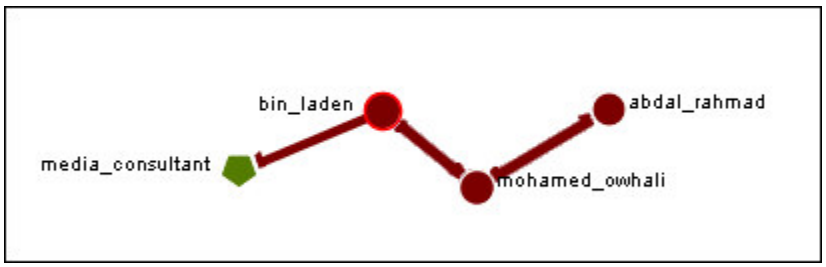


Now select Entity 2. In the search box now type media. This will filter out everything but media_consultant



Now select the [Close] button.

You are now shown the path from abdal_rahmad to media_consultant without any extra entities or edges.

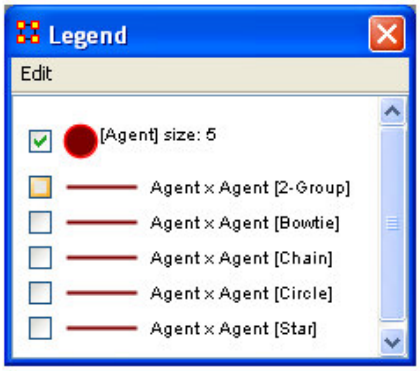


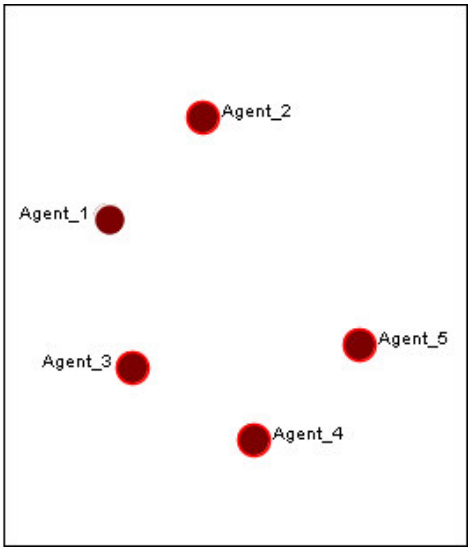
Visualizer Patterns

This is a list of patterns that can make it easier to find various clusters.

No Edges

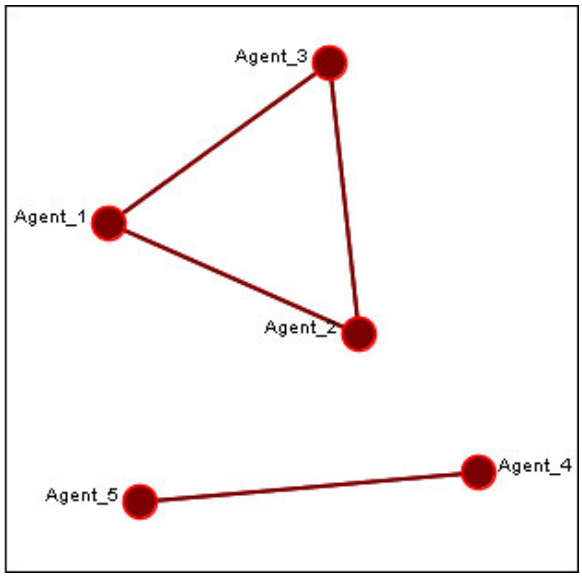
No Edges – 2-Group – Bowtie – Chain – Circle – Star





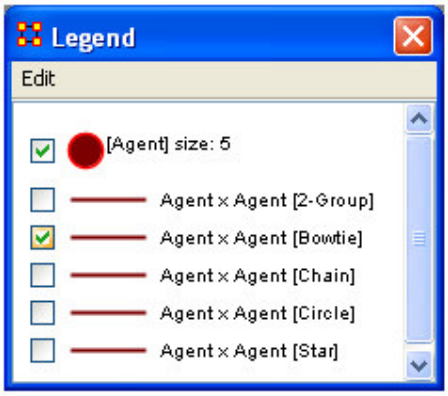
2-Group

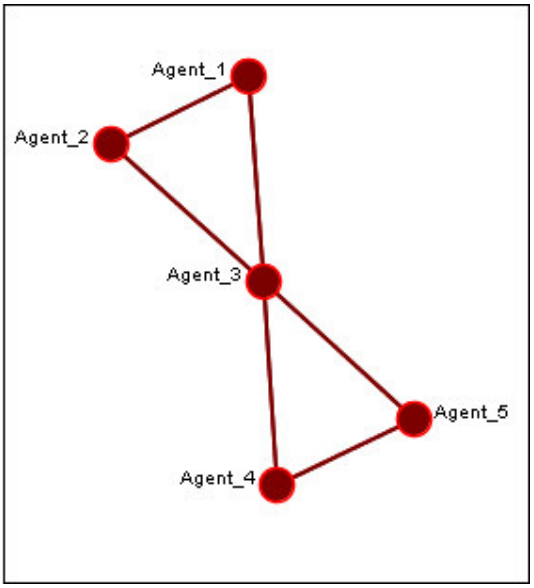
No Edges – 2-Group – Bowtie – Chain – Circle – Star



Bowtie

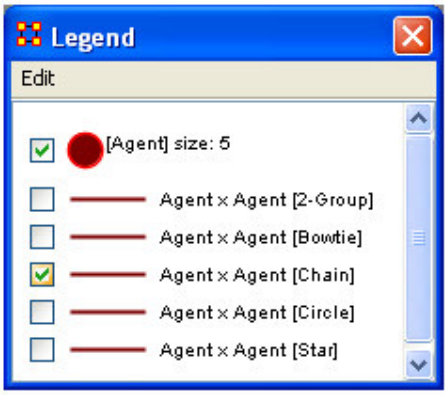
No Edges – 2-Group – Bowtie – Chain – Circle – Star





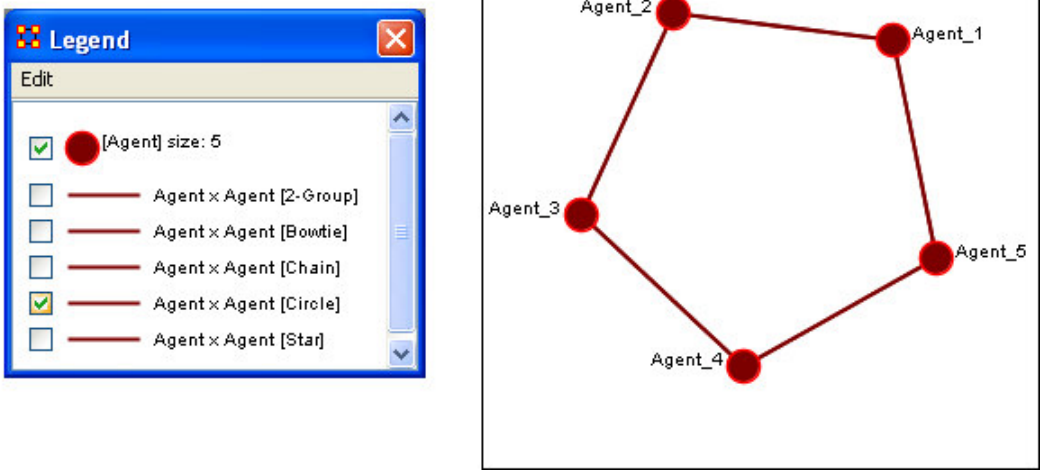
Chain

No Edges – 2-Group – Bowtie – Chain – Circle – Star



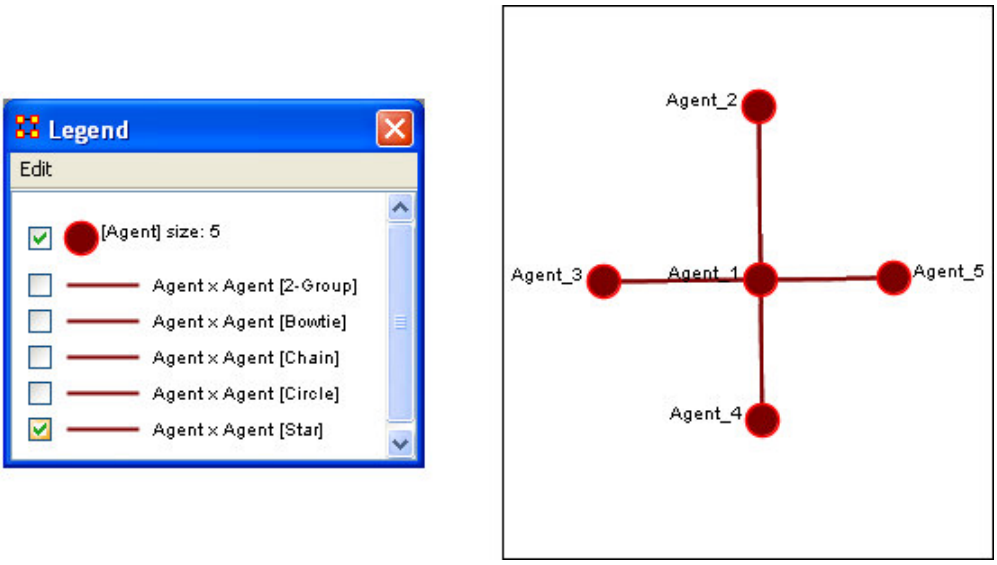
Circle

No Edges – 2-Group – Bowtie – Chain – Circle – Star



Star

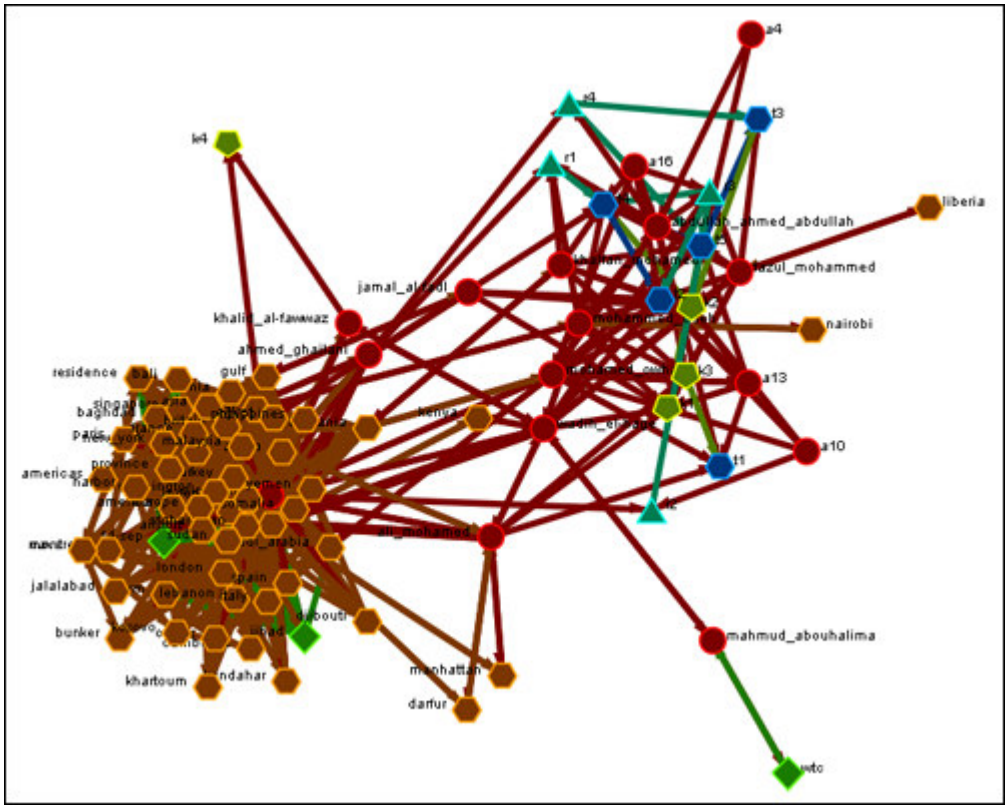
No Edges – 2-Group – Bowtie – Chain – Circle – Star



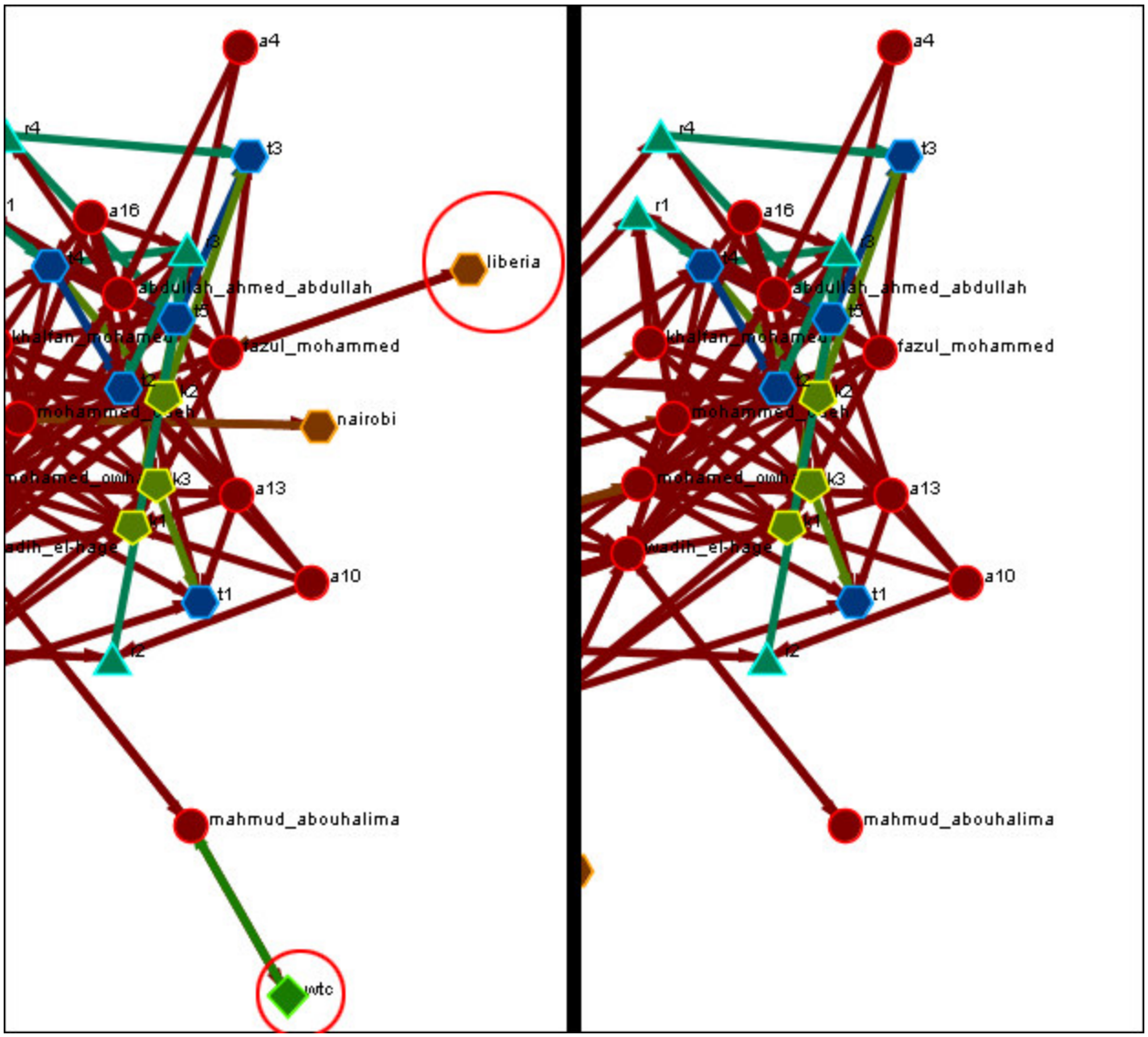
Removing Pendants

Pendant entities share links to other entities. But their linkage is tangential and therefore isolated from the core linkages you may be interested in examining. Pendant entities, like Isolated entities, can be removed.

From the drop down menu in the Visualizer tool bar > Tools > Hide Pendant Entities.



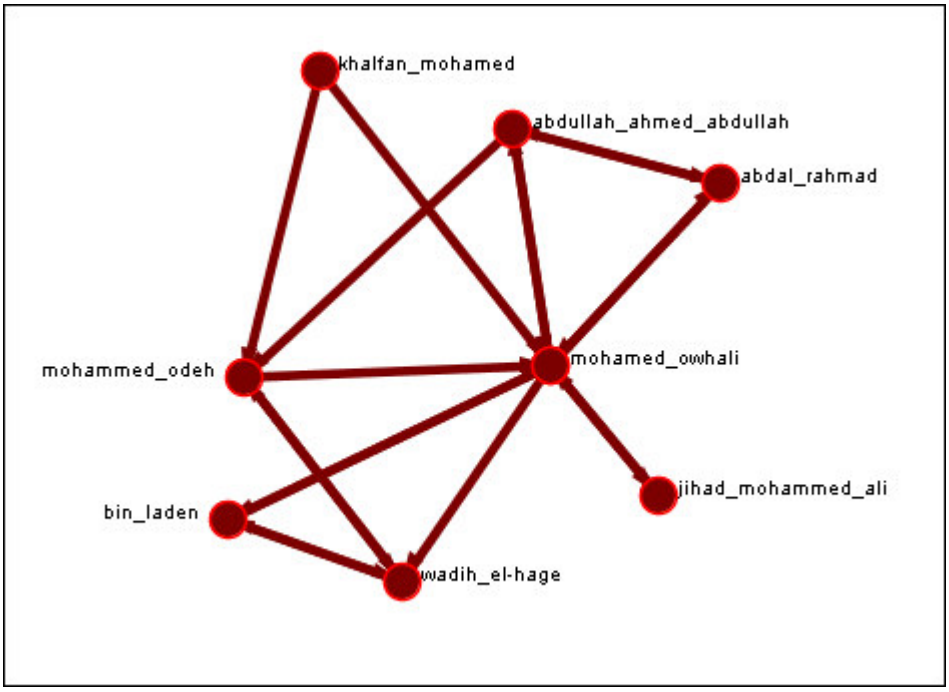
Below is a Before/After screen shot of the visualization before showing the removal of the pendant entities. The red circles show the entities which have been removed.



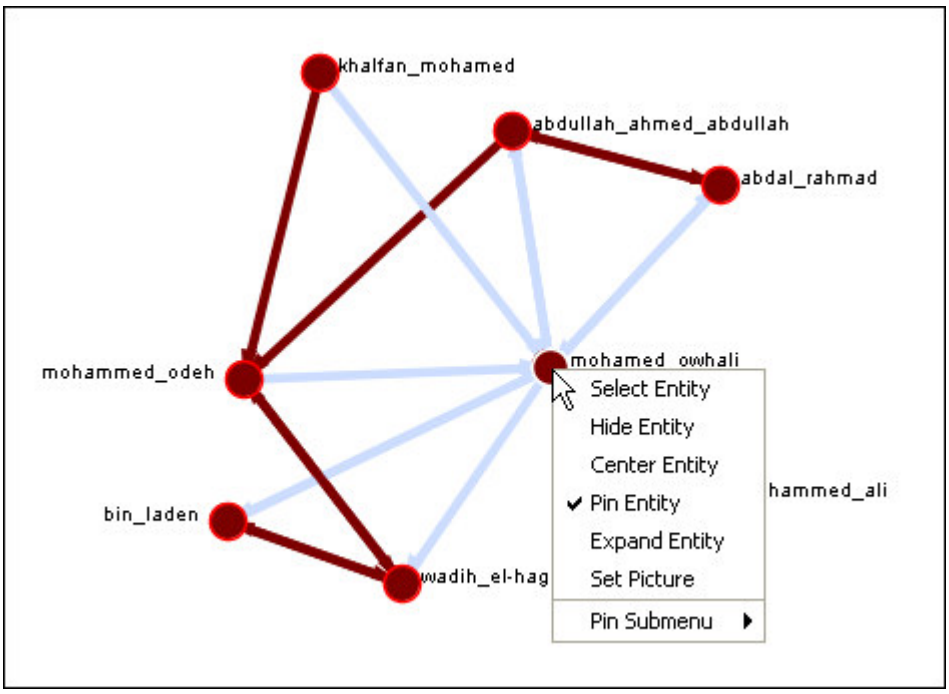
Removing Entities In The Visualizer

You can remove entities directly from the ORA Visualizer by right clicking on a entity and selecting Hide Entity.

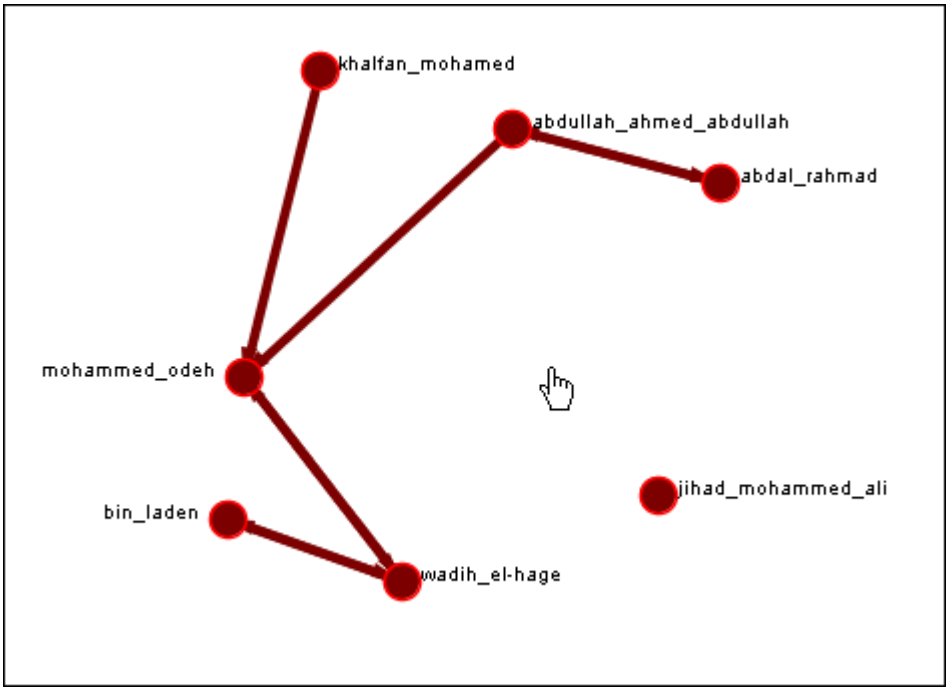
In the Visualizer, find the entity you want to hide. Here we will hide mohamed_owhali.



Place the cursor over the entity and right-click on the entity to bring up the contextual menu. Highlight Hide Entity.



When you release the button mohamed_owhali's entity will be hidden. From this action we see the elimination of mohamed_owhali isolates jihad-mohammed_ali



Resize Entity by Attribute or Measure

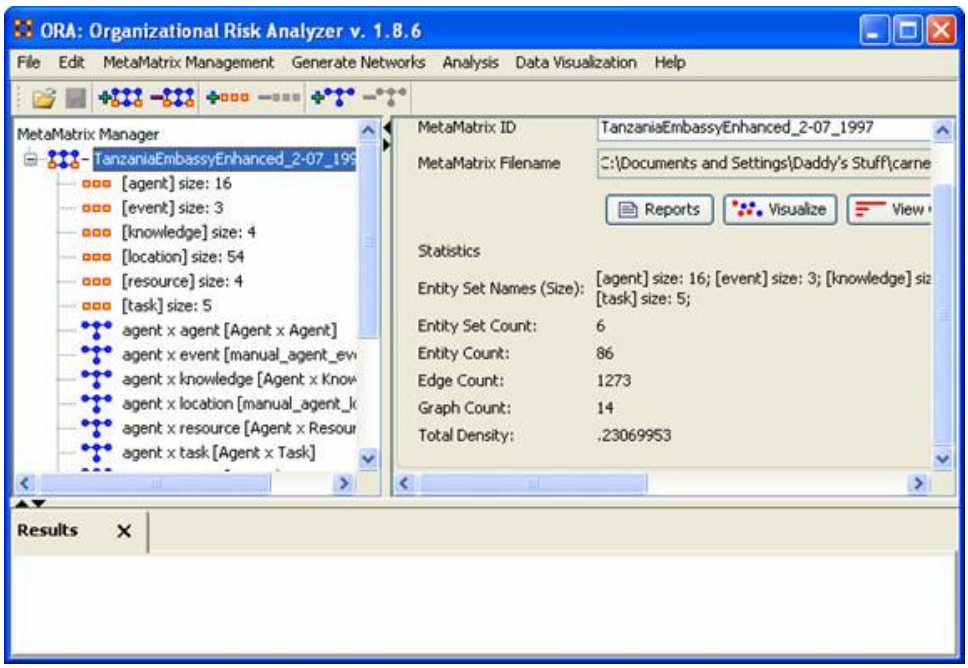
Sizing entities by basic SNA measures

ORA has the capability to visualize entities by scaling them relative to each other in relation to common SNA Measures or Attributes as selected within the ORA Visualizer. The key benefit to sizing entities by Measure or Attribute is the ability to conceptually capture which entities in your network figure more prominently in terms of measures by simply gauging their size visually and intuitively.

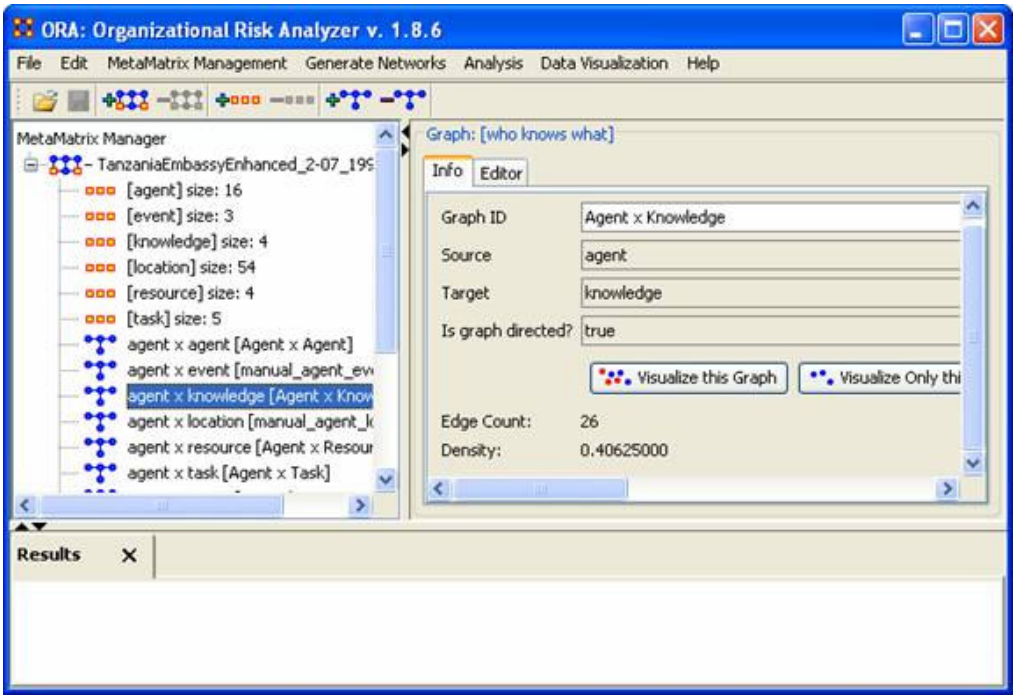
To demonstrate this function will work with a graph of the TanzaniaEmbassyEnhanced_2-07_1999 dataset.

First, we will load our Metadata into ORA.

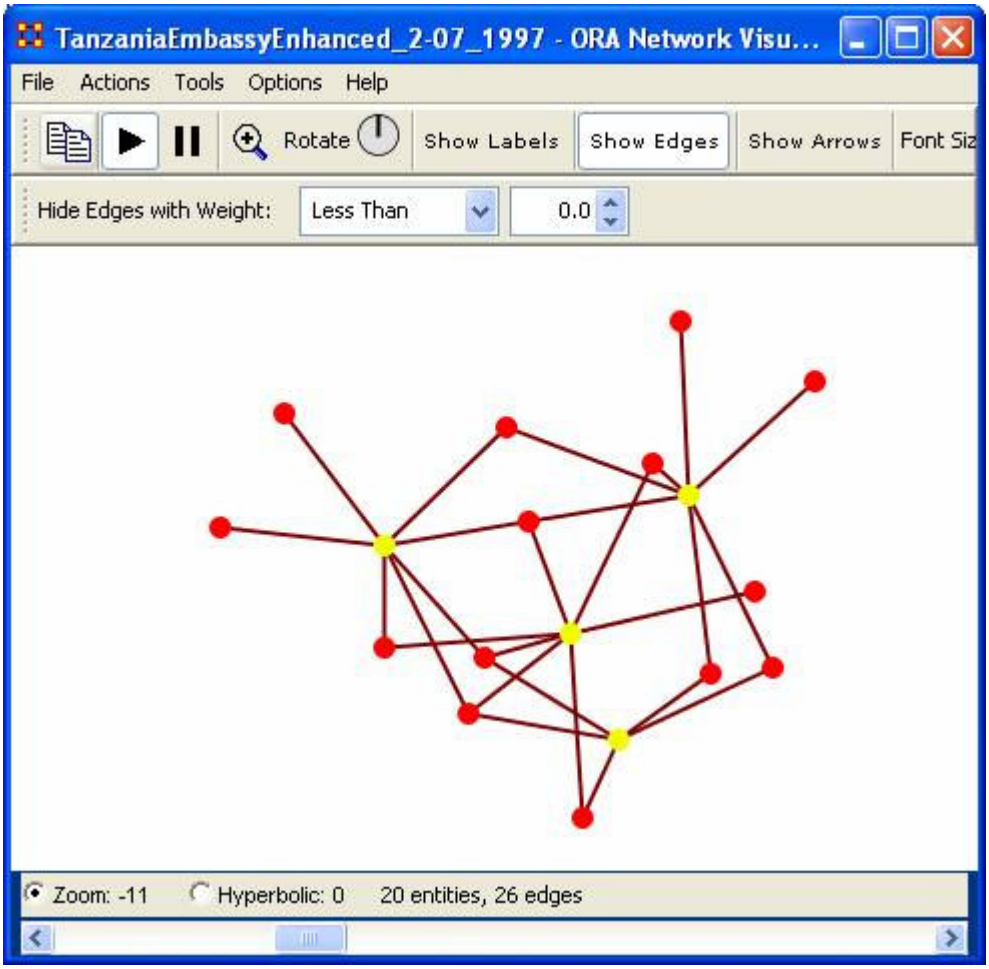
Below is a screen shot of the TanzaniaEmbassyEnhanced-2-07_1999 Metadata set loaded into ORA's main interface:



To better illustrate the functionality of this tool, we will choose to work with a sub-graph part and parcel of the above Tanzania Meta-Matrix. Let us select the agent x knowledge graph of the of the TanzaniaEmbassyEnhanced_2-07_1999 dataset. The screen shot below displays this graph when selected in the ORA Main Interface.



After the graph is selected, click the Visualize this Graph button to display this graph in the ORA Visualizer. The screen shot below displays the result:

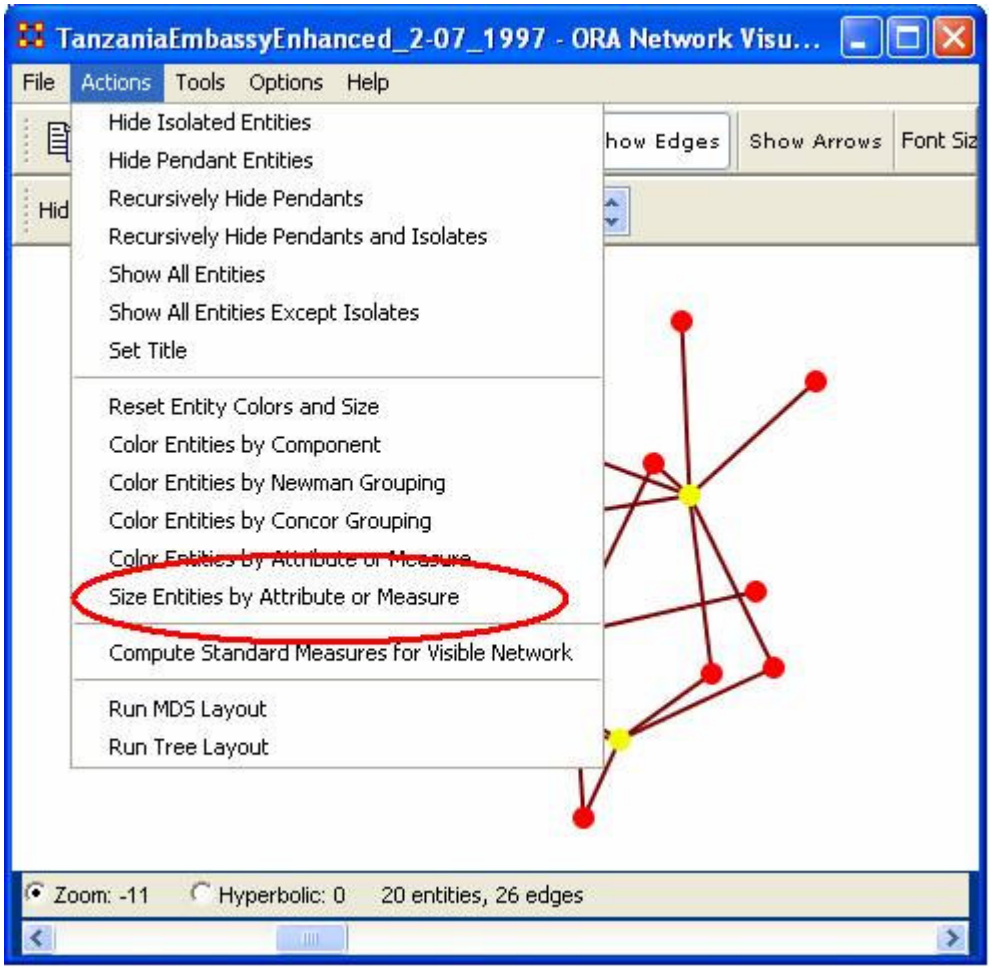


Note: we have zoomed in on this image, thus obscuring from view two isolate nodes.

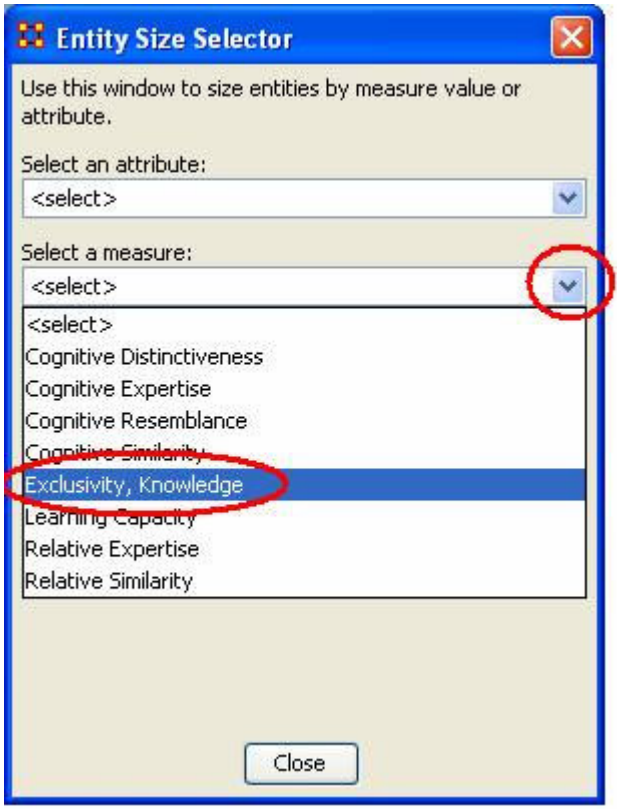
Next, we will size the entities in this graph by accessing the Visualizer's Main Menu bar.

From ORA Visualizer's Main Menu Bar > Size Entities by Attribute or Measure

The red ellipse on the screen shot below shows how to access the Size Entity by Attribute or Measure tool from ORA's Visualizer Main Menu Bar.

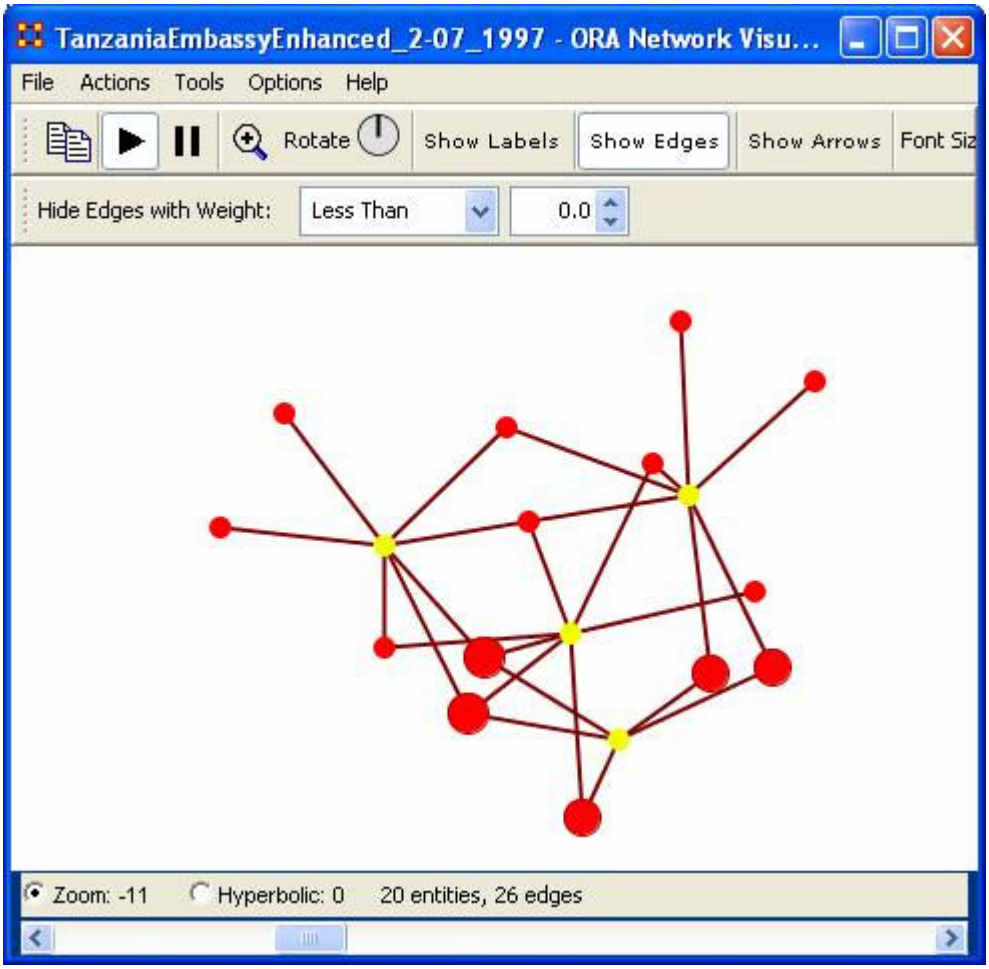


After you select Size Entities by Attribute or Measure, the Entity Size Selector pop-up window will appear:



Using the drop down arrows, you can choose to select a Measure or Attribute by which to size your entities. In our example we are going to choose the measure Exclusivity, Knowledge from Select a Measure drop down arrow selector.

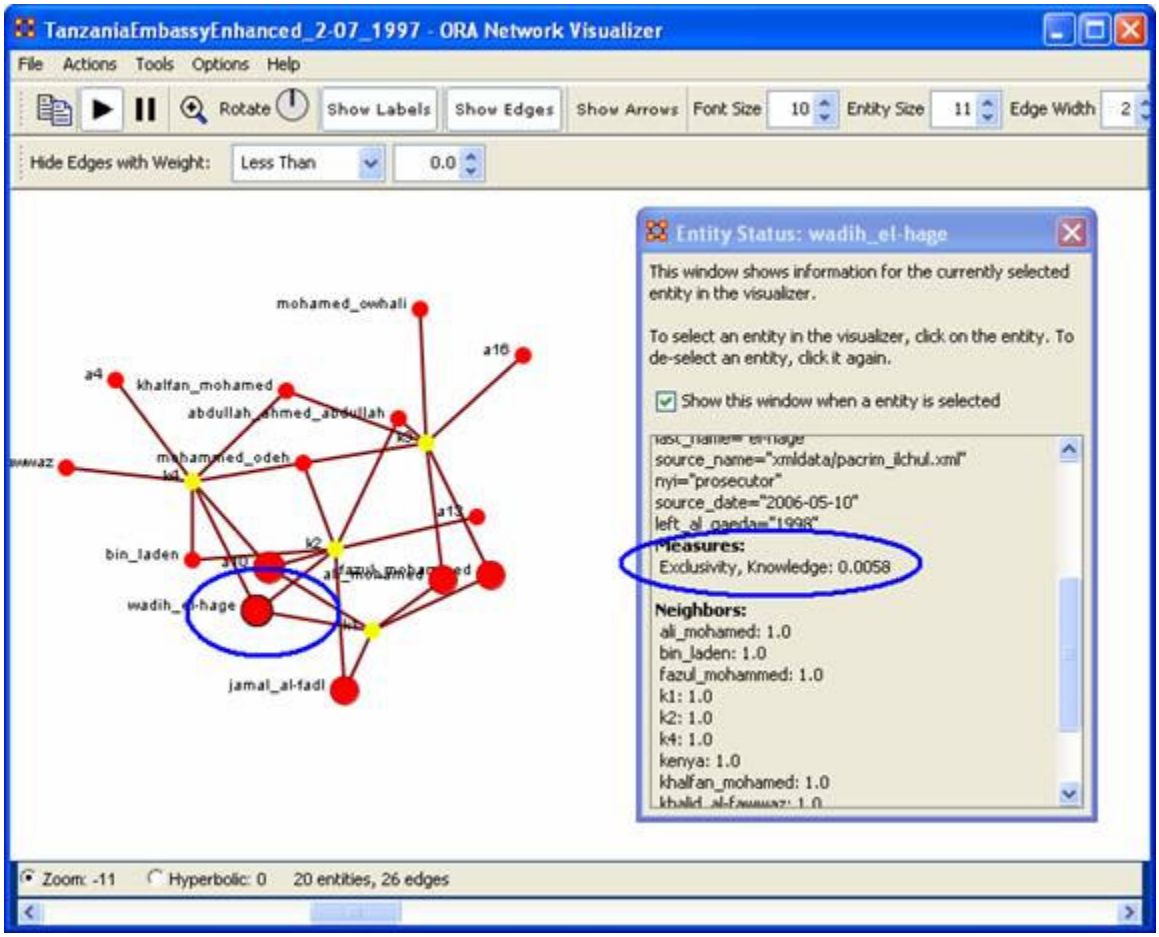
After we choose the measure to size, the Visualization should now scale your entities relative to their respective Exclusivity, Knowledge measure value. The screen shot below shows the result of this selection for our dataset:



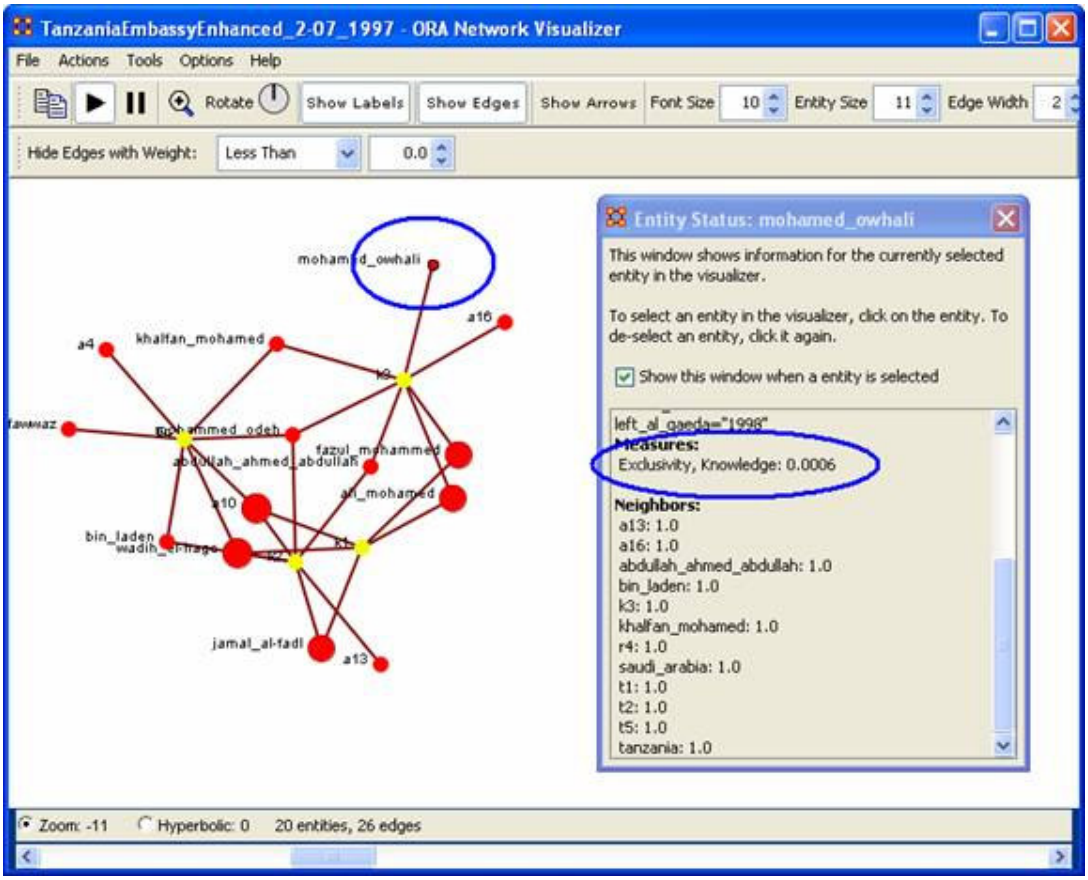
Notice that the size of the nodes has now changed according to the entities relative value of Exclusivity.

Let us drill down on the wadih_el-hage agent entity, which is ostensibly larger than the other agent entities. We will now check to see that this entity's Exclusivity, Knowledge value is higher than a smaller sized entity render in the ORA Visualizer.

To do so, click on the entity wadih_el_hage. The Entity Status window will appear which shows information for the currently selected entity in the Visualizer. Scroll down in this window to you find the Measures value. The screen shot below shows were to find the Measures value in the Entity Status window.



Now we will compare this Measure value with that of the entity Mohamed_owhali, which is ostensibly smaller in size than wadih_el_hage.

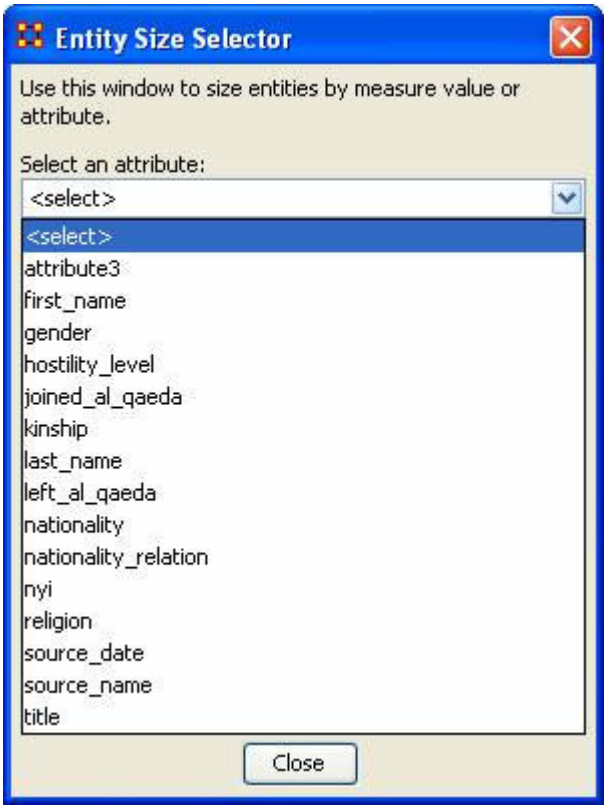


Notice that this much smaller sized entity reflects a much smaller value (.00006) for the Exclusivity, Knowledge measure versus the wadih_el-hage entity (.0058).

Sizing by Attributes

You can also choose to size entities by Attributes. To do so, follow the procedures above until you get to the Entity Size Selector box.

This time opt for the first drop down selector Select an attribute and pick and attribute from the choices available. The screen shot below shows you the attributes available for our example Tanzania Bombing dataset.



The ORA Visualizer will now scale your entity sets according to attribute.

SUMMARY

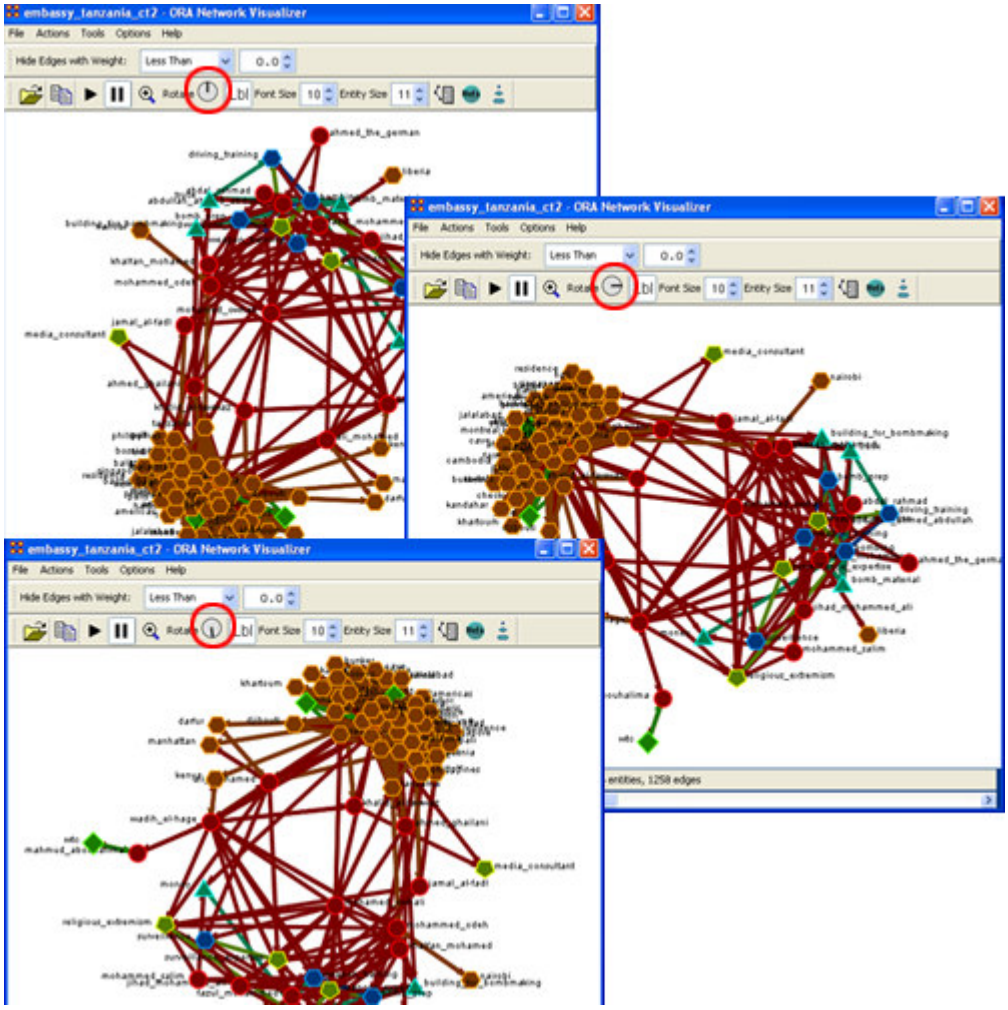
By now you should know how to accomplish the following tasks:

- *Understand* the benefit of sizing an entity set by attribute or measure.
- *Access* the Size Entity by Attribute or Measure tool in the ORA Visualizer.
- *Select* and Attribute or Measure available to your graph and render the graph in the Visualizer scaled according to a measure or attribute value.

Rotating A Visualization

You can rotate a visualization with the slider bar at the bottom of the interface or from the tool bar at the top. To do this from the slide bar, click the rotate option toward the bottom of the interface. This activates the rotate feature. As you move the slider from the left to right, your visualization will rotate correspondingly. From the tool bar, you can click inside the rotate icon, which will turn the visualization depending on exactly where you clicked. In the screen shot below, the yellow ellipses highlight where to access ORA's rotate tool both at the bottom and top of the Visualizer interface.

Note : Use the rotate feature in tandem with the magnifying glass to find a visualization's maximum screen size.



Sphere of Influence

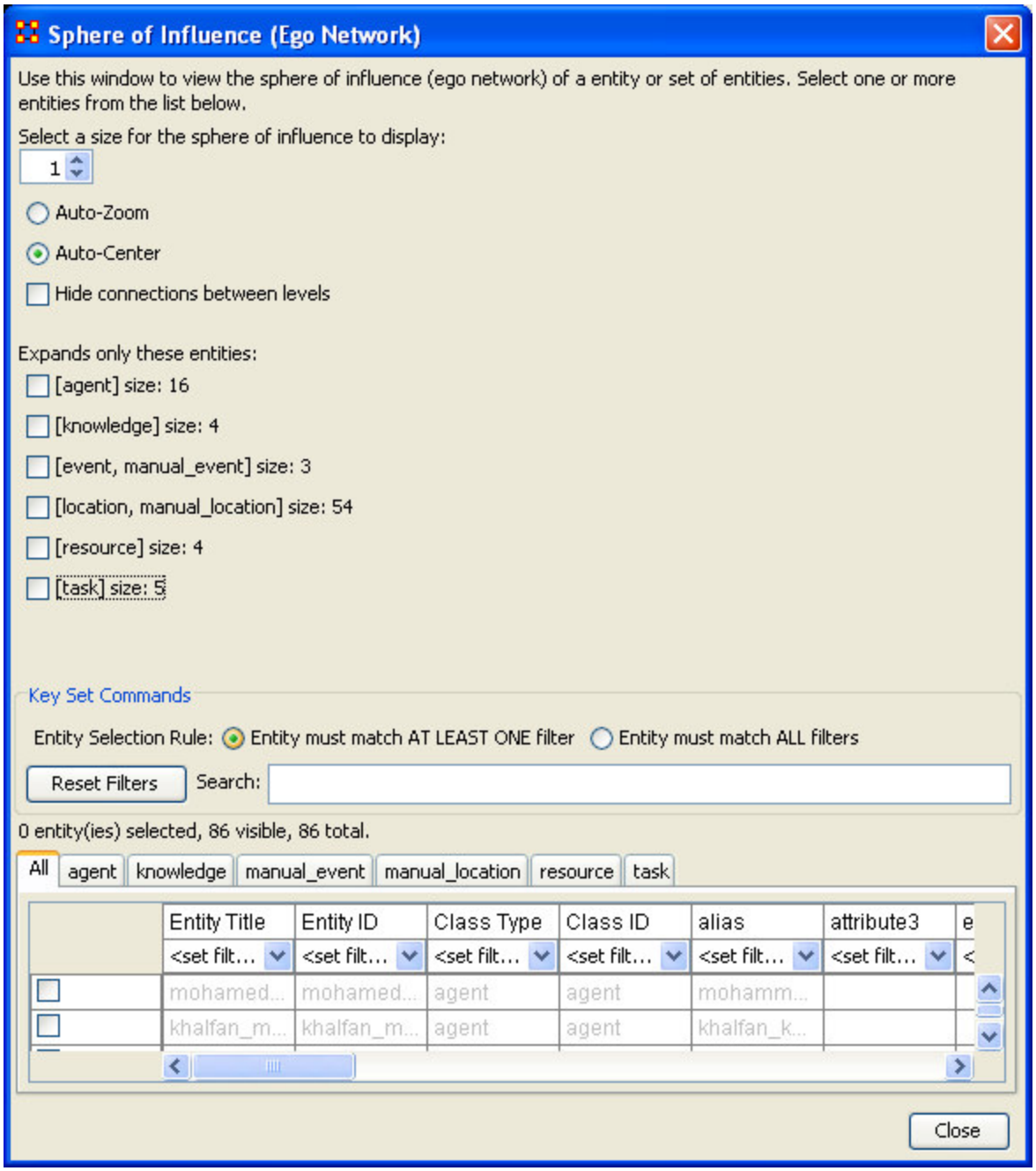
Sphere of Influence Basics

Basics – Filters – Examples

Each entity within a network has a unique Sphere of Influence or Ego Network. Essentially it's a direct relationship with it's neighbors as a function of specified path length. The ORA Visualizer allows you to focus on this relationship by creating an Ego Map centered on any particular entity you choose.

From the Visualizer's Main Menu select: Tools > Sphere of Influence

The following dialog box will then appear. From here you can select the Size of your sphere's influence, the entitySets, and Key Sets to use.



Sphere of Influence Window

Size Selector box : The drop down box allows you to choose the path length you are interested in for that particular entity or set of entities.

Auto-Center : Keeps the visualized Ego Network centered within the Visualizer display.

Auto-Zoom : Maximizes your ego network within the Visualizer.

Expand only these entities : Allows you to select the components you wish to have displayed in a entity's Sphere of Influence.

Key Set Commands :

Entity selection table : Allows the selection of individual entities for visualization.

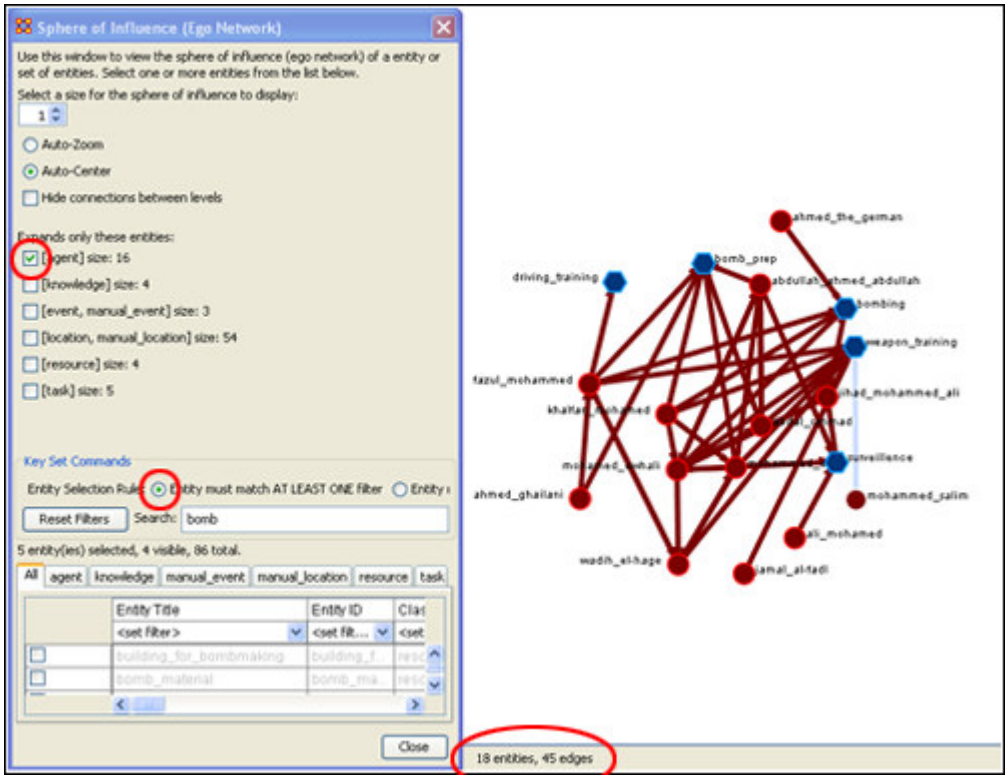
Sphere of Influence Filter

Basics – Filters – Examples

Using the embassy bombing MetaMatrix, we will find the Sphere of Influence of the Task entity bombing by performing a basic analysis. First will we run it with the filter Entity must match AT LEAST ONE filter. On the second we will change that to the filter Entity must match ALL filters so you can see the difference.

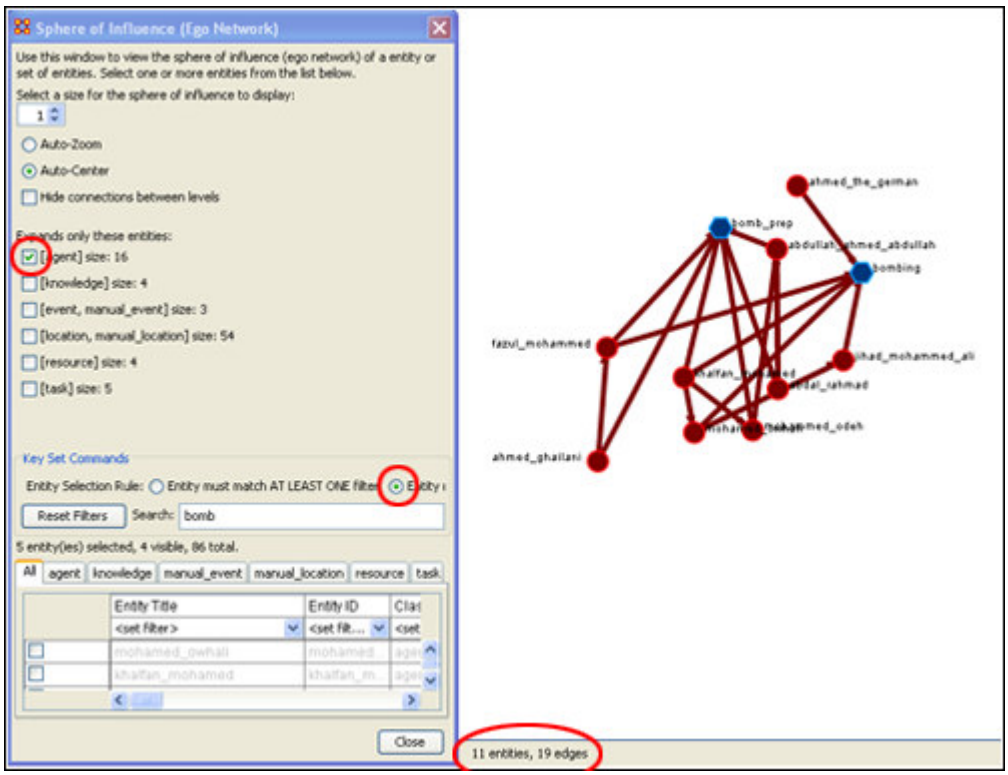
Entity must match AT LEAST ONE filter

Checkmark [agents] under Expands only these entities:. Next make sure the radio button for Entity must match AT LEAST ONE filter is selected. At the bottom of the screen you will notice is states that there are 18 entities and 45 edges.



Entity must match ALL filters

This next example is similar to the above except we are going to change the filter to Entity must match ALL filters. The first thing you notice is the amount of entities and edges has changeed to 11 entities and 19 edges

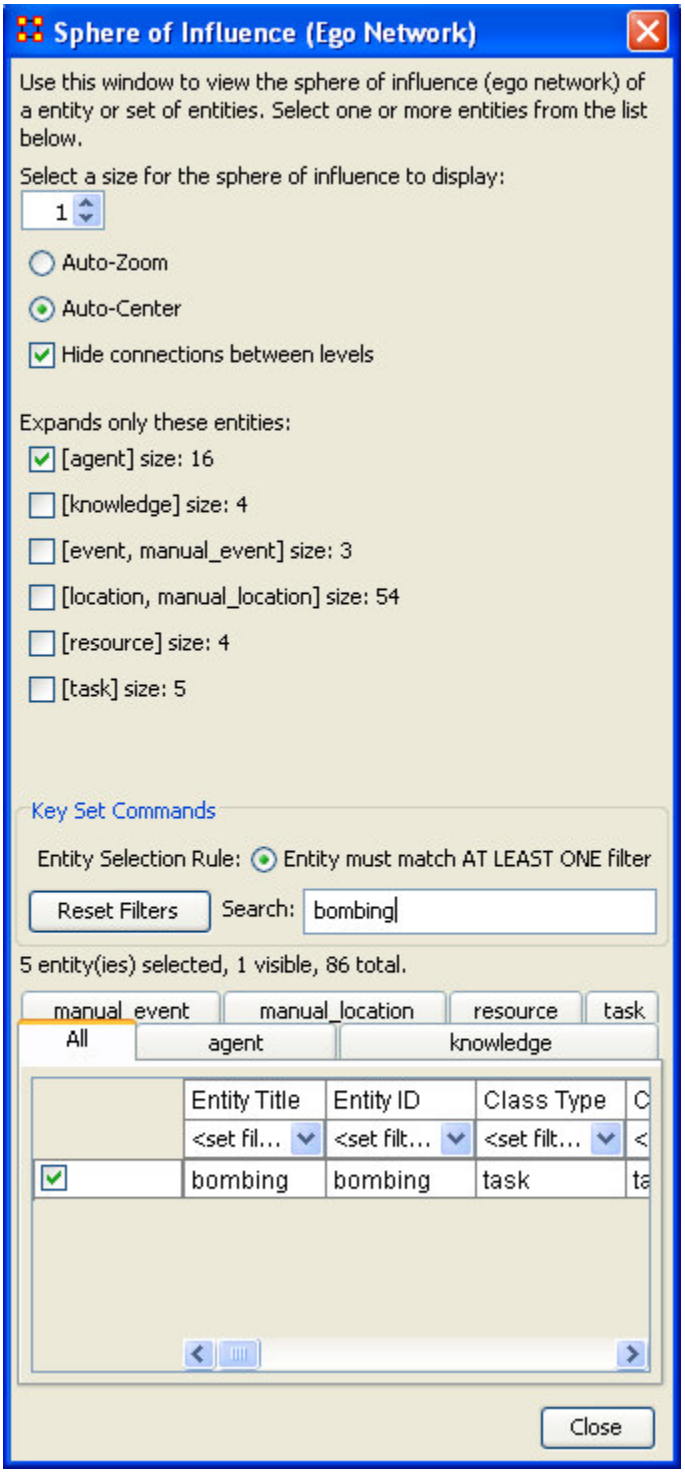


Sphere of Influence Example

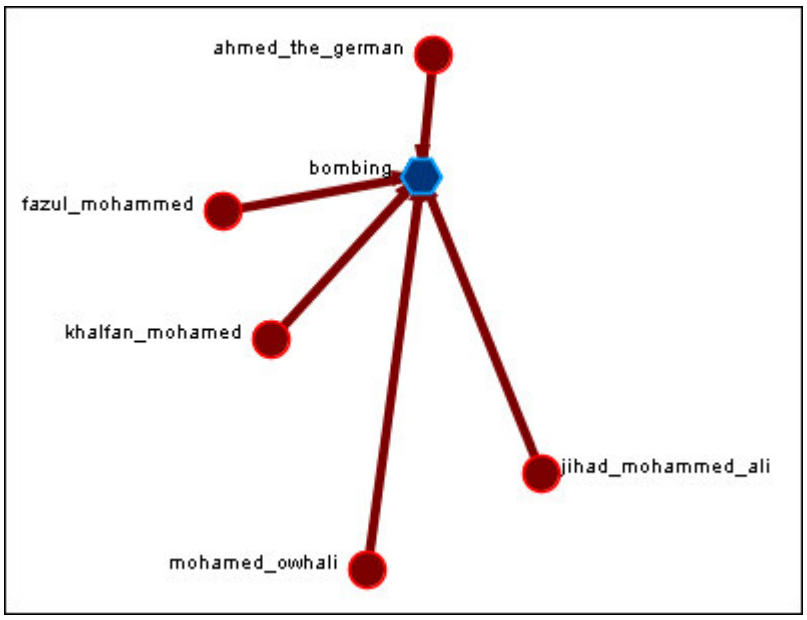
Basics – Filters – Examples

The Sphere of Influence allows you to see how other entities relate to a particular entity you have choosen. For this example we want to see what other entities are connected to bombing.

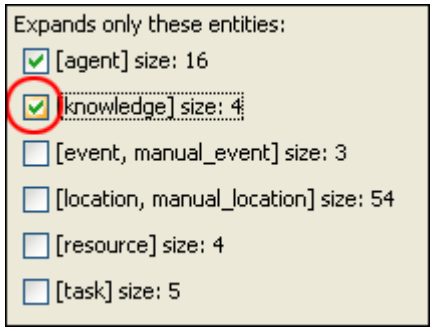
The size is set to 1, Hide connections between levels is checked to turn off extra edges, and all the checkboxes under Expands only these entities are empty except for [agents]. At the bottom of the box, type bombing into the search box. In the table at the bottom, one row will be displayed - bombing. Select the bombing checkbox. Then select the [Close] button.



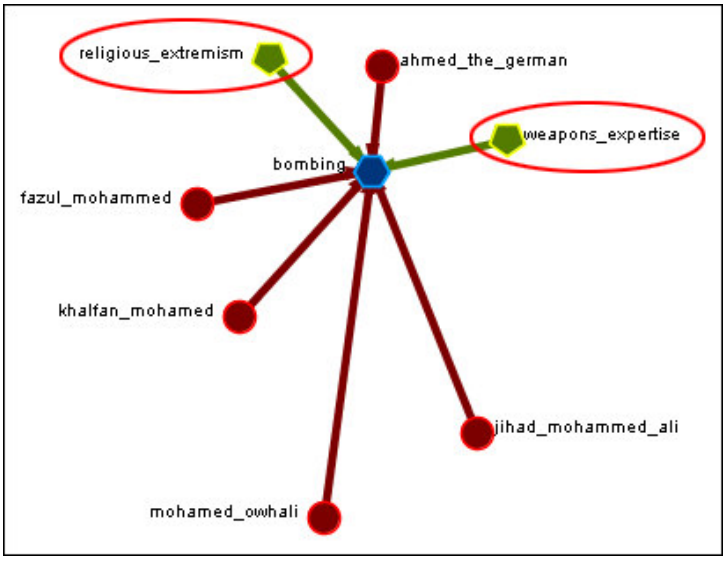
The Visualizer will display the task bombing and any entity that has a connection to bombing. In this instance, there are five agents that are connected.



Next let's add an attribute to the mix. We want to see what other knowledge has connections to the task bombing. Then select the [Close] button.

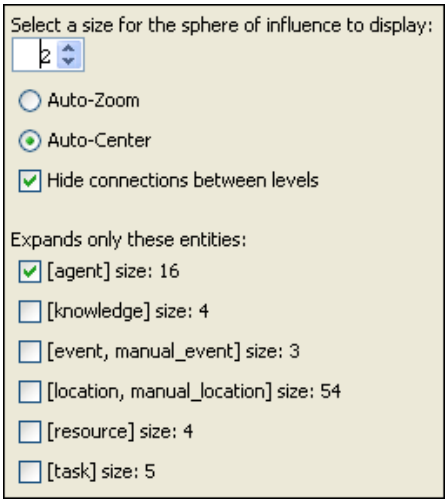


In addition to the five agents previously connected to bombing, we see the knowledges weapons_expertise and religious_extremism have been added to the display.

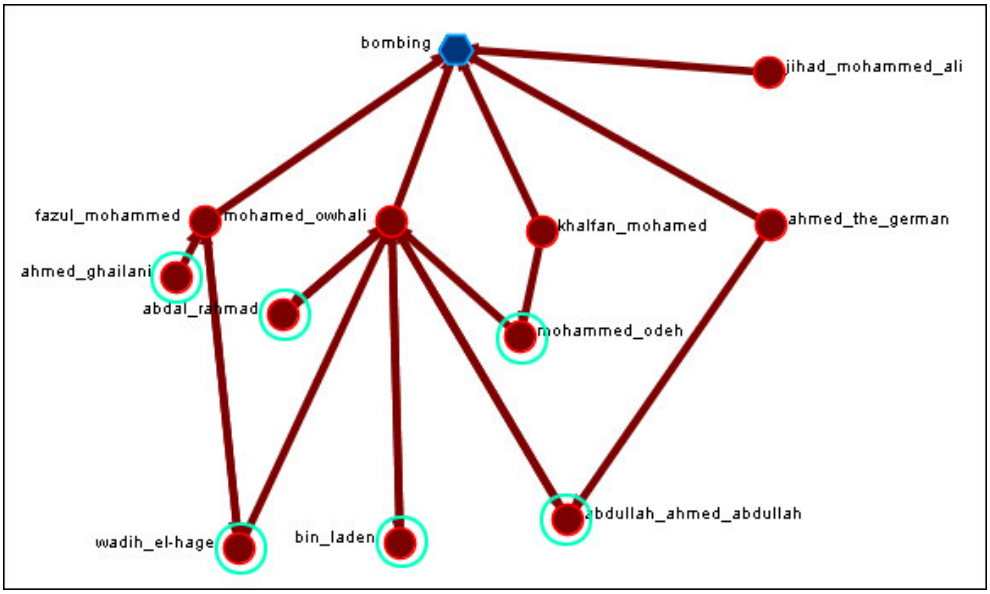


Now let's take a step backwards. and change the way the Visualizer will display the information.

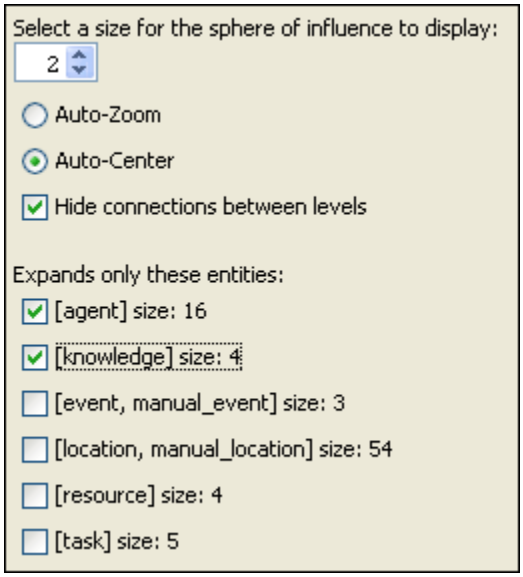
1. Increase to 2 the selector Select a size for the sphere of influence to display.
2. Uncheck the knowledge checkbox.
3. Select the [Close] button.



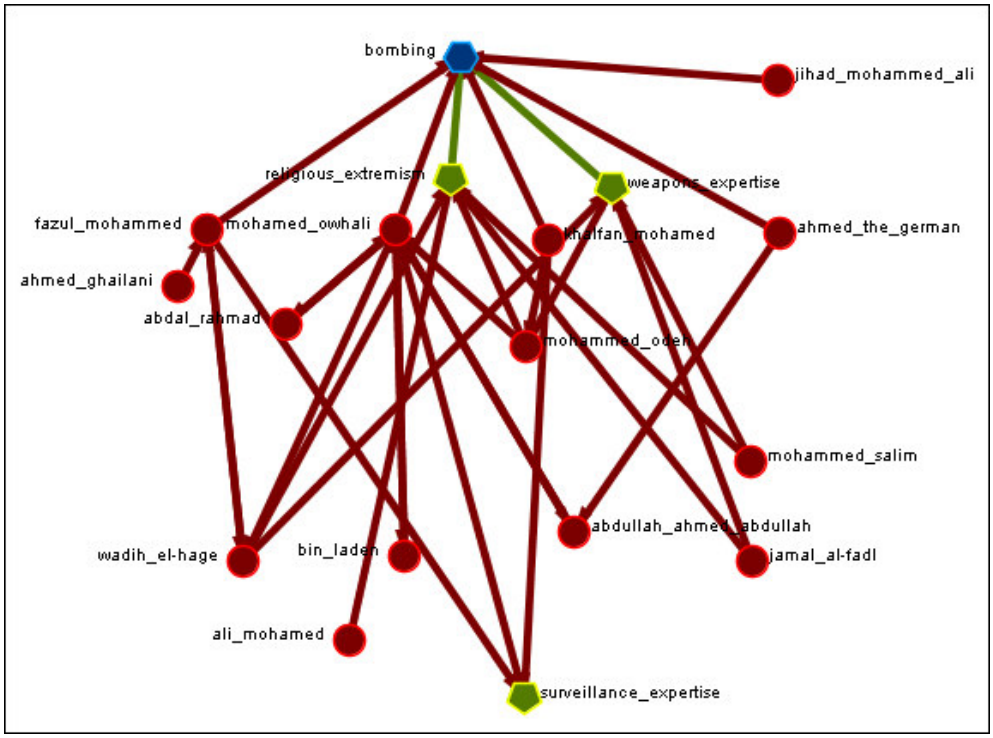
You'll see that weapons_expertise and religious_extremism have displayed form the display. But also you'll notice that six more agents (denoted with the blue circles) have appeared, but the new agents are only connected to agents directly connected to bombing.



Next, we'll add the knowledge attributes back to the display. Once again, add in the Knowledge attributes again. Select the [Close] button.



Notice that in addition to the tasks, weapons_expertise and religious_extremism reappearing the task surveillance_expertise also appears but is only connected as a second level away from bombing.



So by changing the size of the sphere of influence or switching which entities you want displayed will ultimately alter the information displayed in the Visualizer.

The Tool Bar Explained

When you first load a MetaMatrix you will see the pause button depressed in the Visualizer tool bar.

You can layout the network by clicking the play button. The visualization will space apart across the screen. This is called laying out a MetaMatrix. The Visualizer is separating entities and ties that at first appear on top of each other. You can pause this process again when you think the network is satisfactorily spaced apart or you can let ORA lay out the entire MetaMatrix. Your computer speed as well as the complexity of MetaMatrix will determine how long this takes.

This section explains the function of each of the toolbar's buttons.

Copy Paste

The Copy Paste feature allows you quickly capture a visualization and save it to be pasted into another document later.

Play / Pause

The Play Pause function works very similar to the play pause feature on any device. The pause button (two vertical bars) is depressed, the Visualizer stops laying out a network. When the play button is depressed (right pointed triangle) ORA Visualizer begins laying out the network as described above. The red ellipse highlights on the tool bar where this feature is located and accessible.

Magnifying / Maximizing

The Magnifying Glass icon with the plus sign inside it, allows you to instantly fill the Visualizer window pane with the currently rendered MetaMatrix. The red circle in the screen shot below highlights where to access this feature on the Visualizer tool bar.

If there are any entities off screen, clicking the button once will bring all the entities into view on the screen.

Tip! This function works well when selecting a small part of your overall network and magnifying it to fill the visualizer screen.

Rotating The Visualization

See also Rotating a Visualization

To Rotate your visualization look for the word next to the Noon-pointing sundial icon in the tool bar. This feature is another way to manipulate your visualization to fill the entire visualizer window pane.

Tip! Use this feature in conjunction with the magnifying glass function to work your visualization into largest size possible.

Show Labels

See also Show/Hide Labels

The Show Labels button allows you to toggle the labels on & off in the visualizer.

Show Edges

The Show Edges button allows you to toggle the edges on & off in the visualizer.

Show Arrows

The Show Edges button allows you to toggle the arrows on & off in the visualizer.

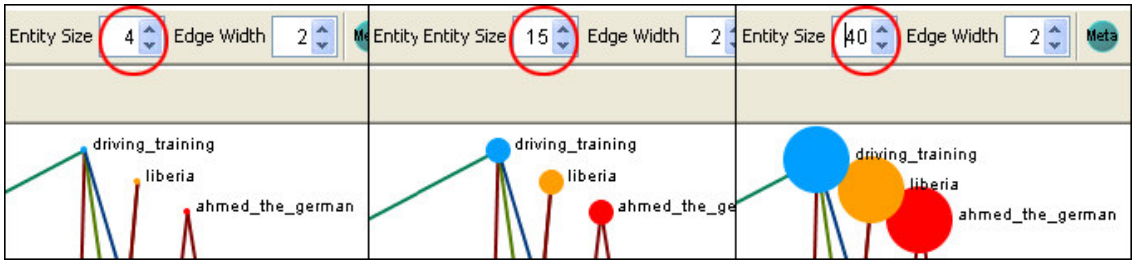
Font Size

The Font Size allows for setting the size of the font in the visualizer

This allows you to change the size of the font to suit you needs for each individual visualizer set. It ranges from 4, which is almost unreadable, to extremely large numbers, which can also be unreadable by virtual of overcrowding. So pick the size of font that best suits your screen.

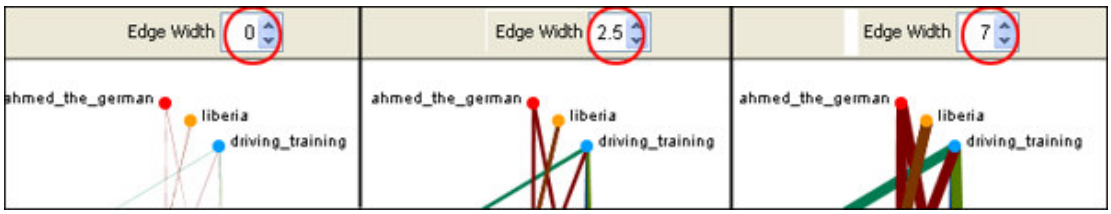
Entity Size

The Entity Size allows for changing the entity size, larger or smaller by increments of one. Four is the smallest size possible and creates a very small, almost indisguishable dot. As the number increases is becomes easier to see the indivdual entities until the number gets to a point where is can simply overpower the screen. But this gives you the ability to customize the entity size to suit your needs.



Edge Width

The Edge Width allows for changing the entity size, larger or smaller. And as the options before you can pick the exact size which best suits your needs for the display.



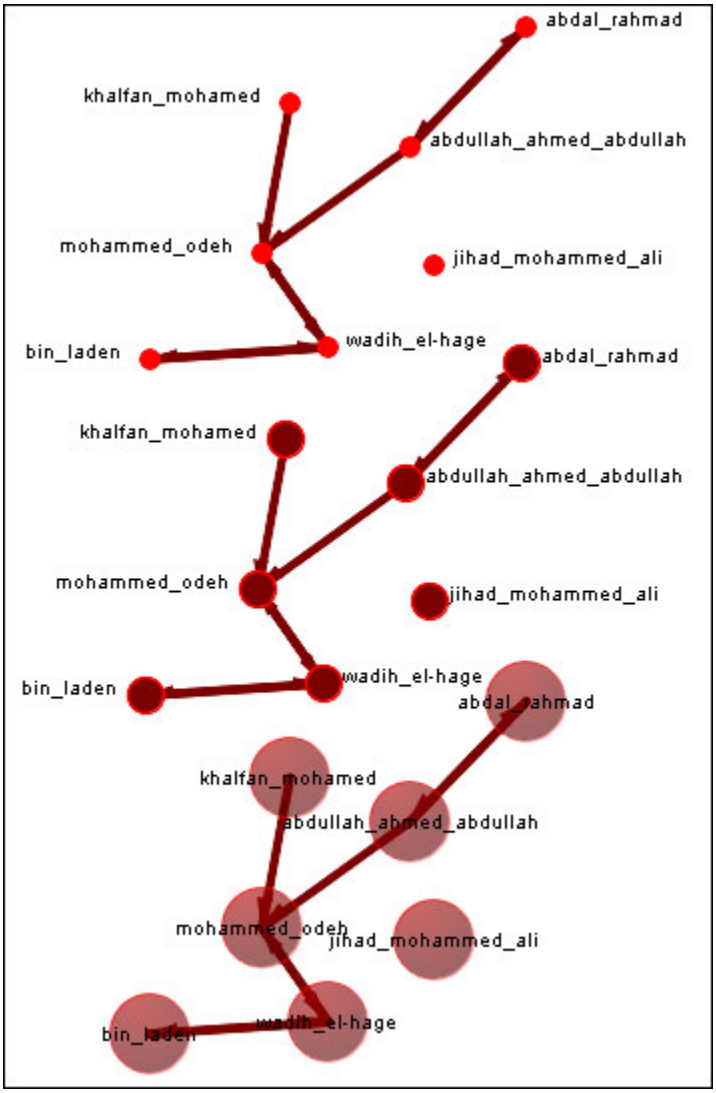
Meta Size

See also Creating a Meta Entity

Use the Meta Entity Manager to handle creating and removing Meta Entities.

Entity Sizes

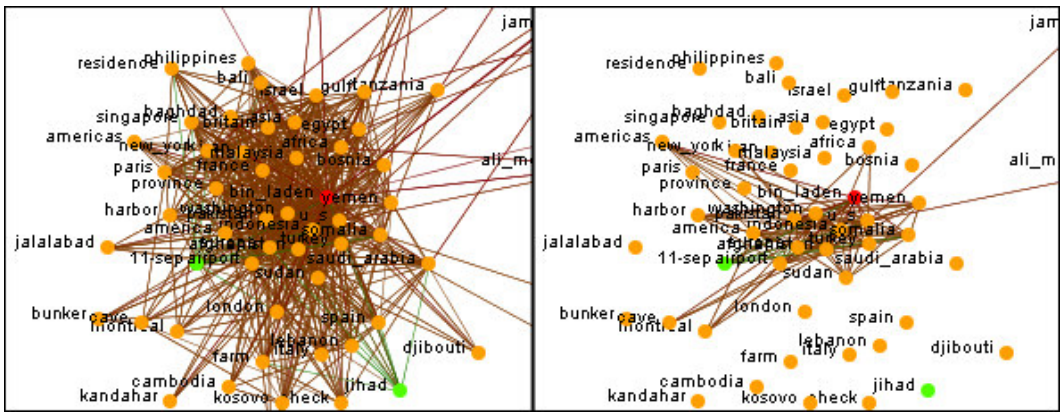
The Toggle Entity Size rotates through three sizes for the entities (As seen below).



Hide Edges by Weight

Hide Edges by Weight

Use the Hide Edges with Weight to select which edges to display or not. As long as there are edges with different values you can hide edges of smaller values leaving only the more important edgesa visible. This can assist in seeing edges that might normally be too cluttered to view.



Visualizer Tools

The ORA Visualizer provides a suite of tools to visually analyze your MetaMatrix:

- Drill Down

  With the ORA Drill-Down Wizard you can quickly visualize ego networks by overall entity class knowledge, tasks, resources, agents) or by choosing individual nodes from a checklist. The ORA Drill-Down Wizard is only accessible through the Visualizer:

- Entity Status

  The Node Status Window is selected by default. It first pops-up when you select any node in the Visualizer. This window provides you with a snapshot of the currently selected node by displaying that nodes unique Attributes, Measures, and Neighbors.

- Group Viewer Allows viewing of current display to be viewed in various grouping: CONCOR, Newman, Johnson, FOG, and K-FOG
- Key Set Selector
- Legend

Allows for toggling visibility of entities and edges on the fly.

- Meta-Entities

  A MetaEntity contains multiple entities collapsed into one. You can create MetaEntities based on the entitysets in your organization, or you can create MetaEntities based on the attributes of the entities. To create MetaEntities, you must access the MetaEntity Manager.

- Path Finder

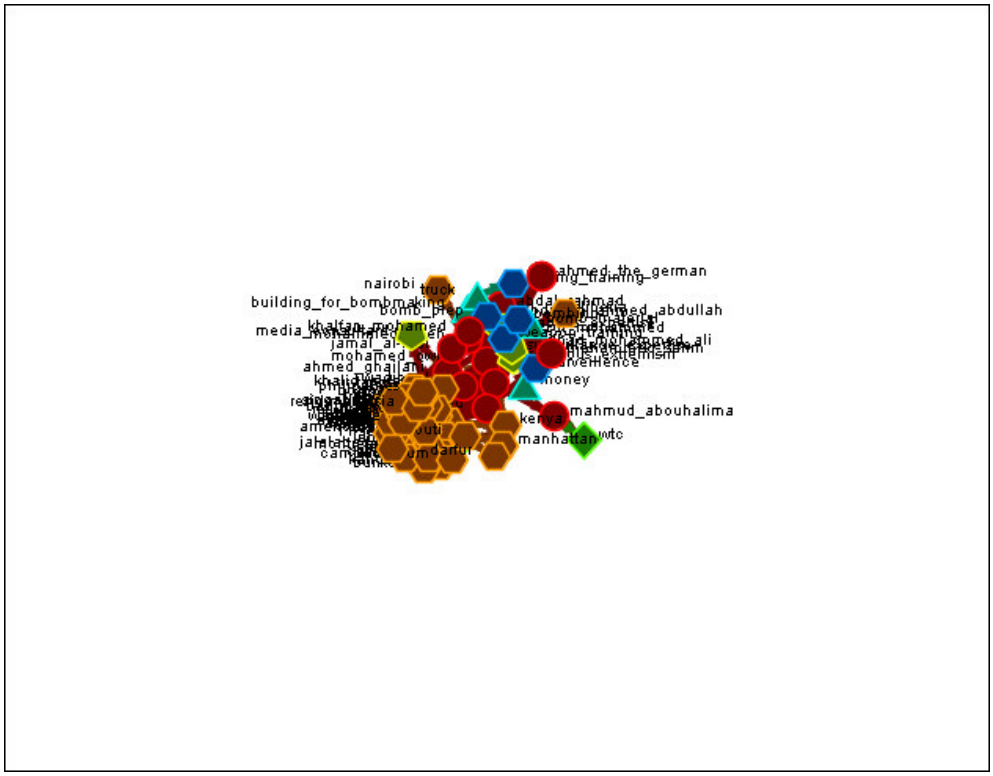
  The Path Finder allows you to focus or drill down on a particular entity, or multiple nodes, that you may be interested in analyzing in greater detail.

- Sphere of Influence

  Each entity within a network has a unique Sphere of Influence or Ego Network, essentially it's direct relationship with it's neighbors as a function of specified path length.

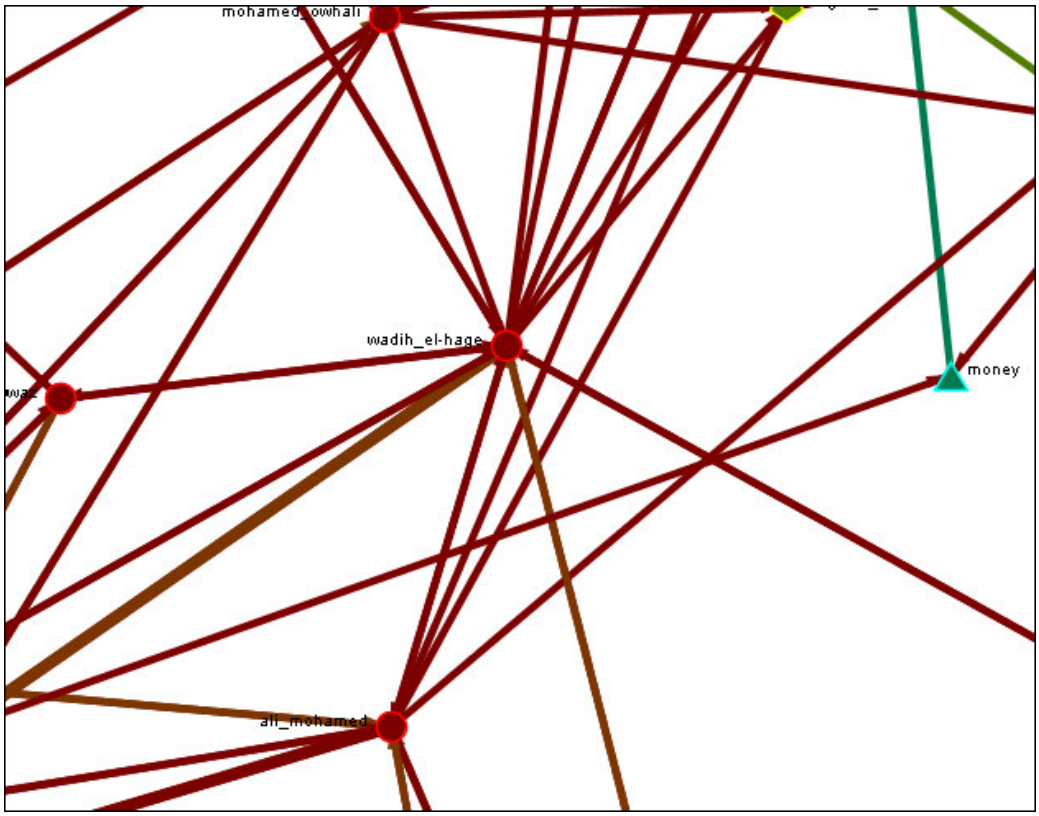
Zooming

At the bottom of the Visualizer interface is a sliding zoom bar. The red ellipse below highlights this feature. You can drag the slider it to the left or to the right increasing or decreasing the magnification of your visualization. In this example, we will click on the slider and move it toward the right. Scroll down to see a screen shot of the following visualization magnified.



In the screen shot below, note the position of the slider on the slide bar highlighted with the red ellipse. You can increase the magnification to the point that parts of the visualization will move off the screen.

Note : Use the Magnifying glass in the Visualizer tool bar to zoom your visualization to the greatest possible size, which still captures the entire visualization.



Tasks

This section explains how to analyze your network or organization by taking you step-by-step through common tasks such as simplifying complex visual networks or how to create your own MetaMatrix from scratch.

- Creating A MetaMatrix From An Excel Spreadsheet
- Eliminating Labels
- Hyperbolic View
- Rotating a Visualization
- Zooming

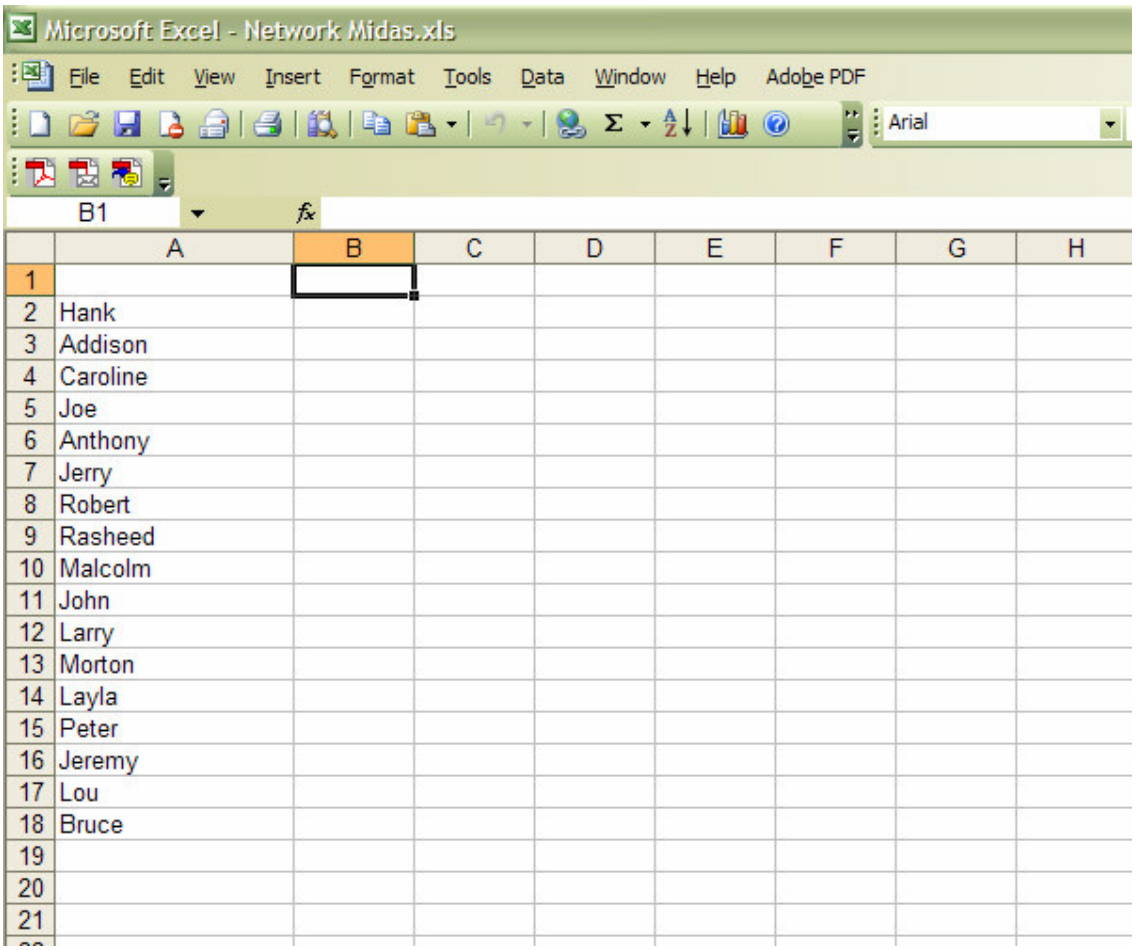
Creating A MetaMatrix From An Excel Spreadsheet

If you don't have a MetaMatrix, you can create one from scratch. Below is step-by-step instruction on how to do this.

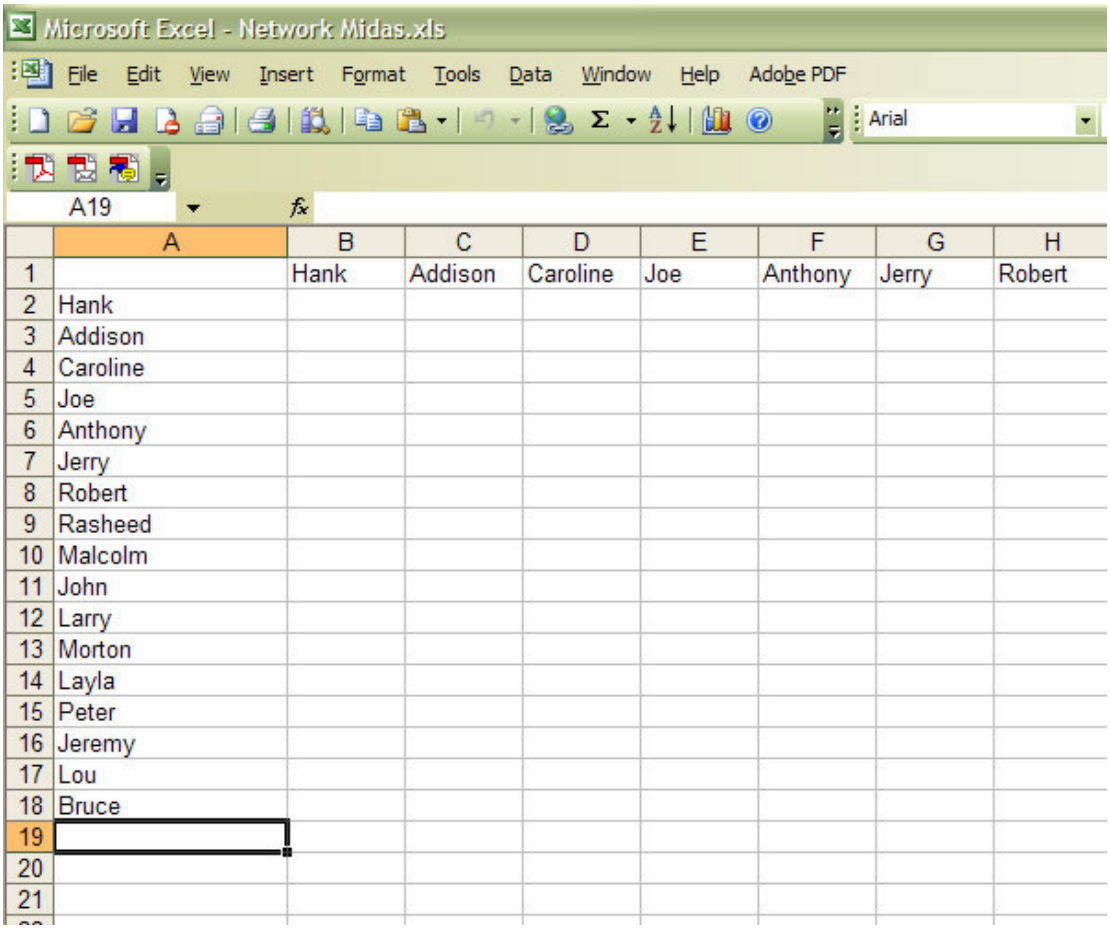
We will create "Network Midas" an agent-by-agent square MetaMatrix. We say it is "square" because all row headings correspond directly to column headings. This is important as it relates to specific measures ORA can run on a graph. If the graph is not square, some measures will not work (See Measures for additional instruction).

Begin by opening a blank Microsoft Excel work book. In "column A" we will enter the name of all agents that make up our social network or organization.

Note: When creating your spreadsheet, do not add any additional titles, notes, or other headings, which will interfere with the "square" properties of the MetaMatrix.



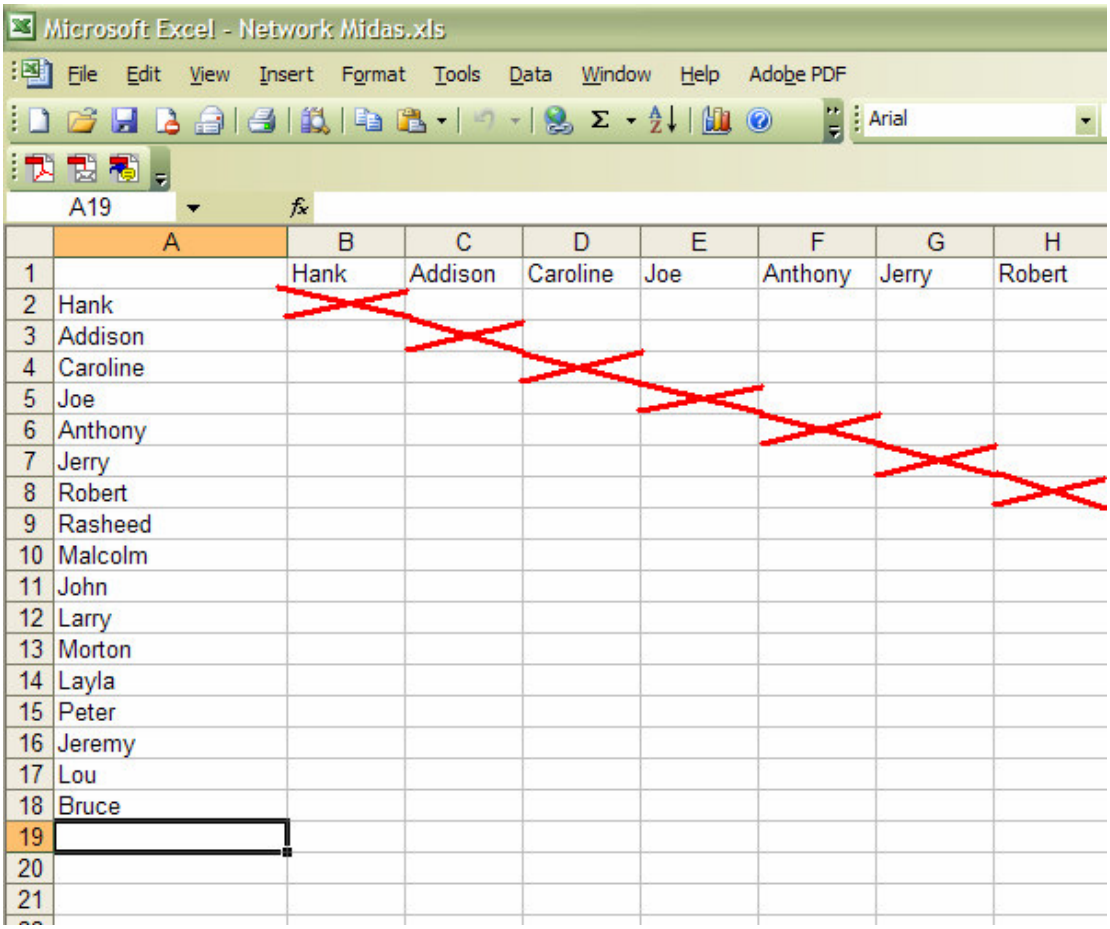
Next, create column headings using the correlating names as they appear in row headings. Again, this will ensure that our MetaMatrix will be square.



	A	B	C	D	E	F	G	H
1		Hank	Addison	Caroline	Joe	Anthony	Jerry	Robert
2	Hank							
3	Addison							
4	Caroline							
5	Joe							
6	Anthony							
7	Jerry							
8	Robert							
9	Rasheed							
10	Malcolm							
11	John							
12	Larry							
13	Morton							
14	Layla							
15	Peter							
16	Jeremy							
17	Lou							
18	Bruce							
19								
20								
21								

Here we will create "links (aka edges, and ties)" between each agent. We do this by entering a "1" if a direct connection or relationship exists and a "0" if it does not. Please note that headings that cross-reference themselves are considered redundant and thus are left blank or "0." For instance, in cell "B2" it is assumed "agent Hank" has a tie to himself.

In the example below, "Red Xs" are used to illustrate the redundant ties. This redundancy should continue as a smooth diagonal line from the top left corner of your MetaMatrix to the bottom right.

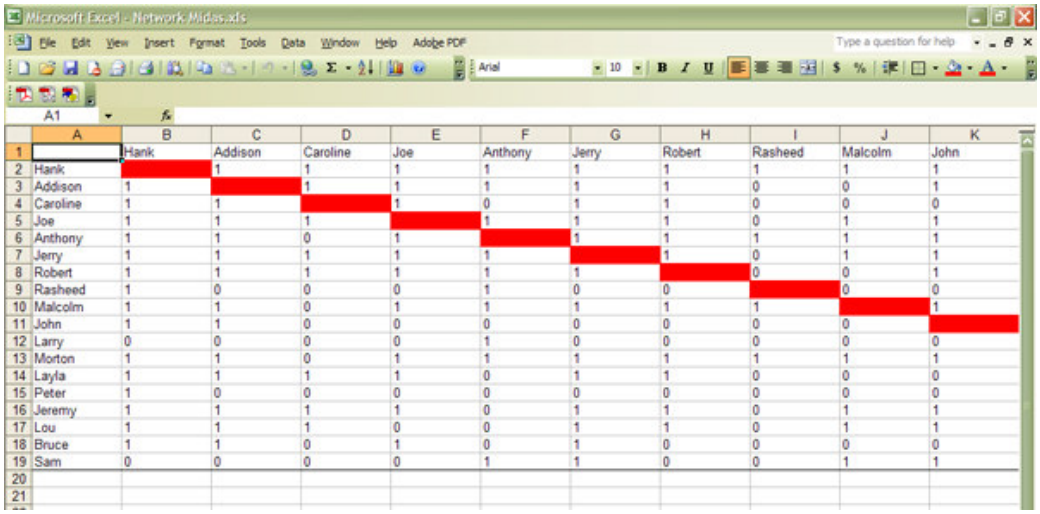


Tip! If you can't make this smooth diagonal line, you graph is not square.

Using *1s* and *0s* to establish linkages, complete your spreadsheet.

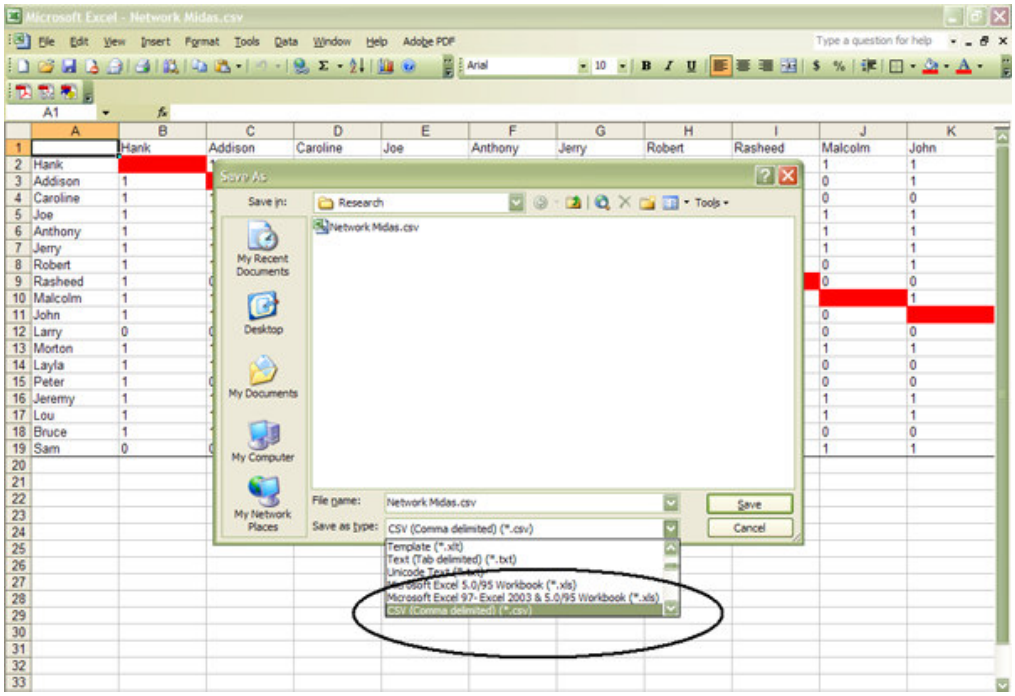
In the "Network Midas" example, we have assigned relationships randomly. Within your organization or network, however, you can describe any direct connections or relationships you are interested in analyzing. For instance, you may determine that a "direct connection" exits if agents within your network consult with each other at least once a month; literally, it can be anything you decide.

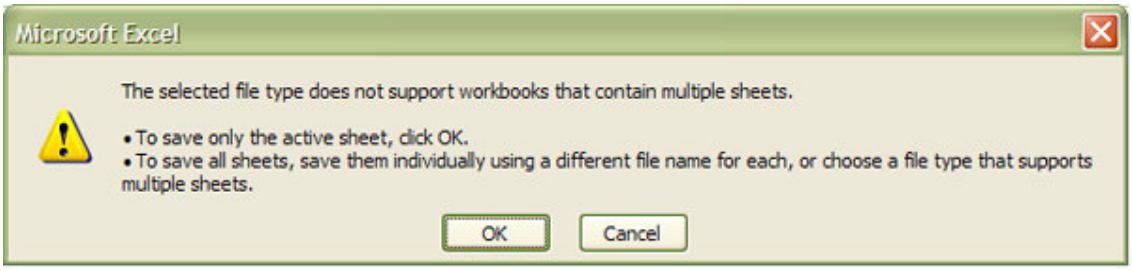
Below is our completed MetaMatrix, Network Midas (The red fill illustrates cells that do not require input due to their redundancy).



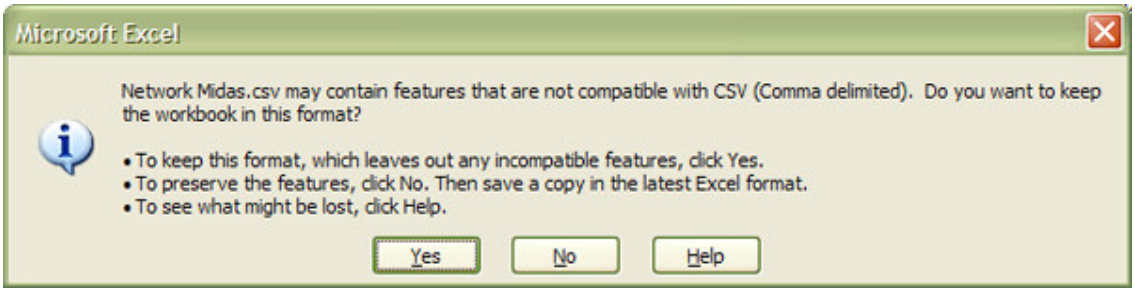
Now that we have essentially built a MetaMatrix from scratch using Excel, the next step is to save it in a compatible file format ORA can interpret. For Excel spreadsheets, in all likelihood, this will be the "CSV" (comma separate values) file format.

From the drop down menu: File > Save As > Save As Type > CSV (comma delimited) (*.csv)





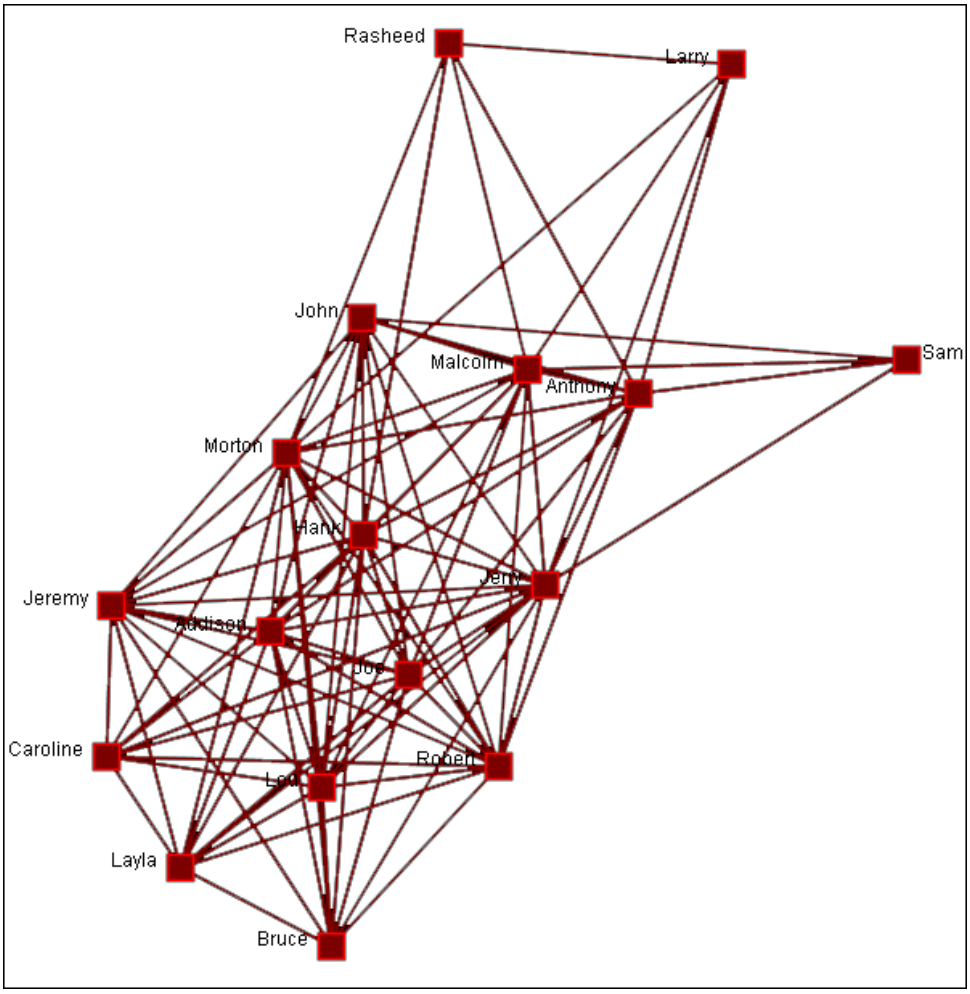
Click "OK"



Click "Yes"

Congratulations! You have now created your own MetaMatrix from scratch. Now, simply load your saved CSV file as you would any DynetML file, and work with your data the same way.

Below is a our MetaMatrix Network Midas rendered in the ORA Visualizer


Rasheed
Larry
John
Sam
Malcolm
Anthony
Morton
Hank
Jerry
Jeremy
Addison
Joe
Caroline
Robert
Lou
Layla
Bruce

Lessons

This sections contains lesson on running various facets of ORA.

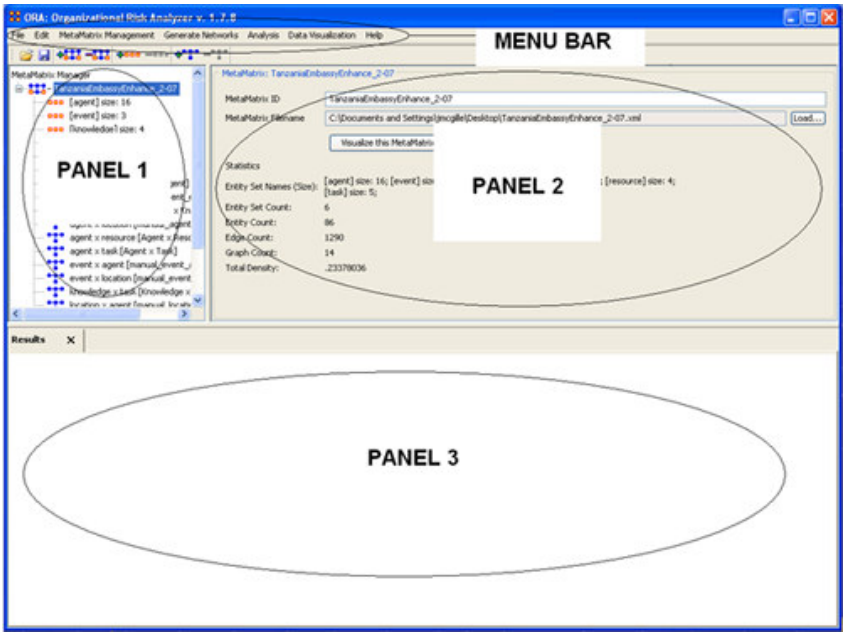
1. ORA Interface
2. Loading, Saving, and Manipulating Data
3. Running an Intelligence Report
4. What's Going on Where
5. Over-Time Viewer
6. Over-Time Viewer-Immediate Impact
7. Over-Time Viewer-Near Term Impact Analysis
8. Using the Data Import Wizard

Lesson 1

Overview of ORA Interface

An overview of the ORA interface

Below is a screen capture showing the ORA interface:



The menu bar runs across the top of the window, and the rest of the screen is divided into three panels.

Panel 1 displays a list of the meta matrix that has been loaded into ORA and its components and sub-matrices. To view information about a particular meta matrix or sub-matrix, single-click on it in **Panel 1** to highlight it.

Panel 2 displays information about whatever meta matrix or sub-matrix is highlighted in Panel 1.

Panel 3 displays information about the results of analyses you run on your meta matrices.

Loading a meta matrix into ORA

You have three options for opening your meta matrix in ORA:

- Go to File in the ORA menu bar and click Open MetaMatrix. A small window titled Help: Opening Meta Matrix pops up. Your data should already be in the correct format, so click [OK].
- Next, a file chooser titled Open pops up. Browse to the location of your dataset, single-click on it, and click the Open button in the bottom right corner.
- Click the first icon in the row directly below the menu bar. It looks like a half-open file folder. A window titled Import Data into ORA will pop up. Click the Select Files button. A file chooser titled Open pops up. Browse to the location of your dataset, single-click on it, and click the Open button in the bottom right corner. You will be returned to the Import Data into ORA window. Click the Finish button in the bottom right corner.

- In panel 2, click the Load button on the far right. A window titled Import Data into ORA pops up. Click the Select Files button. A file chooser titled Open pops up. Browse to the location of your dataset, single-click on it, and click the Open button in the bottom right corner. You will be returned to the Import Data into ORA window. Click the Finish button in the bottom right corner.

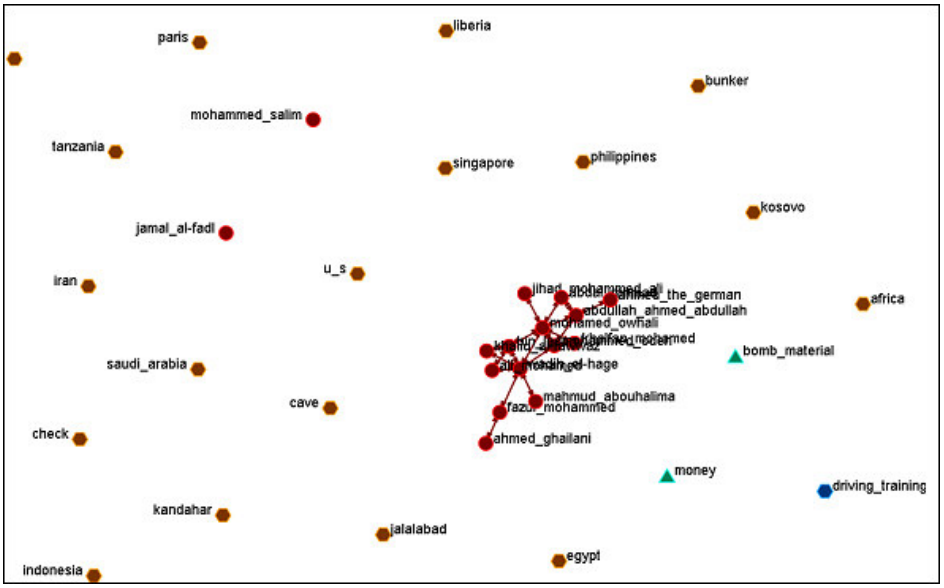
You will see a list of your meta matrix and sub-categories in Panel 1, as well as the location and basic statistics of your meta matrix in Panel 2. You are now ready to begin analyzing the meta matrix.

I. What does the network look like?

To visualize a meta matrix, first make sure the meta matrix you wish to visualize is highlighted in Panel 1. If it is not highlighted, single-click on it.

In Panel 2, click the Visualize this MetaMatrix button. A new window will pop up displaying your meta matrix graphically. A small legend also appears.

Below is a screen capture showing the visualization of the meta matrix for the Tanzania Embassy bombing data:



The visualization displays the connections between all items in the Tanzania Embassy bombing network. For example, the red circles represent key agents in the terrorist network that carried out the Embassy bombing. A line connecting an agent to another agent indicates that those two agents were in direct communication.

You might want to keep this visualization window open for future analysis (minimize it but don't close it).

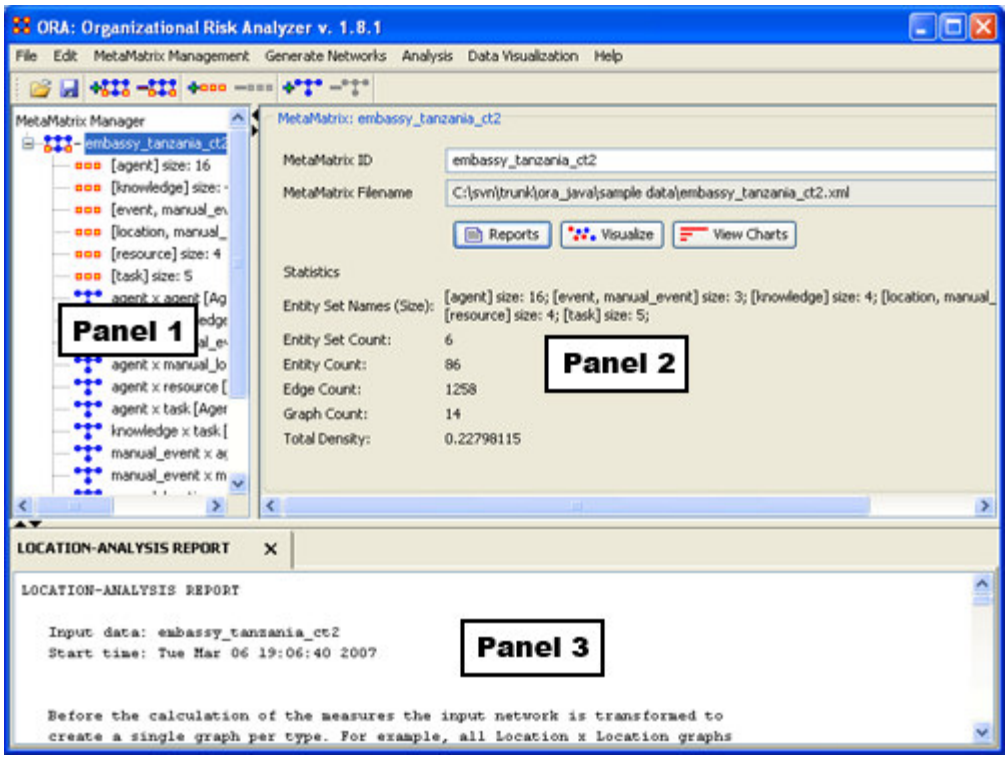
Lesson 2

Loading, Manipulating, and Saving Data

1. Open MetaMatrix
2. Data Import Wizard
3. Import Database
4. Import Attribute File
5. Open Workspace
6. Save MetaMatrix
7. Save MetaMatrix As…
8. Save Workspace
9. Network Format Converter
10. CSN Table Converter

ORA allows a variety of ways to load and Save data: Loading single or multiple MetaMatrices, Appending data into open MetaMatrices or Saving MetaMatrices as single files or Workspaces. All these options are all located in the Main Menu under File.

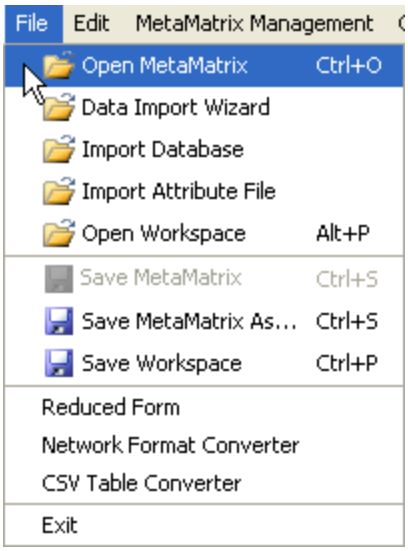
Below is a reminder of the names of the panels we will be using throughout the lessons.



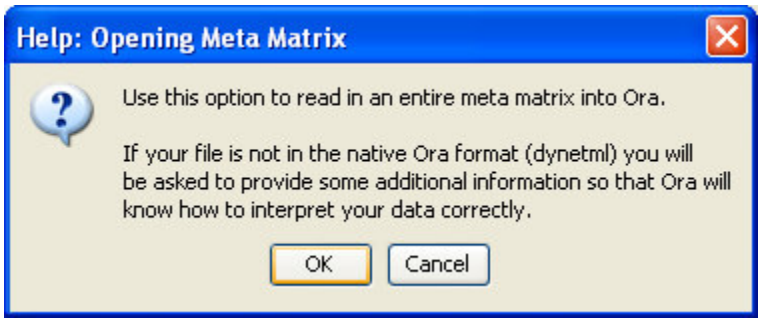
I. Loading Data

Open MetaMatrix opens up a single MetaMatrix file.

- From the Main Menu File > Open MetaMatrix.



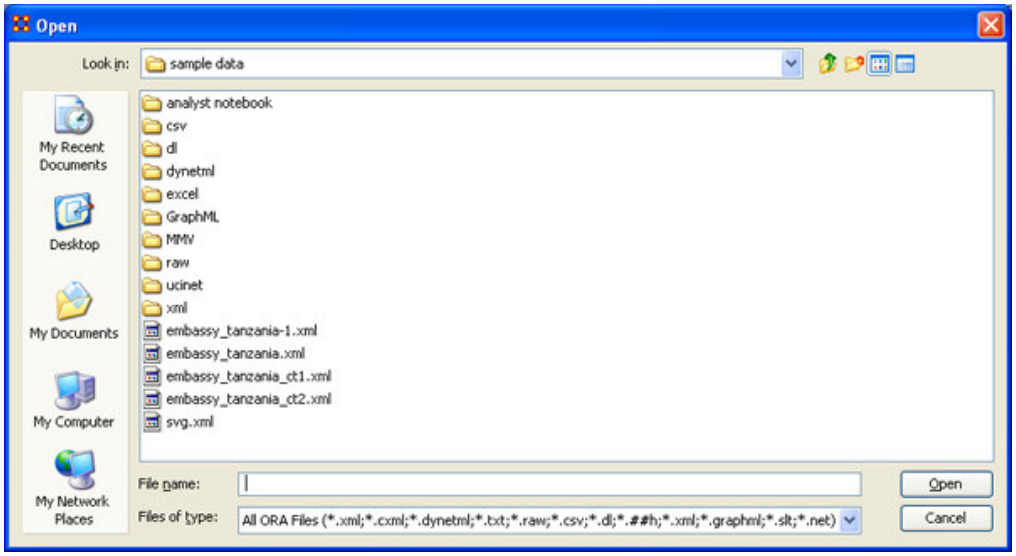
The dialog box below will appear informing you that this option is primarily for opening up a MetaMatrix file.



If you are not sure which format your data is and how to proceed then select [Cancel].

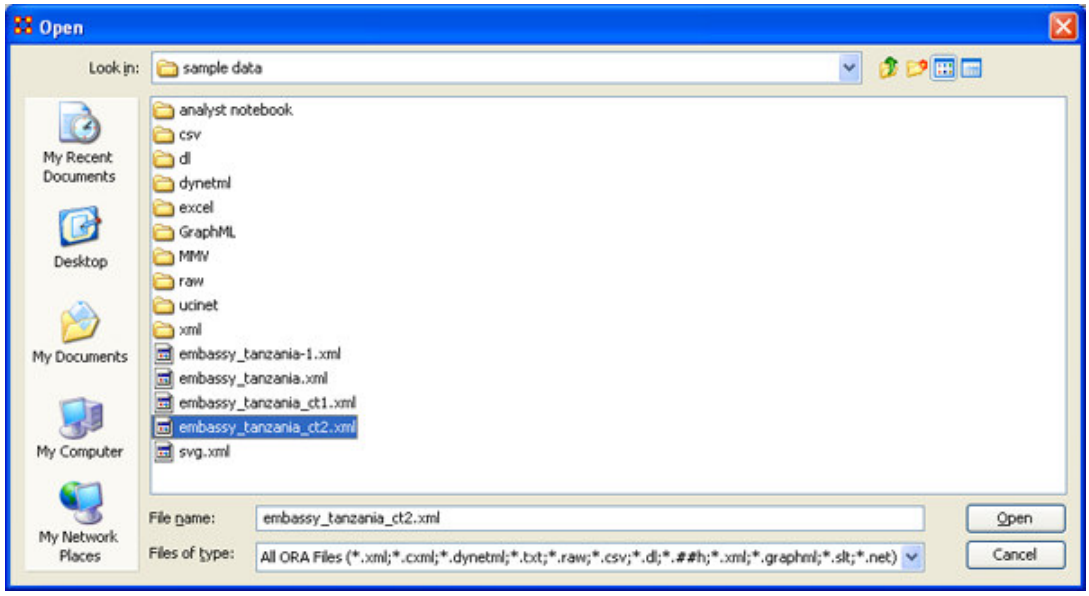
- Select [OK] to bring up the Open dialog box.

From here you can navigate through your directories and find the MetaMatrix you wish to open.

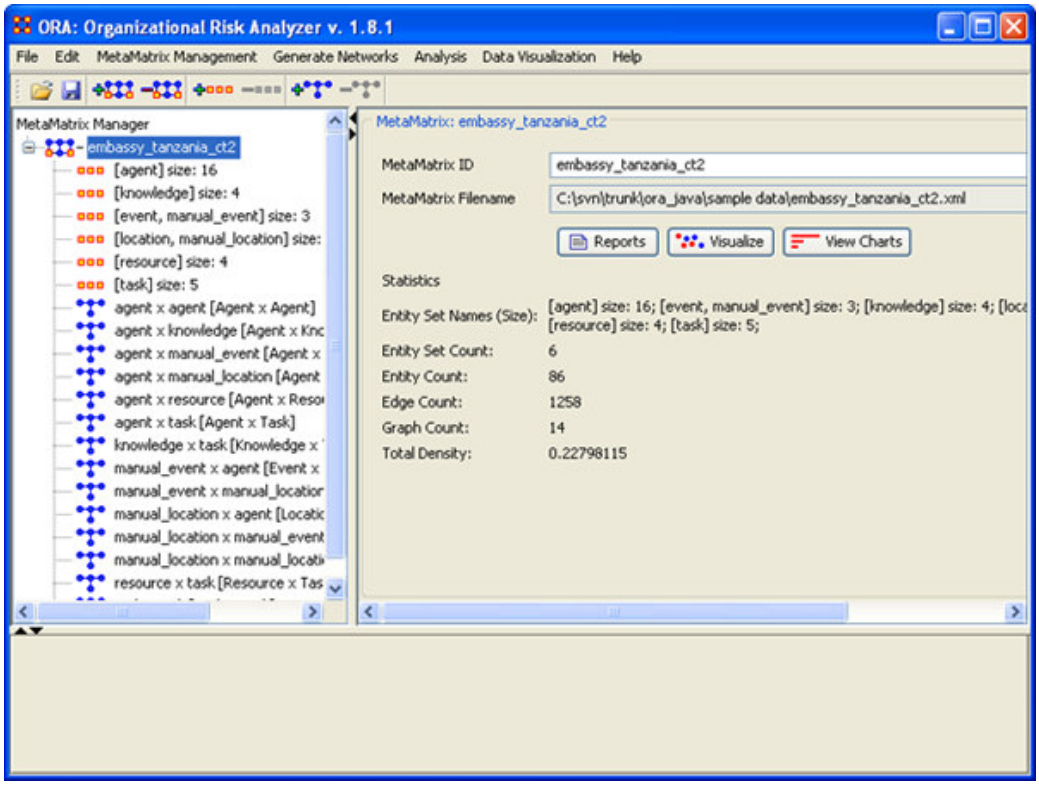


Highlight the file you want in the main window and will it's name will appear in the box titled File name.

- Select the [Open] button.



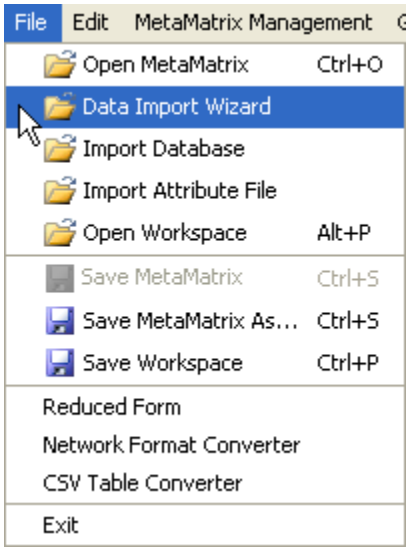
Your Meta Matrix will then appear in Panel 1.



II. Data Import Wizard

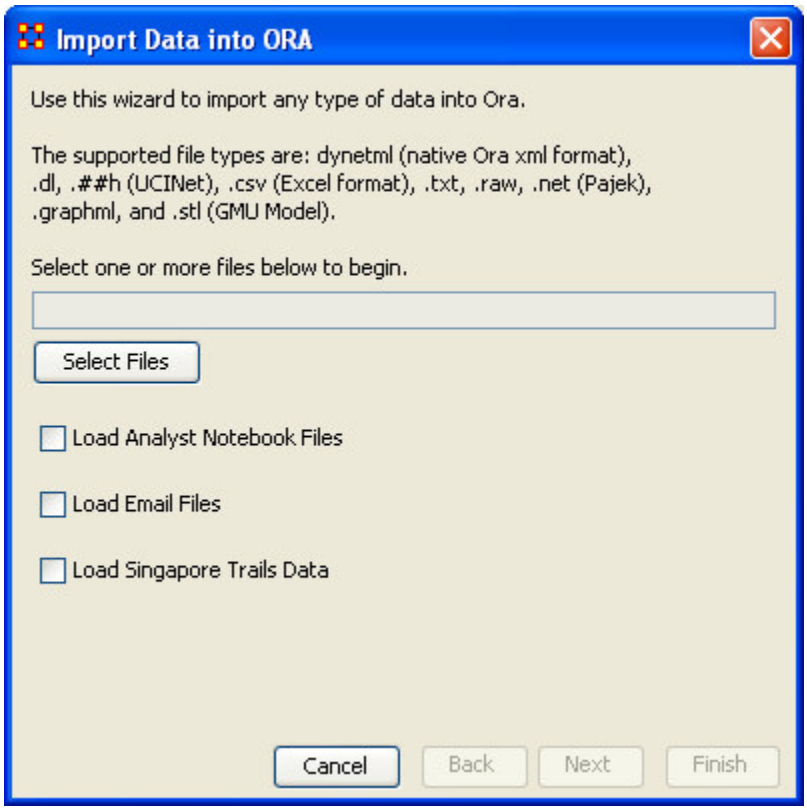
The Data Import Wizard menu item allows you other options in importing MetaMatrix files.

- From the Main Menu select File > Data Import Wizard.



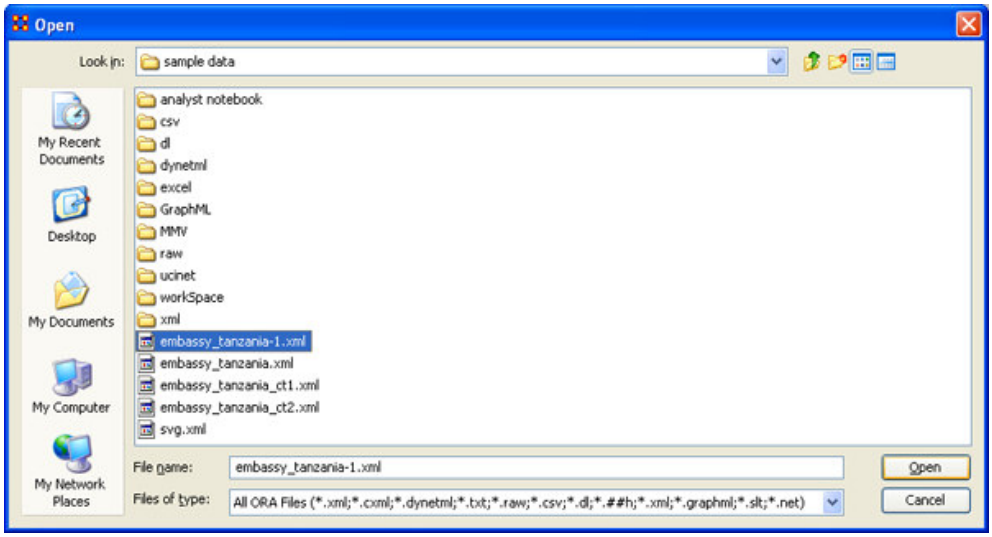
The following dialog box will appear asking you to indicate the file you wish to open.

- Under the section [Select one or more files below to begin] select the [Select Files] button.

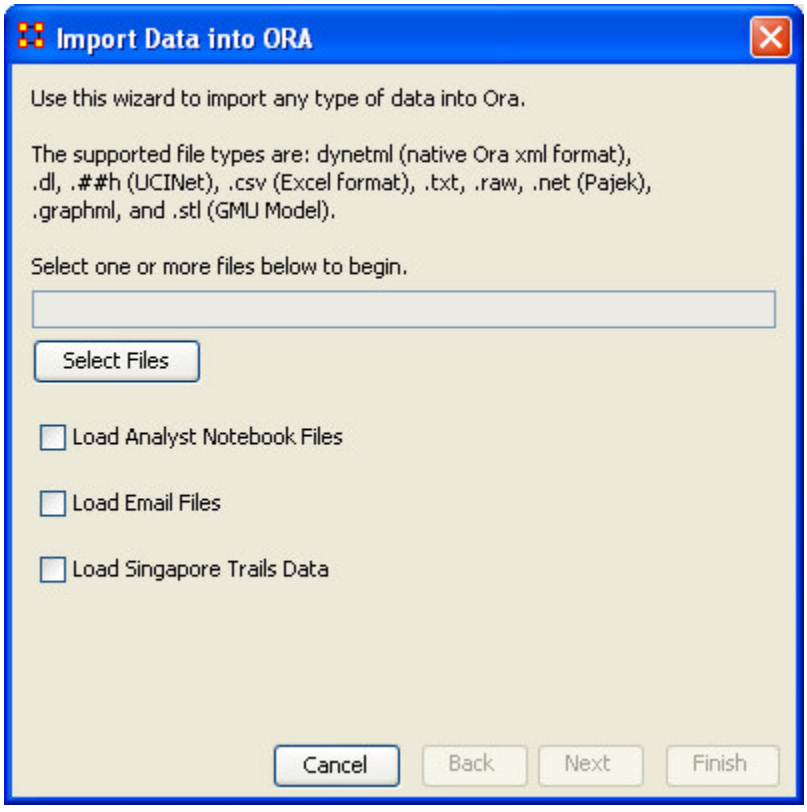


This will bring up the Open dialog box where you can navigate to the directory with the file you wish to open.

- Highlight the file you want to open
- Select the [Open] button.



The file you selected will now appear in the box under [Select one or more files below to begin].



You can also open multiple files from this dialog box. This can be done in two ways. Select the [Select Files] button to call up the Open dialog box and navigate to the directory with your files.

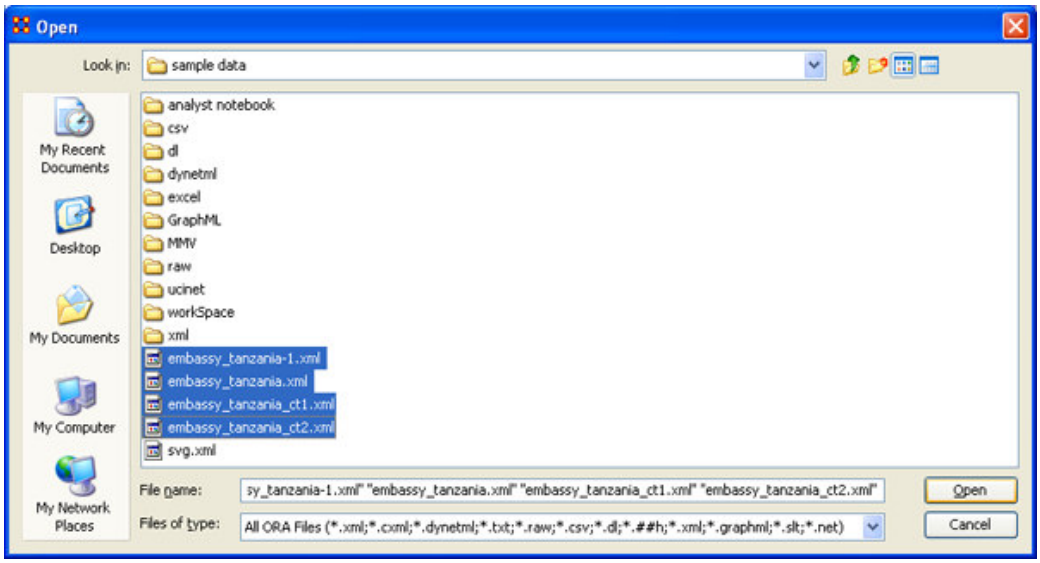
NOTE: You can only open multiple files that are in the same directory with this procedure.

If all the files in sequential order,

- Select the topmost file you want to add.
- Press and hold the Shift key
- Select the bottomost file you want to add

This will highlight a set of files (as per the example below)

- Selecting [Open] will place them in the Import Data into ORA dialog box.

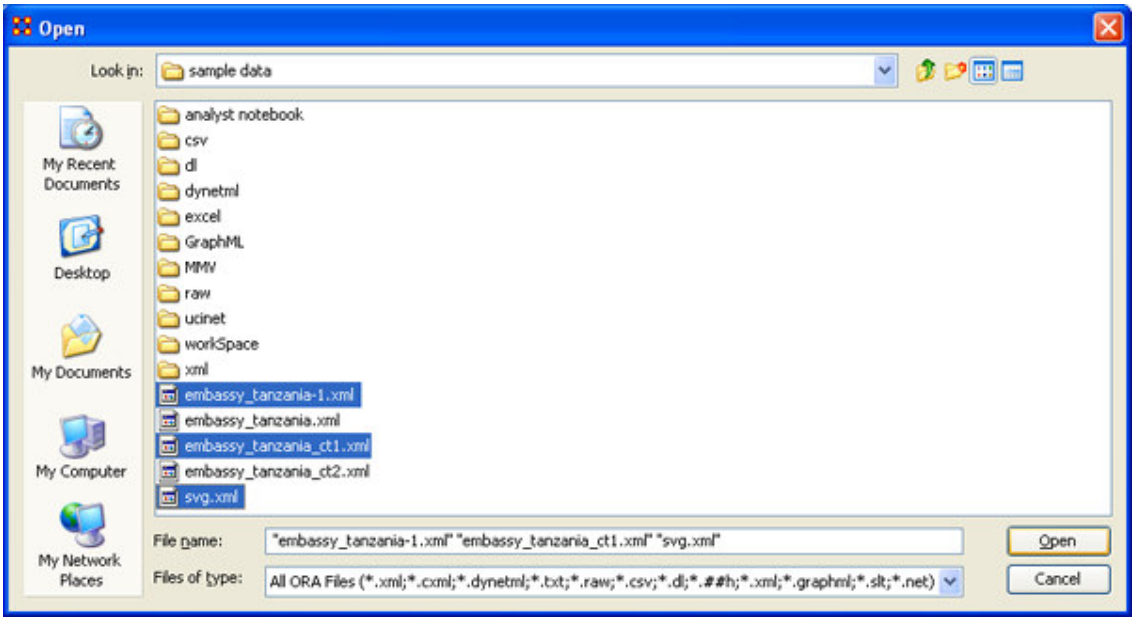


If the files are not in sequential order

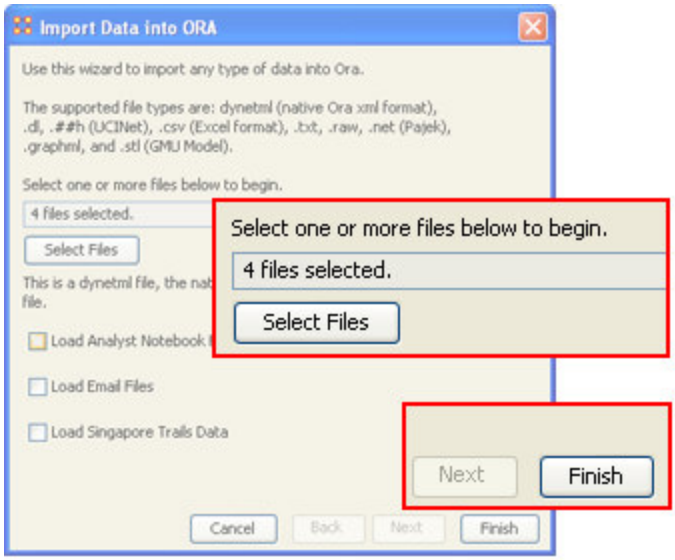
- Highlight the first file you want
- Press and hold the Control key
- Highlight another file
- Continue this procedure till all files you want are highlighted (as per the example below)

NOTE: If you selected a file and change your mind or selected a file in error, then press and hold the Control key and click the mouse pointer on the file to deselect it.

- Selecting [Open] will place them in the Import Data into ORA dialog box.



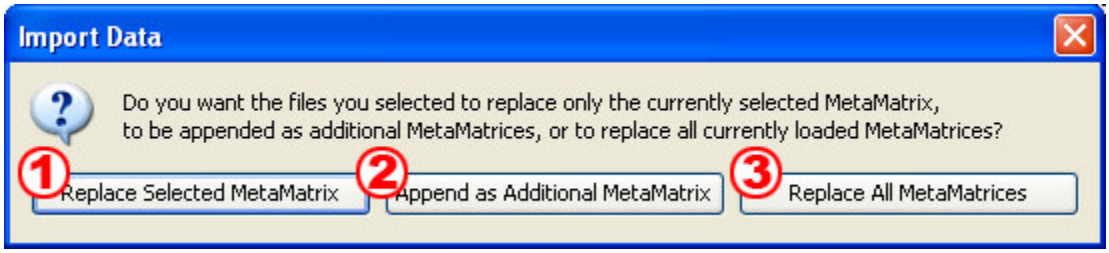
At the Import Data into ORA dialog box the files you have selected are ready to load. (The example below shows 4 files selected)



- When you are sure these are the file(s) you want, select [Finish]

Next a dialog box will appear and you will be asked how you wish to open this file.

The Import Data dialog box has three options for opening files which are explained below.



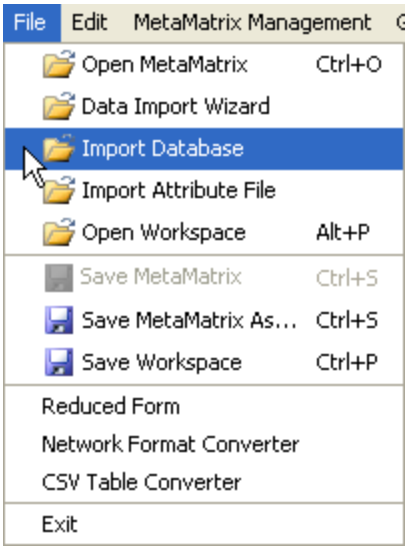
1. Replace Selected MetaMatrix – If you had a MetaMatrix currently selected in Panel 1 then the new MetaMatrix will replace it. All other MetaMatrices will remain unaffected.
2. Append as Additional MetaMatrix –
3. Replace All MetaMatrices – All current MetaMatrices will be deleted and the new MetaMatix(s) will become active.

After selecting one of the three options your files will appear in Panel 1 of the Main Interface.

Below is an example showing the multiple files opened in Panel 1.

III.Import Database

The Import Database function is an advanced feature.

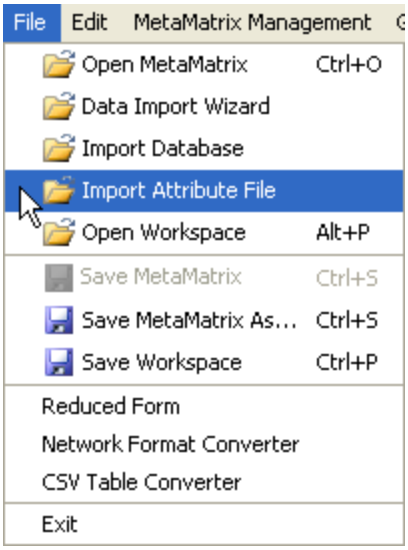


IV. Import Attribute File

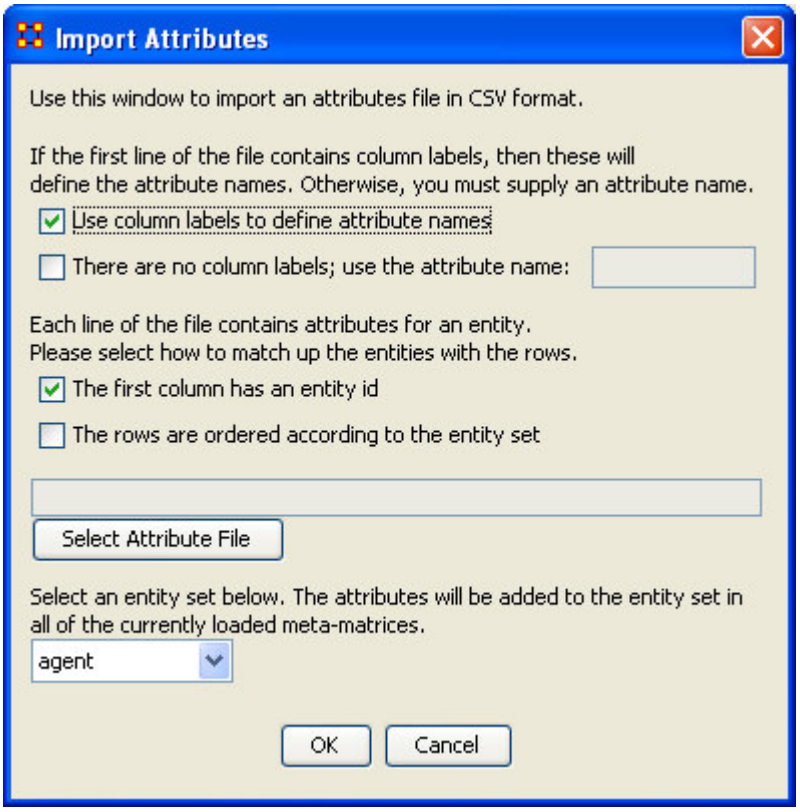
This function requires that a file is set up to match an existing MetaMatrix. It is used to add an attribute into a file. The file selected must be in the CSV format.

The CSV ("Comma Separated Value") file format is often used to exchange data between disparate applications. The file format, as it is used in Microsoft Excel, has become a pseudo standard throughout the industry, even among non-Microsoft platforms.

- From the Main Menu select File > Import Attribute File

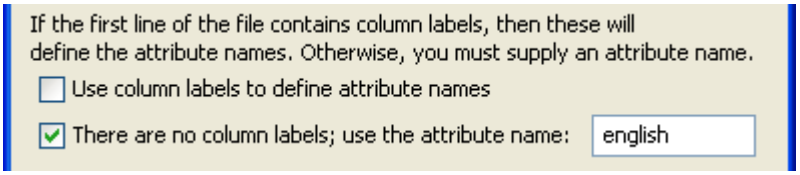


The following dialog box contains the parameters for how the attribute file will be imported. Each section will be explained separately.



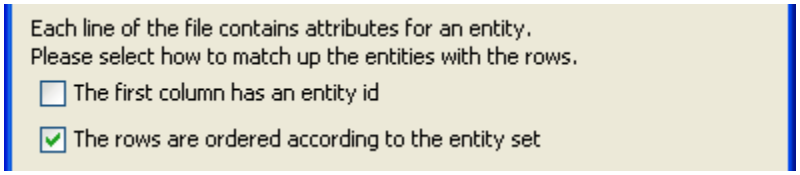
If your CSV file contains a headers row leave the check in the top checkbox. If there is no header row then select the bottom checkbox. You will be prompted to give the data an attribute name. The example file has no column headers so we will give it an attribute name.

- This file has not header so the bottom box is checked. This file will be used to specify whether an agent speaks English. Type english into the box on the right.

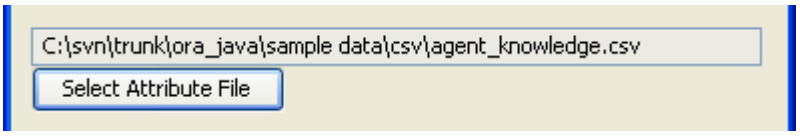


If your CSV file contains information regarding the entities leave the check in the top checkbox. If there is no entity information within the CSV file place the check in the bottom checkbox.

- This file has no information regarding the entities so place a check in the bottom checkbox.

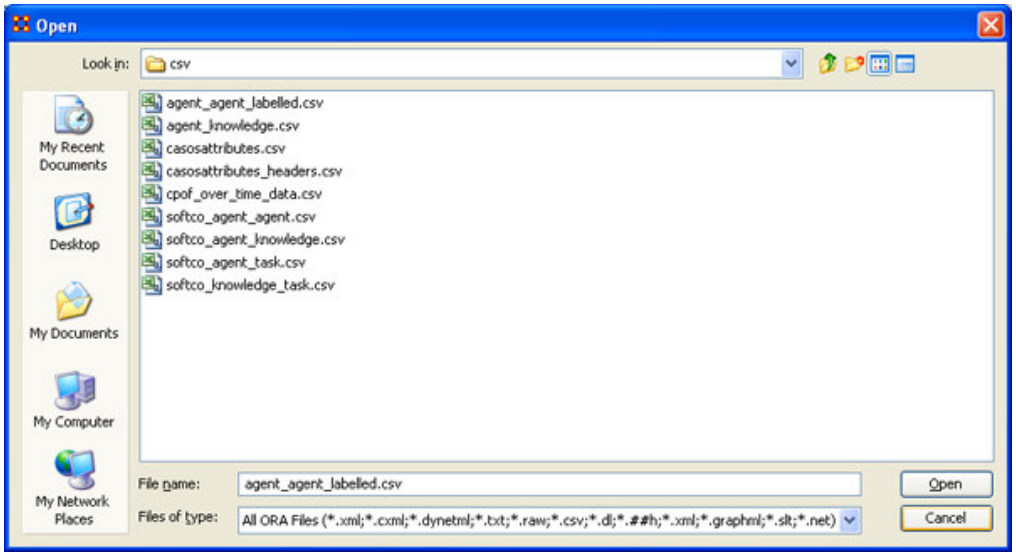


- Select the [Select Attribute File] button to open the Open dialog box. This allows you to select the new attribute file to open.

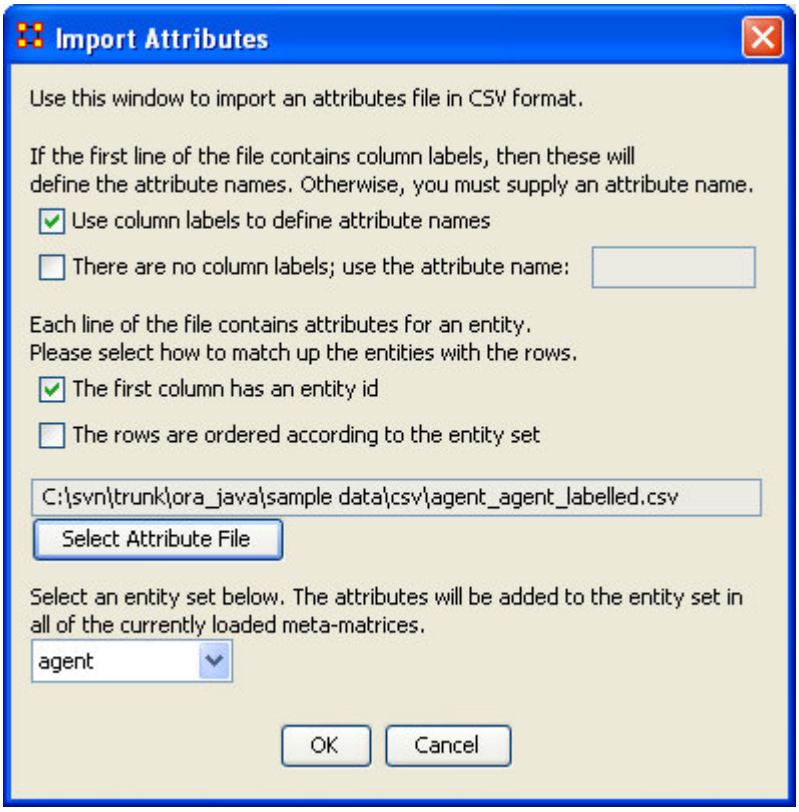


An Open dialog box will appear.

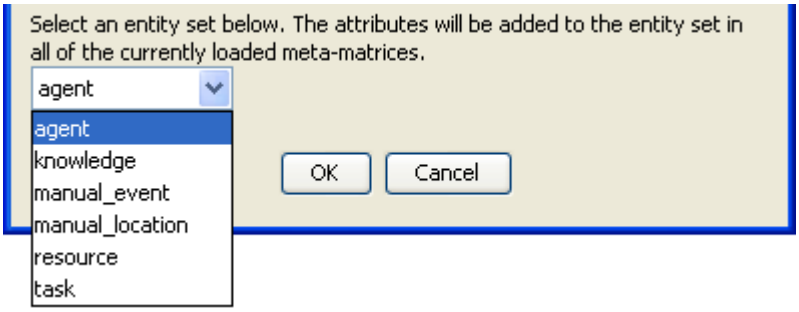
- Navigate to the Attribute file you wish to use and select [Open]



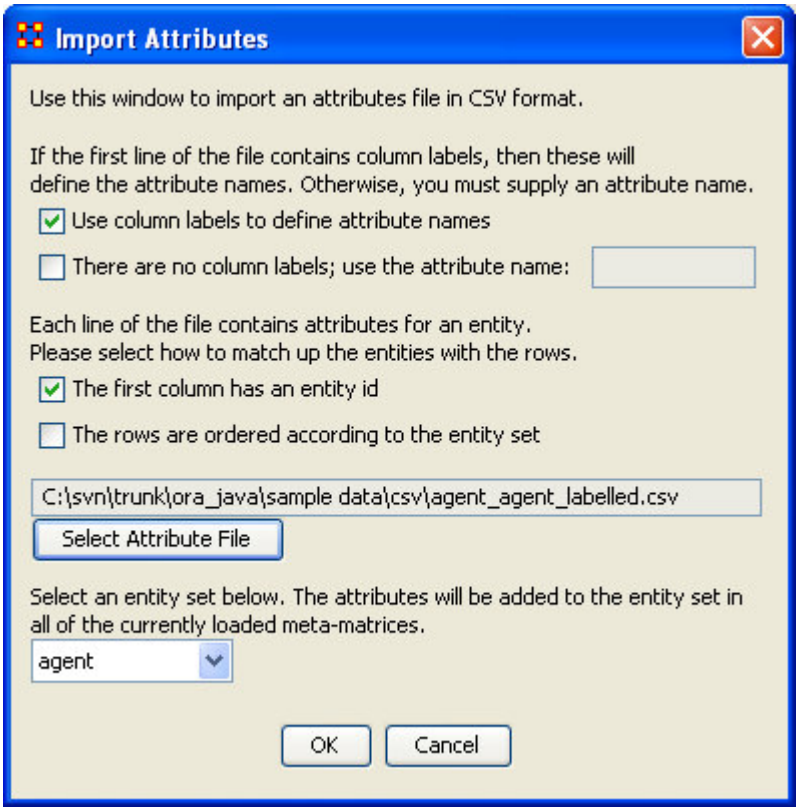
After selecting [Open] at the bottom of the dialog box the Import Attributes dialog box will reflect your choices showing the path to the file you chose.



Finally, at the bottom of the dialog box, is a drop-down menu for choosing the type of entity for this attribute file. The file we chose was agent_knowledge so we will be leaving it set to agent.



Below is the complete dialog box.

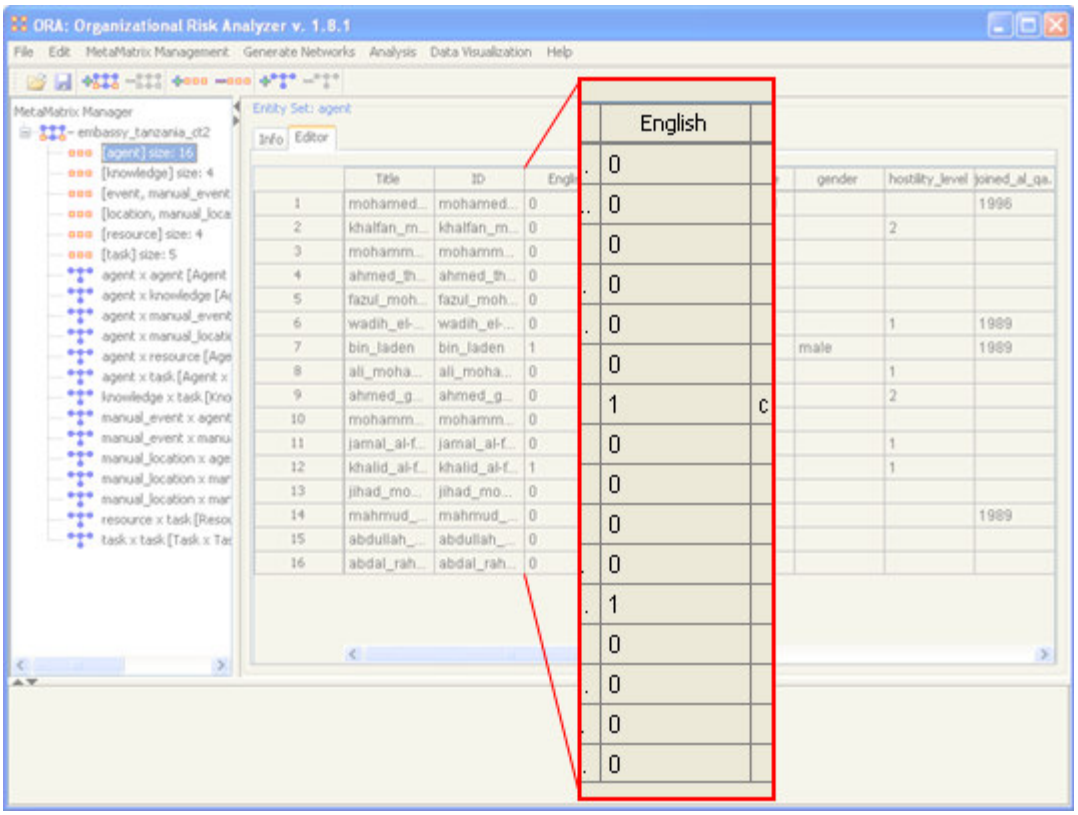


- Select [OK] to load the file(s) into ORA.

Return to the Main Interface.

- Select the [agent] entity from Panel 1
- Select the Editor tab from Panel 2.

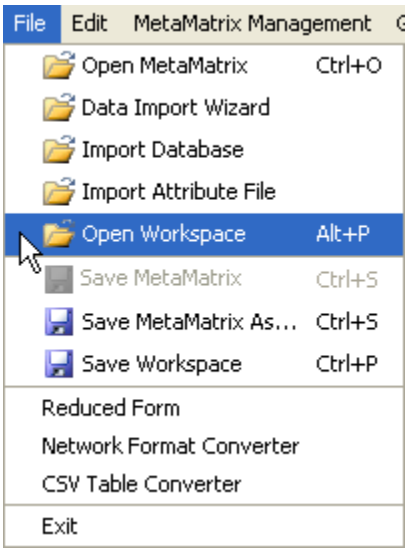
Displayed in the table will be the new attribute that was imported under the heading English with the data from the file.



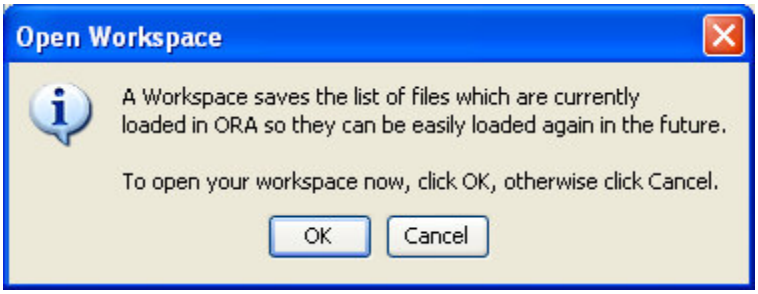
V.Open Workspace

You may open an entire workspace that you were previously using. A workspace consists of a set of MetaMatricx files that were all open at the same time, and saved as a workspace.

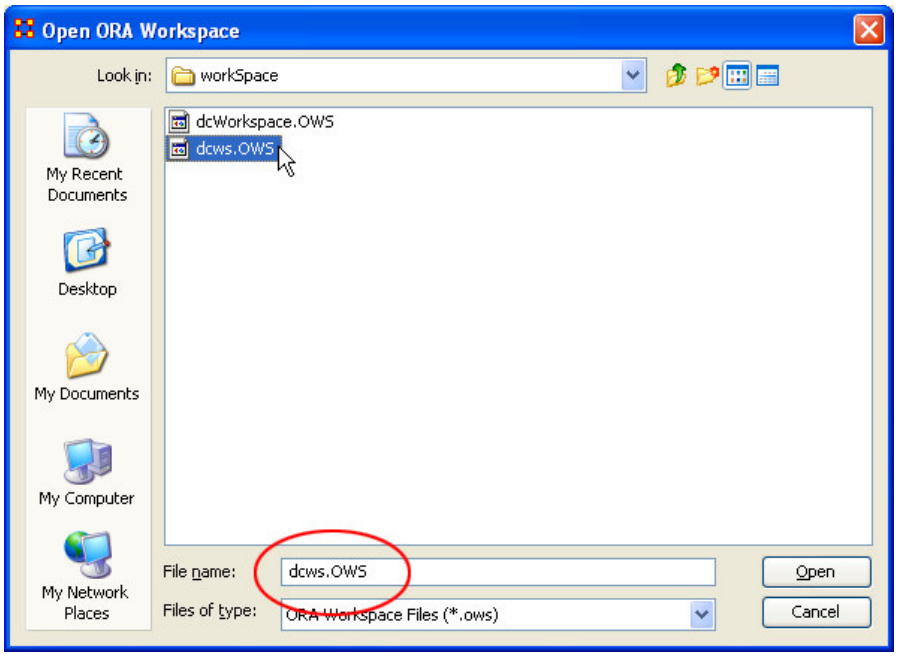
- From the Main Menu select File > Open Workspace



A dialog box will appear to make sure you understand you're asking to open a workspace.



- Select [OK]

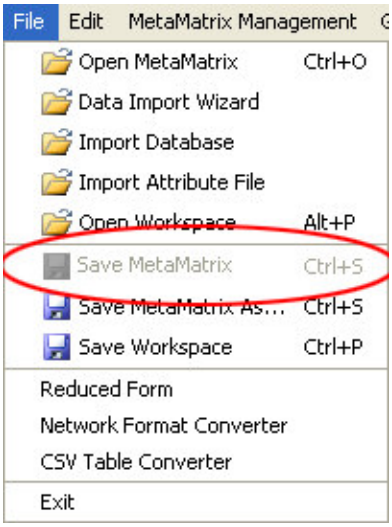


- Navigate to the directory where your Workspaces are saved
- Select one of the Workspaces (files with the extension .ows)
- Select [Open]

All MetaMatrices contained within the choosen workspace will be open in ORA.

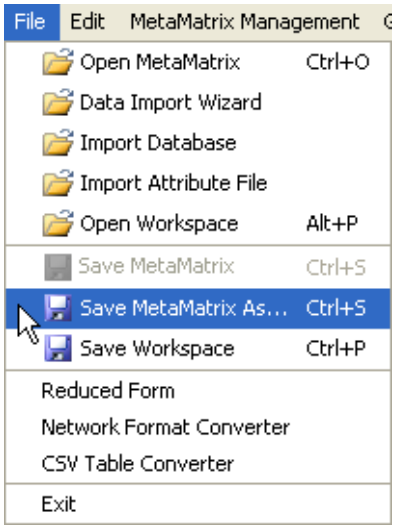
VI. Save MetaMatrix

This option is currently non-functional. Usethe menu item below Save MetaMatrix As...

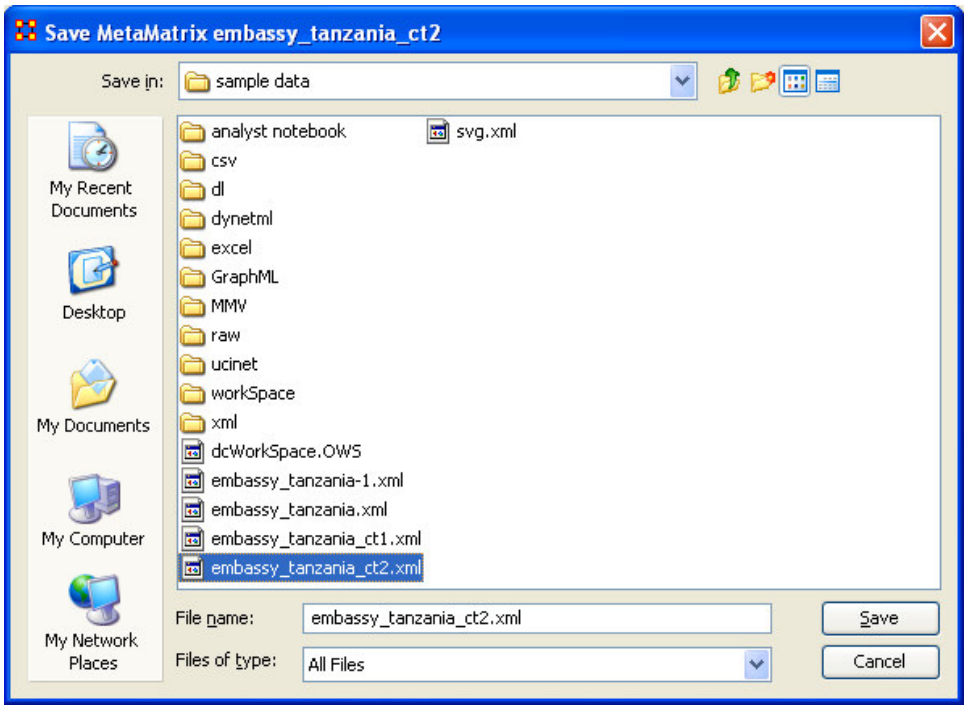


VII. Save MetaMatrix As...

Choose the Save MetaMatrix As... menu item to save the changes you've made in a MetaMatrix.

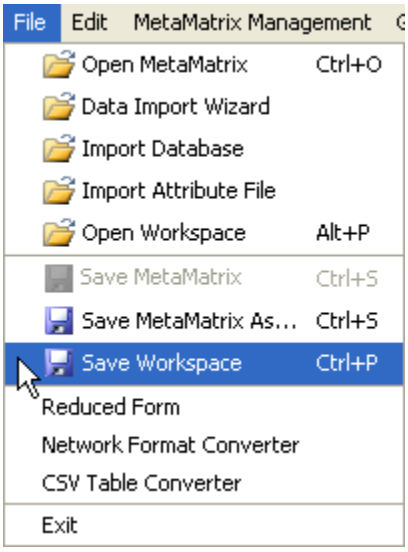


Selecting this option will bring up the Save MetaMatrix dialog box. From here you can save your MetaMatrix to any directory and rename it a different name. You can either lightlight an existing file in the window or type in an entirely new filename.

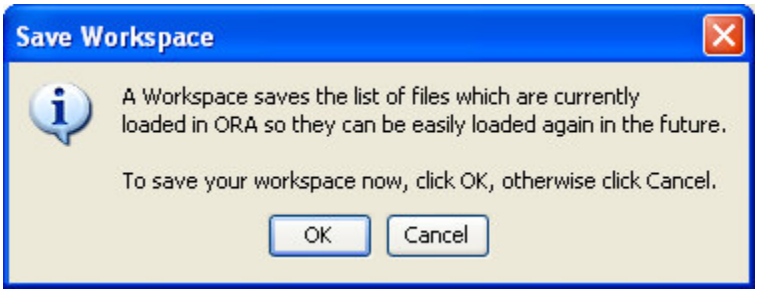


VIII Save Workspace

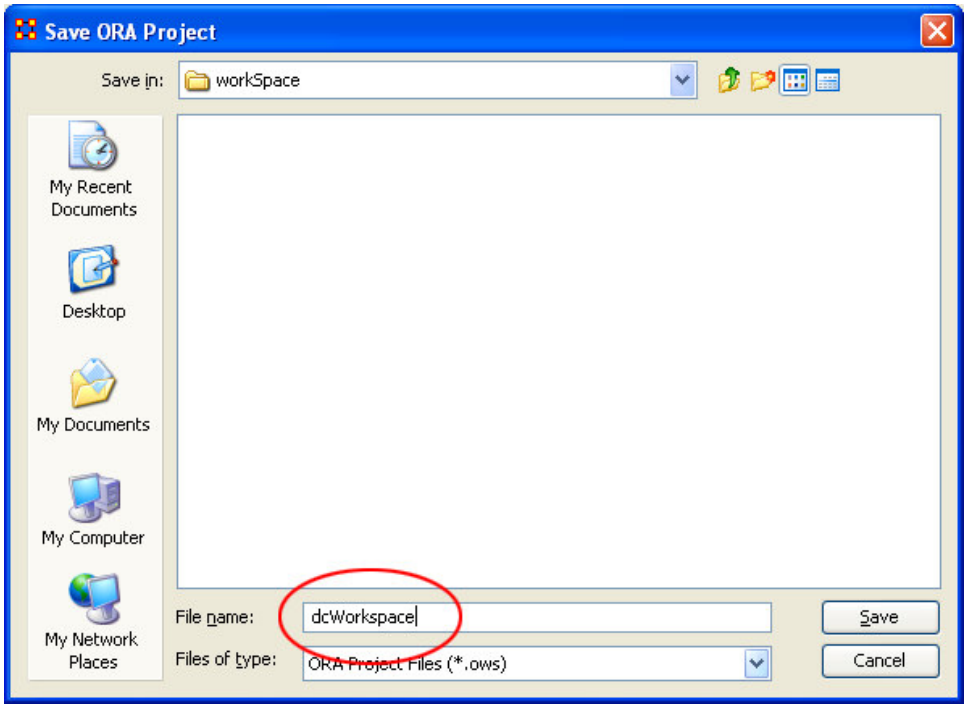
While working with multiple MetaMaarices you may want to retain that information for later use. The Save Workspace menu item



After selecting Save Workspace the following dialog box will appear. This informs you exactly what you're going to do.

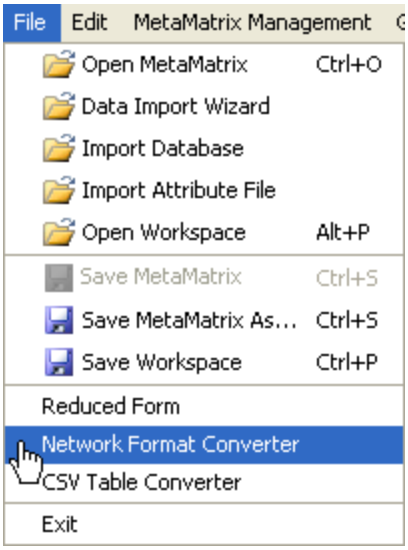


This will bring up the Save ORA Project window. In the File name box, type the name you wish to save your workspace to.

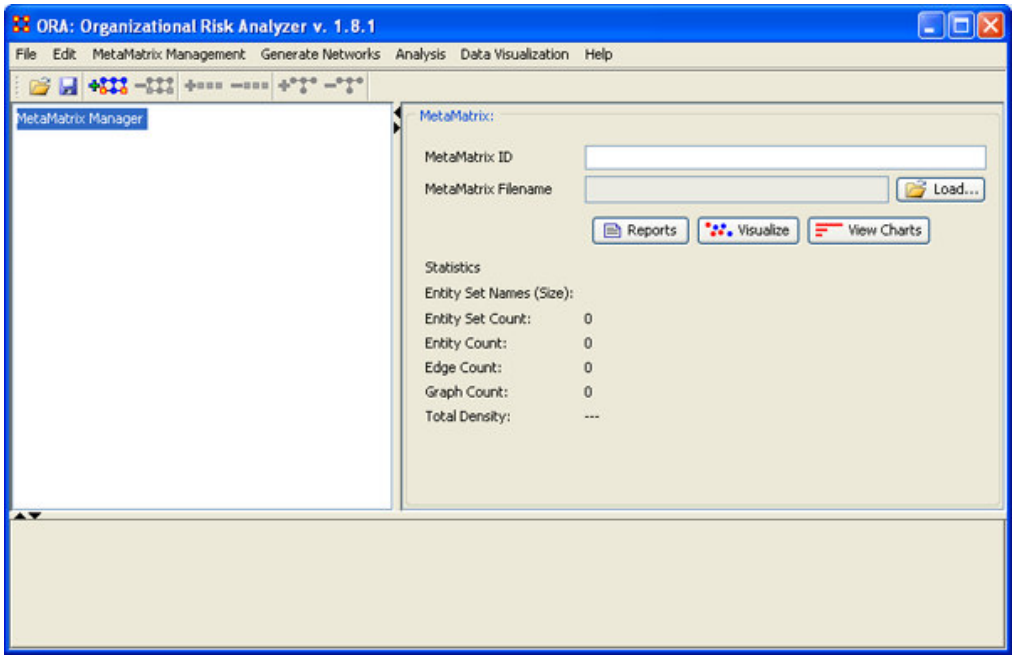


This Workspace can then be called up with the Load Workspace in a future session.

IX. Network Format Converter

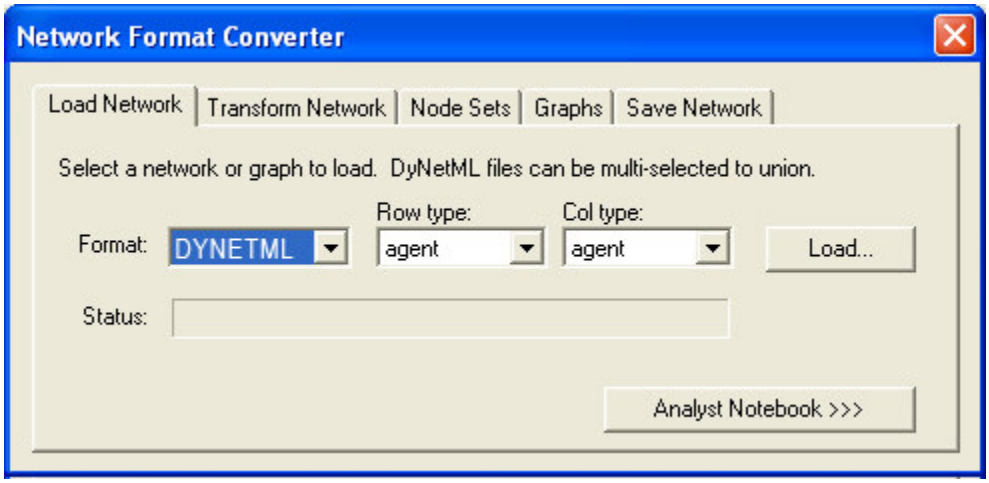


The Network Format Converter takes files from one format and convert it to an ORA format. The screenshot below shows the main interface with no MetaMatrix loaded.



- From the Main Menu File > Network File Converter.

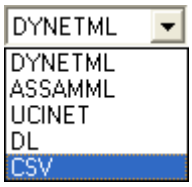
The dialog box will appear. So to the tab marked Load Network.



- Move the pointer over the inverted triangle to select the format of the file to convert.

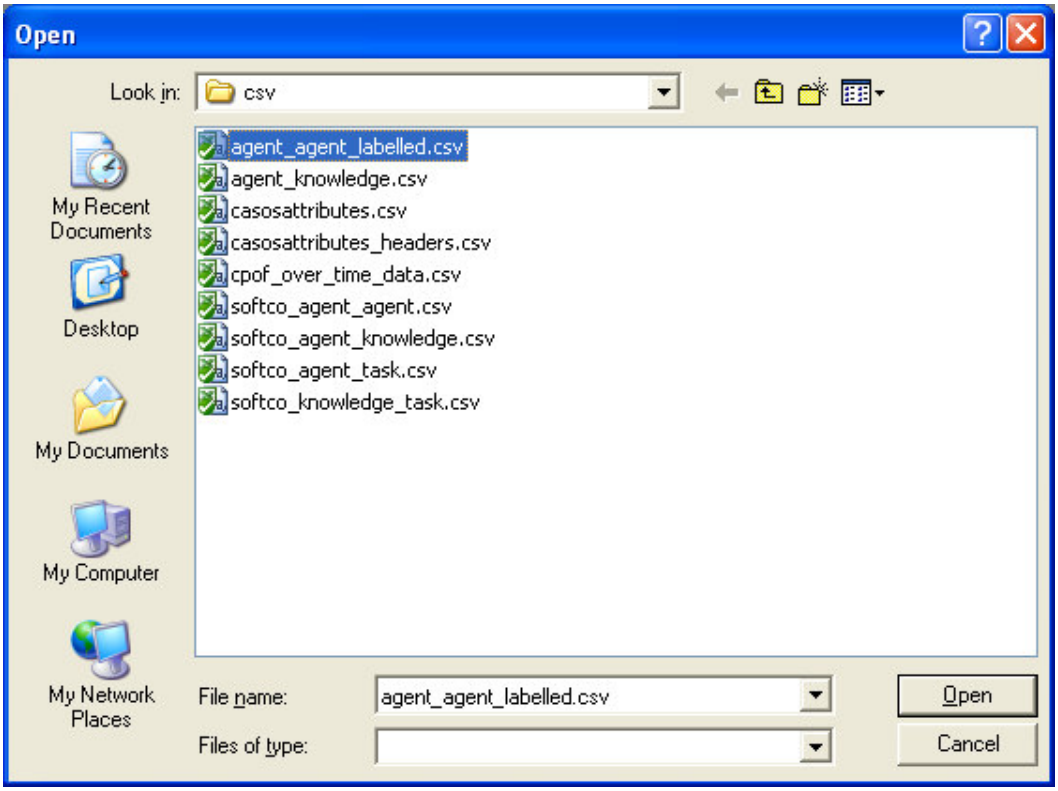
Below is the list of file types available to convert.

Select the file type CSV.



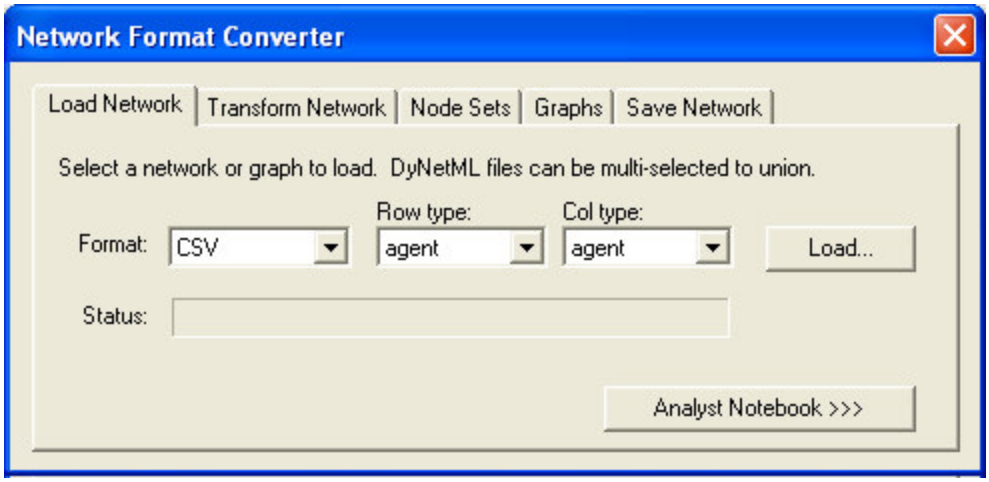
- Select the [Load] button

This will bring up the Open dialog box.

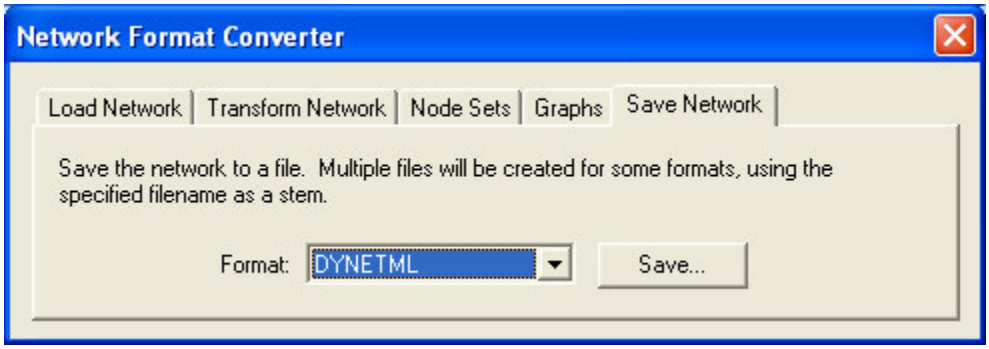


- Select the file you wish to convert and select the Open button.

Your screen should now look like that below.

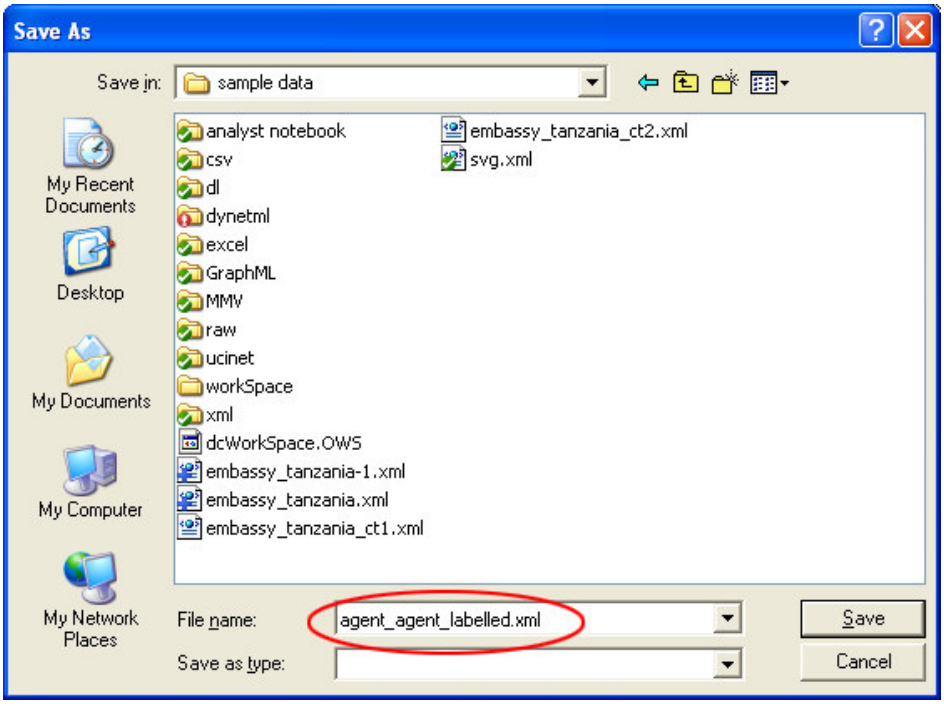


Now select the Save Network tab. Select the file format you want to convert your file to. In this case we'll leave it at DYNETML.



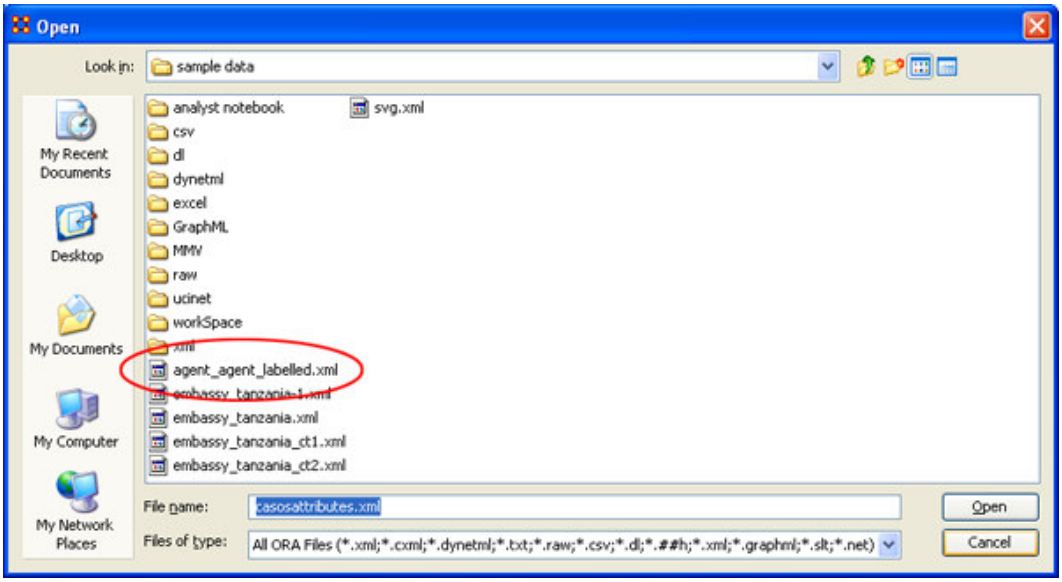
- Select the [Save] button
- Navigate to the directory you want to save your file.
- Type in the name you want your file to be called.

NOTE: Remember to type in the extension .xml so it will be recognized by ORA.

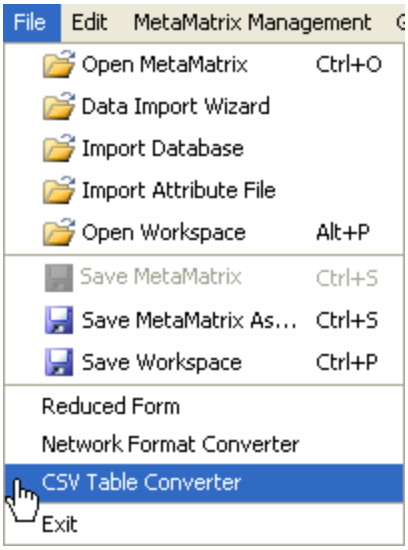


In order to access this file in ORA goto File > Open MetaMatrix and open it normally.

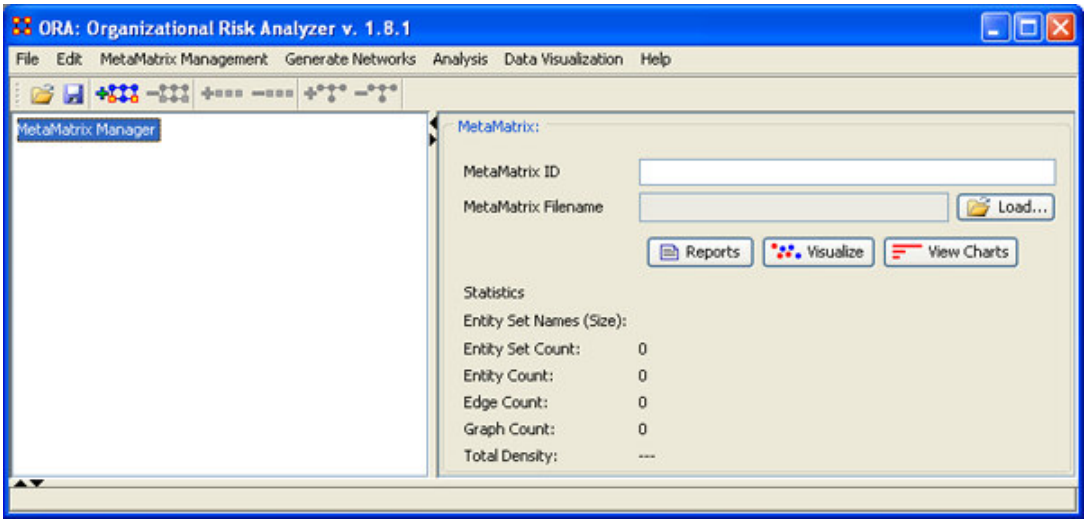
Below is a screenshot showing the newly saved file agent_agent_labelled.xml.



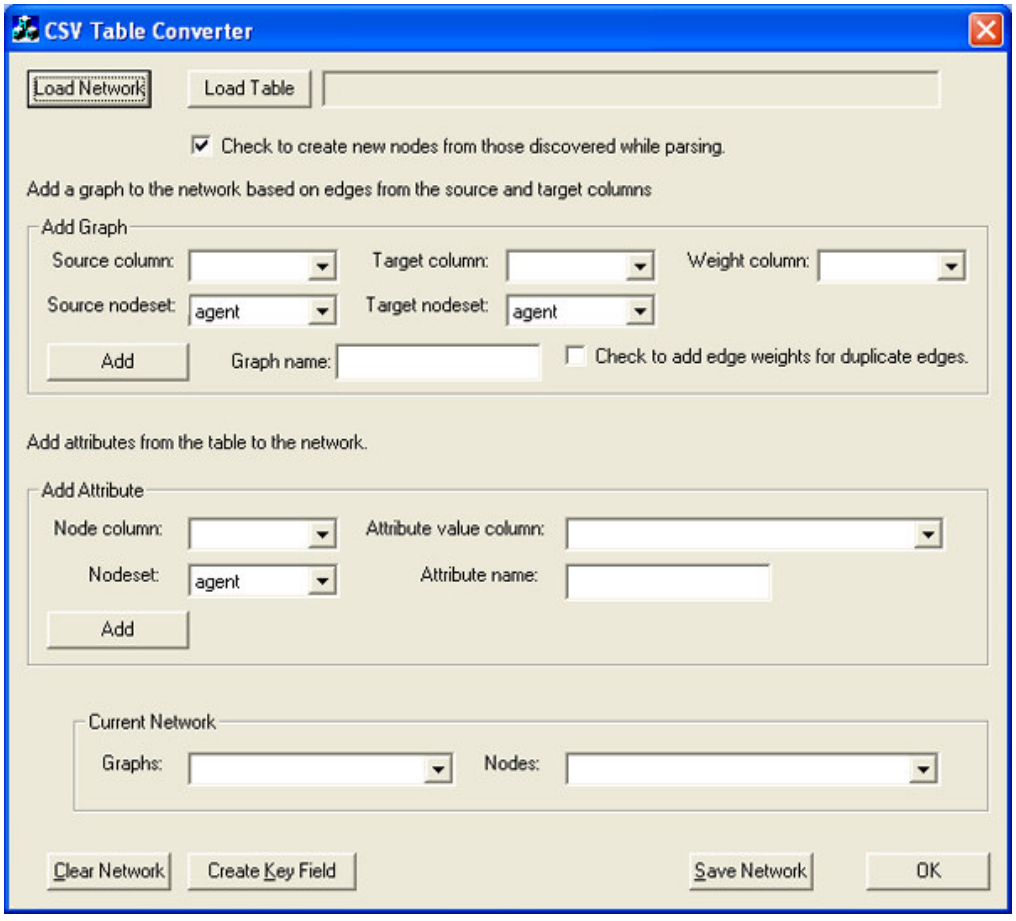
X. CSV Table Converter



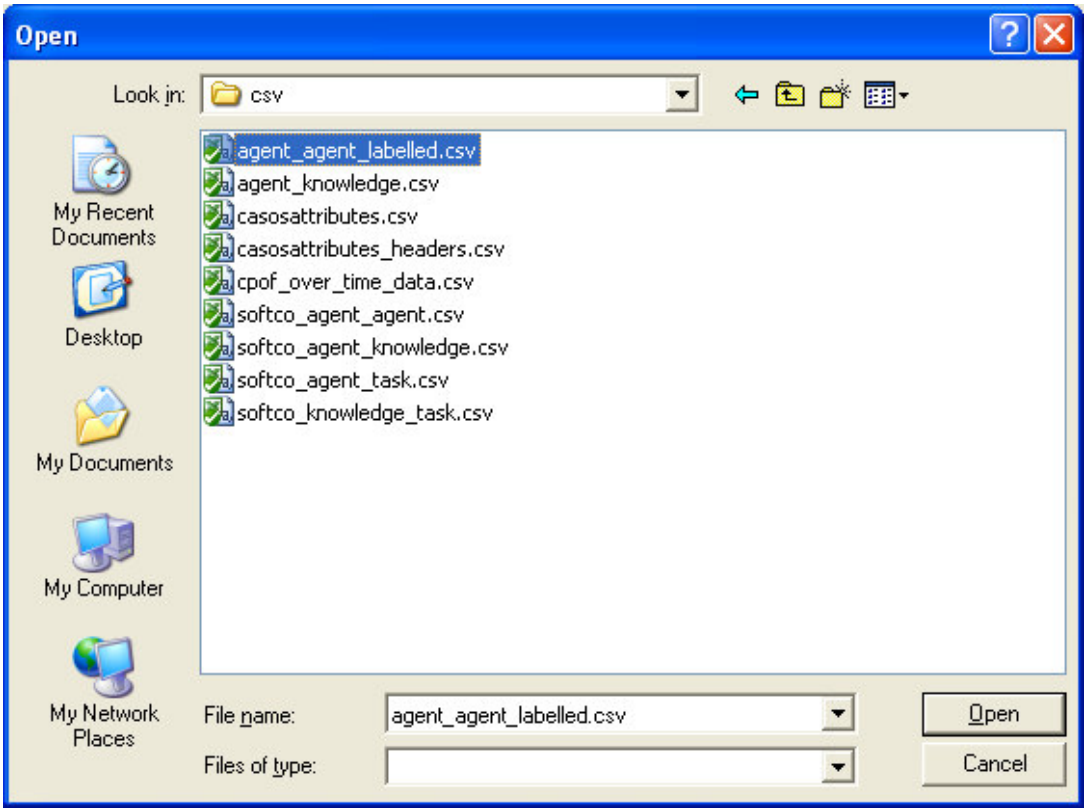
Below is a screenshot of ORA with no MetaMatrices loaded. From here we'll convert a .csv file and load it into ORA.



- From the Main Menu goto File > CSV Table Converter to bring up the CSV Table Converter.



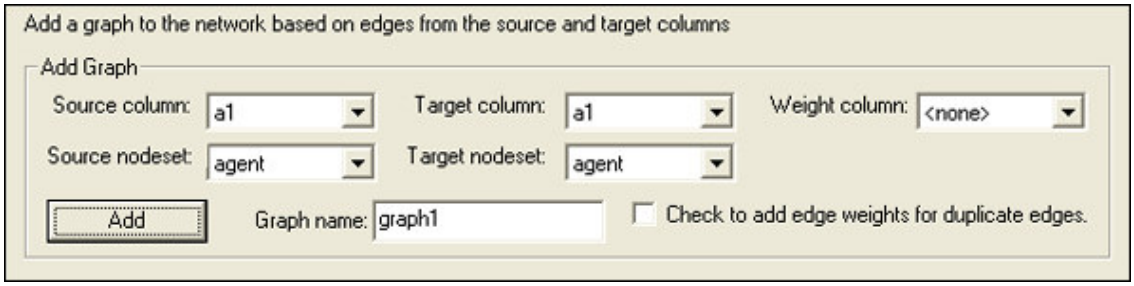
- Select the [Load Table] button at the top which will bring up the Open window
- Navigate to the file directory you want, highlight the file, and select the [Open] button.



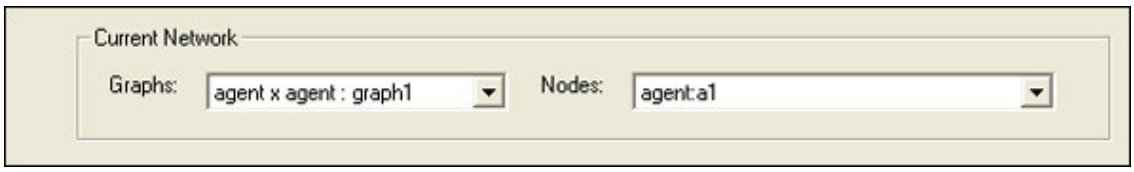
The window will show the file you selected in the text field.

We want to show this information in some sort of graph.

- Type in the name of the graph in the field Graph Name
- Select the [Add] button



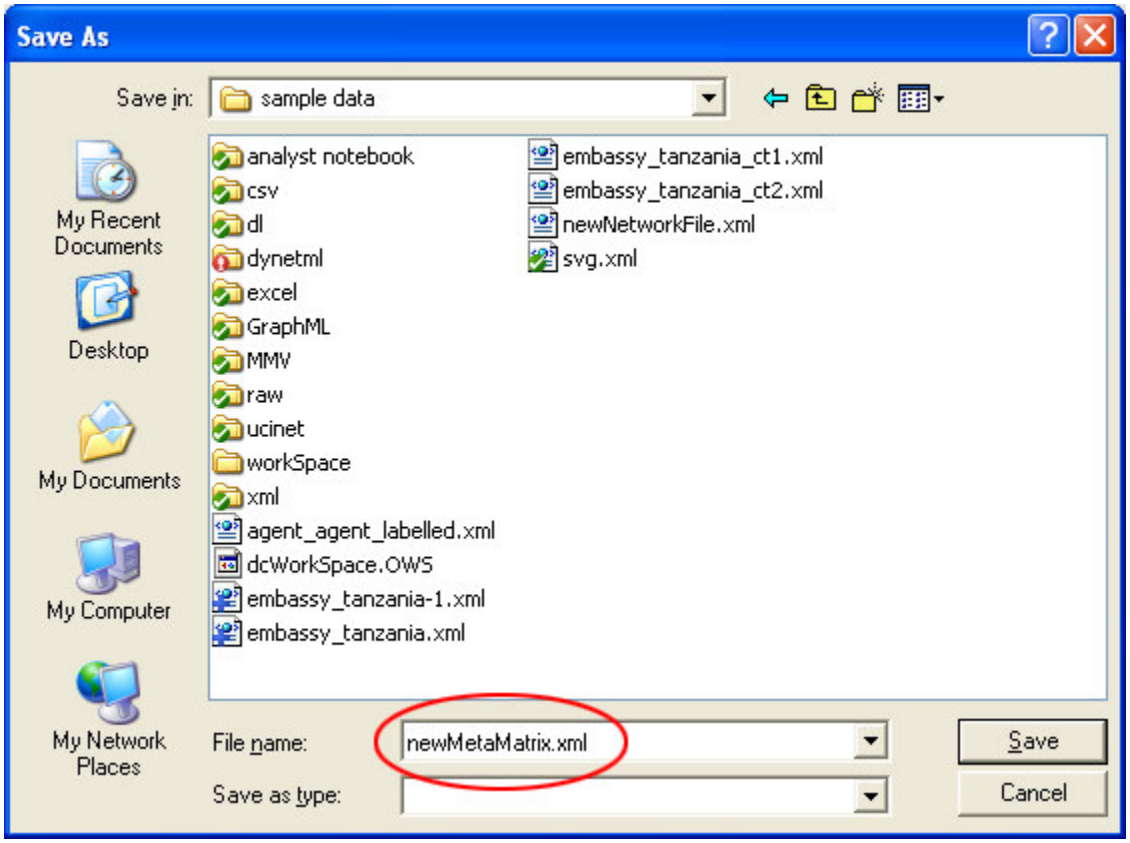
Near the bottom of the window it will reflect the graph you just created.



- Select the [Save Network] button at the bottom to create a new MetaMatrix.

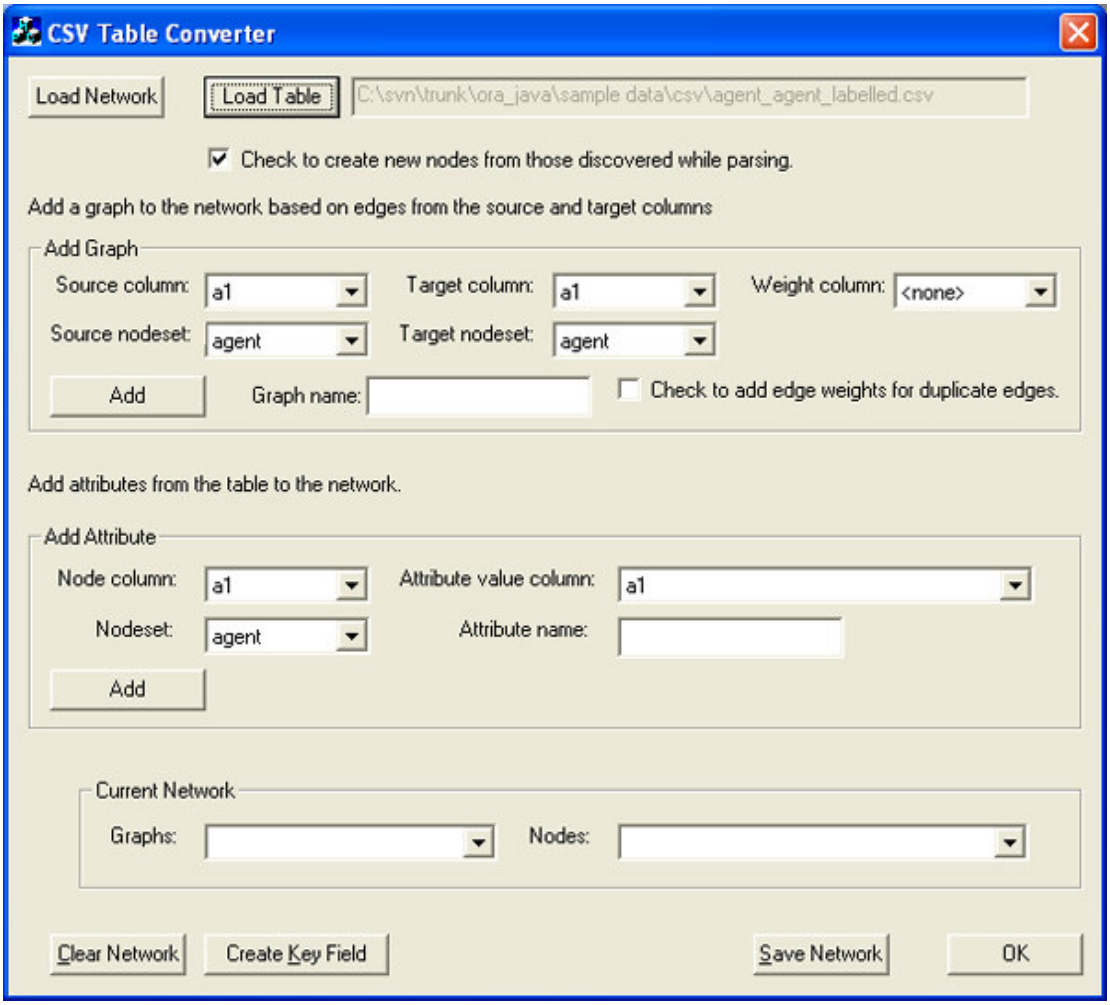
This will bring up the Save dialog box.

- Navigate to the file directory where you want to save your file.
- Type in the name for your file (remembering to attach the .xml extension).
- Select the [Save] button.



You will return to the CSV Table Converter dialog box

- At the bottom of the CSV Table Converter window select the [OK] button to close the window.



The exit dialog box till appear.

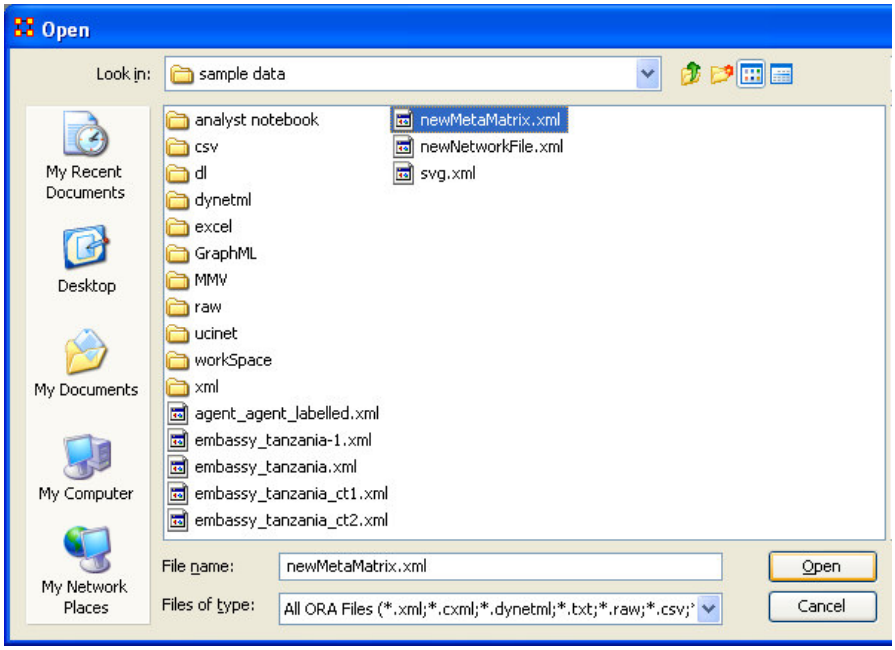
- Select [Yes] to exit and return to ORA.

Now you are ready to load your newly created MetaMatrix into ORA.

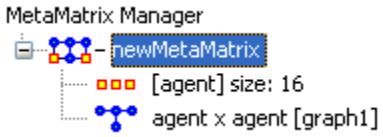
- From the Main Menu goto File > Open MetaMatrix.

This will bring up the Open dialog box.

- Find the file you just created
- Highlight the new file
- Select the [Open] button.



Below is Panel 1 in the Main Interface showing the newly loaded file.



You could then go and convert any number of individual CSV files and load them into ORA as shown below.

Lesson 3

Running an Intelligence Report

Who are the critical actors?

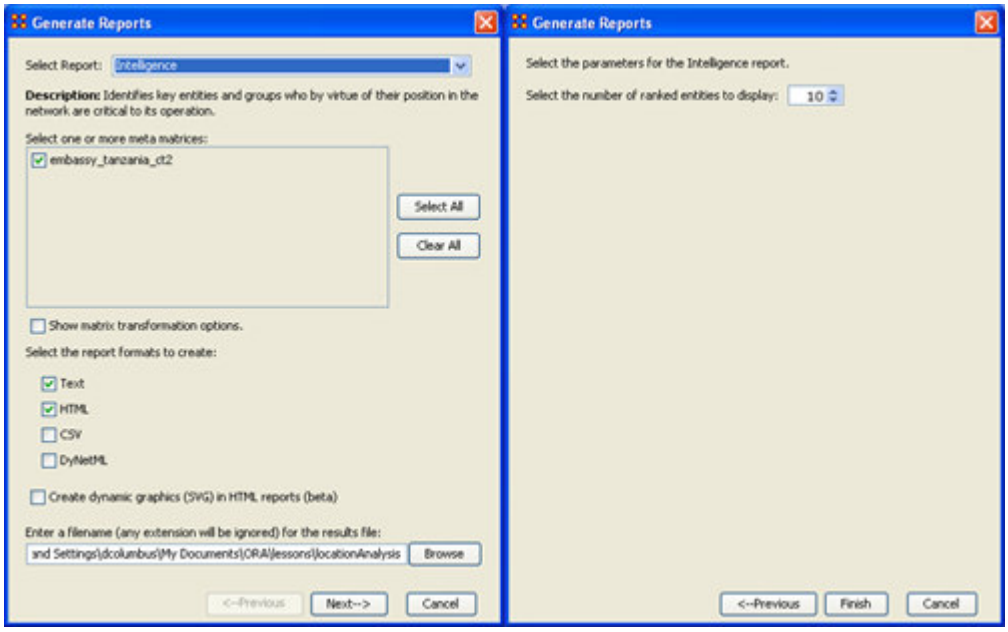
An Intelligence Report identifies key actors (individuals and groups) who are positioned in the network in ways that make them critical to its operation.

To run an Intelligence Report:

- Return to the ORA interface.

- Go to Analysis in the menu bar and click Generate Reports which brings up the Generate Reports dialog box.
- At the top of the window is a pull-down menu titled Select Report. Pull down the menu by clicking the small inverted arrow icon to its right, and select Intelligence.
- In the box titled Select one or more meta matrices: select the box for the Tanzania Embassy bombing meta matrix.
- At the bottom of the popup window is a file chooser titled Enter a file name (any extension will be ignored) for the results file: Select the [Browse] button to the right and navigate to the location you want. Type in a filename (for example, IntelOutput) and select Open.

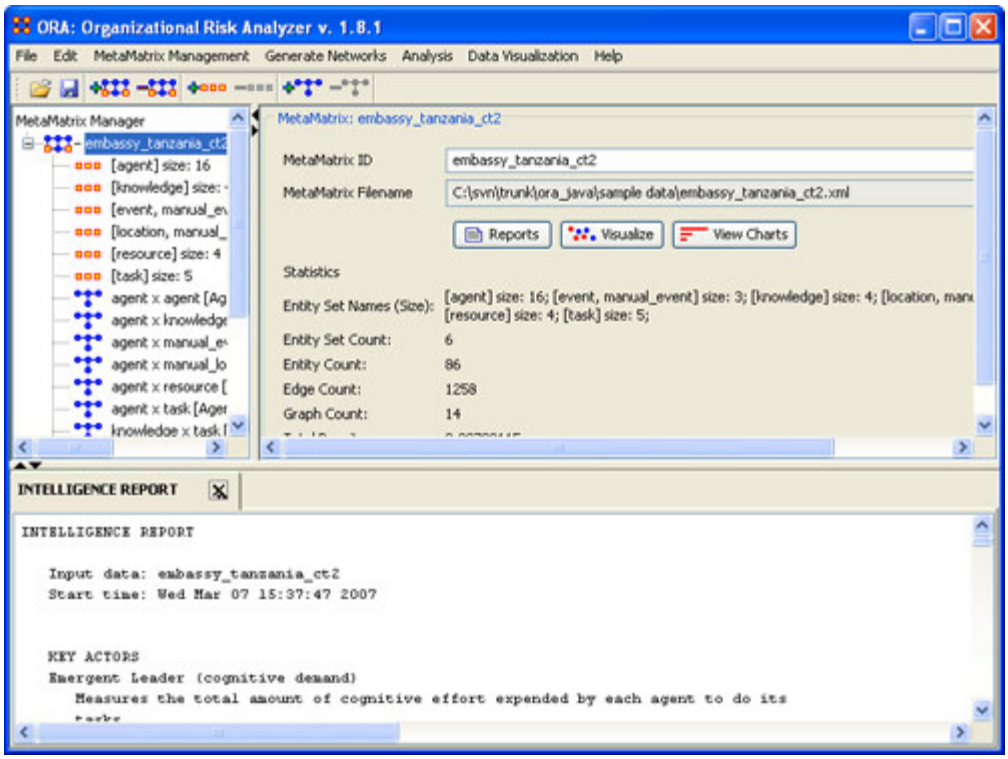
Below is a screen capture showing the popup windows with the correct options chosen:



- Select the [Next] button at the bottom of the dialog box. Select the [Finish] button.

An HTML file will pop up in your browser displaying the Intelligence Report. The same text is also displayed in Panel 3 in ORA.

Below is a screen capture of the ORA interface with the Intelligence Report displayed in Panel 3:



Below is the HTML file for the Intelligence Report on the Tanzania Embassy bombing data:

INTELLIGENCE REPORT

Input data: **TanzaniaEmbassyEnhance_2-07**

Start time: Fri Feb 23 10:30:55 2007

KEY ACTORS

Emergent Leader (cognitive demand)

Measures the total amount of cognitive effort expended by each agent to do its tasks.

Rank	Value	Nodes
1	0.378917	fazul_mohammed
2	0.341104	khalfan_mohamed
3	0.299063	mohamed_owhali
4	0.280313	a13
5	0.269833	mohammed_odeh
6	0.243792	abdullah_ahmed_abdullah

7 0.192542 a10
8 0.183771 a4
9 0.180042 wadih_el-hage
10 0.176083 a16

In-the-Know (total degree centrality)

The Total Degree Centrality of a node is the normalized sum of its row and column degrees.

Input graph(s): Agent x Agent

Rank	Value	Nodes
1	0.4	wadih_el-hage
2	0.266667	mohamed_owhali
3	0.266667	bin_laden
4	0.2	abdullah_ahmed_abdullah
5	0.133333	ali_mohamed
6	0.133333	khalid_al-fawwaz
7	0.133333	a16
8	0.1	mohammed_odeh
9	0.0666667	fazul_mohammed
10	0.0666667	a13

Number of Cliques (clique count)

The number of distinct cliques to which each node belongs.

Input graph(s): Agent x Agent

Rank	Value	Nodes
1	2	wadih_el-hage
2	2	bin_laden
3	1	mohamed_owhali
4	1	ali_mohamed
5	1	khalid_al-fawwaz
6	1	abdullah_ahmed_abdullah
7	1	a16

8	0	khalfan_mohamed
9	0	mohammed_odeh
10	0	a4

Most Knowledge (row degree centrality)

The Row Degree Centrality of a node is its normalized out-degree.

Input graph(s): Agent x Knowledge

Rank	Value	Nodes
1	0.75	mohamed_owhali
2	0.75	mohammed_odeh
3	0.75	fazul_mohammed
4	0.5	khalfan_mohamed
5	0.5	wadih_el-hage
6	0.5	ali_mohamed
7	0.5	a10
8	0.5	jamal_al-fadl
9	0.5	a13
10	0.25	bin_laden

Most Resources (row degree centrality)

The Row Degree Centrality of a node is its normalized out-degree.

Input graph(s): Agent x Resource

Rank	Value	Nodes
1	0.75	abdullah_ahmed_abdullah
2	0.5	fazul_mohammed
3	0.5	ahmed_ghailani
4	0.25	khalfan_mohamed
5	0.25	mohammed_odeh
6	0.25	wadih_el-hage
7	0.25	bin_laden
8	0.25	a10
9	0.25	a16

10	0	mohamed_owhali

Leader of Strong Clique (eigenvector centrality)

Calculates the principal eigenvector of the network. A node is central to the extent that its neighbors are central.

Input graph(s): Agent x Agent

Rank	Value	Nodes
1	0.167408	wadih_el-hage
2	0.147407	bin_laden
3	0.101381	mohamed_owhali
4	0.0992916	ali_mohamed
5	0.0992915	khalid_al-fawwaz
6	0.0836873	abdullah_ahmed_abdullah
7	0.0791944	mohammed_odeh
8	0.0583699	a16
9	0.0527998	mahmud_abouhalima
10	0.0527997	fazul_mohammed

Potentially Influential (betweenness centrality)

The Betweenness Centrality of node v in a network is defined as: across all node pairs that have a shortest path containing v, the percentage that pass through v.

Input graph(s): Agent x Agent

Rank	Value	Nodes
1	0.233333	wadih_el-hage
2	0.197619	mohamed_owhali
3	0.192857	bin_laden
4	0.0690476	abdullah_ahmed_abdullah
5	0.0452381	mohammed_odeh
6	0	khalfan_mohamed
7	0	a4
8	0	fazul_mohammed
9	0	ali_mohamed
10	0	ahmed_ghailani

Connects Groups (high betweenness and low degree)

The ratio of betweenness to degree centrality; higher scores mean that a node is a potential boundary spanner.

Input graph(s): Agent x Agent

Rank	Value	Nodes
1	0.26046	mohamed_owhali
2	0.254184	bin_laden
3	0.205021	wadih_el-hage
4	0.158996	mohammed_odeh
5	0.121339	abdullah_ahmed_abdullah
6	0	khalfan_mohamed
7	0	a4
8	0	fazul_mohammed
9	0	ali_mohamed
10	0	ahmed_ghailani

Unique Task Assignment (task exclusivity)

Detects agents who exclusively perform tasks.

Rank	Value	Nodes	Speciality
1	0.205078	fazul_mohammed	t3
2	0.0136876	mohamed_owhali	t1
3	0.0136876	a13	t1
4	0.011305	abdullah_ahmed_abdullah	t1
5	0.00995741	ali_mohamed	t1
6	0.00507781	khalfan_mohamed	t5
7	0.00366313	a4	t5
8	0.00141468	mohammed_odeh	t4
9	0.00141468	a16	t4
10	0.00134759	ahmed_ghailani	t4

Special Expertise (knowledge exclusivity)

Detects agents who have singular knowledge.

Rank	Value	Nodes	Speciality
1	0.0919699	bin_laden	k4
2	0.0919699	khalid_al-fawwaz	k4
3	0.00214043	mohamed_owhali	k3
4	0.00214043	mohammed_odeh	k3
5	0.00214043	fazul_mohammed	k3
6	0.00191246	khalfan_mohamed	k3
7	0.00191246	ali_mohamed	k3
8	0.00168449	abdullah_ahmed_abdullah	k3
9	0.000455941	wadih_el-hage	k1, k2
10	0.000455941	a10	k1, k2

Special Capability (resource exclusivity)

Detects row nodes who have singular ties to column nodes.

Input graph(s): Agent x Resource

Rank	Value	Nodes	Speciality
1	0.108996	abdullah_ahmed_abdullah	r4
2	0.0965488	ahmed_ghailani	r4
3	0.0919699	bin_laden	r2
4	0.0919699	a10	r2
5	0.0170257	fazul_mohammed	r3
6	0.0124468	wadih_el-hage	r3
7	0.0124468	a16	r3
8	0.00457891	khalfan_mohamed	r1
9	0.00457891	mohammed_odeh	r1
10	0	mohamed_owhali	

Workload (actual based on knowledge and resource)

The knowledge and resources an agent uses to perform the tasks to which it is assigned.

Rank	Value	Nodes
1	0.692308	fazul_mohammed
2	0.307692	mohamed_owhali

3	0.307692	khalfan_mohamed
4	0.230769	mohammed_odeh
5	0.230769	a13
6	0.230769	abdullah_ahmed_abdullah
7	0.153846	wadih_el-hage
8	0.153846	a16
9	0.0769231	ali_mohamed
10	0.0769231	ahmed_ghailani

KEY KNOWLEDGE

Dominant Knowledge (total degree centrality)

The Total Degree Centrality of a node is the normalized sum of its row and column degrees.

Rank	**Value**	**Nodes**
1	0.571429	k2
2	0.428571	k1
3	0.333333	k3
4	0.0952381	k4

KEY RESOURCES

Dominant Resource (total degree centrality)

The Total Degree Centrality of a node is the normalized sum of its row and column degrees.

Rank	**Value**	**Nodes**
1	0.333333	r3
2	0.285714	r1
3	0.190476	r4
4	0.142857	r2

KEY LOCATIONS

Dominant Location (total degree centrality)

The Total Degree Centrality of a node is the normalized sum of its row and column degrees.

Rank	Value	Nodes
1	1.125	u_s
2	0.847222	afghanistan
3	0.833333	pakistan
4	0.722222	washington
5	0.708333	indonesia
6	0.701389	europe
7	0.673611	airport
8	0.604167	america
9	0.527778	turkey
10	0.506944	somalia

PERFORMANCE INDICATORS

Entity class	Size
agent	16
event	3
knowledge	4
location	54
resource	4
task	5

Overall Complexity = 0.22707503

Density of the Meta-Matrix: **Social Density** = 0.11666667

Density of the Agent x Agent network: **Social Fragmentation** = 0.45

Fragmentation of the Agent x Agent network: **Communication Congruence** = 0.416667

Measures to what extent the agents communicate when and only when it is needful to complete tasks. Perfect congruence requires a symmetric Agent x Agent network: **Knowledge Congruence** = 0.55

Measures the similarity between what knowledge are assigned to tasks via agents, and what knowledge are required to do tasks. Perfect congruence occurs when agents have access to knowledge when and only when it is needful to complete tasks: **Performance As Accuracy** = 0.36

Measures how accurately agents can perform their assigned tasks based on their access to knowledge and resources: **Avg Communication Speed** = 0.438406

The average speed with which any two nodes can interact. This is based on the inverse of the shortest path lengths between node pairs.

Produced by ORA developed at CASOS - Carnegie Mellon University

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From this Intelligence Report, it appears that Fazul Mohammed, Khalfan Mohamed, Mohamed Owhali, Mohammed Odeh, Abdullah Ahmed Abdullah, and Wadih El-Hage are among the most important people in the terrorist network. This means they may have a great deal of knowledge, influence over many other agents in the network, special expertise or capability, or access to important resources and locations.

For example, Wadih El-Hage is important because he is the most in-the-know, commands important cliques within the network, and has the most potential influence in the network.

III. What do we know about an actor of interest?

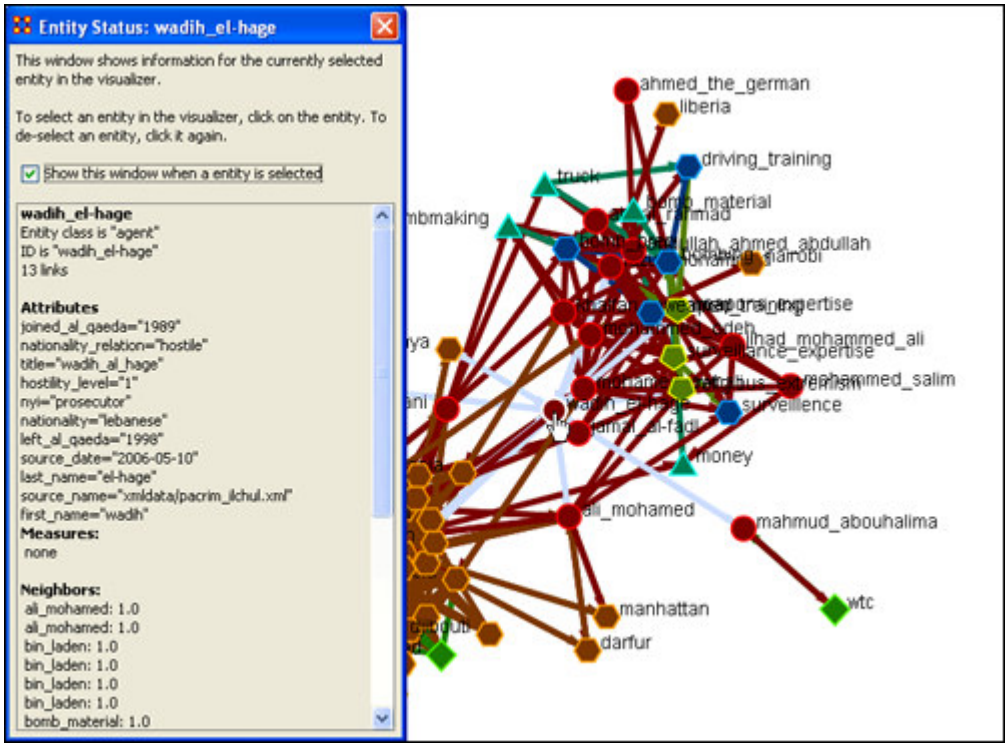
There are three ways to get additional information about an actor of interest:

1. Visualize information about a selected actor

For example, we can view information about Wadih El-Hage.

- Return to the meta matrix visualization pop-up window.
- Single-click on the red circle for the actor of interest. A window will pop up displaying information on the actor.

Below is a screen capture of the information resulting from clicking on the red circle for Wadih El-Hage:



2. Visualize an actor's sphere of influence

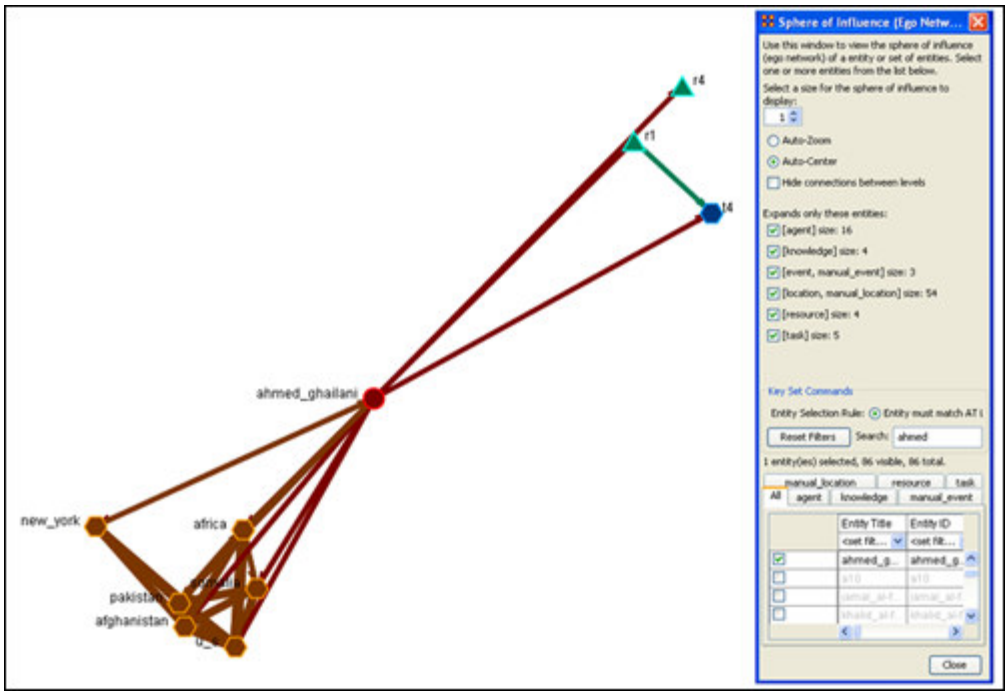
A sphere of influence is the set of actors, groups, knowledge, resources, events, and locations that influence and are influenced by a particular actor of interest.

For example, we can examine the sphere of influence of Ahmed Ghailani.

To visualize an actor's sphere of influence:

- Return to the meta matrix visualization pop-up window.
- Make sure the whole meta matrix is visualized. If it isn't, go to Actions in the menu bar and select Show All Entities.
- Go to Tools in the menu bar and select Sphere of Influence. A window titled Sphere of Influence (Ego Network) will pop up.
- In the Search field halfway down the popup window, type the beginning of the actor's name. From the options that appear in the chart below, click the box next to the name of your actor of interest. That actor's sphere of influence will be displayed in the visualization window.

Below is a visualization of the sphere of influence of Ahmed Ghailani:



To return to the original full meta matrix visualization, go to Actions in the menu bar and select Show All Entities.

3. Run a Sphere of Influence Report

A Sphere of Influence Report for an individual identifies the set of actors, groups, knowledge, resources, events, and locations that influence and are influenced by that actor.

For example, we can examine the sphere of influence of Ahmed Ghailani.

To run a Sphere of Influence Report:

- Return to the ORA interface.
- Go to Analysis in the menu bar and click Generate Reports. A window titled Generate Reports pops up.
- At the top of the window is a pull-down menu titled Select Report. Pull down the menu by clicking the small inverted arrow icon to its right, and select Sphere of Influence.
- In the box titled Select one or more meta matrices: click the box for the Tanzania Embassy bombing meta matrix.
- At the bottom of the popup window is a file chooser titled Enter a file name (any extension will be ignored) for the results file: Click the Browse button to the right and navigate to the location you want. Type in a filename (for example, SOIOutput) and click Open.
- Click the Next button at the very bottom of the popup window.
- From the pull-down menu titled Select an Entity: choose Ahmed Ghailani.

- Click the Finish button.

It may take a few minutes for ORA to run the Sphere of Influence Report. When ORA is finished, a small window will pop up tell you the analysis was successfully completed. Click OK.

An HTML file displaying the Sphere of Influence Report will pop up in your browser window.

Below is the HTML file for Ahmed Ghailani's sphere of influence:

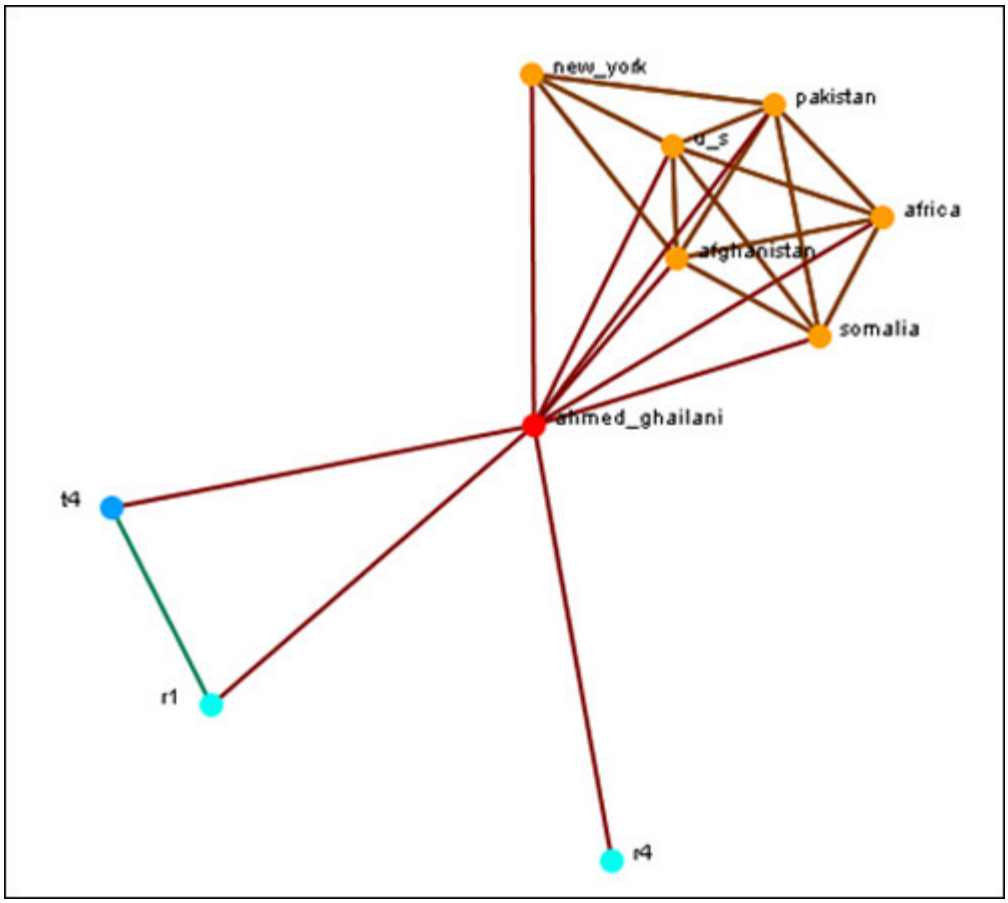
SPHERE-OF-INFLUENCE REPORT

Input data: TanzaniaEmbassyEnhance_2-07

Start time: Fri Feb 23 11:10:54 2007

Sphere of Influence Analysis for agent ahmed_ghailani

The radius of the network is 1



Size Statistics

Contains the size of each node type within the ego network, expressed as an absolute value and as a percentage of the nodes in the original input network.

Node Type	Size	Percent
agent	1	+6%
manual_location	6	+11%
resource	2	+50%
task	1	+20%

Attributes

These are the attributes of the ego node.

Name	Value
first_name	ahmed

hostility_level	2
kinship	mother
last_name	ghailani
nationality	tanzanian
nationality_relation	hostile
nyi	president
source_date	2006-05-10
source_name	xmldata/pacrim_ilchul.xml
title	ahmed_khalfan_ghailani

Exclusive Connections

Find nodes that have connections exclusively to the ego node. These are also called pendant nodes of the ego.

There are no pendants attached to this node.

Most Similar Node

Computes the node that is most similar to the ego node with respect to Cognitive Similarity. This is computed two ways: first, using just the ego network, and second, using the original input network.

Network	Node Type	Node Name
Original Network	agent	abdullah_ahmed_abdullah
Ego Network	agent	ahmed_ghailani

Top Measures

Computes a collection of standard network analysis measures and reports those for which the ego node is among the top 10 nodes.

Measure Name	Measure Input	Rank	Value
Centrality, Row Degree	Agent x Resource	3	0.5
Centrality, Betweenness	Agent x Agent	10	0
Boundary Spanner, Potential	Agent x Agent	10	0
Exclusivity, Task	Agent x Task	10	0.00134759
Exclusivity	Agent x Resource	2	0.0965488
Actual Workload	Agent x Knowledge	10	0.0769231

Measure Value Range

Computes a collection of network analysis routines for all the nodes in the network and reports whether the ego node has a Low, Medium, or High value with respect to the other nodes. Low means less than one standard deviation from the mean; high means more than one standard deviation from the mean; Medium is neither low nor high.

Measure Name	Measure Input	Range
Cognitive Demand	Agent x Agent	Medium
Centrality, Total Degree		Medium
Clique Count	Agent x Agent	Medium
Centrality, Eigenvector	Agent x Agent	Low
Centrality, Betweenness	Agent x Agent	Medium
Boundary Spanner, Potential	Agent x Agent	Medium
Exclusivity, Task	Agent x Task	Medium
Exclusivity, Knowledge	Agent x Knowledge	Medium
Exclusivity	Agent x Resource	High
Actual Workload	Agent x Knowledge	Medium

Resource Analysis Section

Computes the resources that ahmed_ghailani can directly leverage and that can be mobilized. Direct resource are those directly connected to it, and indirect resources are those directly connected to a neighbor.

Resources that can be leveraged

Resources that can be mobilized

ahmed_ghailani does not have any resources to mobilize.

Measure	Value	Percent of total
Direct resources	2	+50%
Indirect resources	0	0%
Possibly constrained resources	0	0%

Possibly constrained resources are both directly and indirectly linked to the ego entity.

Contacts with the most resources (directly linked entities with the most resources):

Name Number of resources

Contacts with the unique resources (directly linked entities with exclusive resources):

Name Unique resources

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IV. What are the connections between two actors of interest?

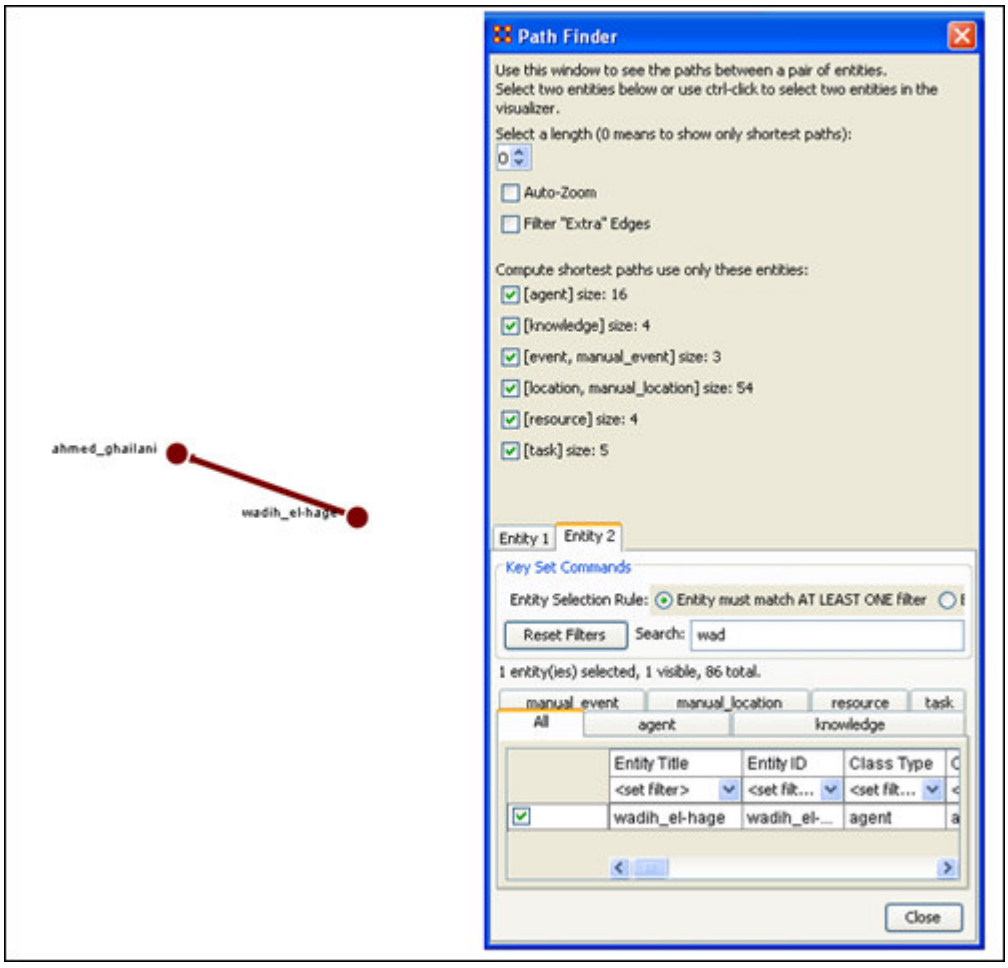
Sometimes, rather than influencing an actor directly, you may want to examine whether that actor has a connection with someone who is more interesting to you. For this, the Path Finder feature is most useful.

For example, we can look at how Ahmed Ghailani and Wadih El-Hage are connected.

To use the Path Finder feature:

- Return to the meta matrix visualization pop-up window.
- Make sure the whole meta matrix is visualized. If it is not, go to Actions in the menu bar and select Show All Entities.
- Go to Tools in the menu bar and select Path Finder. A window titled Path Finder will pop up.
- In the bottom half of this pop-up window, there are two tabs titled Entity 1 and Entity 2. Entity 1 is the from entity, and Entity 2 is the to entity. In other words, Path Finder searches for communication and information that is passed from Entity 1 to Entity 2.
- In the Entity 1 tab, type the name of your first actor of interest into the Search field. From the chart of agents below the Search field, check the box for the name of that agent. (For example, Ahmed Ghailani).
- Click on the Entity 2 tab and type in the name of your second actor of interest into the Search field. From the chart of agents below the Search field, check the box for the name of that agent. (For example, Wadih El-Hage).
- The visualization of the connections between Entity 1 and Entity 2 will appear in the visualization window.

Below is a screen capture showing the connection between Ahmed Ghailani and Wadih El-Hage:



V. What is the immediate impact of a particular agent on the network?

VI. What happens to the network when certain entities are removed?

We can examine the impact of removing a particular entity from the network by using Near Term Analysis (NTA). NTA removes a given entity and estimates the changes in the remaining network.

This provides a what if?... analysis of the network. We can simulate strategic interventions or eliminations of certain agents, and examine how the network should react and change. For example, we can look at how the Tanzania Embassy bombing network changes if Ahmed Ghailani and/or Wadih El-Hage are eliminated.

To run a Near Term Analysis:

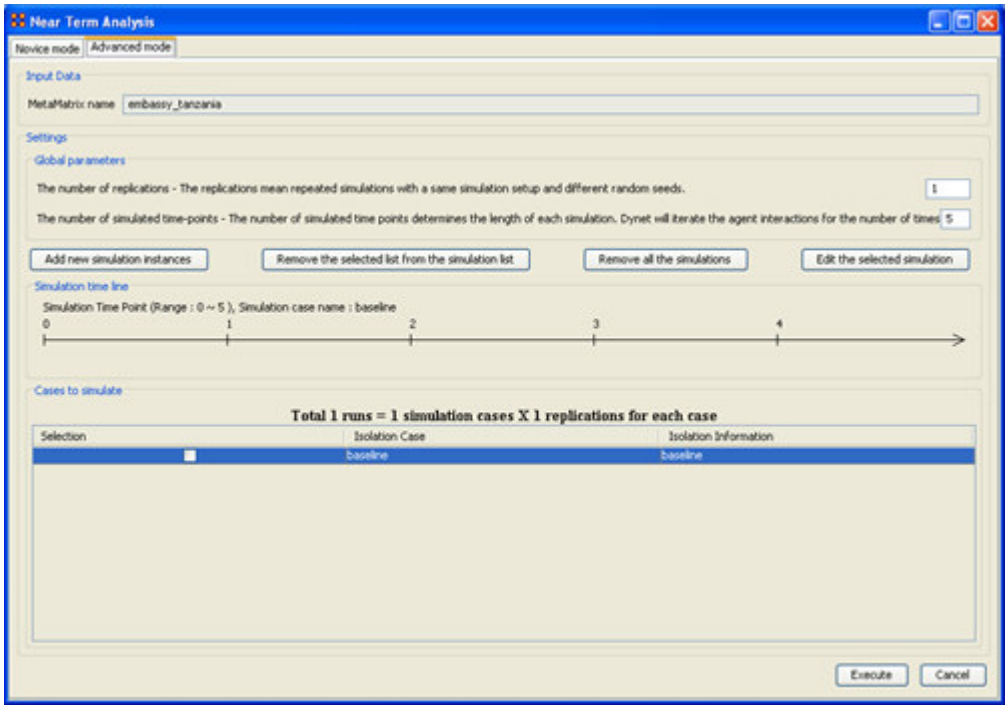
1. Start the Near Term Analysis window

- Return to the ORA interface.
- Make sure the meta matrix is highlighted in Panel 1. If it is not highlighted, single-click on it.
- Go to Analysis in the menu bar and select Near-Term Analysis. A window titled Near Term Analysis will pop up.

NTA has two modes, Novice and Advanced, displayed as tabs in the Near Term Analysis pop-up window. Novice mode provides an automatic analysis set-up, but does not allow users to set up their own hypotheses.

- Click on the Advanced mode tab to switch to Advanced mode.

Below is a screen capture showing the Advanced mode tab in the Near Term Analysis pop-up window:

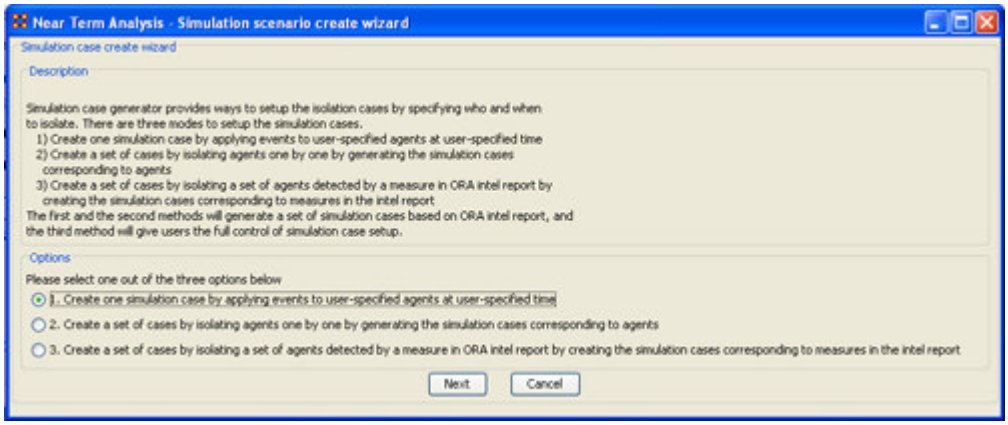


- In the field titled Settings, find the number boxes on the far right. Change the number of replications (the top number box) to 2, and the number of simulated time-points (the bottom number box) to 52. The timeline in the Simulated time line field will expand to include 52 time-steps.

2. Open the simulation scenario wizard

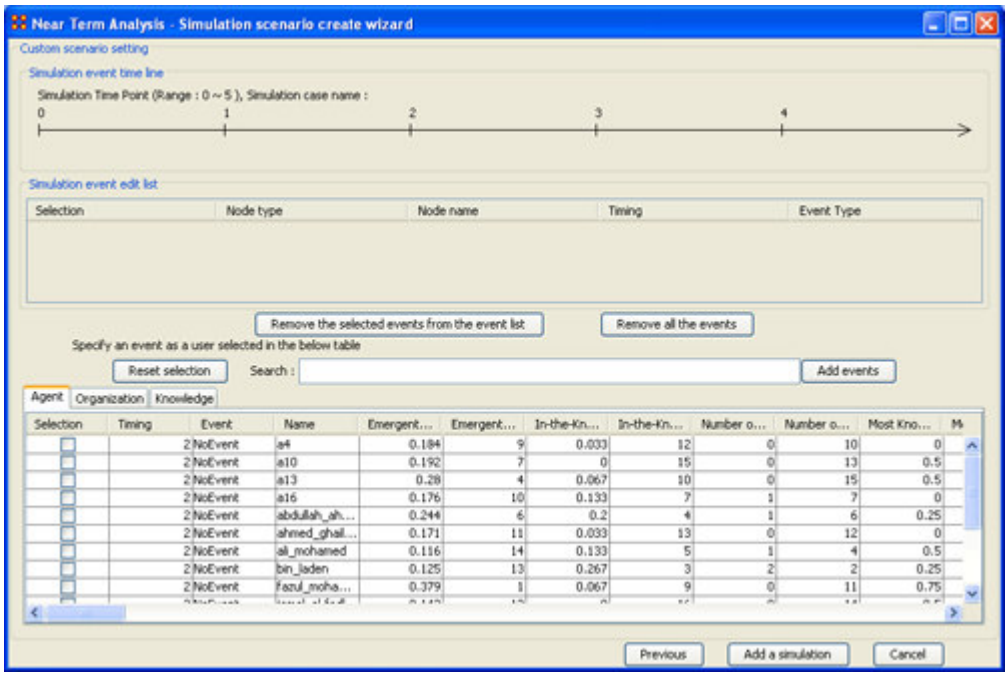
- In the middle of the pop-up window, find and click the Add new simulation instances button. A small window titled Near Term Analysis - Simulation scenario create wizard will pop up.

Below is a screen capture showing this wizard window:



- In this wizard window, make sure the first option in the Options field is selected. Click the Next button. The wizard window will display options for creating a custom scenario.

Below is a screen capture showing this custom scenario field in the wizard window:

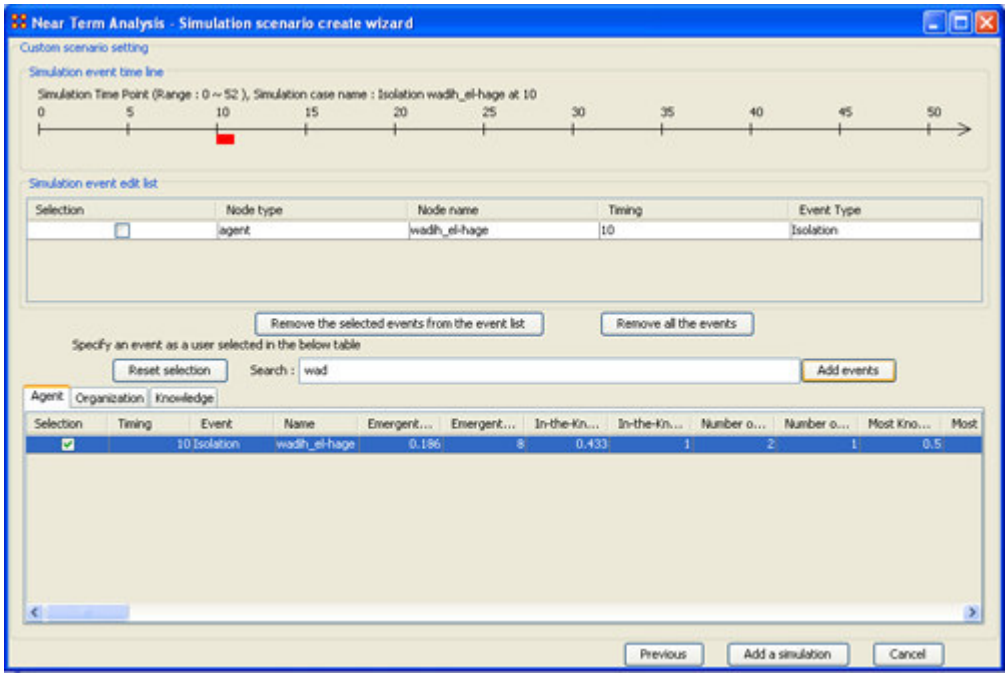


3. Remove Wadih El-Hage

- Click the box for Wadih El-Hage in the table of agents in the wizard window. Change the Timing box to 10 in the same row.
- To add this event set-up to the Near Term Analysis, click the Add events button located next to the Search field (above the list of agents).

The timeline at the top of the wizard window will mark the isolation of Wadih El-Hage at time 10.

Below is a screen capture of this timeline:



- Click the Add a simulation button at the bottom of the wizard window. The wizard window will close automatically. In the NTA window, the new simulation case will appear in the Cases to simulate field.

4. Remove Ahmed Ghailani

- Follow Step 3, but replace Wadih El-Hage with Ahmed Ghailani.

Your two simulation cases appear in the Near Term Analysis window in the Cases to simulate field, along with the Baseline case. The Baseline case is simply the network with no entities removed.

You can view your different simulation cases by clicking on them in the Cases to simulate field, and the simulation time-line will change accordingly.

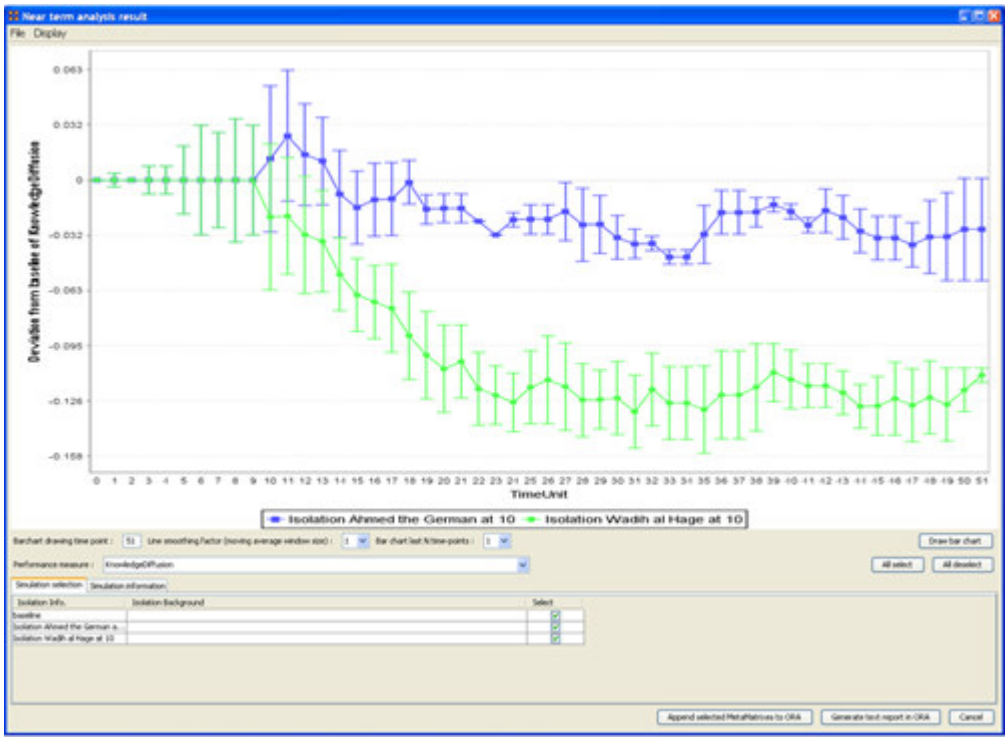
5. Run the Near Term Analysis

- Click the Execution button at the bottom of the Near Term Analysis window.
- A small window will pop up to warn you that the execution may take a long time. Click OK. Another small window will pop up to show you how the simulations are progressing in the Near Term Analysis.

6. View the results of the Near Term Analysis

- When the analysis is complete, a new window titled Near Term Analysis Results will pop up.

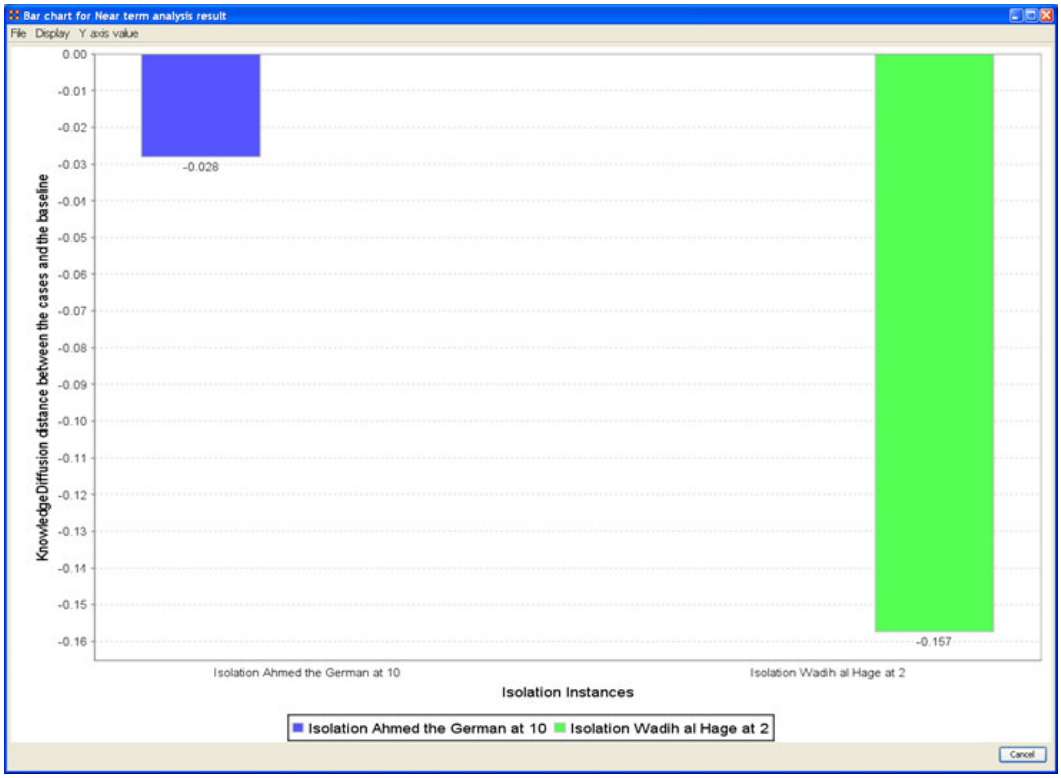
Below is a screen capture of the results pop-up window:



These two performance lines correspond to deviations from the baseline of knowledge diffusion over time. Examining this performance change over time reveals how much an agent's elimination impacts the performance of the organization.

- To draw a bar chart, click the Draw bar chart button in the results window. The resulting bar chart displays a performance comparison for each time-point.

Below is a screen capture of the bar chart:



The results of the Near Term Analysis are also available in HTML format.

7. Save the results of the Near Term Analysis in HTML format

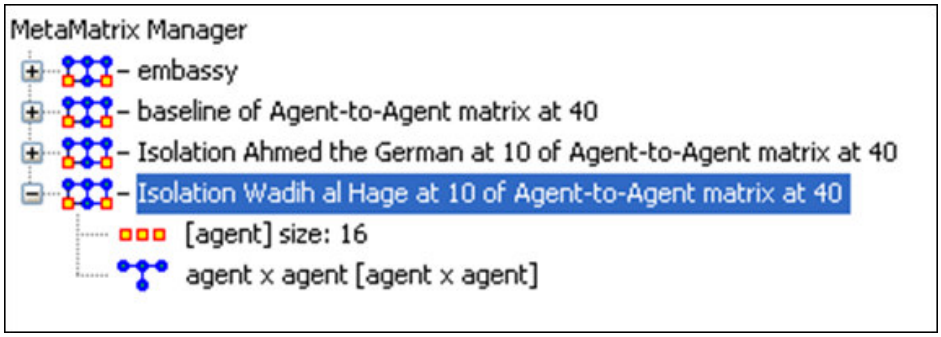
- Go to File in the menu bar and select Save the html report. A file chooser window will pop up. Navigate to the location you want and type a filename for your HTML report.
- A window titled Image Size Input will pop up. Type in the width of the image and click OK.
- Another window titled Project Saved will pop up displaying the location of your saved analysis results. Click OK.

8. Save the organizational structures resulting from your simulations in ORA

- Return to the ORA interface.
- To save the Agent-to-Agent communication network at time-step 40 in the simulation, go to File and select Save the Agent-to-Agent communication matrices during evolution.
- A small window titled Save the probability of interaction matrix will pop up. Click the Yes button.
- Another small window titled Save timing will pop up. Enter 40 and click OK.
- A final window titled Saved will pop up. Click OK.

You can view saved simulations in Panel 1 of the ORA interface.

Below is a screen capture of Panel 1 after simulations have been saved:



Lesson 4

What is Going on Where?

We want to identify what events are related to what agents and the locations pertinent to both.

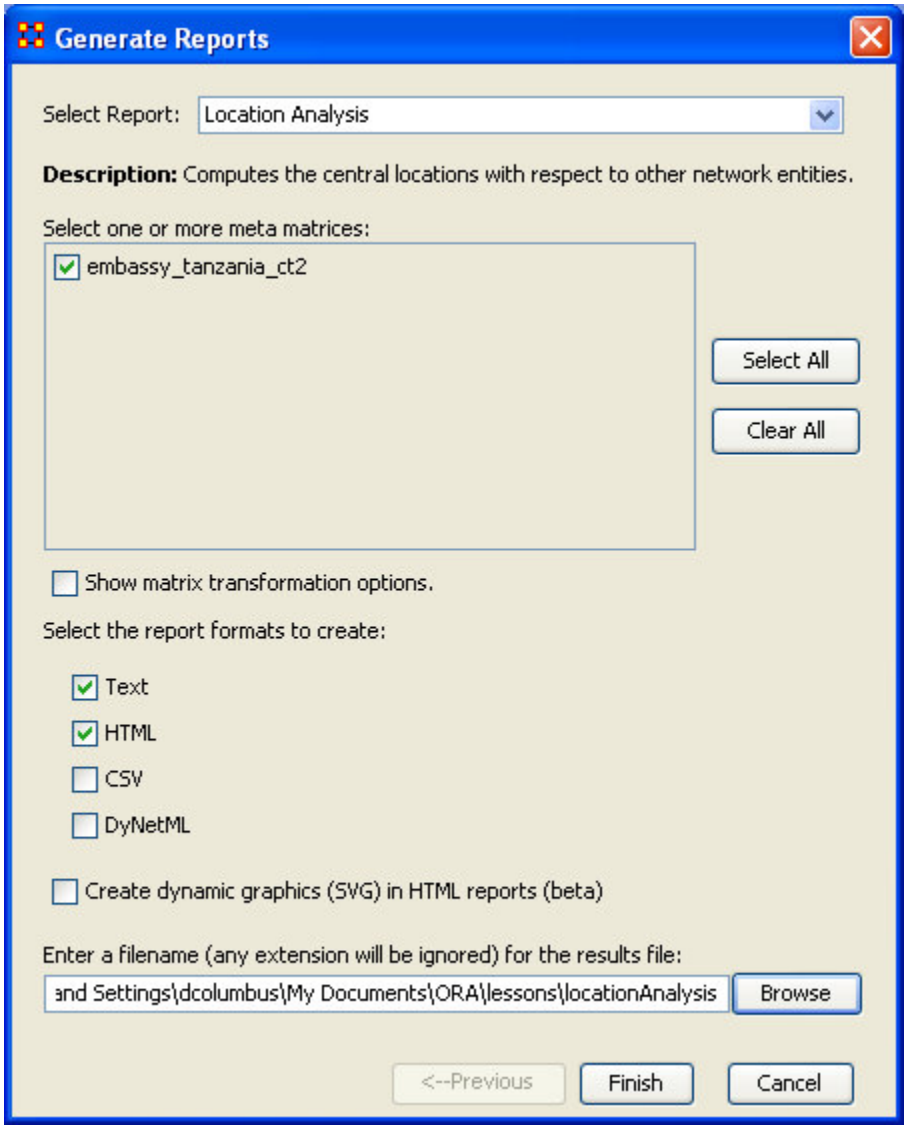
I. Who are the critical actors and where were they seen together?

A Location Report identifies the central locations with respect to other network entities.

To run a Location Report:

- Return to the ORA interface.
- Under Analysis in the menu bar and select Generate Reports.
- A window titled Generate Reports pops up (see below).
- At the top of the window is a pull-down menu titled Select Report. Pull down the menu by selecting the small inverted arrow icon to its right, and select Location Analysis.
- In the box titled Select one or more MetaMatrices: select the box for the Tanzania Embassy bombing MetaMatrix.
- At the bottom of the popup window is a file chooser titled Enter a file name (any extension will be ignored) for the results file: Select the Browse button to the right and navigate to the location you want. Type in a filename (for example, locationReport) and select Open.

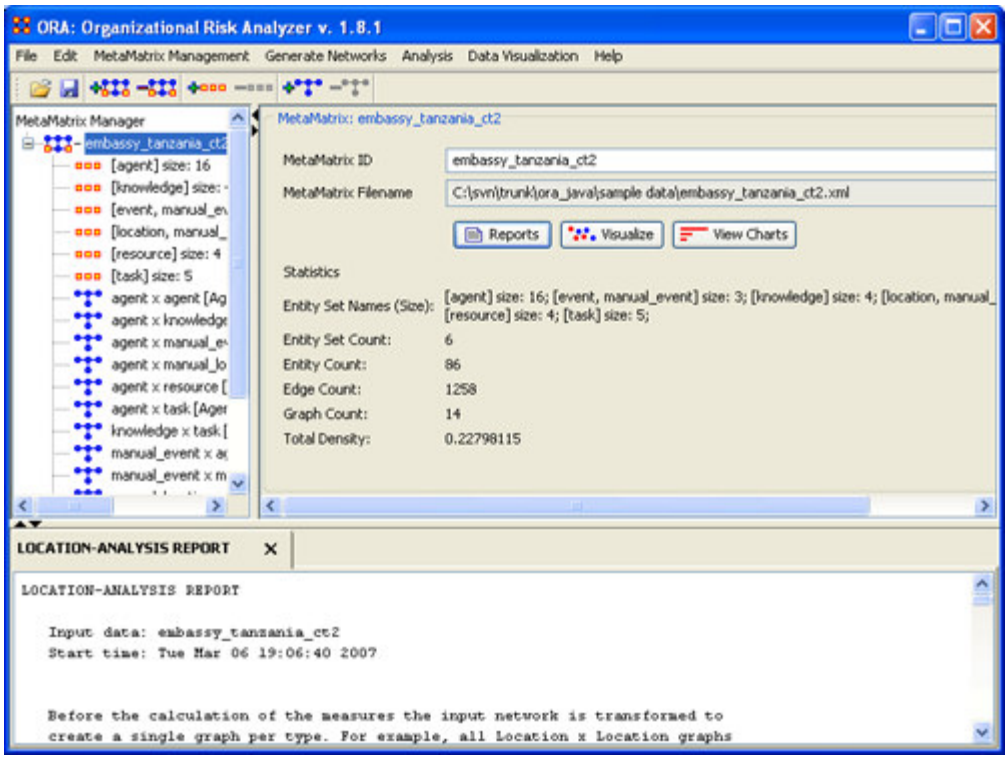
Below is the popup window with the correct options chosen:



- When you've chosen the parameters you want, select the Finish button.

ORA will now create an HTML file which will open your internet browser and display the file. The same text is also displayed in Panel 3 in ORA.

Below is the ORA interface screen with the Intelligence Report displayed in Panel 3:



Below is the HTML file for the Location Analysis Report on the Tanzania Embassy bombing data:

LOCATION-ANALYSIS REPORT

Input data: embassy_tanzania

Start time: Mon Feb 26 09:56:07 2007

Before the calculation of the measures the input network is transformed to create a single graph per type. For example, all Location x Location graphs are unioned. Further, bi-modal graphs, such as Location x Agent, are unioned with their transposes, in this case Agent x Location.

Key locations (the most connections to non-location entities)

The Row Degree Centrality of a node is its normalized out-degree.

Input graph(s): location x agent, location x event

Rank	Value	manual_location
1	1.05263	u_s

2	0.631579	afghanistan
3	0.578947	pakistan
4	0.473684	america
5	0.421053	somalia
6	0.368421	europe
7	0.315789	saudi_arabia
8	0.315789	tanzania
9	0.315789	london
10	0.315789	indonesia

Central locations (the most connections to other locations)

The Total Degree Centrality of a node is the normalized sum of its row and column degrees.

Input graph(s): manual_location_location

Rank	Value	manual_location
1	1.33962	u_s
2	1.03774	afghanistan
3	1.0283	pakistan
4	0.924528	washington
5	0.90566	indonesia
6	0.886792	europe
7	0.877358	airport
8	0.735849	america
9	0.679245	turkey
10	0.641509	sudan

Most active locations for events.

The Row Degree Centrality of a node is its normalized out-degree.

Input graph(s): location x event

Rank	Value	manual_location
1	2	u_s
2	2	afghanistan

3	1.66667	pakistan
4	1.66667	america
5	1	europe
6	0.666667	saudi_arabia
7	0.666667	london
8	0.666667	indonesia
9	0.666667	somalia
10	0.666667	spain

Highest concentration of actors

The Row Degree Centrality of a node is its normalized out-degree.

Input graph(s): location x agent

Rank	Value	manual_location
1	0.875	u_s
2	0.375	tanzania
3	0.375	pakistan
4	0.375	somalia
5	0.375	afghanistan
6	0.375	africa
7	0.25	saudi_arabia
8	0.25	israel
9	0.25	london
10	0.25	indonesia

Actors at the most locations

The column Degree Centrality of a node is its normalized in-degree.

Input graph(s): location x agent

Rank	Value	agent
1	2.40741	bin_laden
2	0.222222	ahmed_ghailani
3	0.185185	ali_mohamed
4	0.111111	wadih_el-hage

5	0.0740741	mohamed_owhali
6	0.0740741	mohammed_odeh
7	0.0740741	jamal_al-fadl
8	0.037037	khalfan_mohamed
9	0.037037	fazul_mohammed
10	0.037037	khalid_al-fawwaz

Produced by ORA developed at CASOS - Carnegie Mellon University

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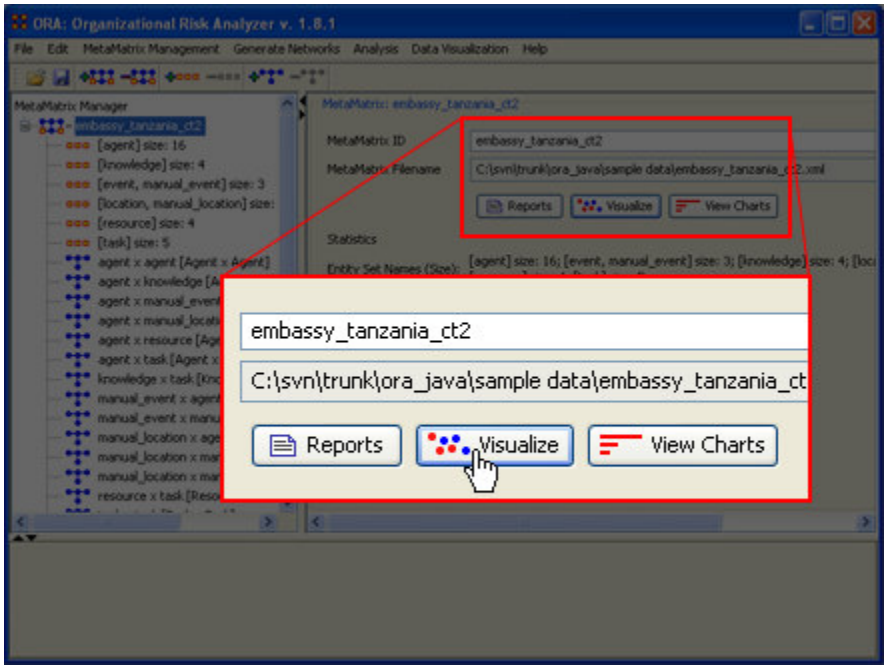
From the report we notice a couple of locations that contain high values in multiple tables: U.S., Afghanistan, Pakistan, and Somalia. In the last table, Actors at the most locations, we see both Bin Laden and Ahmed Ghailani have the highest degrees of Centrality. We will explore how Bin Laden and Ahmed Ghailani relate to each other as well as to the five most prominent locations.

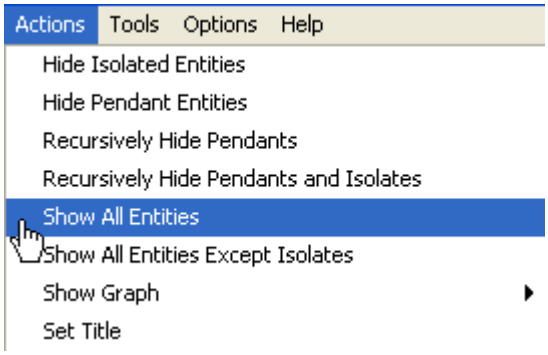
II. What do we know about the actors of interest?

First run the Sphere of Influence tool to find any connection between Bin Laden and Ahmed Ghailani and the location(s) they have both been reported to be seen at.

- First make the Visualizer the active window by selecting the Visualize button underneath the filename path in the middle of the Main Interface window.

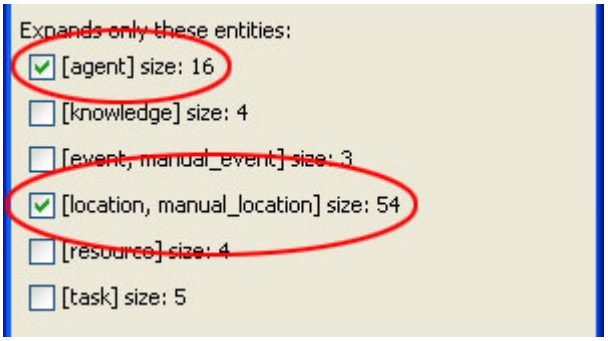


- Under Actions on the menu select Show All Entities.

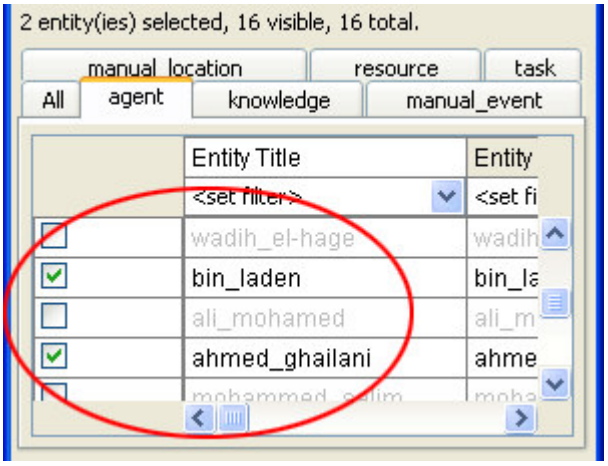


- Under Tools on the menu select Sphere of Influence.

- In the dialog box that appears find the section Expands only these entities:. Make sure that only the [agent] and [location] boxes contain checkmarks.

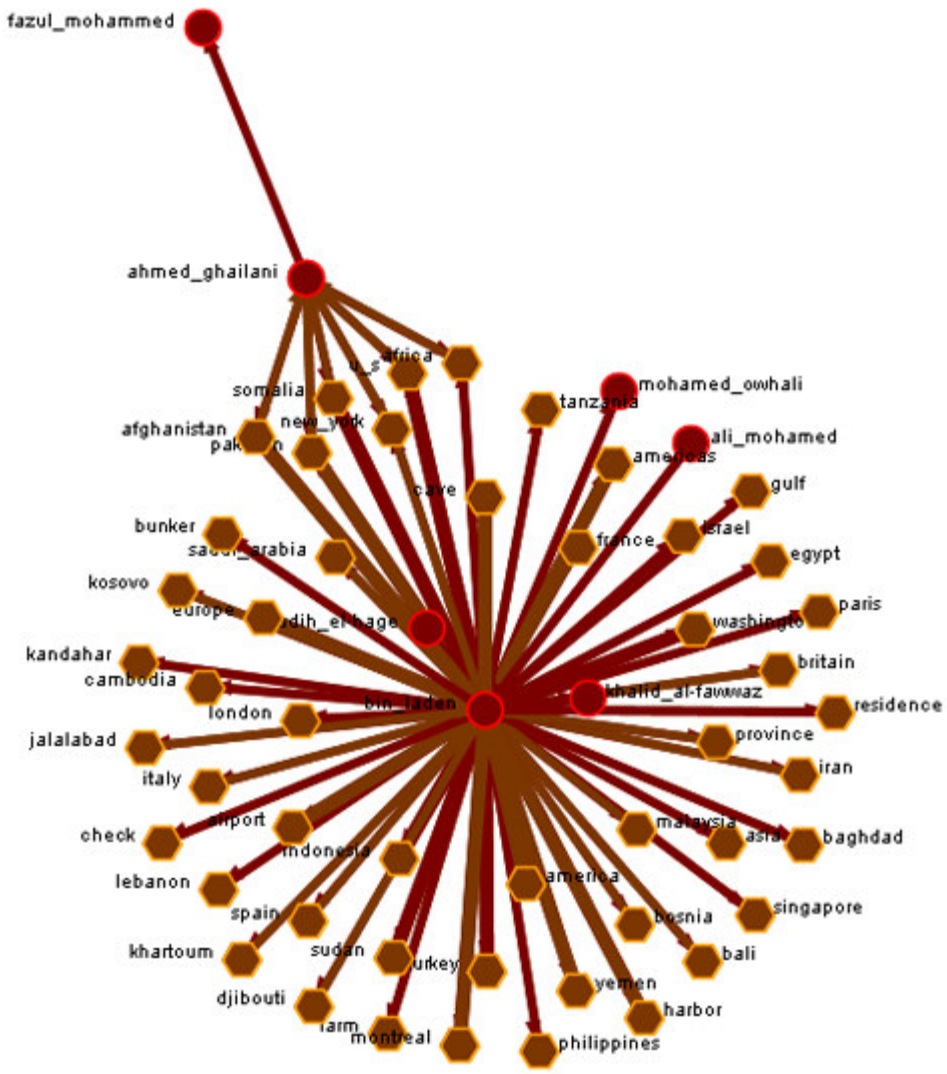


- In the lower part of the dialog box there is a table. Select the tab labeled agent. Then find the rows containing the names of both Bin Laden and Ahmed Ghailani. Place a checkmark in the box in each of these rows. Make sure you have no other agents selected.



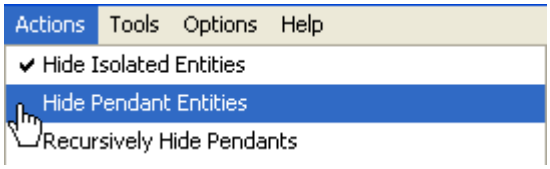
The visualizer will now display all the locations that are connected to both Bin Laden and Ahmed Ghailani. At this time, it will display every location that they have in common.

- Select Close in the Sphere of Influence dialog box.

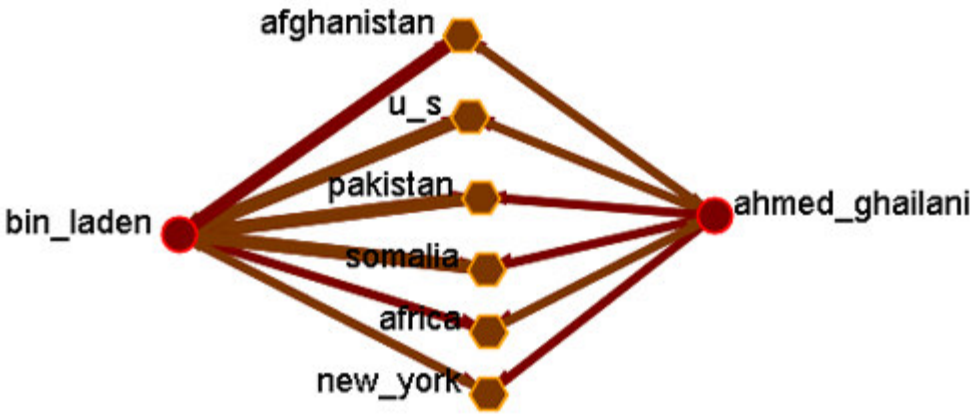


Obviously this is more information than we want to displayed at this time. There's a way to reduce the amount of information displayed.

- Under Actions on the menu, select Hide Pendant Entities. This will effectively reduce the information to only the locations that are common between Bin Laden and Ahmed Ghailani.



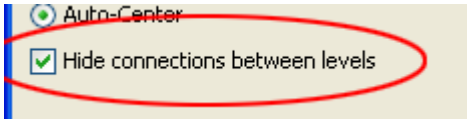
Below is the new display in the Visualizer. This has removed all the locations that were attached to only one or the other agent, Bin Laden or Ahmed Ghailani, and show the locations they have in common.



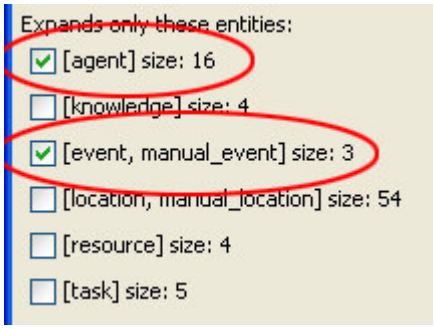
III. What are the important locations?

Now let' take a look at the individual locations in the above display and the events that they have in common.

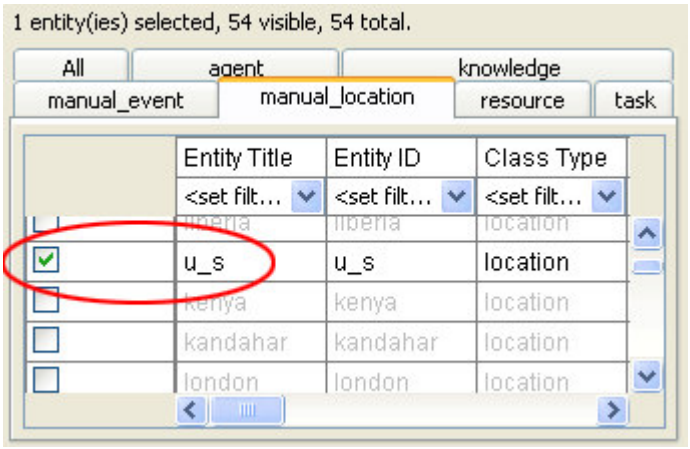
- Under Tools on the menu select the Sphere of Influence.
- First make sure the Hide connections between levels box contains a check in order to make the extra edges invisible.



- Next, under Expands only these entities: select both [agent] and [event].



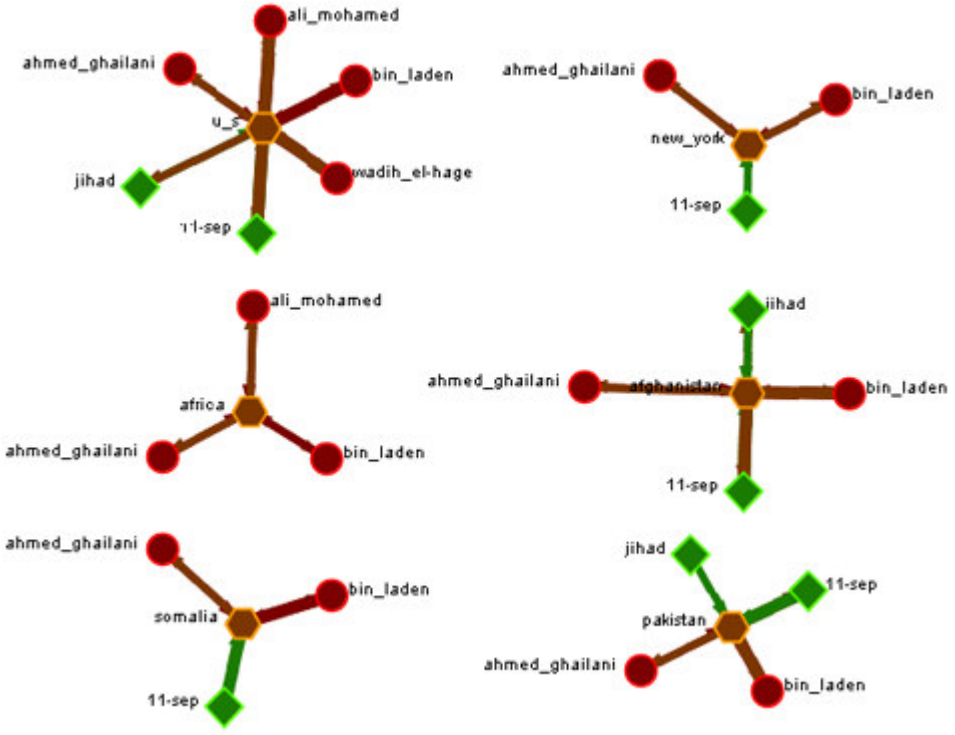
- In the lower table select the tab labeled manual-location.



- Select each of the locations in the display above, individually.

After doing this for each of the six locations you will be able to view how the six locations relate to Bin Laden, Ahmed Ghailani, and the events within the database. The six figures below show the screenshots of the six locations displayed individually and their connections to people and events.

Remember; deselect the current location before selecting the new location.

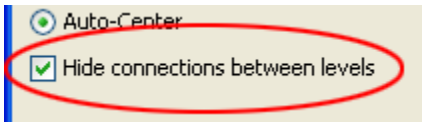


From these six displays we can see the following information:

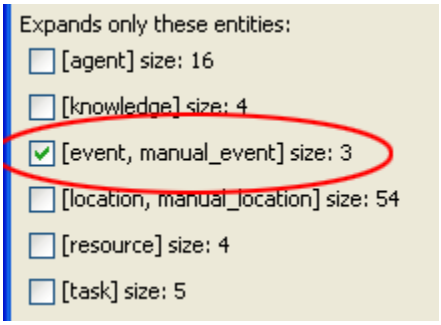
- Five of the locations, U.S., New York, Afghanistan, Somalia, and Pakistan, are all connected to 11-sep.
- Three of the locations, U.S., Afghanistan. And Pakistan, are connected to jihad.
- From the Actions menu, select Show all entities in order to display all information.
- From the Tools menu, select the Sphere of Influence.

This brings up the Sphere of Influence dialog box again.

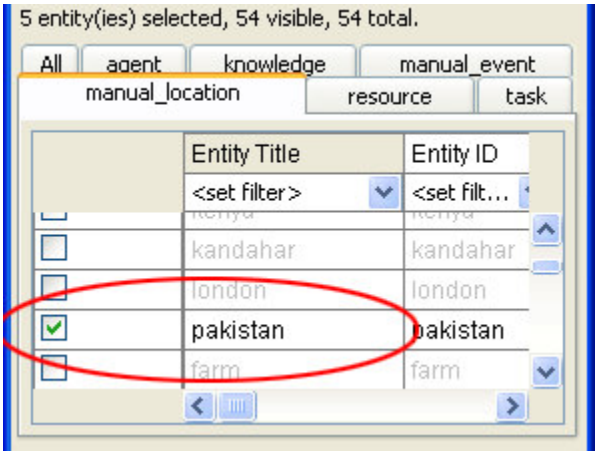
- Make sure to select Hide connections between levels to remove any extra edges.



- Under Expands only these entities: Select [event]

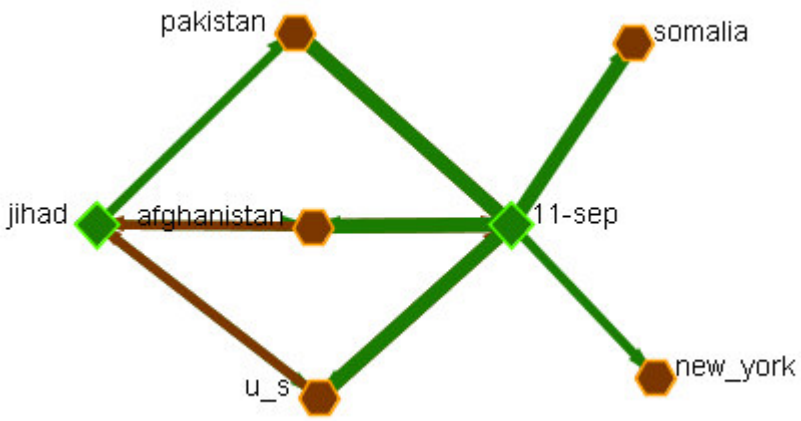


- In the bottom table select the tab labeled manual-location.



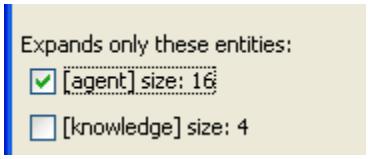
- One at a time place a checkmark next to the five locations obtained from the last Sphere of Influence report: U.S., New York, Afghanistan, Somalia, and Pakistan.

The following will be displayed in the visualizer. This shows how each of the five locations relates to each of the events.

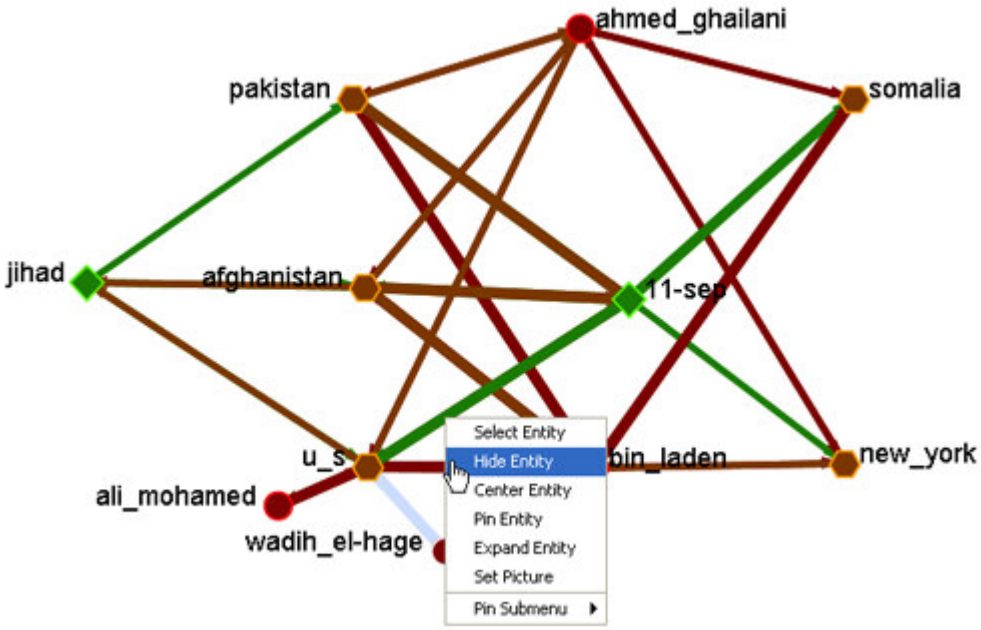


IV. How do the agents, locations and events tie together?

- In the Sphere of Influence dialog box place a checkmark next to [agent].



Find all of the agents other than Bin Laden and Ahmed Ghailani, and right-click on each to bring up the contextual menu. Select Hide Entity to hide them form the current display.



Now you have the two Agents (Bin Laden & Ahmed Ghailani), how they relate to the five Locations (U.S., New York, Afghanistan, Somalia, and Pakistan), and their relationship to the two Events (Jihad & 11 SEP).

Lesson 5

Performing a View Network Over-Time Analysis

The purpose of this lesson is to perform both a View Network Over Time and View Measures Over Time Analysis. To do so requires multiple network datasets representative of your network over different time periods. The goal is to analyze how a network changes across multiple time periods. The time period is determined by the intervals of collected network data and presented as multiple Meta-Matrices, which are loaded into ORA in sequential order. The steps below provide detailed instruction on how type of analysis.

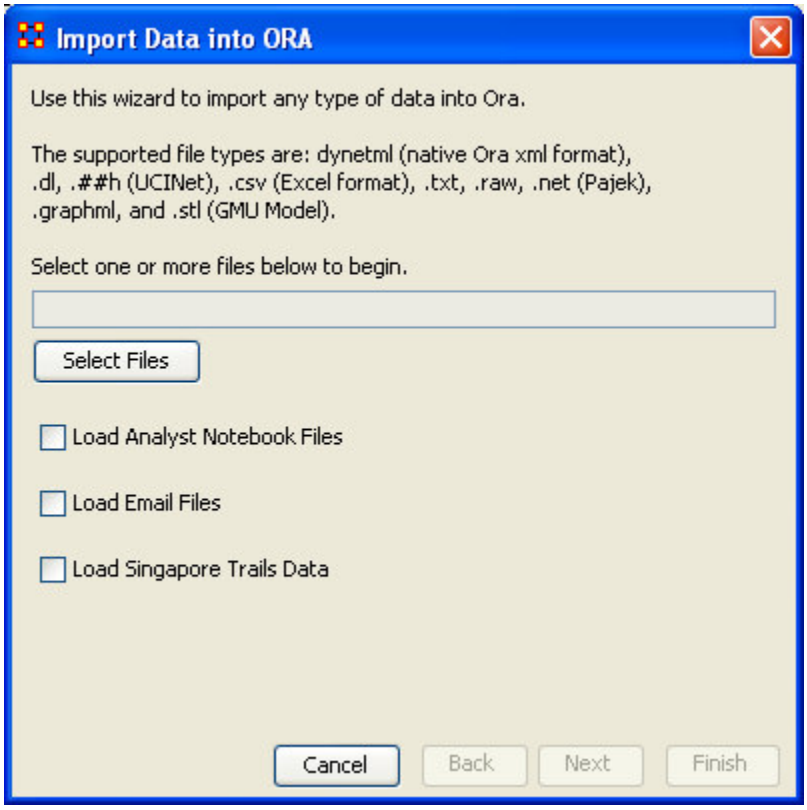
To perform a View Network Over-Time Analysis, you must load Meta-Matrices that relate to different time captures of your network data, which need to be in the form of multiple Meta-Matrices.

In the following example, we will use network time captures of the 1998 Embassy Bombing in Tanzania Meta-Matrix data set and compare the same data set as we knew it in 1997 and 1996 and 1998. We will then compare all the Meta-Matrices in the Network Over-Time Viewer to gain a visual representation of how this network changed between 1996 and 1998.

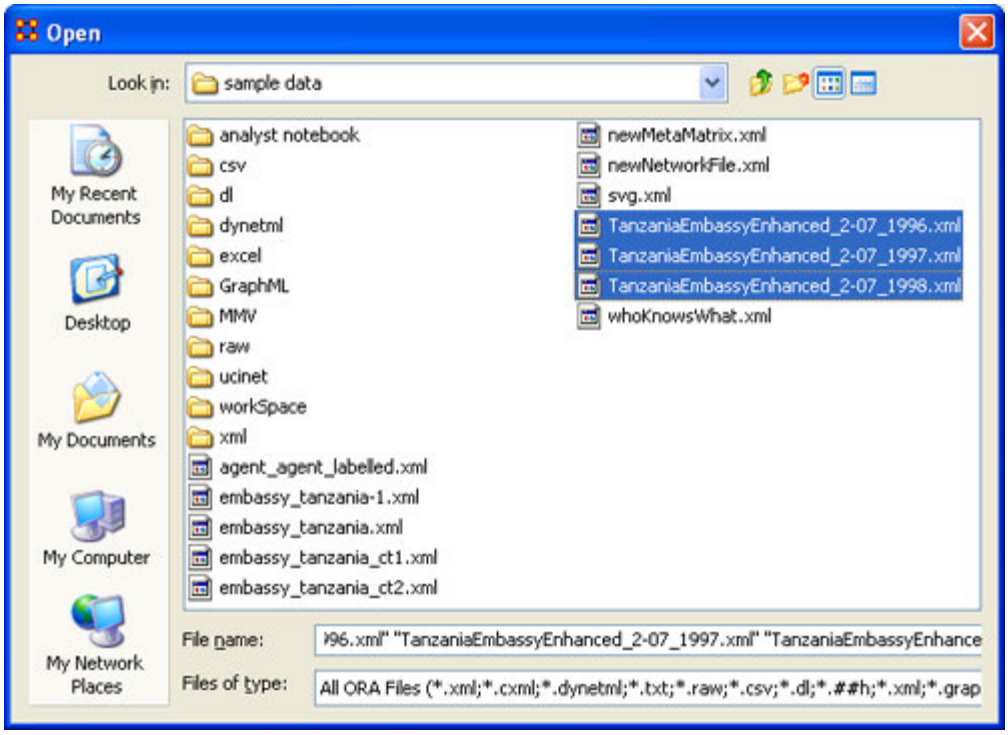
Note: For our purposes, we have changed data in this example and have renamed the Meta-matrix for three different years. This will denote different network variables that have changed over time.

You will see in the left window pane under input dataset three Meta-Matrices, 1998, 1997, and 1996, have been loaded.

From the menu bar: File > Open Meta Matrix

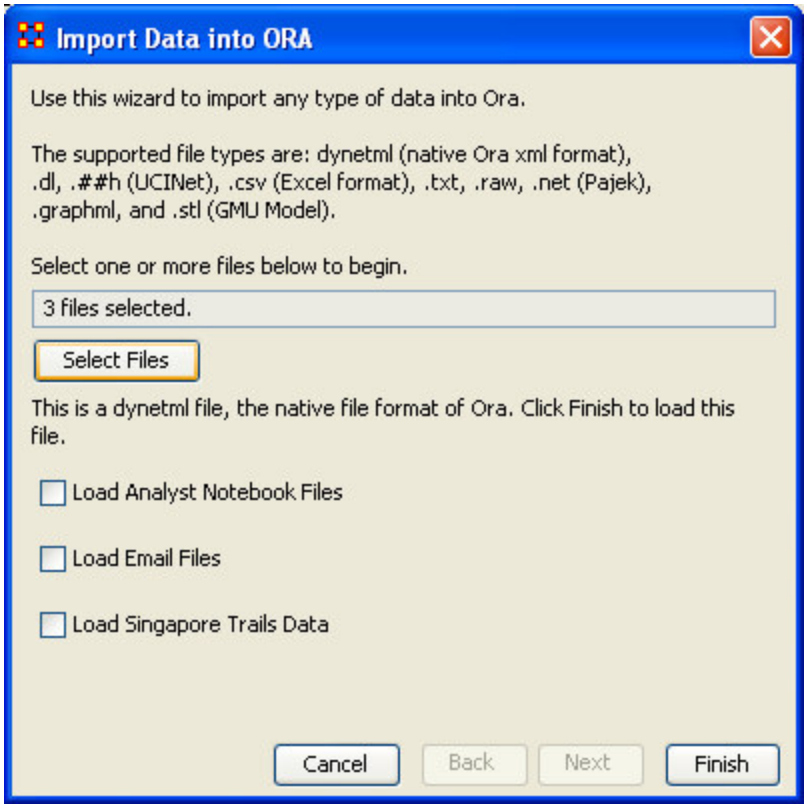


Choose [Select Files]

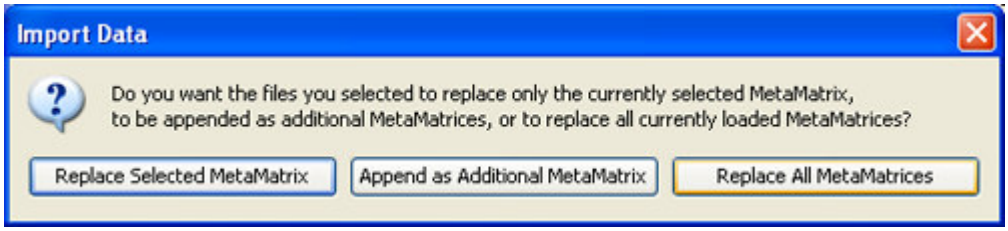


You will see all of our example data sets, which will load simultaneously into ORA, buy highlighting and selected all the files.

Highlight all files you analyze in Over-Time Viewer. Press [Enter].

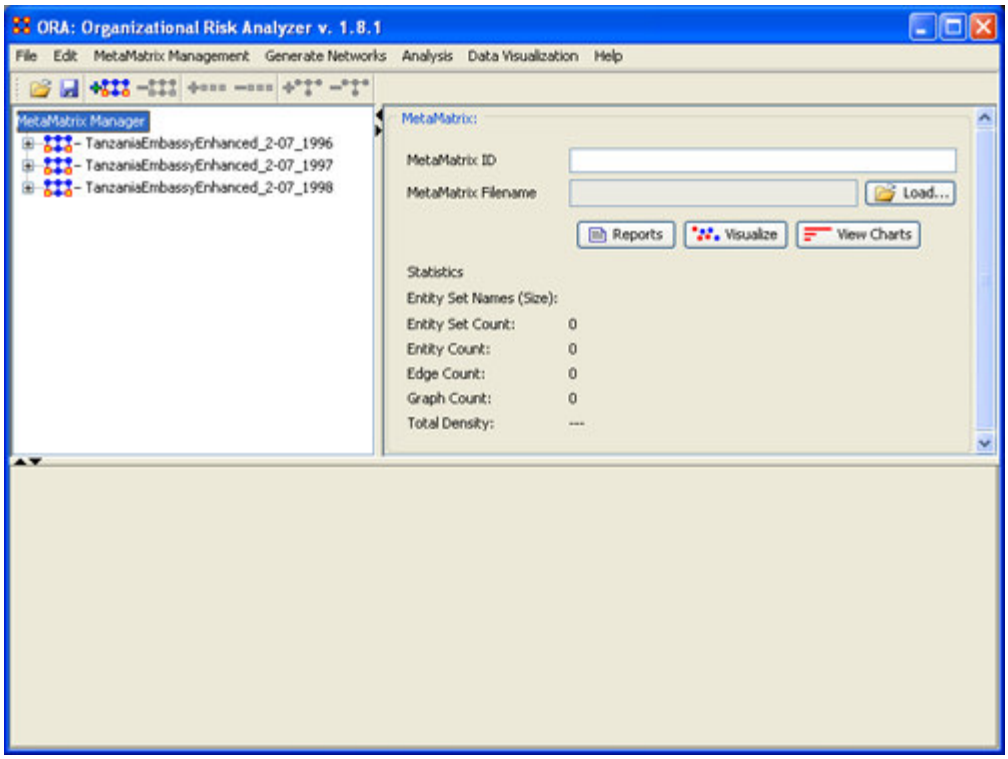


The import data window will appear (below). This will confirm the files you wish to analyze.



Select [Finish].

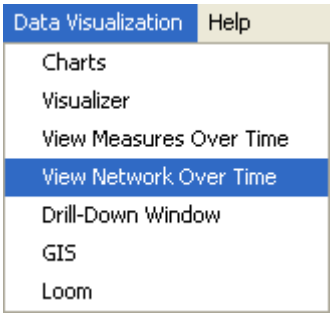
All three Meta-Matrices should display in Panel 1.



Performing the Over-Time Analysis

Now that we have time captures of our network data represented and loaded into ORA in the form of three Meta-Matrices relating to 1996, 1997 and 1998, we can perform the Over-Time Analysis.

From the Menu Bar > Data Visualization > View Network Over-Time



The ORA Visualizer will render all of the loaded Meta-Matrices.

Please take special note of the Time Viewer pop-up Window. This window displays a slider, which will allow you to quickly change from the first Meta-Matrix time capture of 1996, to 1997 and 1998 respectively.

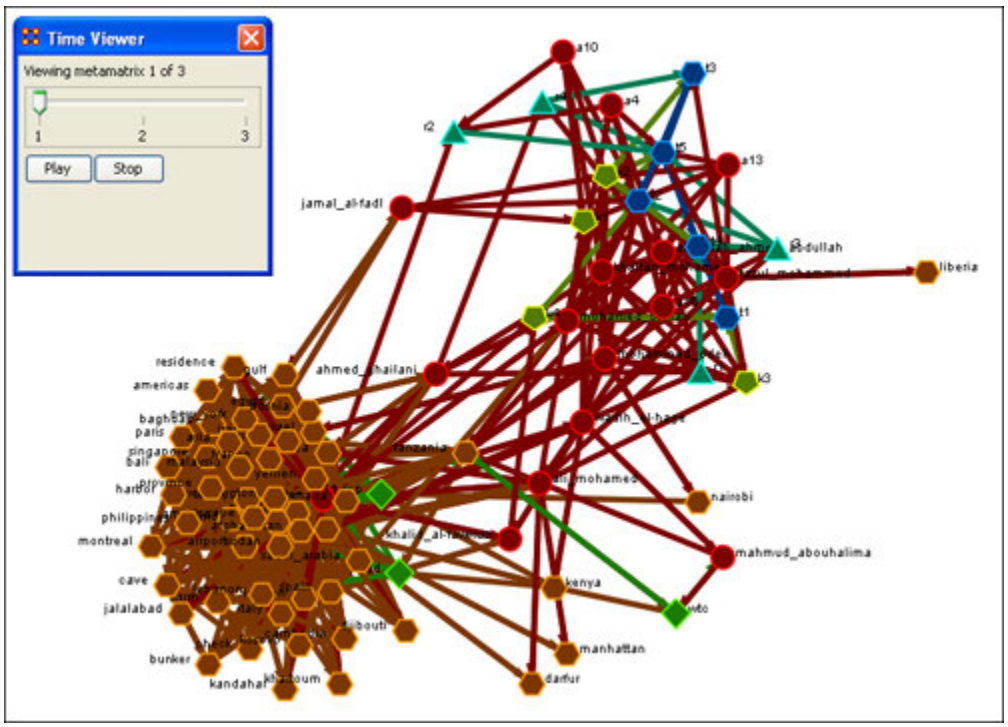
By moving the slider from one Meta-Matrix to the next, you will gain a visual perspective on how the network has changed over Time.

The series of screen shots below display how the visualized data changes from one slider to position to the next. These renders then allow you a picture of how the network changes Over-Time.

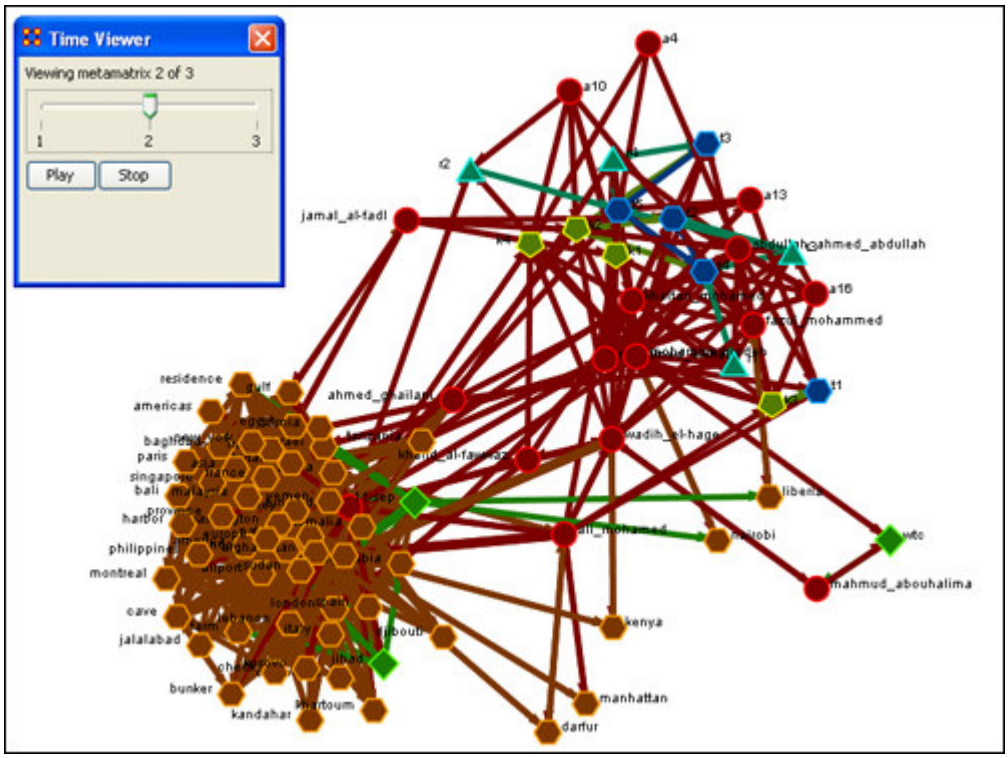
Please note: Depending on the complexity of the network and the extent to which relationships (ties) have changed, the visualization of those changes may be subtle.

The screen shots below, however, will emphasize the extent to which the role of the WTC Event entity has changed from 1996 to 1998 in relation to the network of which it is part of namely the Tanzania data set. Below these screen captures, are a series of detail screen captures focusing on the WTC Event node.

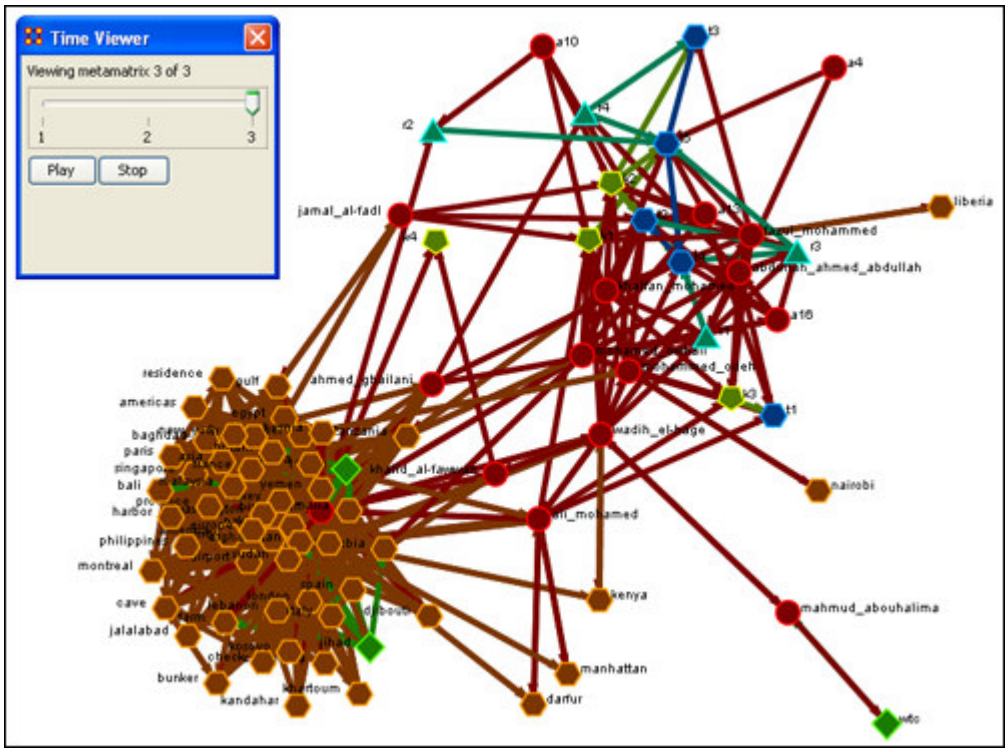
Example Slider Position 1



Example Slider Position 2

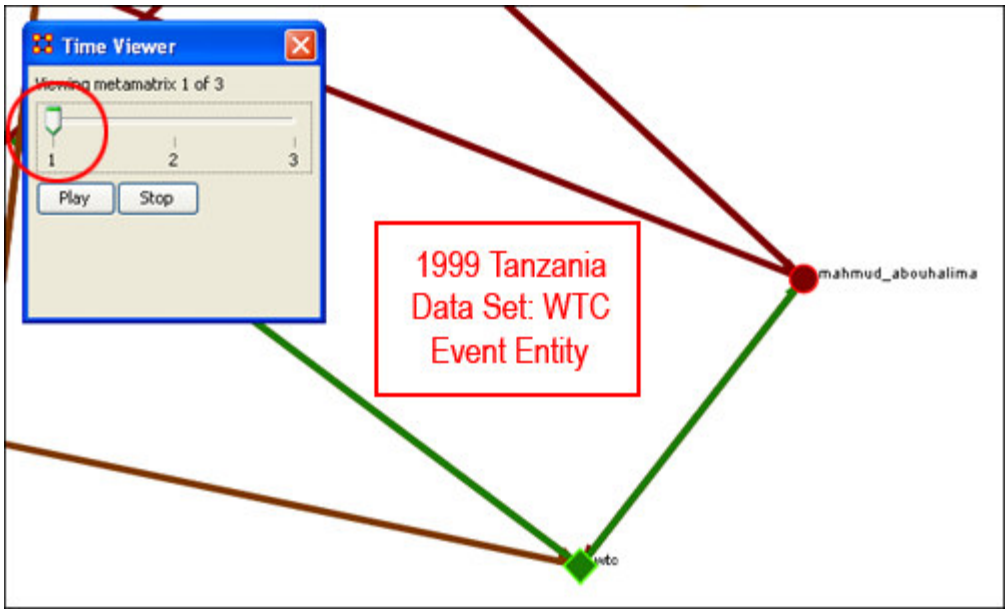


Example Slider Position 3



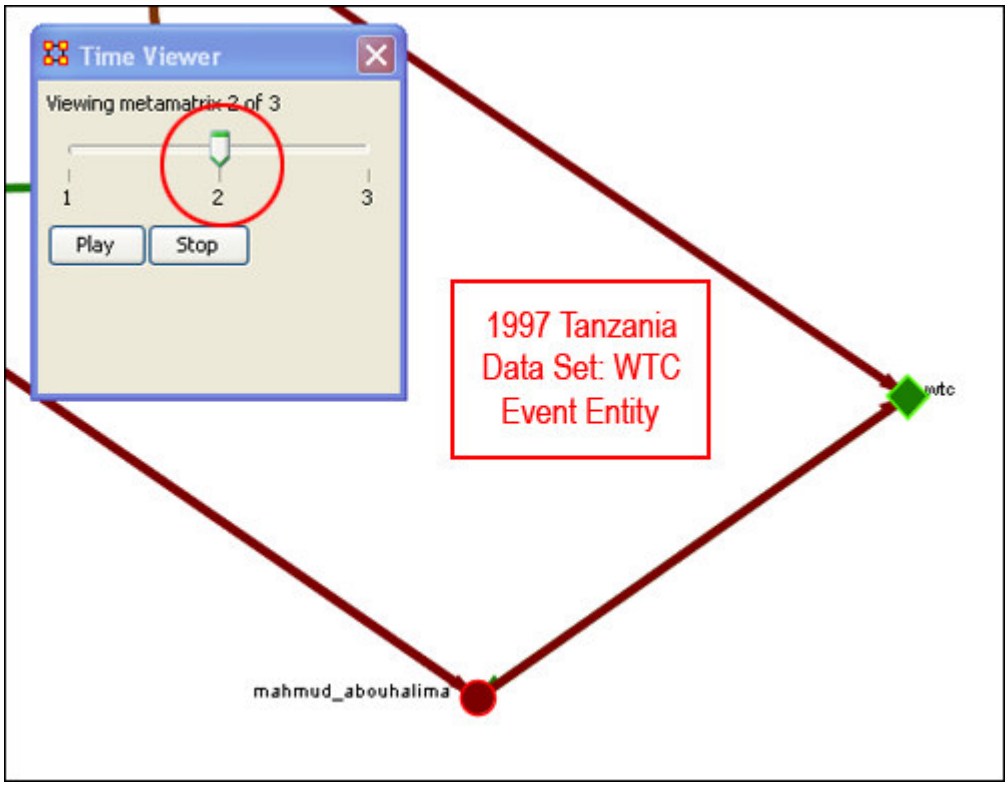
Detail of WTC Event Node when visualized in the Over-Time Viewer as part of the 1996, 1997 and 1998 Tanzania Data Sets.

WTC Event Node: Detail 1 - 1996

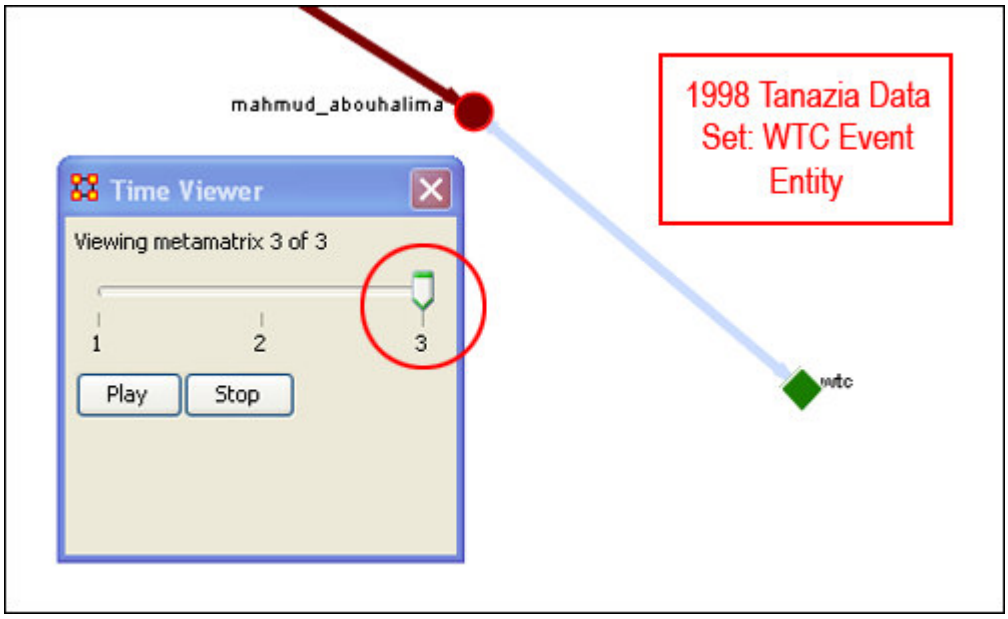


WTC Event Node: Detail 2 - 1997

Notice who how the relationships of this node to the rest of the network has changed from 1996 to 1997.



Notice that the connections (links) have changed from 1996 to 1997.



As you can see, as we progress through the data sets pertaining to 1996, 1997 and 1998, the event node WTC lost direct ties to other parts of the network. In the 1996 data set, WTC had 3 ties to other entities in the Tanzania Embassy network; In 1997, only 2; Finally, in 1998, the WTC event node had only 1 link to Tanzania Network. This may indicate that the WTC node may have lost importance from one year to the next.

Summary of Lesson

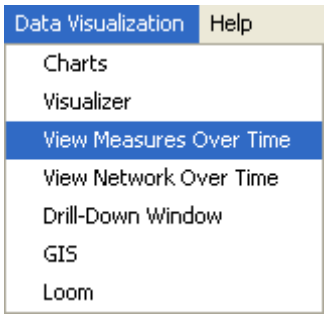
At this point, you should be able to complete the following tasks to perform an Over-Time Network Analysis.

- Load multiple Time Data Captures in the form of Meta-Matrices, which are representative of your network (Meta-Matrix) over time.
- Use the Over-Time slider window tool to move from one time capture to the next.
- Gain a visual perspective of how your overall network has changed from one time capture to the next.

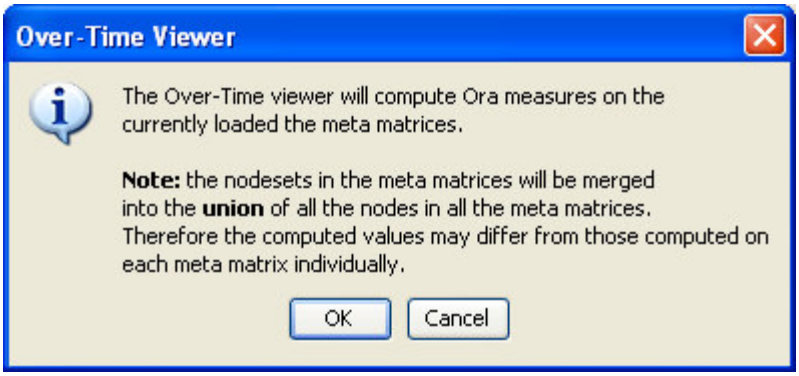
Performing the View Measures Over-Time Analysis

ORA provides an alternative method to analyzing your network data (in the form of MetaMatrices captured over time) than the only in the Visualizer. By running a View Measures Over Time analysis you can visualize how your network changes in relation to any given measure in the form of charts, which take you from one time point to the next. Below is a series of screen captures and instruction on how to access the View Measures Over Time feature:

From the main menu bar: Data Visualization > View Measures Over Time



Select View Measures Over Time.



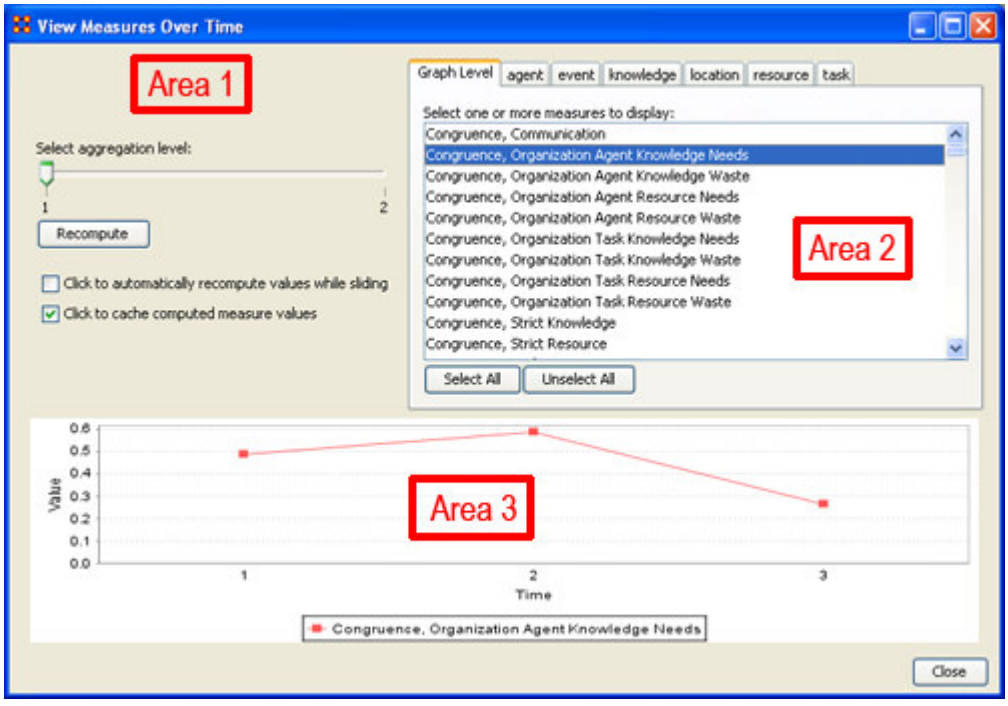
Select [OK]

The View Measure Over Time Window will appear. You will see that this window is primarily organized into three sections.

Area 1: is a slider where you can control various inputs that affect the aggregation level of your Meta Matrices.

Area 2: is a tabbed index allowing you to select the graph level you desire and the individual entity sets you are interested in analyzing.

Area 3: displays the actual chart based on the measures you selected in the tabbed index and the position of the aggregation slider.

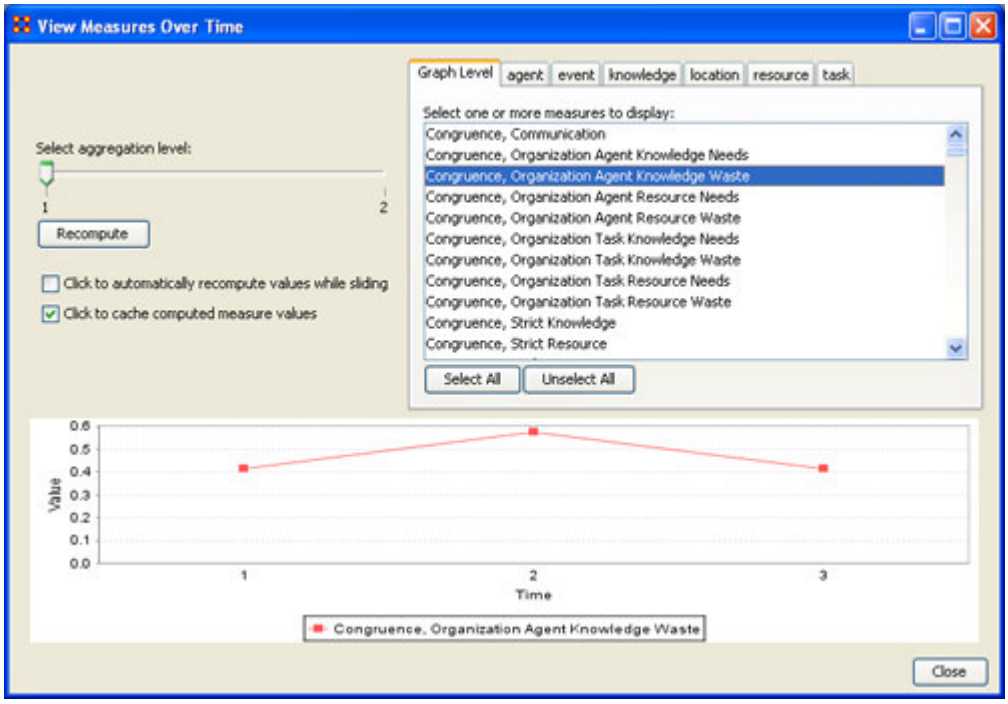


Interpreting The Results After Performing View Measures Over-Time Analysis

In the example above, we have loaded all three of our network time captures into the View Measures Over Time Analysis tool. The result of our analysis, as we have indicated before, will be displayed as a chart in the bottom section of the ORA interface in Panel 3. But, what does this tell us? To find out, we will examine the Graph Level measure Knowledge Waste. From the tabbed measures window:

Graph tab > Congruence, Organization Measure, Knowledge Waste.

The result is displayed below.



We can see the chart displays an axis scale correlating to our networks over time. The graph level measure of Knowledge Waste was selected using the View Measures Over Time tool and the result is displayed in the chart area of the window.

We can see that the graph level measure of Knowledge Waste held a value slightly above 40 in the first Meta Matrix, 1996, displayed with 1 on the Time axis. We can deduce from the chart that in 1997 something affected our measure of Knowledge Waste to increase the value to nearly 60. This corresponds to the time scale axis of 2, which represents 1997, our second year of network data. In the final year, 1998, our measure of Knowledge Waste declined to the value in 1996. This should be visually evident with its relative line graph position.

It is clear that the value for the Knowledge Waste Measure increased from the first Meta Matrix (1996) to the second (1997) and then retreated back to its original (1996) level. It would be up to you to determine what may have affected that measure for it to undergo this progression and regression.

Summary of Lesson

At this point, you should be able to complete the following tasks to perform a View Measures Over-Time Analysis:

- Load multiple data files into ORA (in the form of Meta-Matrices) representative of your network across certain periods of time.
- Select an aggregation level and choose a graph level or entity entity set to analyze.
- Analyze the data output in the charting tool located in the bottom section of the View Measures Over Time window.
- See how your network may have changed from one time capture to the next for any given graph level or entity node measure.
- Use this visual comprehension to draw conclusions about how your network changed across multiple time periods.

Lesson 6

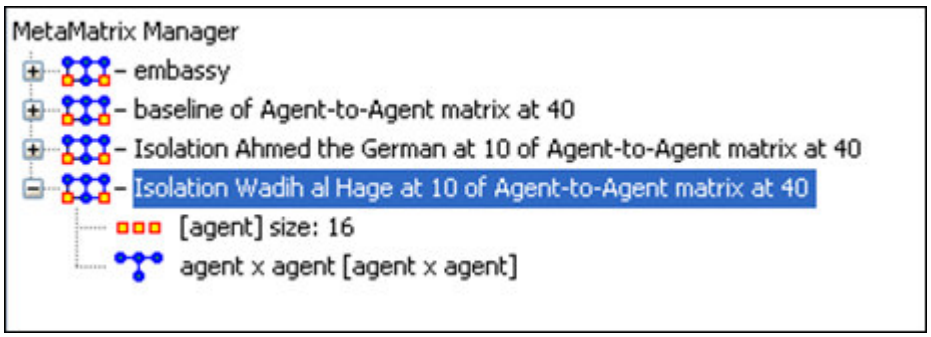
Immediate Impact

The Immediate Impact report in ORA allows you to analyze what happens to a network after isolating or removing a key actor. The actor can be any entity: knowledge, task, location or agent. The idea behind the report is to give you a statistical breakdown of key changes that are affected by removing or isolating any particular agents.

To access the Immediate Impact report:

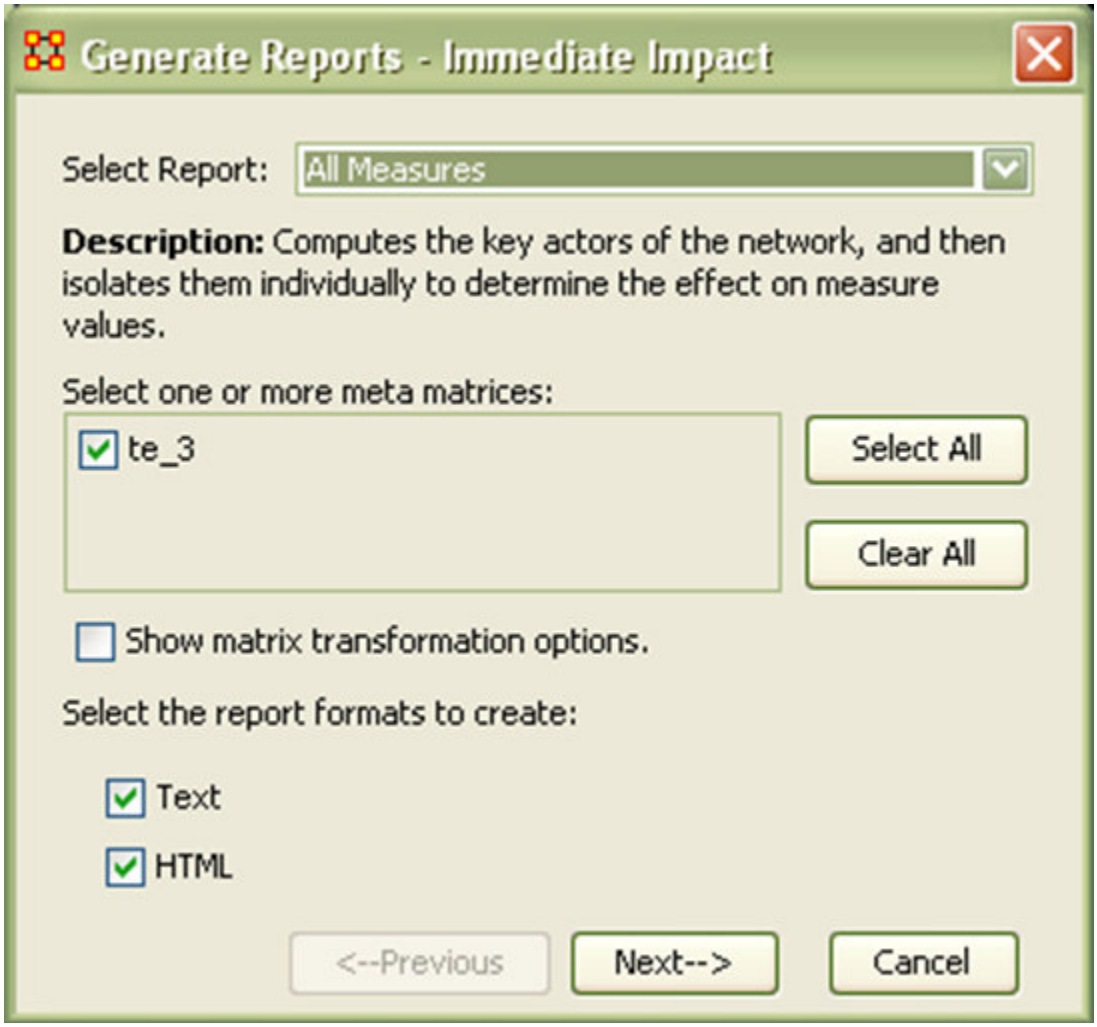
From the menu bar: Analysis > Generate Reports > Immediate Impact

The highlight bar in the following series of screen shots show how to access this report from the ORA main interface.

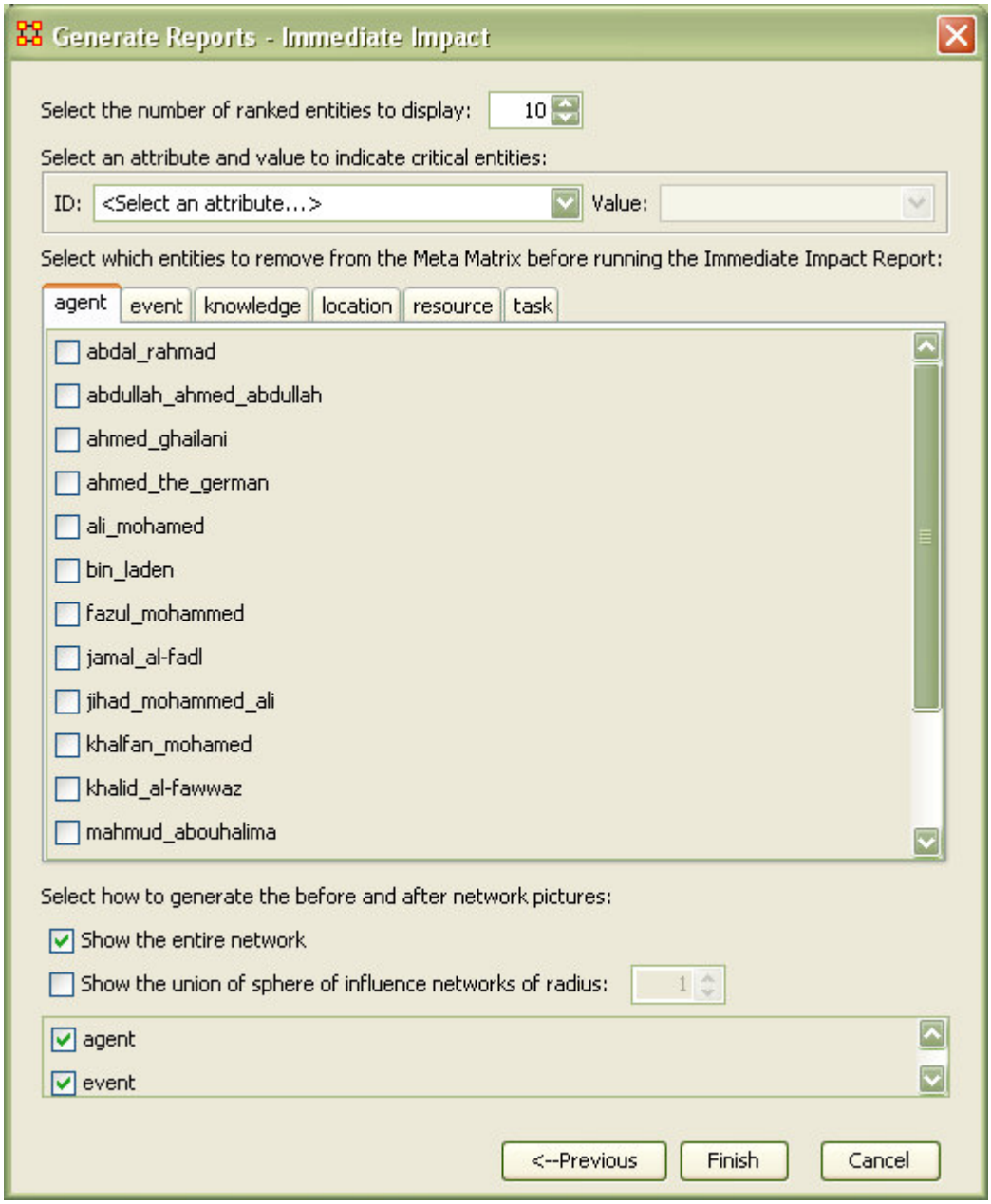


At this point the Generate Reports window will appear. You can find the Immediate Impact report under the drop down arrow menu. It will also list the other reports available in ORA. Note that on the Generate Reports window you can choose text or html output or both. You can also select one or more of the MetaMatrices currently loaded into ORA.

For our example we are using the Tanzania Embassy bombing data set. The version we are using is te_3. Once you have selected or changed all variables, select Next.

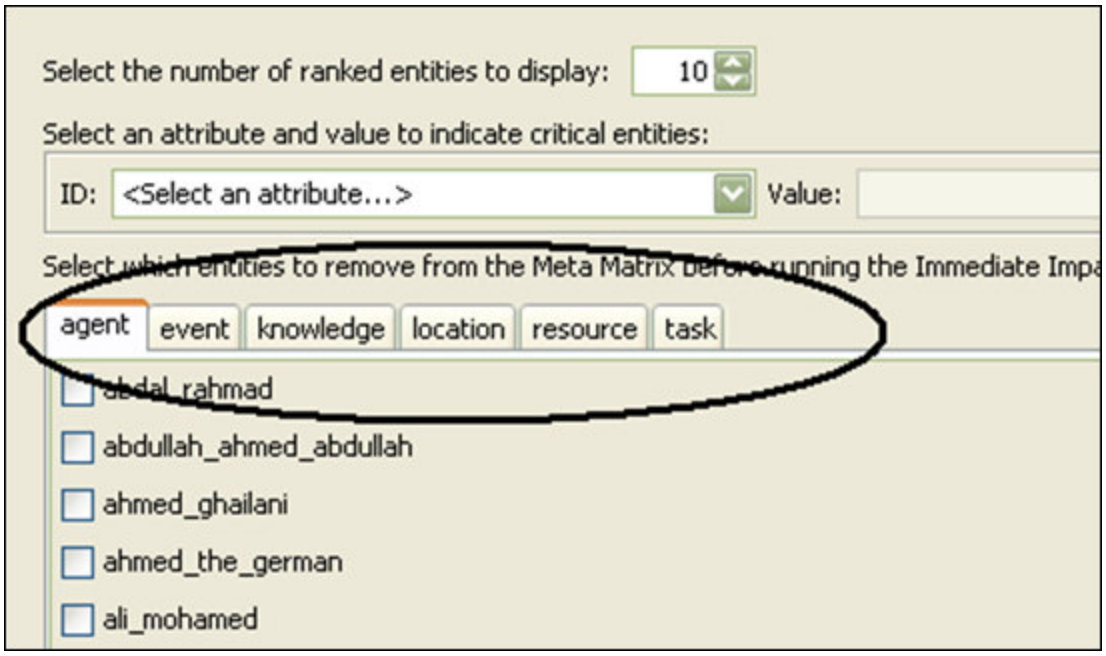


The Generate Reports Immediate Impact window will appear.

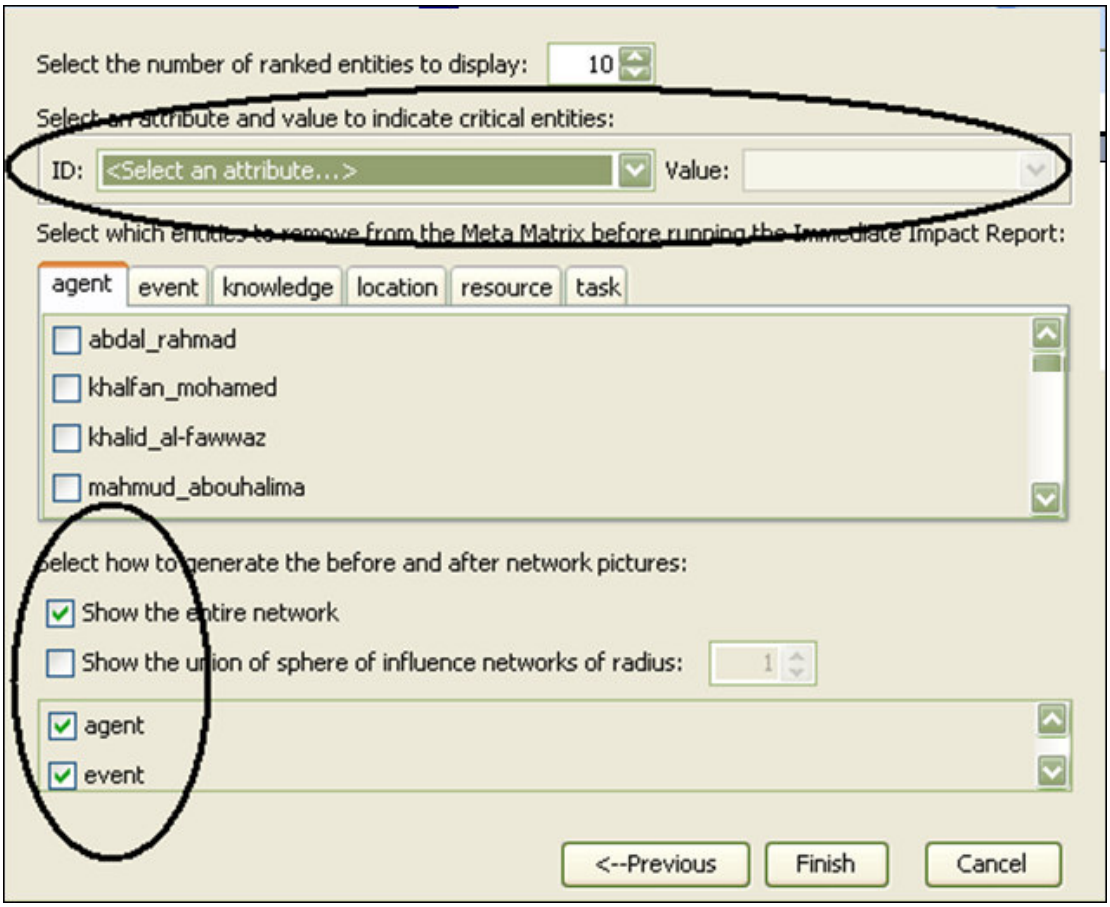


The Generate Reports Window provides you with options relating to the specific type of analysis you wish to produce and what variables you would like to change. Pay particular attention to the tabbed window pan, where you can access individual agents, events, knowledge, location, resources, and task entities for removal.

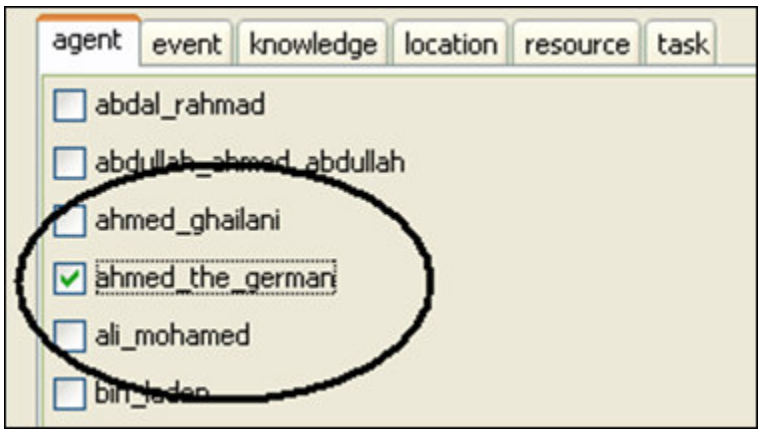
The screen shot below shows where the tabbed options are located. Here you can specify exactly which entity you would like to isolate (remove). The tabs separate your entities by entity class, such as knowledge.



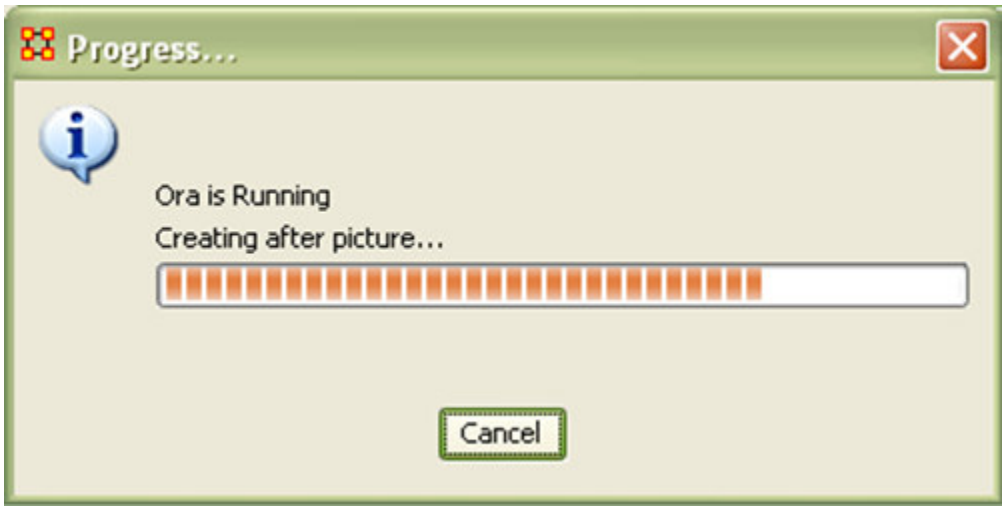
The Generate Reports – Immediate Impact window does allow additional filtering of your entities according to any entities particular attributes. The screen shot below shows the attribute and value filters.



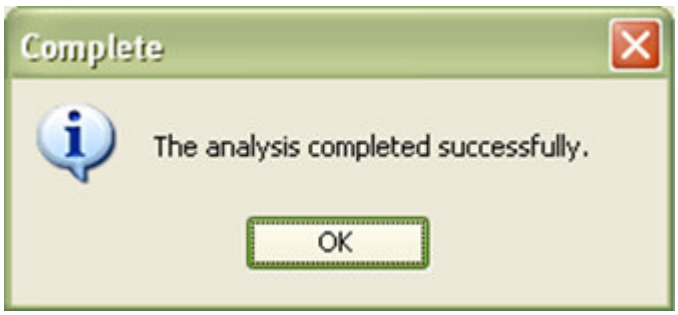
In our example we are going to select ahmed_the_german. This will be the entity we chose to isolate. Select ahmed_the_german by checking the appropriate box. We will leave all the other boxes checked to their default settings.



After you have finished selected your entity to be isolated, in our case, ahmed_the_german, select the finish button. The Progress window should appear as ORA completes the report.

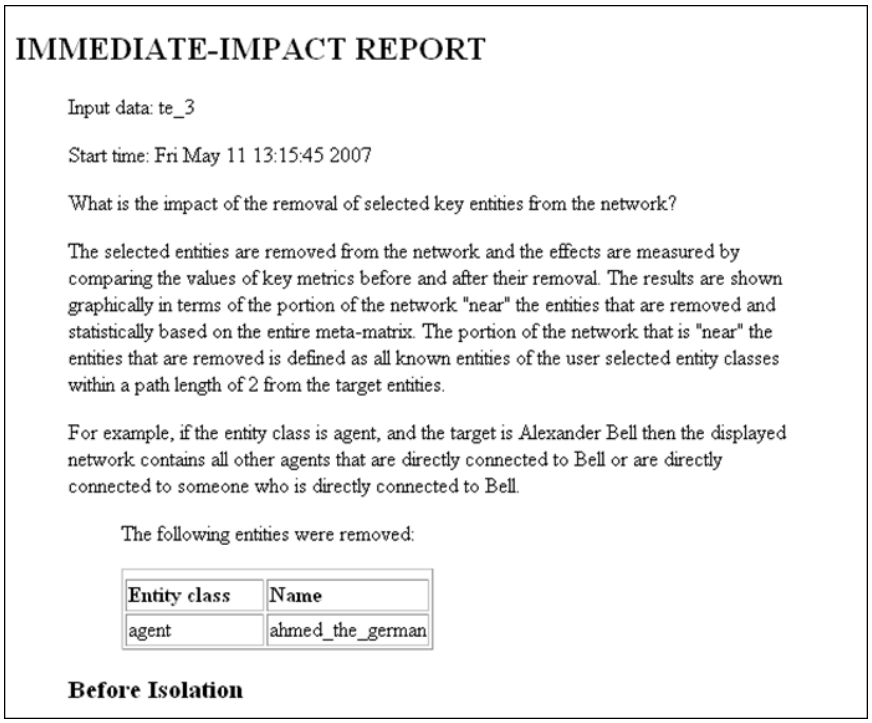


You should see a complete box when the analysis has been completed successfully by ORA.



You may recall we selected both the HTML and Text output options previous. The HTML report will be displayed in a web browser. The text report will be displayed in the bottom window of the main ORA Interface.

Below is the completed immediate impacted analysis as displayed in HTML. Here are results are displayed in a Mozilla Firefox web browser.



IMMEDIATE-IMPACT REPORT

Input data: te_3

Start time: Fri May 11 13:15:45 2007

What is the impact of the removal of selected key entities from the network?

The selected entities are removed from the network and the effects are measured by comparing the values of key metrics before and after their removal. The results are shown graphically in terms of the portion of the network "near" the entities that are removed and statistically based on the entire meta-matrix. The portion of the network that is "near" the entities that are removed is defined as all known entities of the user selected entity classes within a path length of 2 from the target entities.

For example, if the entity class is agent, and the target is Alexander Bell then the displayed network contains all other agents that are directly connected to Bell or are directly connected to someone who is directly connected to Bell.

The following entities were removed:

Entity class	Name
agent	ahmed_the_german

Before Isolation

Below is the full report as produced in the HTML out put option.

IMMEDIATE-IMPACT REPORT

Input data: te_3

Start time: Fri May 11 13:15:45 2007

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The following entities were removed:

Entity class	Name
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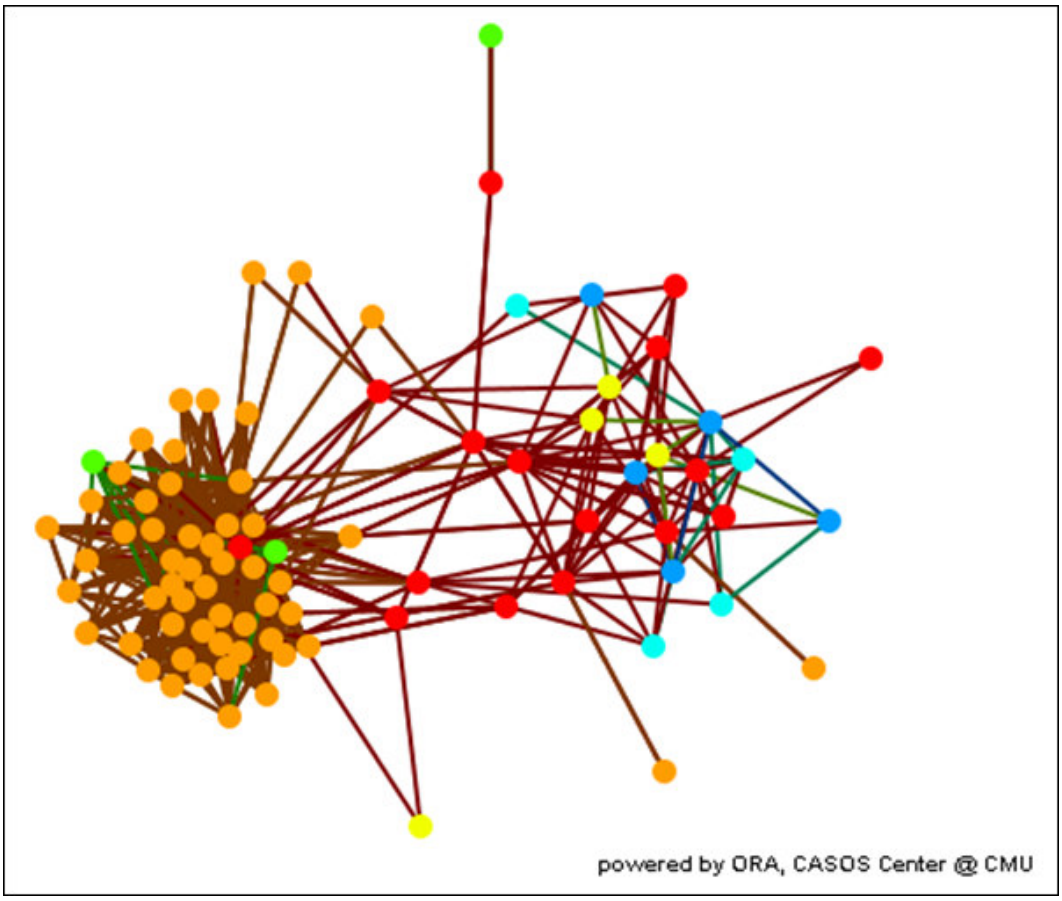
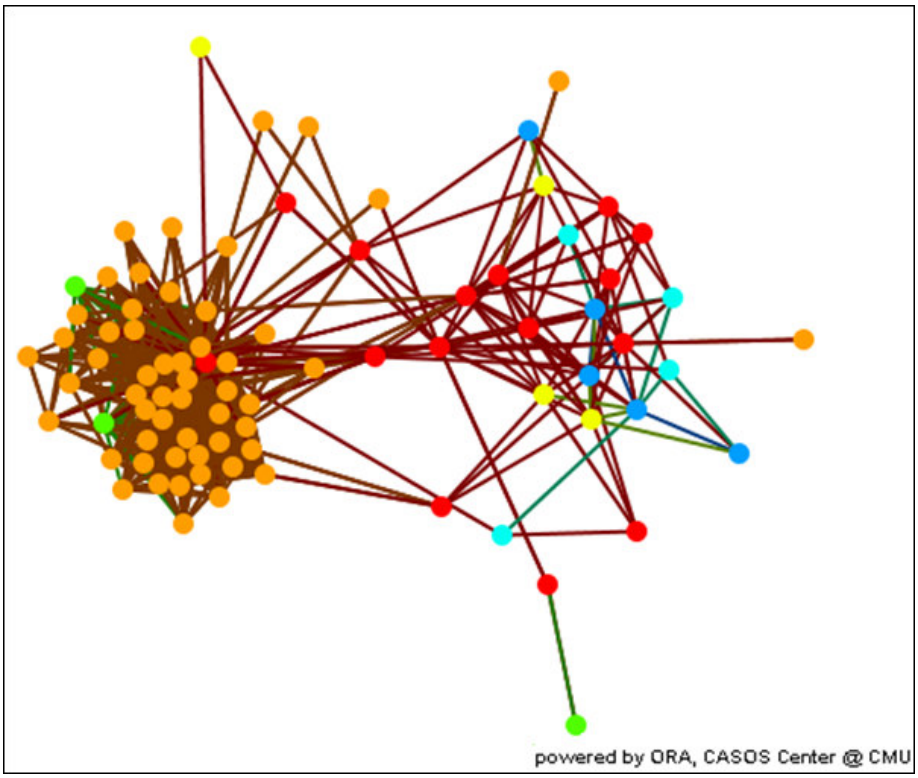
Before Isolation



After Isolation



	Before	After	Percent Change
Number of nodes	86	85	-1.16%
Density	0.227981	0.234285	+2.76%
Diffusion	0.558594	0.586667	+5.03%
Performance As Accuracy	0.16	0.16	0.00%

Emergent Leader (cognitive demand)

Measures the total amount of cognitive effort expended by each agent to do its tasks.

Name	Rank Before	Value Before	Rank After	Value After	Value Change(%)
fazul_mohammed	1	0.378917	1	0.379524	+0.16%
khalfan_mohamed	2	0.353604	2	0.354857	+0.35%
mohamed_owhali	3	0.305313	3	0.307667	+0.77%
jihad_mohammed_ali	4	0.280313	4	0.281	+0.25%

mohammed_odeh	5	0.276083	5	0.278238	+0.78%
abdullah_ahmed_abdullah	6	0.243792	6	0.245762	+0.81%
mohammed_salim	7	0.192542	7	0.193429	+0.46%
ahmed_the_german	8	0.183771		Entity removed	
wadih_el-hage	9	0.180042	8	0.183429	+1.88%
ahmed_ghailani	10	0.177292	10	0.178143	+0.48%

Centrality (the nodes with the most links to other nodes)

The Total Degree Centrality of a node is the normalized sum of its row and column degrees.

Input graph(s): agent x agent

>tr>

Name	Rank Before	Value Before	Rank After	Value After	Value Change(%)
wadih_el-hage	1	0.433333	1	0.464286	+7.14%
mohamed_owhali	2	0.366667	2	0.392857	+7.14%
bin_laden	3	0.266667	3	0.285714	+7.14%
abdullah_ahmed_abdullah	4	0.2	4	0.178571	-10.71%
mohammed_odeh	5	0.166667	5	0.178571	+7.14%
abdal_rahmad	6	0.133333	6	0.142857	+7.14%
ali_mohamed	7	0.133333	7	0.142857	+7.14%
khalid_al-fawwaz	8	0.133333	8	0.142857	+7.14%
fazul_mohammed	9	0.1	9	0.107143	+7.14%
jihad_mohammed_ali	10	0.0666667	10	0.0714286	+7.14%

Potentially Influential (betweenness centrality)

The Betweenness Centrality of node v in a network is defined as: across all entity pairs that have a shortest path containing v, the percentage that pass through v.

Input graph(s): agent x agent

Name	Rank Before	Value Before	Rank After	Value After	Value Change(%)
wadih_el-hage	1	0.292857	1	0.319597	+9.13%
mohamed_owhali	2	0.271429	2	0.28663	+5.60%
bin_laden	3	0.104762	3	0.117216	+11.89%
mohammed_odeh	4	0.0690476	4	0.0677656	-1.86%
abdullah_ahmed_abdullah	5	0.0571429	6	0.010989	-80.77%
fazul_mohammed	6	0.047619	5	0.0549451	+15.38%
abdal_rahmad	7	0	7	0	NA

Produced by ORA developed at CASOS - Carnegie Mellon University

Below is the completed Immediate Impacted analysis as rendered with the TEXT output option.

Summary

At this point you should be able to do the following in ORA:

- Understand the purpose of the Immediate Impact Report analysis;
- Locate the Immediate Impact Report in ORA;
- Perform a Immediate Impact Analysis
- Filter your network data and use the Generate Reports – Immediate Impact window.
- Choose variable relating to the output of your analysis in either HTML or TEXT format.

Lesson 7

Near Term Impact analysis

In this step, we use a Tanzania bombing dataset to see how Near Term Analysis (NTA) in ORA is working. NTA is an analysis function utilizing a multi-agent model, Dynet. Particularly, NTA assumes a set of node removals from a given organizational structure and estimates the performance changes and the emergent structures. Thus, the what-if analysis with NTA will provide an answer on how the organization will behave and change with a sequence of strategic interventions or unexpected personnel loss. This demonstration hypothesizes two agent removals: Wadih-Al Hage and Ahmed the German, from the bombing dataset.

1) Loading an organizational structure and starting the Near Term Analysis function.

The target data should be loaded in the dataset management panel in ORA main window, as in Figure 1. Also, the data must be highlighted before starting NTA.

Figure 1 – a loaded dataset in the ORA main window

Under the Analysis menu in the ORA main window (Figure 2), you can find Near-Term Analysis. Click the menu to start NTA.

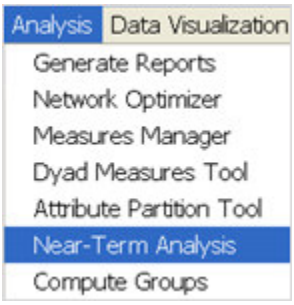


Figure 2 – menu for starting Near Term Analysis

If your dataset has all the necessary information for the analysis, ORA should display the NTA main window, Figure 3.

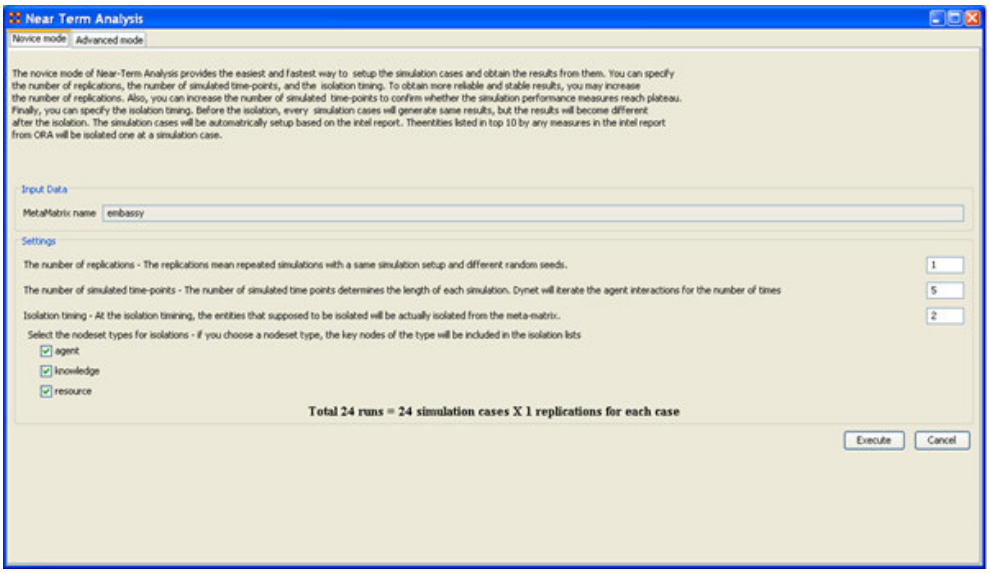


Figure 3 – a novice mode of Near Term Analysis

NTA has two modes: Novice and Advanced (Figure 4). Novice mode provides an instant analysis setup, so you can just click the button, Execute, at the bottom of the window. However, this demonstration will not use this mode because Novice mode does not allow users to setup their own analysis question and virtual experiment hypothesis. Instead of using Novice mode, we will use Advanced mode, and you can switch Novice mode to Advanced mode by clicking on the tab of Advanced mode.

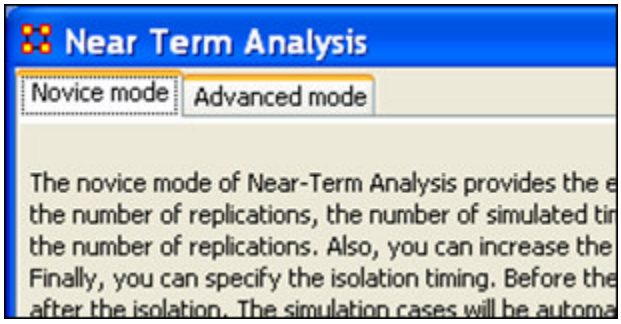


Figure 4 – tabs for Novice mode and Advanced mode

2) Analysis Setup in the Advanced mode of Near Term Analysis

After clicking the Advanced mode tab, the NTA main window will change like Figure 5. We will proceed our rest of the demonstration in this mode. The NTA main window consisted of four sub panels: input panels, settings, simulation time line and cases to simulate. We will see the usage of the sub panels throughout this sub section.

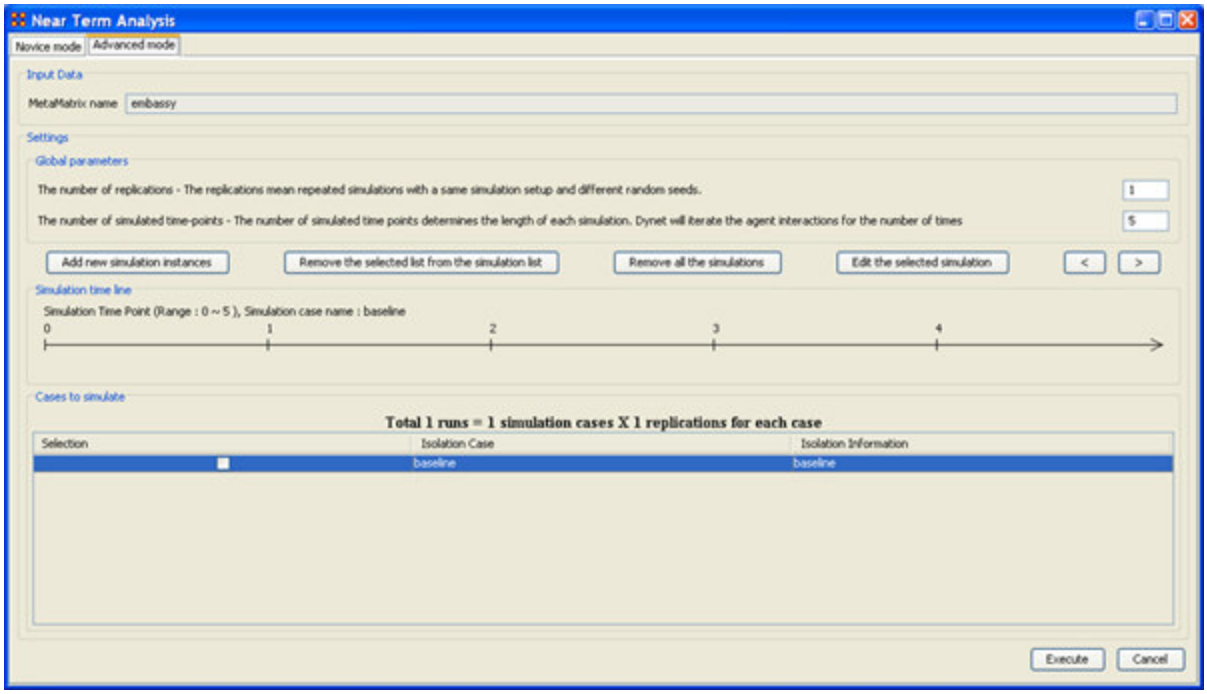


Figure 5 – an advanced mode of Near Term Analysis

First, we change the global parameter in Settings. As in Figure 6, we change the number of replication and the number of simulated time-points to 2 and 52, respectively. The inside analysis engine of NTA is Dynet, a stochastic multi-agent social simulation. Therefore, we specify the number of replication and the simulation length for each virtual experiment cell. After specifying the simulation length as 52, you should see that the simulation time line expands to 52 time steps.

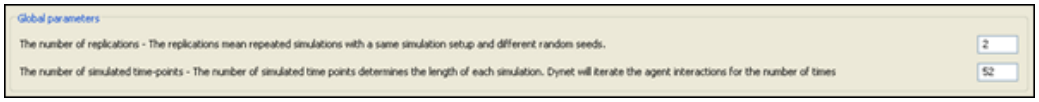


Figure 6 – global parameter setting

Figure 7 – simulation time line

After setting up the global parameters, we setup the virtual experiment cells. Initially, there is a pre-defined simulation cell, Baseline. Baseline is the cell without any entity removals, so it can be a result when the organization does not experience any interventions. Besides Baseline, we will setup two more cells, the removal of Wadih-Al Hage and that of Ahmed the German. We start setting an experiment cell by clicking Add new simulation instances, located above the simulation time line and under the global parameters.

After clicking Add new simulation instances button, you should see a dialog, titled as Near Term Analsys – Simulation scenario create wizard. This wizard supports the creation of virtual experiment cells in three different ways. First, you can setup as you want by choosing the first option, and we will use this option. The second and the third option will ask you a set of criteria for selecting important agents in the network and make experiment cells according to the selection. Therefore, the first option give full flexibility to users, and the second and the third option provides a systematic analysis setup method. To proceed this demonstration, we select the first option and click Next.

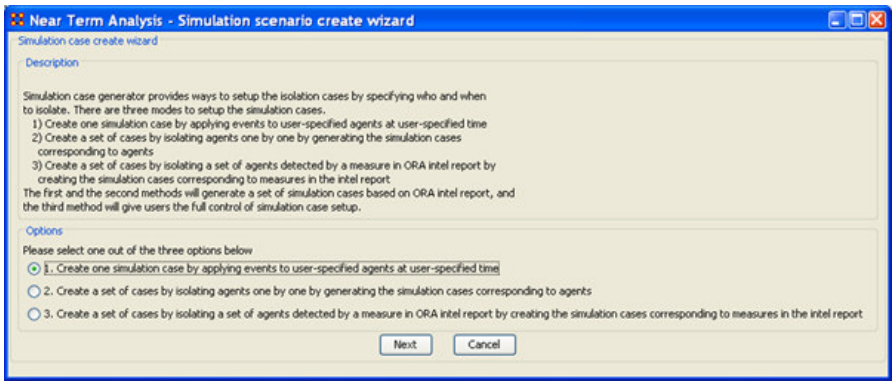


Figure 8 – a simulation scenario creation wizard

Selecting the first option brings the dialog window in Figure 9. We can setup events by using the table in the window, add the events to the simulation case, and add the finished simulation case to the NTA main window.

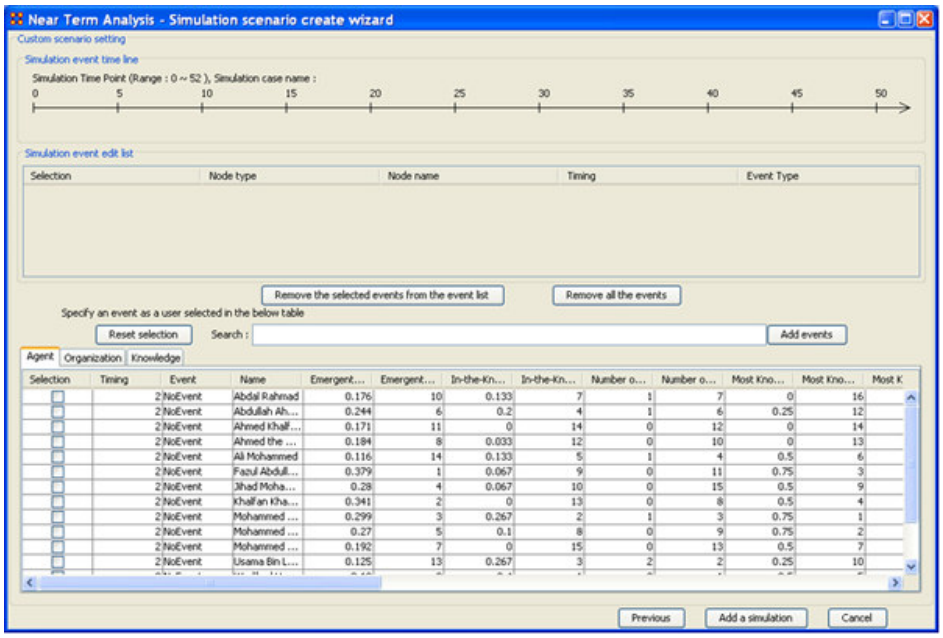
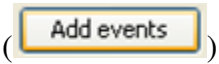
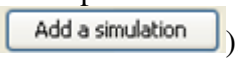


Figure 9 – a scenario creation wizard for user specified event option

First, we will make a case experimenting the removal of Wadih-Al Hage. This case consists of an event, the removal (isolation) or Wadih-Al Hage. To create the event, we find his name in the table located at the bottom of the dialog window. Then, we check his name in the left most check box, and change the event timing at 10 (or the time step when you want to isolate him). After that, the setup should look like Figure 10.

Figure 10 – select an agent and assign an event and its timing to that agent

We finished the setup of one event, so we have to add the event to the simulation case. To add the setup event, we click Add events button () located next to the search text input display. After adding the event, the time line in the dialog will change as Figure 11, which means that we are isolating one agent at time 10. For now, we finished making one simulation case because we are removing just one agent for each case. To finish the setup of the case, we click Add a simulation button located at the bottom of the dialog (). After clicking add a simulation button, the dialog will disappear, and the NTA dialog will have one simulation case at Cases to simulate display.

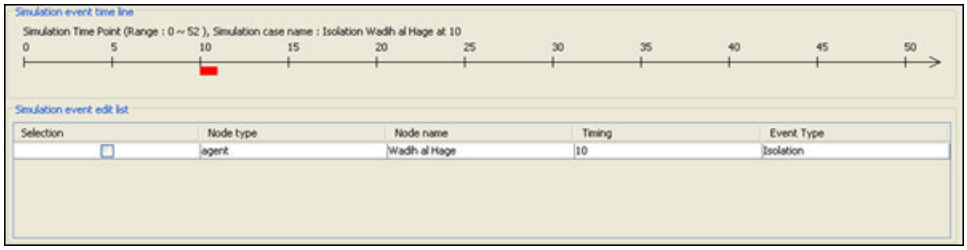


Figure 11 – after 'add event' in the case creation wizard

Just going through the above one more time, we create one more simulation case by only differentiating the removed agent name, from Wadih-Al Hage to Ahmed the German. Thus, we have two removal simulation cases in the list.

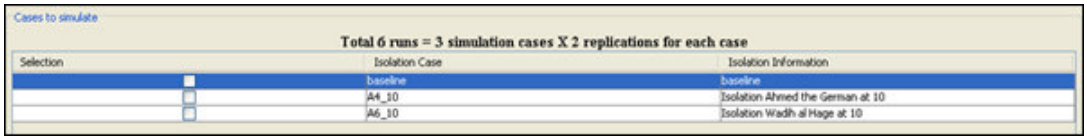


Figure 12 – simulation case list in NTA main window after add simulation in the wizard.

NTA dialog window tells you that we have total six simulations to run because we have three cases (one baseline + two removal case) that should be replicated for two times. Also, you can highlight the simulation case by clicking it, and the simulation time line will change as you change the highlight. The simulation time line tells how the simulation case is designed.

Figure 13 – information on how many simulation runs will be initiated.

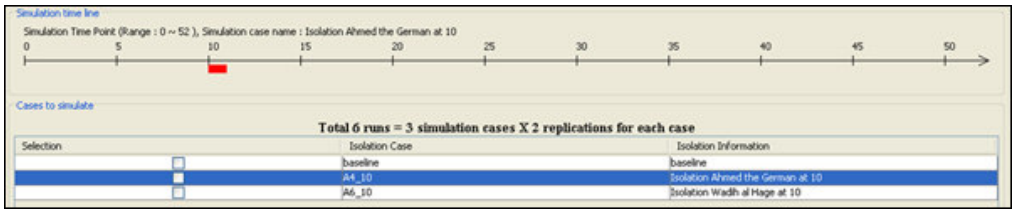


Figure 14 – simulation time line display for each of different cases.

3) Running the Near Term Analysis

Since we finished setting the three simulation cases, we have to execute the simulations. We click Execute button (

) at the bottom to start the simulations. After starting the execution, you will see a small warning dialog, Figure 15. This is just a warning about the long execution time when you have a large network. This dataset should not

take such a long time. After clicking OK, a dialog will display how many simulations are done, Figure 16.

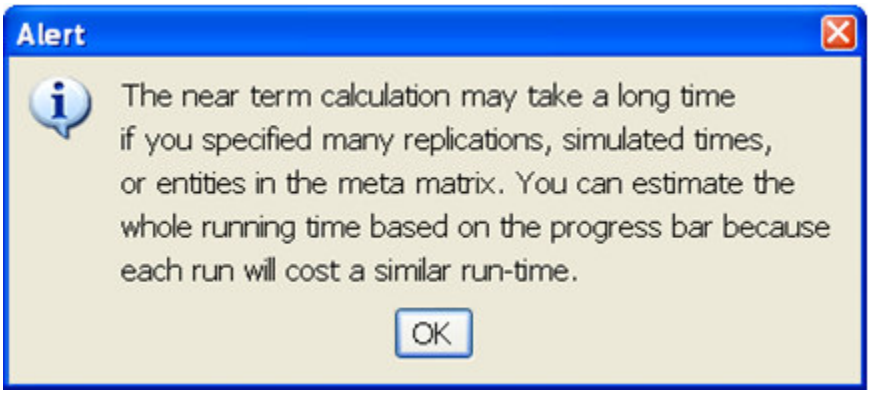


Figure 15 – a warning about long simulation time when the dataset is big.

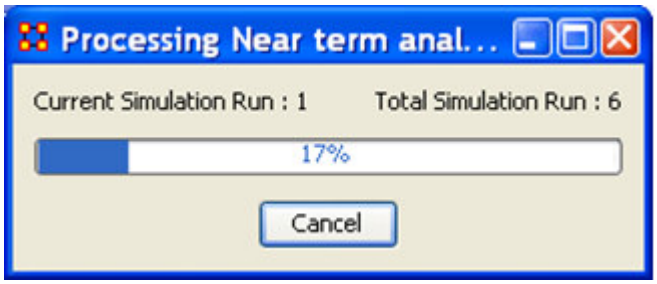


Figure 16 – simulation processing procedure.

4) Results from Near Term Analysis

The simulation results will be displayed in a new window Near term analysis result, Figure 17. Because we have two removal experiment cells, we have two performance lines over time. The lines represent the deviation from the baseline in terms of a performance measure, Knowledge diffusion. Examining this performance change over time reveals how much the removal of the agent will impact to the performance of the organization. Also, we can draw a bar chart by clicking Draw bar chart button (

). The bar chart, Figure 18, will display the performance comparison at the end time of the simulation.

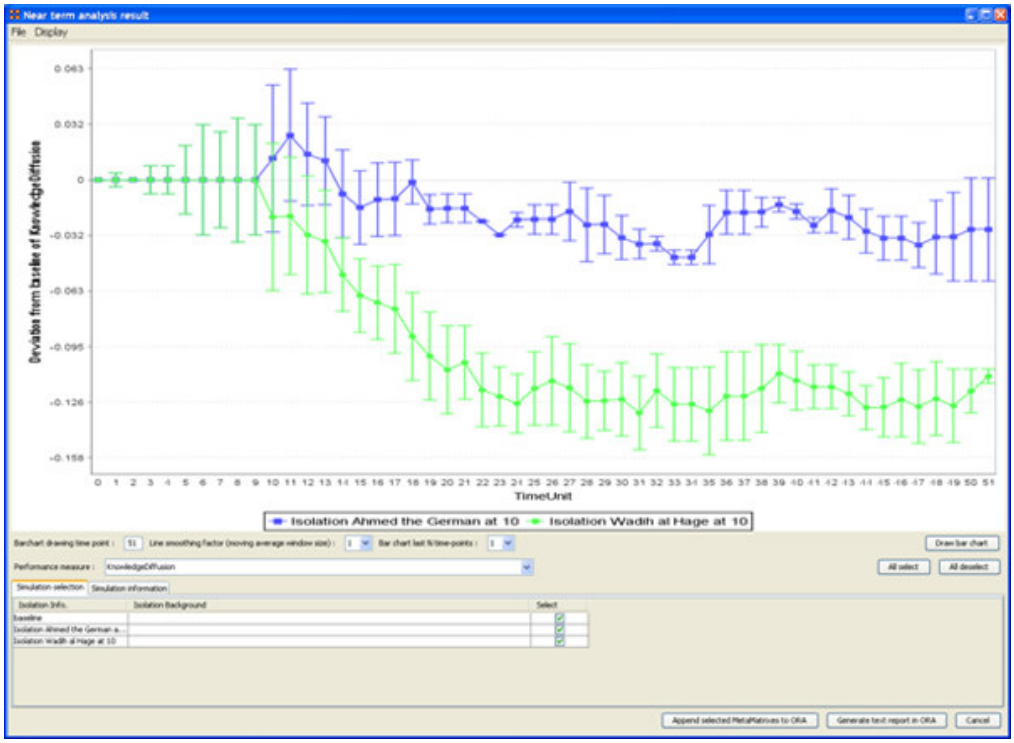


Figure 17 – a line chart from Near Term Analysis displaying the performance over time.

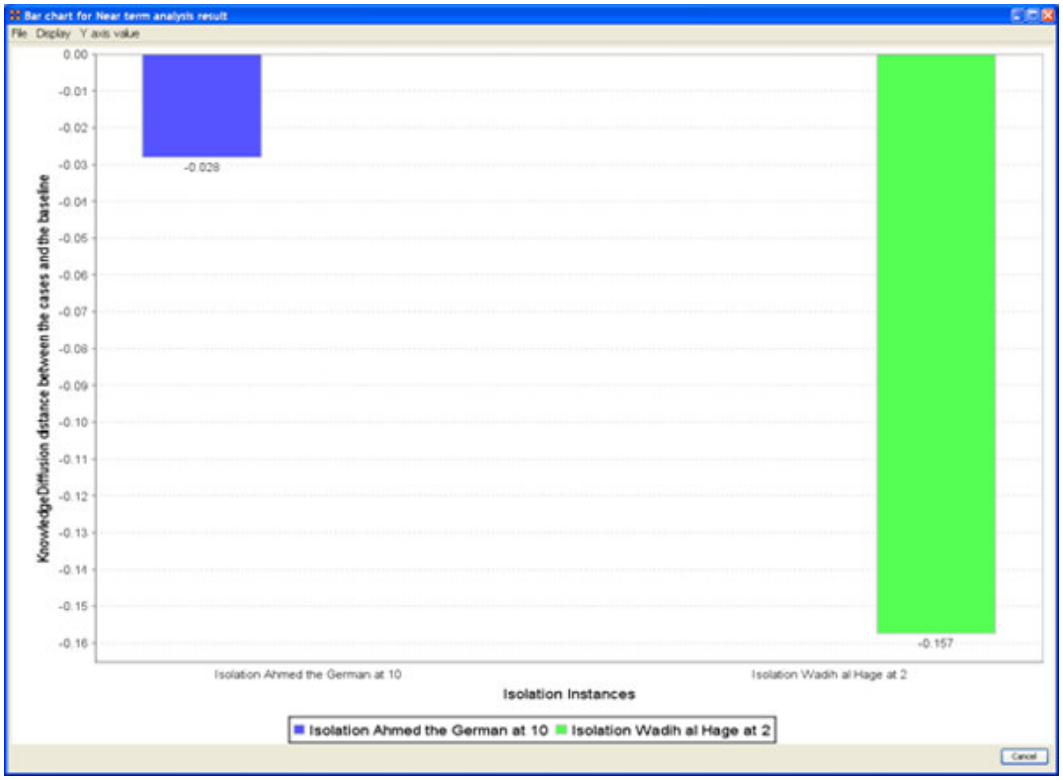


Figure 18 – a bar chart from Near Term Analysis describing the deviation of performance at the end time.

We can obtain just the displayed charts, Figure 20 and 21, by putting the chart in the clipboard of Windows. You can find a menu, Copy the chart in the clipboard, Figure 19, and it will take the displayed charts in the clip board, so you just paste in any Word Documents or Graphics editing tools.

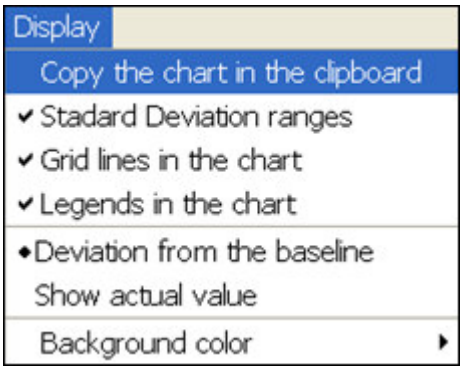


Figure 19 – a menu for copying the images into the windows clipboard.

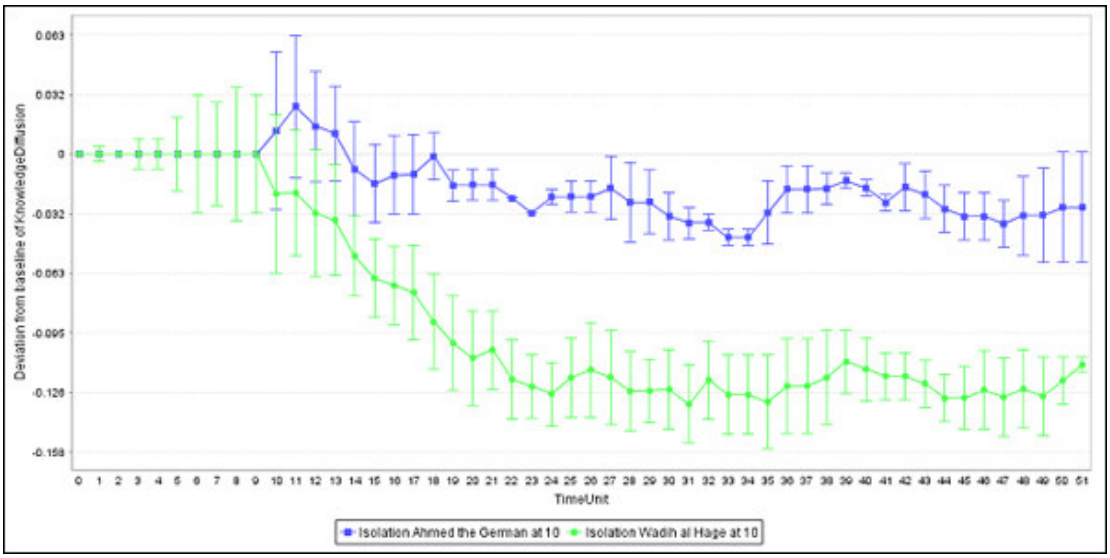


Figure 20 – copied line char image.

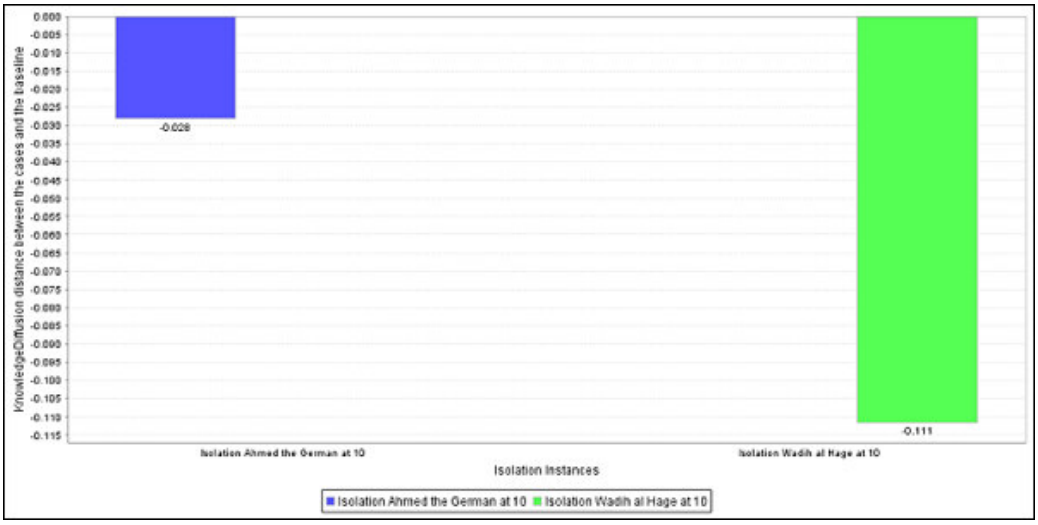


Figure 21 – copied bar chart image.

NTA produces three performance different estimations: knowledge diffusion, binary task accuracy and energy task accuracy. You can change the Y-axis performance value by selecting one of the three performance metrics from the drop down box at the middle of the result window, Figure 22.

Figure 22 – performance metric change.

The text output is available in HTML format. You can save the result HTML document by clicking Save the html report menu under File menu, Figure 23. After the click, you will be asked to provide a file name, the width and the height of images, Figure 24 and 25. If the HTML report is successfully saved, NTA will pop up a dialog saying that the document is well saved, Figure 26. The produced HTML report will look like Figure 27.

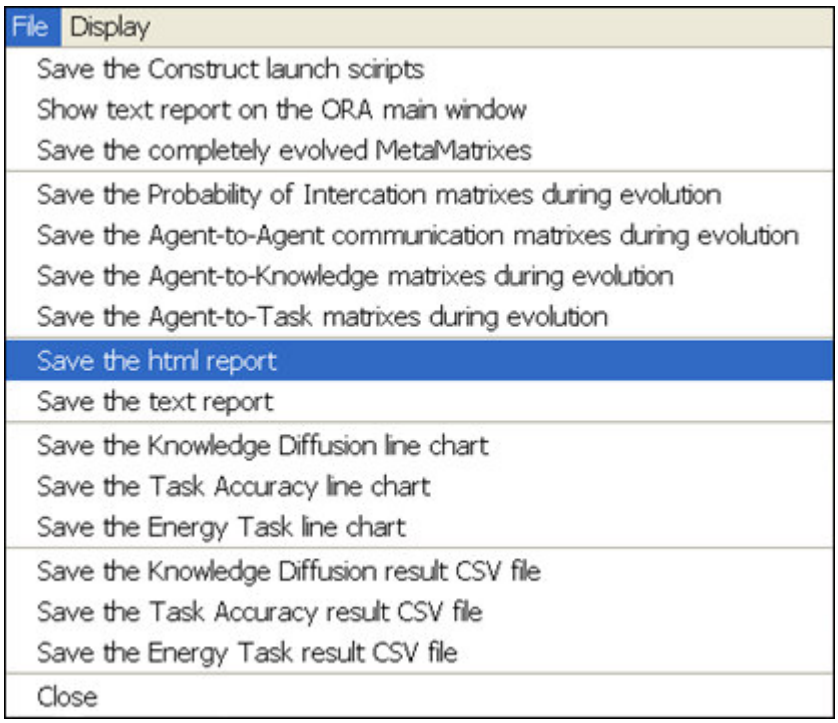


Figure 23 – a menu for saving the HTML report.

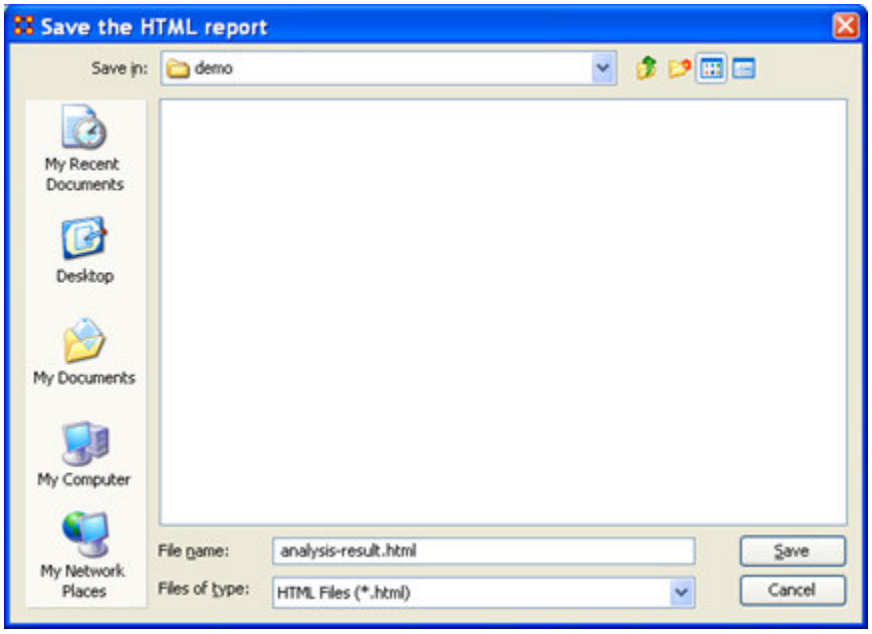


Figure 24 – file name specification

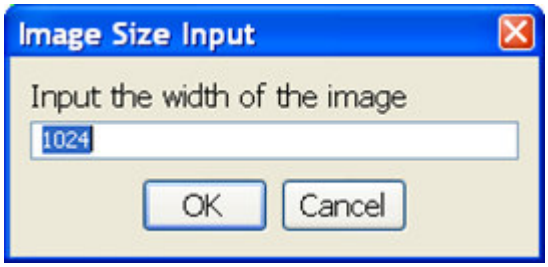


Figure 25 – width/height specification for the images in the HTML report.

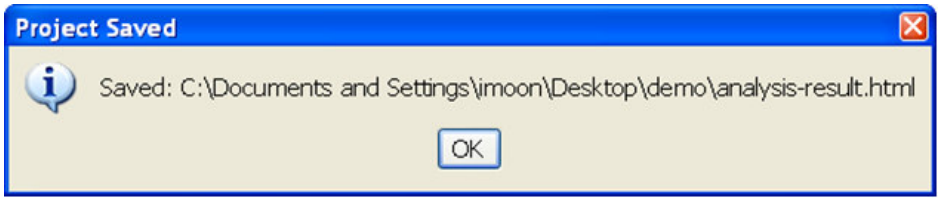


Figure 26 – success indication about saving HTML report.

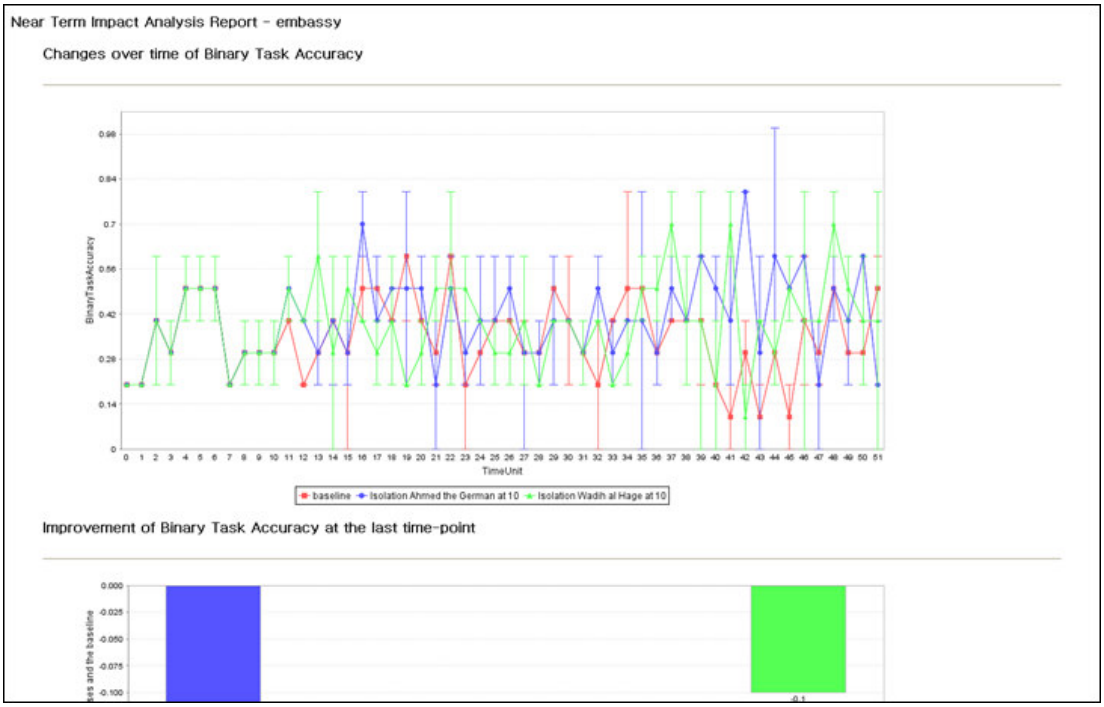


Figure 27 – the saved HTML report.

Finally, you can save the emerged organizational structures after simulations in the ORA main window. Under File menu, there is a set of menus about saving different emergent structures. This demonstration will save the Agent-to-Agent communication network at simulation time step 40. First, you can find Save the Agent-to-Agent communication matrixes during evolution menu under File menu, Figure 28. If you click it, NTA shows a warning, Figure 29, that the saved networks will be from the simulation cases that you

selected. You can select or deselect a simulation case by changing check boxes in the simulation case table at the bottom of the NTA window, Figure 30. If you click okay at the warning, NTA will ask you which time step you want to save, so we specify time step 40, Figure 31. If saving is successful, it will produce a popup dialog. After this, you will be able to see additional saved meta-matrixes in the ORA main window, as in Figure 33, so you can run additional ORA reports on the saved networks.

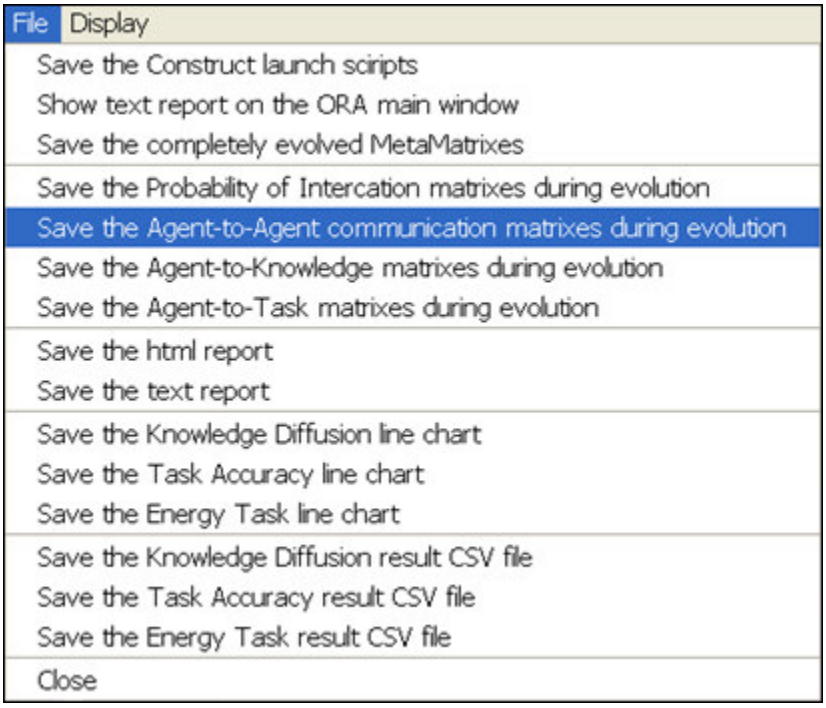


Figure 28 a menu for saving the evolved organizational structure

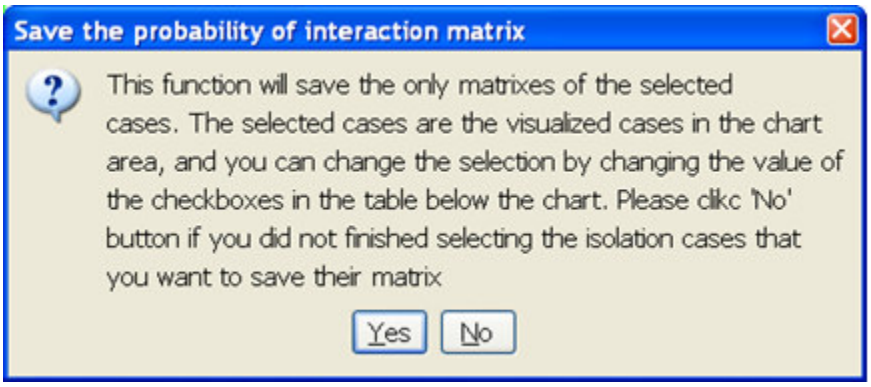


Figure 29 a warning about selecting cases to save

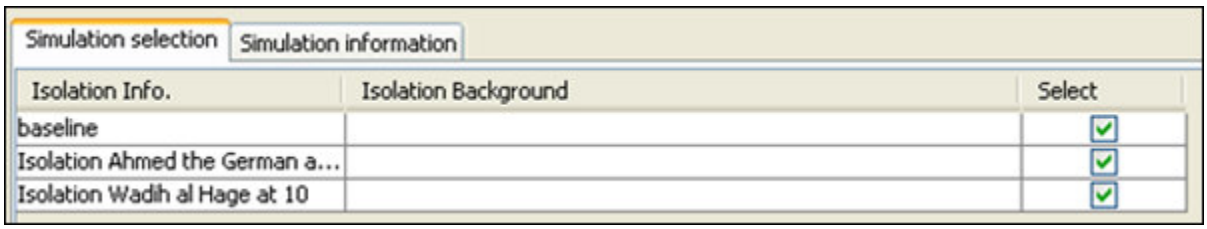


Figure 30 the simulation case list for selection

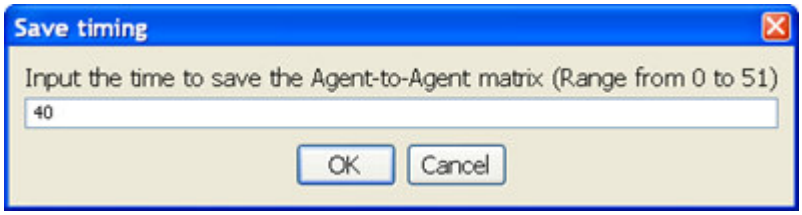


Figure 31 the simulation time-step to save

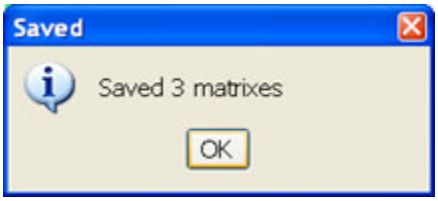


Figure 32 success message about saving the emerged structure

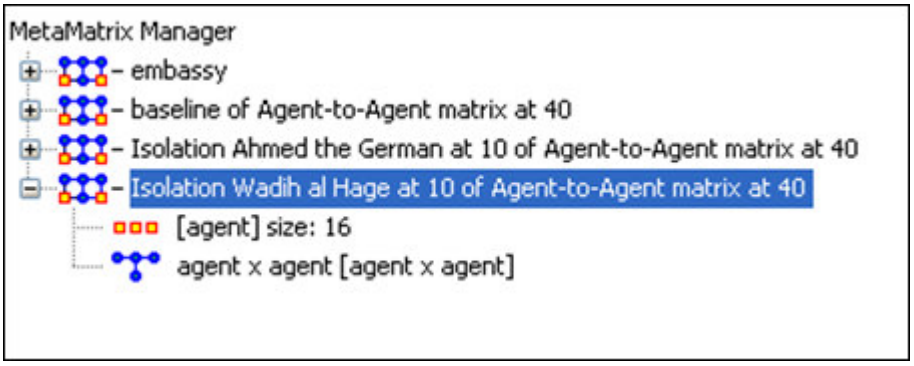


Figure 33 ORA main window showing the saved meta-matrixes

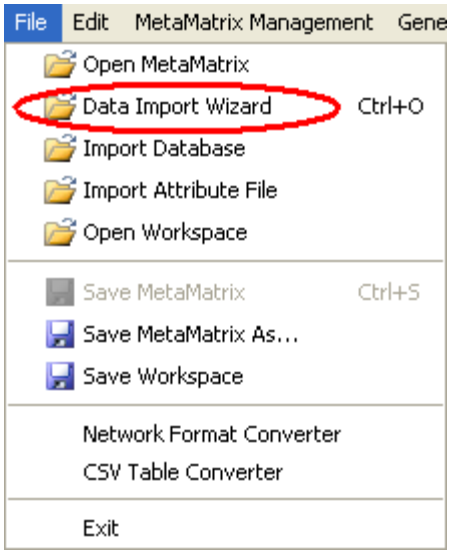
Lesson 8

Import Data

The purpose of this lesson is to become familiar with loading your own network data into ORA. Your primary tool for doing so is the ORA Data Import Wizard, which is accessible from ORA Main Menu bar. The goals of this lesson are following:

- How to locate the Data Import Wizard
- Learn what formats ORA can read.
- How to work with a CSV file
- How to work with an ODBC compliant Database

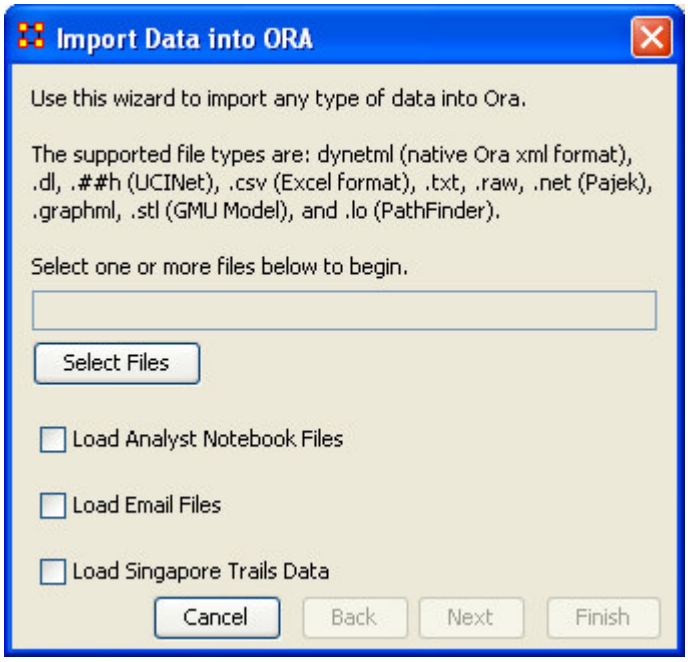
The screen shot below illustrates where to find the Data Import Wizard from the Main Menu bar.



In this example, we are first going to load a MetaNetwork, TanzaniaEmbassyEnhanced_2-07_1996.xml, which is already is in ORA's native formatting language - Dynet.ml.

From the Main Menu Bar: Data Import Wizard > Import Data into ORA window (should appear)

The screen shot below displays the Import Data into ORA wizard.



The Import Data into ORA window lists the acceptable file formats that can be read into ORA. They are the following:

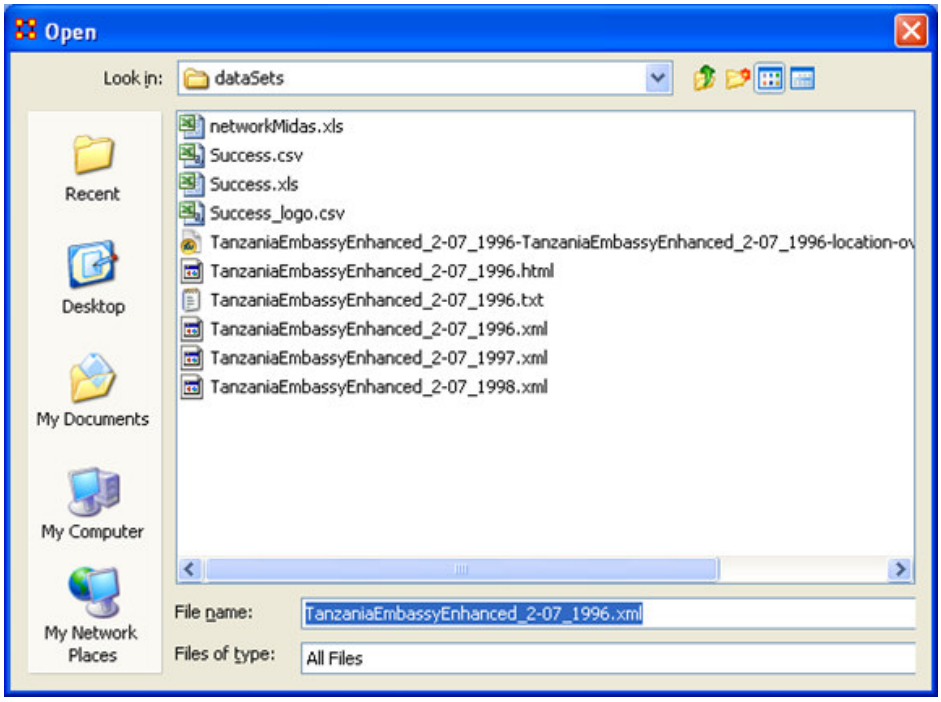
- Dynetml (the native ORA xml format)
- .dl
- .##h (UCINet)
- .CSV (comma separated values, Excel spreadsheet out)
- .txt (text files)
- .raw
- .net (Pajek)
- .graphml
- .stl (GMU model)
- .lo (pathfinder)

Note! ORA will only recognize the file extension to determine what form the data is in. Additionally, the ORA Import Data Wizard is a separate tool from the ORA application (e.g. When accessed, ORA launches a separate executable file - .exe).

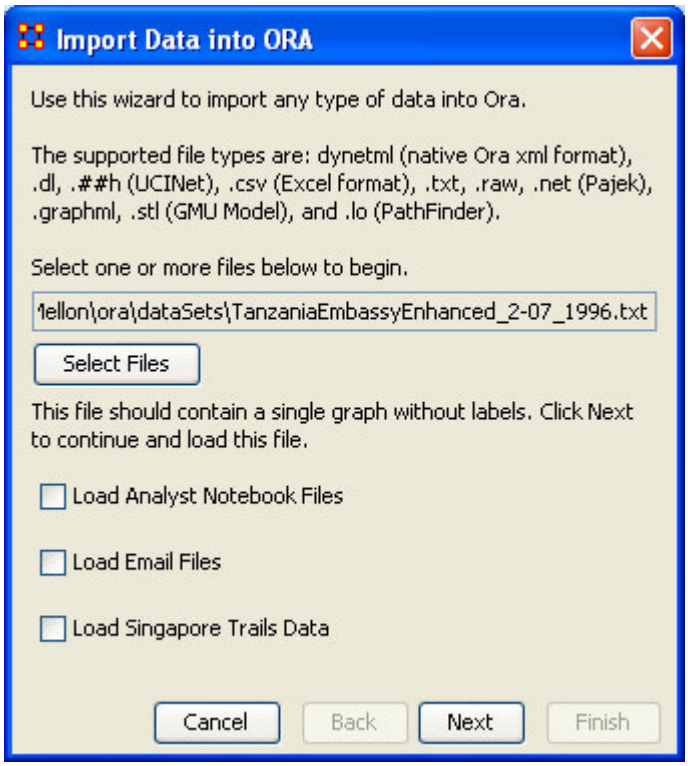
From the Import Data Into ORA window, click the Select Files button.

From the Main Menu Bar: Data Import Wizard > Import Data into ORA window > Select Files

The ORA Open window will appear (screen shot below).

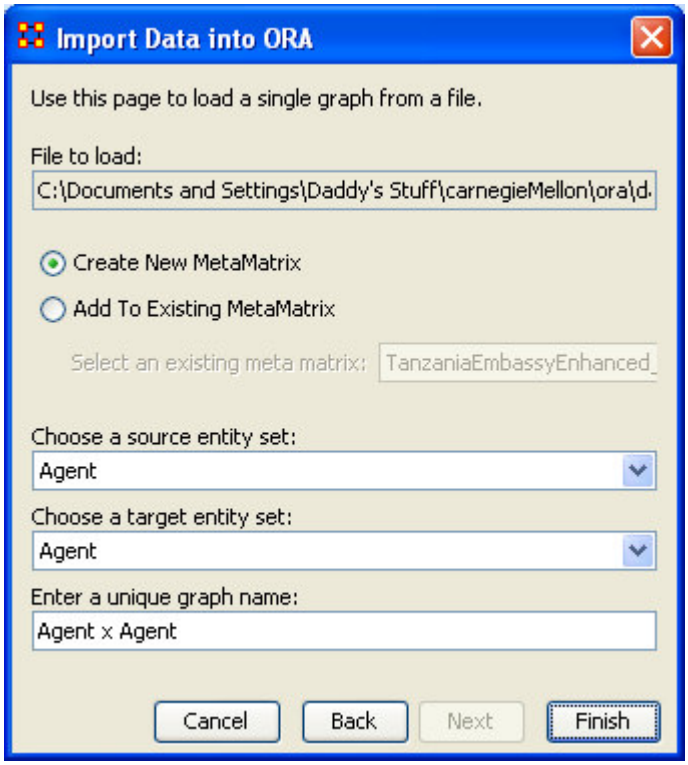


We will select the .xml file TanzaniaEmbassyEnhanced_2-07 in this example. You will see that the file path is now populated in the Select Files field.

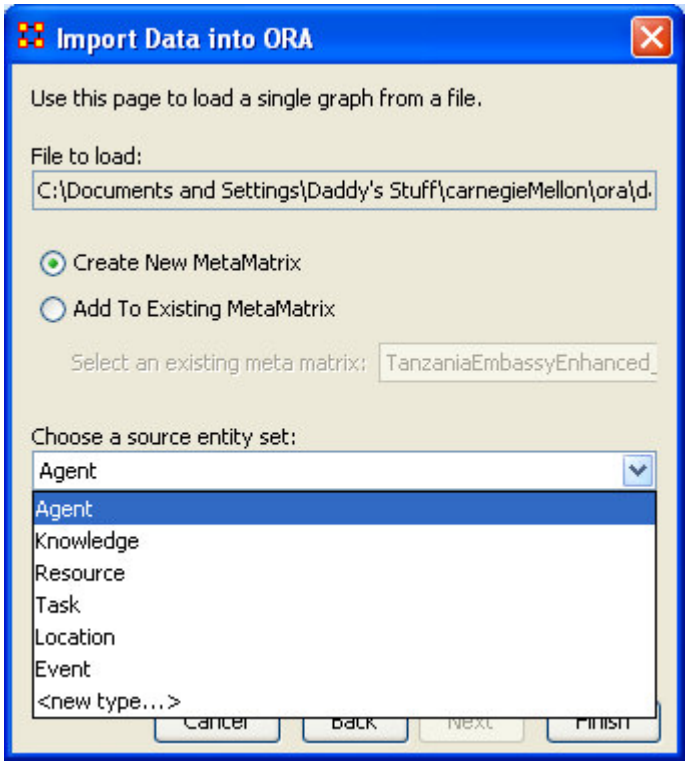


Click Next.

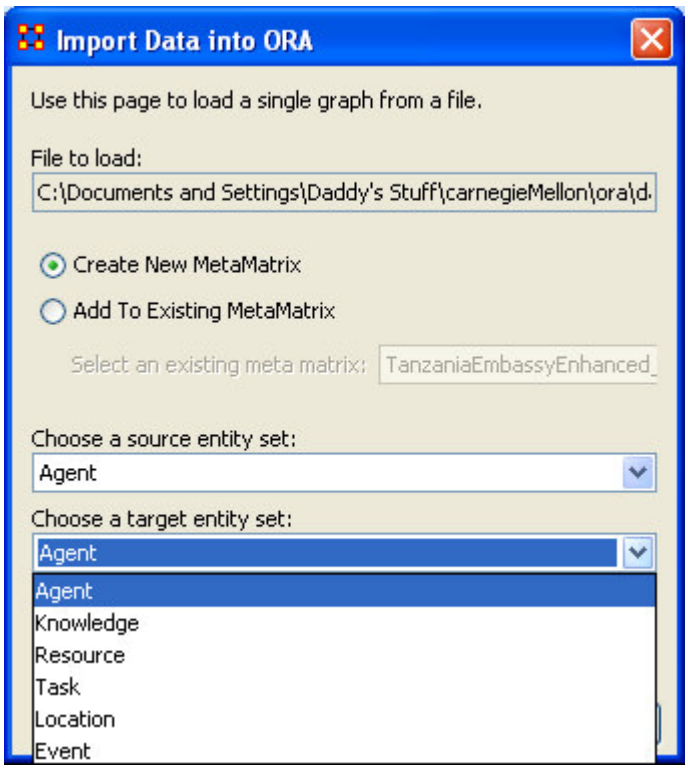
The Import Data into ORA window will now prompt you for several options concerning the network you are importing. In particular, you need to specify what kind of graph you are creating and if you are adding it to a MetaNetwork already in ORA or if this will be a new one completely. The screen shot below shows these options.



Select the drop down menu under Choose a source entity set: to specify a source entity.

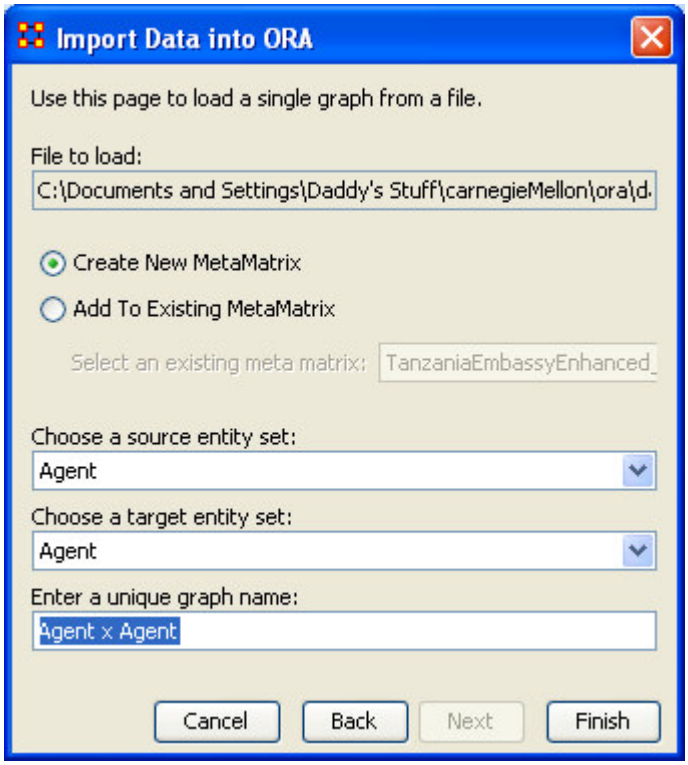


Next select a target entity under Choose a target entity set:.



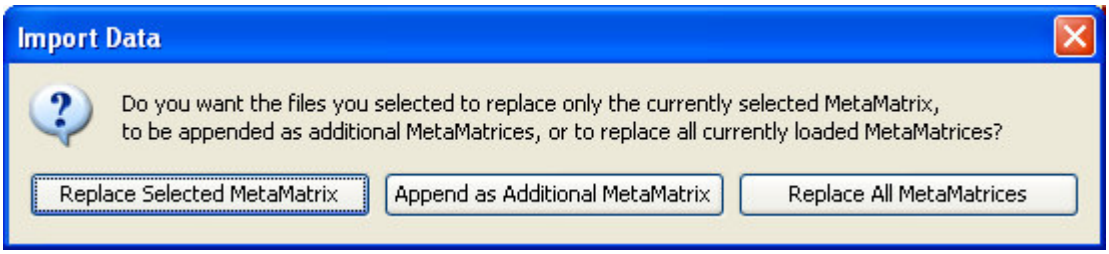
At this point you have an option to specify a graph name. You can call it whatever you choose. By default, it will name your graph based on the source and target entity set.

If you are working in a CSV file, please be aware that the rows are the source and columns are the target.



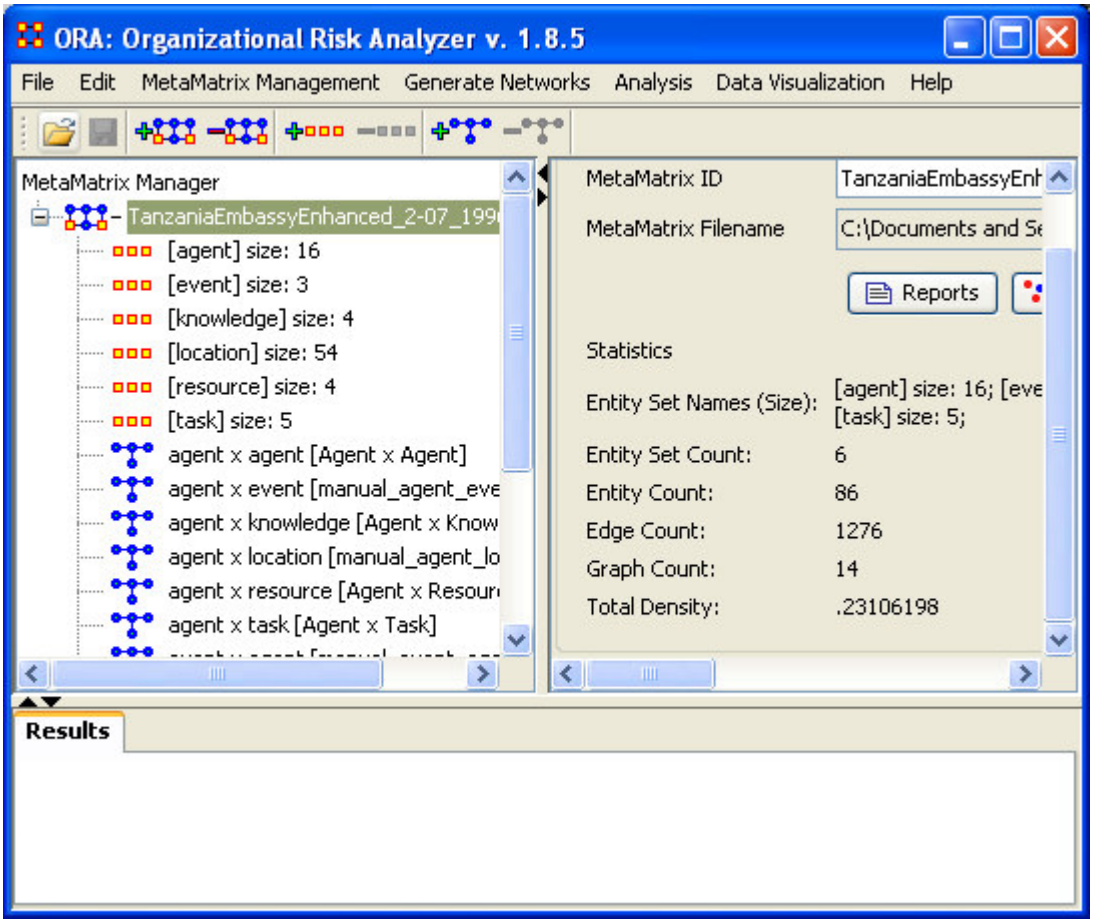
Select Finish.

The Import Data window will appear.



Now you can choose to replace any selected MetaMatrix already loaded into ORA; Append your new graph to a MetaMatrix; or, choose to replace all MetaMatrices.

You should now see your MetaMatrix loaded into ORA's main interface.



ODBC Compliant Databases

(O)pen (D)ata (B)ase (C)onnectivity

ORA has the capability to read ODBC compliant databases. Generally speaking, ORA will need to know what type of query to run. To do so requires wrapping a query in the proper XML format. Therefore a user must be familiar with writing an XML script to accomplish this task. The details of exactly how to do this are beyond the scope of this lesson. However, should you require technical assistant in doing just that, please contact the CASOS Center for specific instructions.

Summary

After completing this lesson, you should be able to:

- Locate the Data Import Wizard from the ORA Interface.
- Learn what formats ORA can read.
- How to work with a CSV file
- How to work with an ODBC compliant Database

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