Centralities - Measures and Reports

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Agenda

- Guiding Questions
- Review of Centrality Measures
- ORA Walk Through 1
- ORA Walk Through 2
- ORA Walk Through 3

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Guiding Questions

- Who is most important to this operation?
- Is Fred a connector or a broker?
- Which shipping port is most vulnerable?
- Which doctor should receive the referral bonus?

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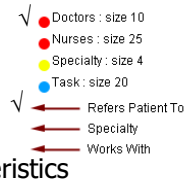
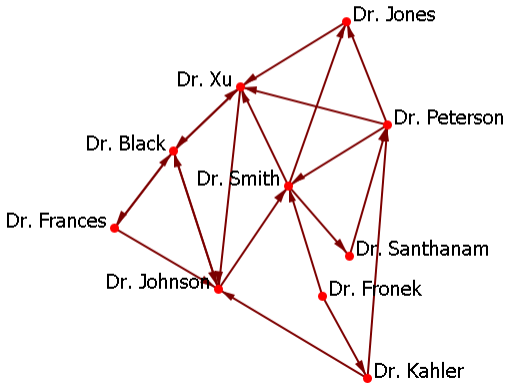
Guiding Questions

- Question?
- Please list all the Drs. to whom you have referred patients in the past six months.





1. Characteristics
   - One Way
   - One mode
   - One type of link
     - Binary
     - Directed

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Steps in a Structural Analysis

- Collect network data.
  - Connections among people, knowledge, resources, events …
- Enter data into ORA.
- Visualize.
- Generate Report.
- If multiple networks create combined measures.
- If needed look at some measures in more depth.
- Possibly drop isolates and pendants
- Check interpretations.

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Ego-centric

- Please tell me, within the last six months, the first names or initials of up to 5 people you talk to most often about important matters?

Respondent					
1 2 3 4 5	Name _____				
1 2 3 4 5	No Yes	Name _____			
1 2 3 4 5	No Yes	No Yes	Name _____		
1 2 3 4 5	No Yes	No Yes	No Yes	Name _____	
1 2 3 4 5	No Yes	No Yes	No Yes	No Yes	Name __

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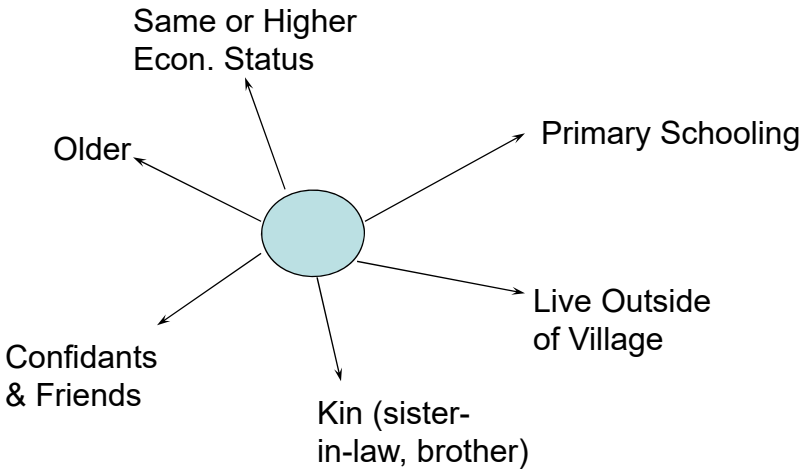
Ego-centric Network Data are Node-based



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Critical Personnel

- Individual whose absence will dramatically alter performance of organization
  - Only person who can do a task
  - Only person with certain organizationally critical knowledge
  - Person who spreads good morale
  - Person who is only one with critical knowledge
  - Only person who knows key people
- Examples
  - Lead scientist
  - Long term administrative assistant
  - One person lab/technician

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Critical Personnel

- Direct identifiers
  - The key entities: e.g., degree centrality
  - The exclusivities: e.g., task
  - The integrators: e.g., simmelian ties
  - The loads: e.g., workload and cognitive demand
- Indirect
  - Those who have access to, can influence, those who are critical

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Node Level SNA Metrics Common Used: Centralities

- Degree Centrality
  - Node with the most connections
- Betweenness Centrality
  - Node in the most best paths
- Eigenvector Centrality
  - Node connected well-known people
- Closeness Centrality
  - Node that is closest to all other nodes

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Critical Actors
What Nodes Matter?

Degree & Eigenvector	Betweenness	Closeness
0.417 Mohamed Atta	0.334 Nawaf Alhazm	0.571 Mohamed Atta
In the know power	Connects groups	Rapid access

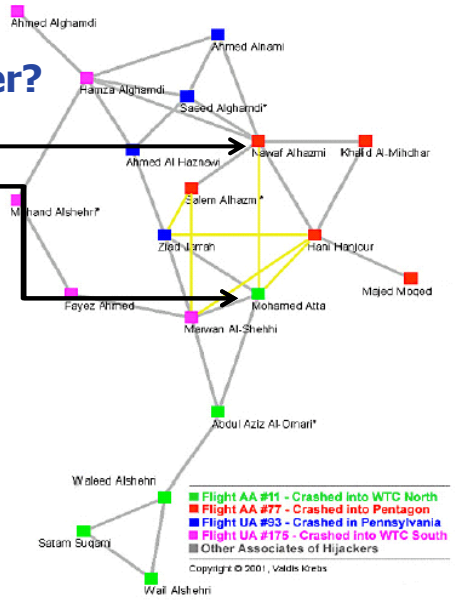

Figure 3 Trusted Prior Contacts + Meeting Ties [shortcuts]

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Simple SNA Measures

Measure	Definition	Meaning	Usage
Degree Centrality	Node with the most connections	In the know	Identifying sources for intel; Reducing information flow
Betweenness	Node in the most best paths Needs symmetric data	Connects groups	Typically has political influence, but may be too constrained to act
Eigenvector centrality	Node most connected to other highly connected nodes	Strong social capital	Identifying those who can mobilize others
Closeness	Node that is closest to all other nodes	Rapid access to all information	Identifying sources to acquire/transmit information

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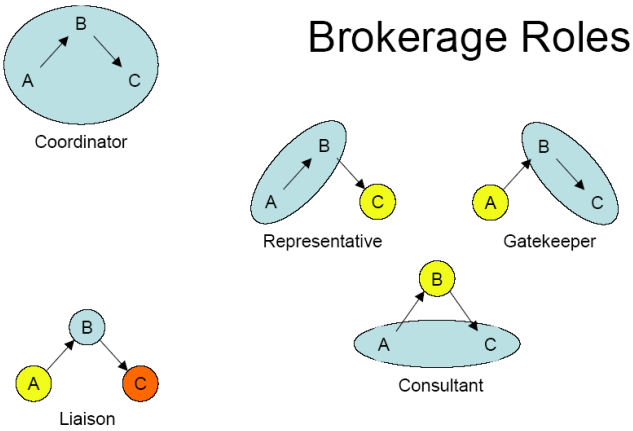
Brokerage



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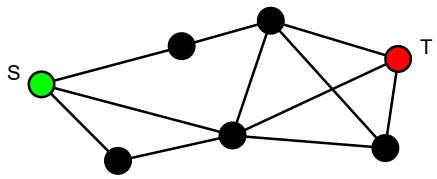
Connectivity

- Line connectivity λ(s,t) is the minimum number of lines that must be removed to disconnect s from t
- Node connectivity κ(s,t) is minimum number of nodes that must be removed to disconnect s from t



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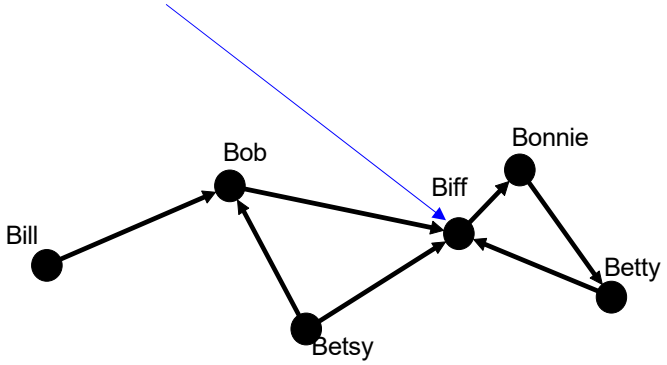
Cutpoints

- Nodes which, if deleted, would disconnect net



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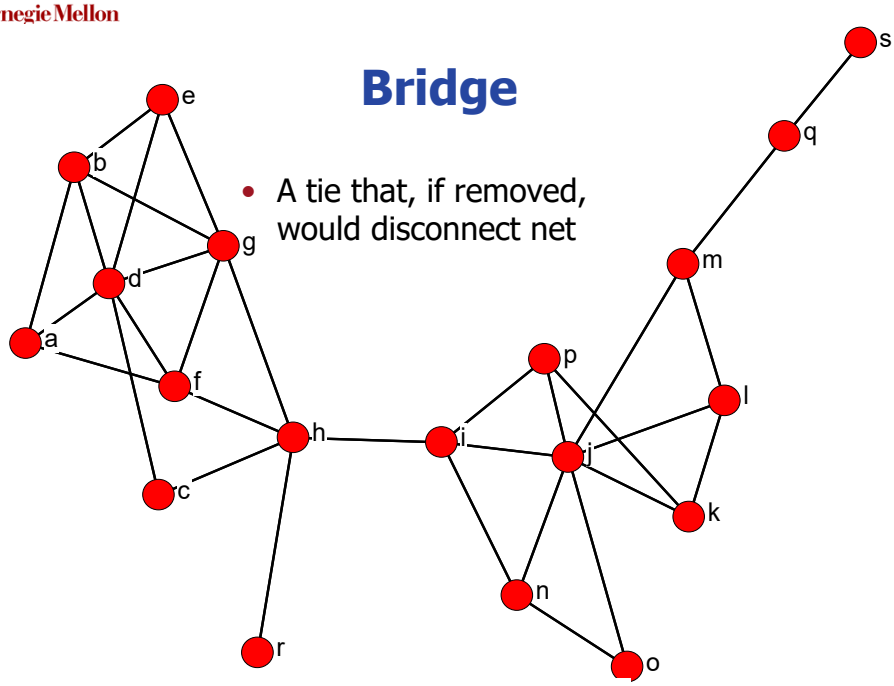
Bridge

- A tie that, if removed, would disconnect net



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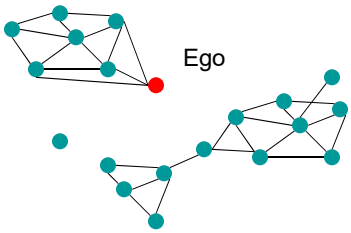
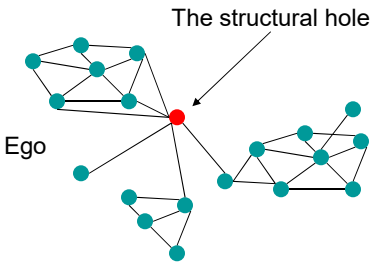
Structural Holes

Local Betweenness



Few structural holes



Many structural holes

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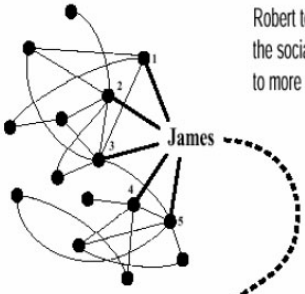
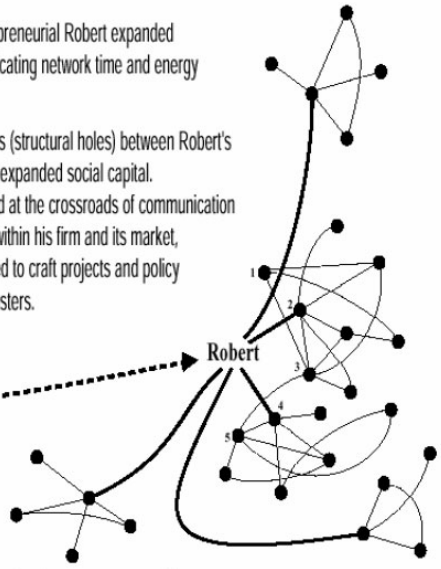
Structural Holes



Robert took over James' job. Entrepreneurial Robert expanded the social capital of the job by reallocating network time and energy to more diverse contacts.

It is the weak connections (structural holes) between Robert's contacts that provide his expanded social capital. Robert is more positioned at the crossroads of communication between social clusters within his firm and its market, and so is better positioned to craft projects and policy that add value across clusters.



Research shows that people like Robert, better positioned for entrepreneurial opportunity, are the key to integrating across functions and across the people of increasingly diverse backgrounds in today's flatter organizations. In research comparisons between managers like James and Robert, it is the people like Robert who get promoted faster, earn higher compensation, receive better performance evaluations, and perform more successfully on teams.

Slide from Ron Burt

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Alternative Measures

- Page rank
  - Iteratively Weighted degree centrality
  - Page rank of node i is PR(pi)
  - D is the dampening factor
  - L(pj) is the outdegree of node j

$$PR(p_i) = \frac{1-d}{N} + d \sum_{p_j \in M(p_i)} \frac{PR(p_j)}{L(p_j)}$$

- Authority Centrality –
  - A node is authority-central to the extent that its in-links are from nodes that have many out-links.
  - The authority of a node are calculated by: $a(i) = \sum_{(j,i)\in E} h(j)$,
  - Where a(x) is the authority of node x ∈ {i, j}

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Clustering Coefficient

(Carley et al., 2013: 845-847)

NODE LEVEL –
Measures the degree of clustering in a network by averaging the clustering coefficient of each node, which is defined as the density of the node's ego network.

Let **G=(V, E)** be the graph representation of a square network.
Define for each node **v∈V** its Clustering Coefficient $\mathbf{cc_v}$:
let $\mathbf{G_v}$ **= ego network of entity v**

Then **Clustering Coefficient for entity: entity v =** $\mathbf{CC_v}$ **= density (**$\mathbf{G_v}$**)**

GRAPH LEVEL -

Then **Clustering Coefficient for graph: graph =** $\frac{\sum_{v\in V} CC_v}{|V|}$

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Bonacich

- Bonacich's power measure corresponds to the notion that the power of a vertex is recursively defined by the sum of the power of its alters.
  - The nature of the recursion involved is then controlled by the power exponent: positive values imply that vertices become more powerful as their alters become more powerful (as occurs in cooperative relations), while negative values imply that vertices become more powerful only as their alters become *weaker* (as occurs in competitive or antagonistic relations).
  - The magnitude of the exponent indicates the tendency of the effect to decay across long walks; higher magnitudes imply slower decay.
  - One interesting feature of this measure is its relative instability to changes in exponent magnitude (particularly in the negative case). If your theory motivates use of this measure, you should be very careful to choose a decay parameter on a non-ad hoc basis.
- Bonacich, P. (1987). "Power and Centrality: A Family of Measures.'" *American Journal of Sociology*, 92, 1170-1182.

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Bonacich's power centrality measure

$$c_i(\alpha,\beta) = \alpha(I - \beta A)^{-1} A\vec{1}$$

- *beta* is an attenuation parameter (set here by exponent)
- *A* is the graph adjacency matrix.
- *alpha* acts as a scaling parameter, and is set here (following Bonacich (1987)) such that the sum of squared scores is equal to the number of vertices.
  - This allows 1 to be used as a reference value for the ``middle'' of the centrality range.
- When *beta->1/lambda_A1* (the reciprocal of the largest eigenvalue of *A*), this is to within a constant multiple of the familiar eigenvector centrality score; for other values of *β*, the behavior of the measure is quite different.
- *β* gives positive and negative weight to even and odd walks, respectively, as can be seen from the series expansion *C_BP(alpha,beta) = alpha sum(beta^k A^(k+1) 1, k in 0..infinity)* which converges so long as */beta/<1/lambda_A1*.
- The magnitude of *beta* controls the influence of distant actors on ego's centrality score, with larger magnitudes indicating slower rates of decay.
- High rates imply a greater sensitivity to edge effects.

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ORA Walkthrough 1

- We'll use Sampson data to get hands on training with Centrality Measures
- Sampson Data: http://bit.ly/1NSa067 (Also on Thumb Drive)

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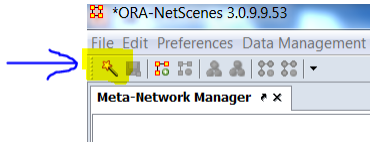
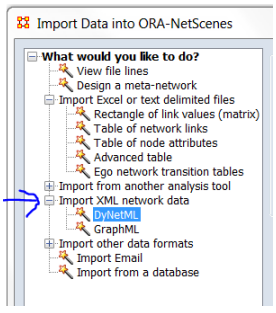
ORA Walkthrough 1

1. Click Import Wizard Button



2. Select Import XML Network Data -> DynetML



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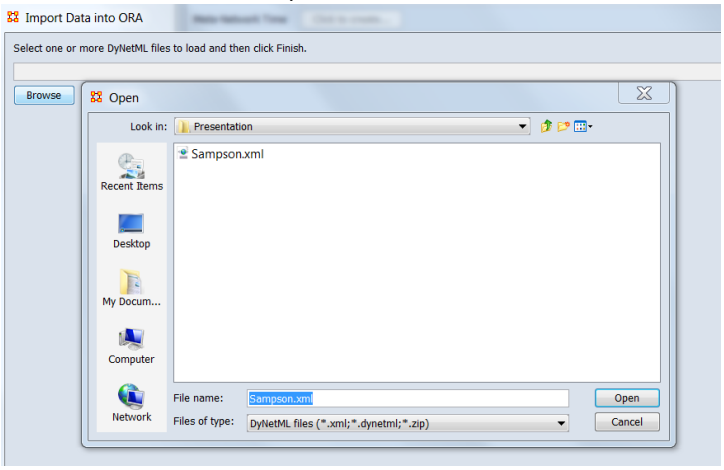
3. Click Browse, and select the sampson data from thumb drive



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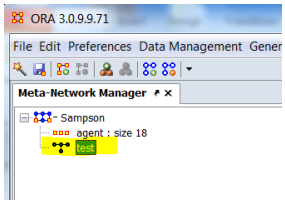
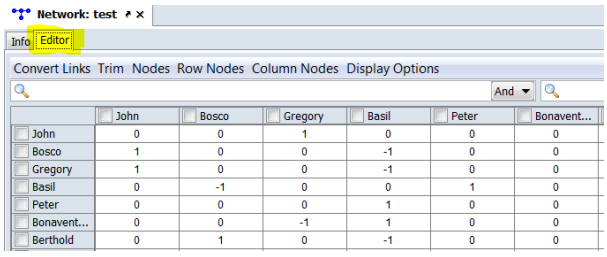
4. Click on test network



5. Click on Editor, to manipulate the data



	John	Bosco	Gregory	Basil	Peter	Bonavent...
John	0	0	1	0	0	0
Bosco	1	0	0	-1	0	0
Gregory	1	0	0	-1	0	0
Basil	0	-1	0	0	1	0
Peter	0	0	0	1	0	0
Bonavent...	0	0	-1	1	0	0
Berthold	0	1	0	-1	0	0

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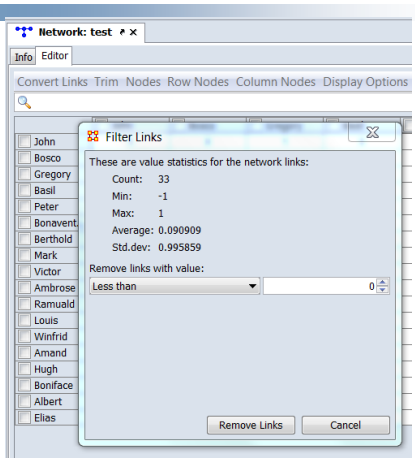
6. Click Trim -> Remove links by value
7. Select Less than, 0
8. Click Remove Links

Now we only have links where one monk liked the other



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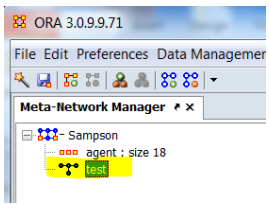
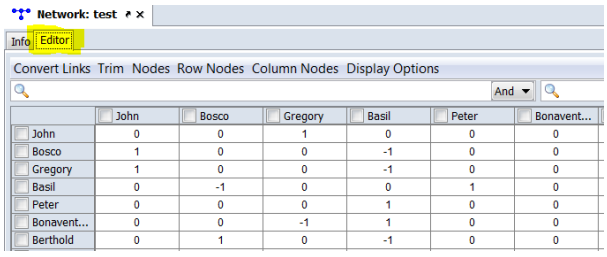
9. Click on test network



10. Click on Editor, to manipulate the data



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11. Click Convert Links -> Binarize link values

Now we're sure that all links have value 1, completing our data cleaning

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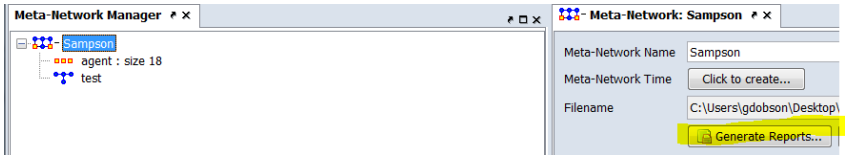
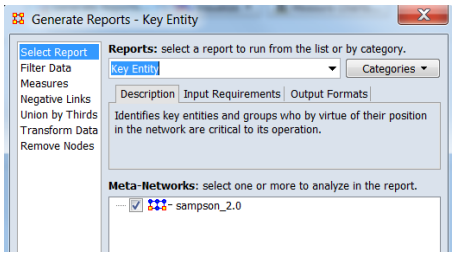
12. Select Sampson Meta Network, Click Generate Reports



13. Select Key Entity Report



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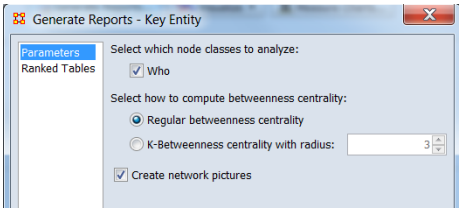
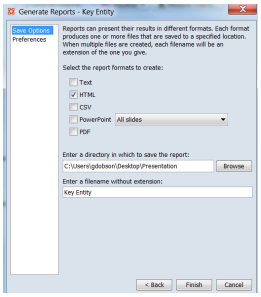
14. Leave the Defaults



15. Leave the Defaults, click Finish



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16. Click on Key Agent - Who Analysis

KEY ENTITY REPORT

Input data: Sampson

Start time: Mon Jun 4 21:42:26 2018

Data Description

Table of Contents

Key Agent - Who Analysis

Performance Indicators - measures performance of the organization(s) as a whole

Produced by ORA, a joint product of the CASOS center at Carnegie Mellon University and Netanomics

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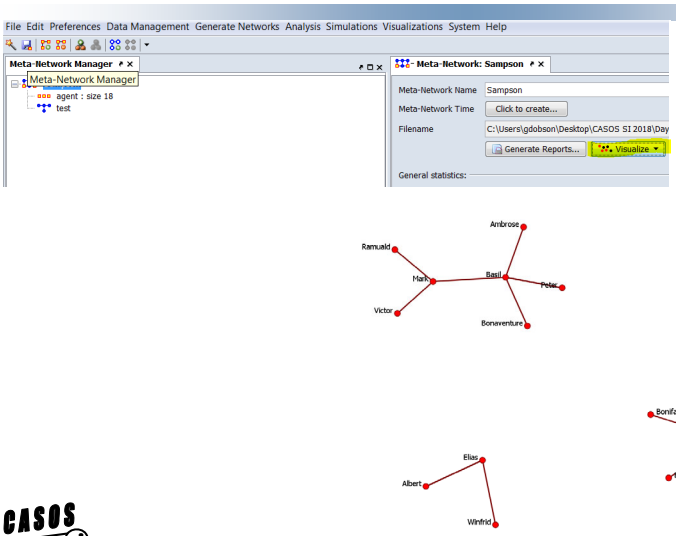

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Eigenvector Centrality

Leaders of strong cliques are individuals or organizations who are collected to others that are themselves highly connected to each other. In other words, if you have a clique then the individual most connected to others in the clique and other cliques, is the leader of the clique. Individuals or organizations who are connected to many otherwise isolated individuals or organizations will have a much lower score in this measure then those that are connected to groups that have many connections themselves. The scientific name of this measure is eigenvector centrality and it is calculated on agent by agent or organization by organization matrices.

If the node of interest has a higher than normal value (greater than 1 standard deviation(s) above the mean) the row is colored red. The row is green if the node is within 1 standard deviation of the mean. Finally, the row is colored blue if the node has a lower than normal value (less than one standard deviation(s) below the mean).

Input network: test (size: 18, density: 0.0588235)

Show 10 entries Search:

Rank	Agent	Value	Unscaled	Context*
1	Bosco	3.551874e-01	2.511554e-01	3.749497e-01
2	John	3.551874e-01	2.511554e-01	3.749497e-01
3	Basil	3.453620e-01	2.442078e-01	3.457115e-01
4	Mark	2.749860e-01	1.944444e-01	1.362862e-01
5	Elias	1.666667e-01	1.178511e-01	-1.860506e-01
6	Ambrose	1.587632e-01	1.122626e-01	-2.095697e-01
7	Bonaventure	1.587632e-01	1.122626e-01	-2.095697e-01
8	Peter	1.587632e-01	1.122626e-01	-2.095697e-01
9	Amand	1.542431e-01	1.090664e-01	-2.230206e-01
10	Berthold	1.542431e-01	1.090664e-01	-2.230206e-01

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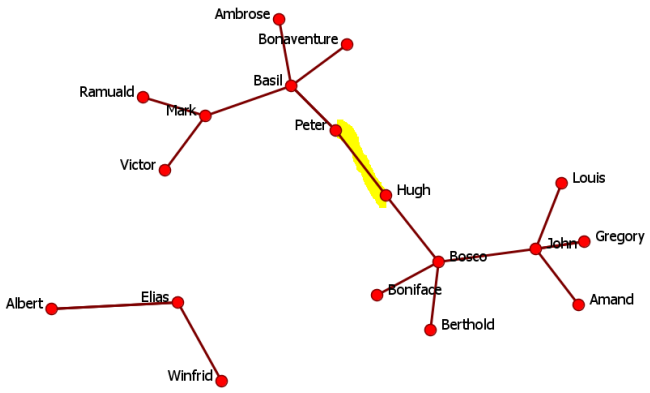
16. Open Visualizer, add link between Peter and Hugh



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17. Re-Run Generate Reports -> Key Entity -> Save as “likes add peter hugh” - observe “Eigenvector Centrality” rankings

Show 10 entries Search:

Rank	Agent	Value	Unscaled	Context*
1	Bosco	3.551874e-01	2.511554e-01	3.749497e-01
2	John	3.551874e-01	2.511554e-01	3.749497e-01
3	Basil	3.453620e-01	2.442078e-01	3.457115e-01
4	Mark	2.749860e-01	1.944444e-01	1.362862e-01
5	Elias	1.666667e-01	1.178511e-01	-1.860506e-01
6	Ambrose	1.587632e-01	1.122626e-01	-2.095697e-01
7	Bonaventure	1.587632e-01	1.122626e-01	-2.095697e-01
8	Peter	1.587632e-01	1.122626e-01	-2.095697e-01
9	Amand	1.542431e-01	1.090664e-01	-2.230206e-01
10	Berthold	1.542431e-01	1.090664e-01	-2.230206e-01

Show 10 entries Search:

Rank	Agent	Value	Unscaled	Context*
1	Bosco	5.963698e-01	4.216971e-01	1.063982e+00
2	John	5.355839e-01	3.787150e-01	8.831583e-01
3	Hugh	3.794598e-01	2.683186e-01	4.187265e-01
4	Basil	3.458540e-01	2.445557e-01	3.187574e-01
5	Peter	3.052566e-01	2.158490e-01	1.979898e-01
6	Berthold	2.509890e-01	1.774760e-01	3.655693e-02
7	Boniface	2.509890e-01	1.774760e-01	3.655693e-02
8	Amand	2.254066e-01	1.593865e-01	-3.954473e-02
9	Gregory	2.254066e-01	1.593865e-01	-3.954473e-02
10	Louis	2.254066e-01	1.593865e-01	-3.954473e-02

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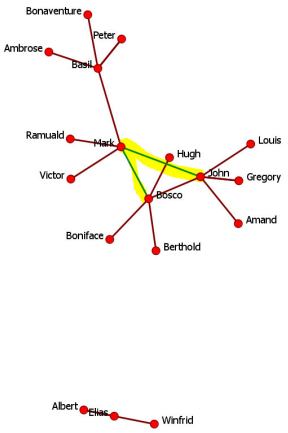
ORA Walkthrough 1

18. Open Visualizer, add link from Mark to Bosco and John to Mark



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ORA Walkthrough 1

20. Re-Run Generate Reports -> Key Entity -> Save as “likes add mark” - observe “Eigenvector Centrality” rankings

Show 10 entries Search:

Rank	Agent	Value	Unscaled	Context*
1	Bosco	5.963698e-01	4.216971e-01	1.035323e+00
2	John	5.355839e-01	3.787150e-01	8.545626e-01
3	Hugh	3.794598e-01	2.683186e-01	3.902934e-01
4	Basil	3.458540e-01	2.445557e-01	2.903593e-01
5	Peter	3.052566e-01	2.158490e-01	1.696340e 01
6	Berthold	2.509890e-01	1.774760e-01	8.257561e-03
7	Boniface	2.509890e-01	1.774760e-01	8.257561e-03
8	Amand	2.254066e-01	1.593865e-01	-6.781746e-02
9	Gregory	2.254066e-01	1.593865e-01	-6.781746e-02
10	Louis	2.254066e-01	1.593865e-01	-6.781746e-02

Show 10 entries Search:

Rank	Agent	Value	Unscaled	Context*
1	Mark	5.519503e-01	3.902878e-01	9.033718e-01
2	Bosco	5.318373e-01	3.760658e-01	8.427256e-01
3	John	5.140632e-01	3.634976e-01	7.891317e-01
4	Basil	2.968666e-01	2.099164e-01	1.342238e-01
5	Hugh	2.278233e-01	1.610954e-01	-7.396071e-02
6	Ramuald	1.791029e-01	1.266449e-01	-2.208662e-01
7	Victor	1.791029e-01	1.266449e-01	-2.208662e-01
8	Berthold	1.725764e-01	1.220299e-01	-2.405453e-01
9	Boniface	1.725764e-01	1.220299e-01	-2.405453e-01
10	Peter	1.702571e-01	1.203900e-01	-2.475386e-01

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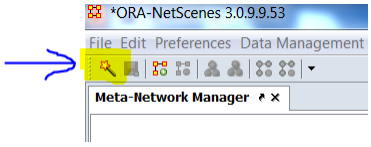
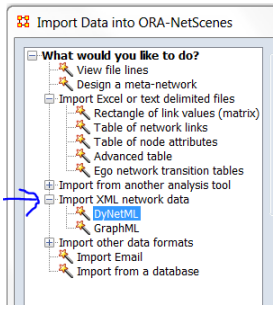
ORA Walkthrough 2

1. Click Import Wizard Button



2. Select Import XML Network Data -> DynetML



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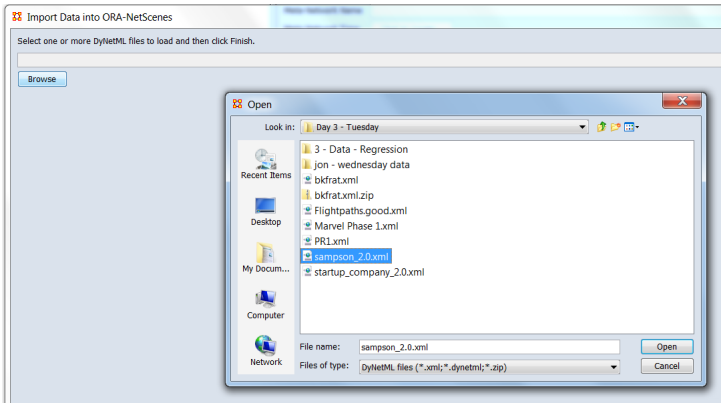
3. Click Browse, and select the sampson data from thumb drive



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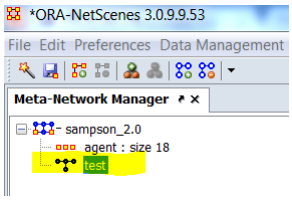
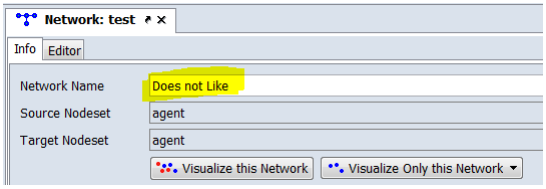
4. Click on test network



5. Change the name to “Does not Like”



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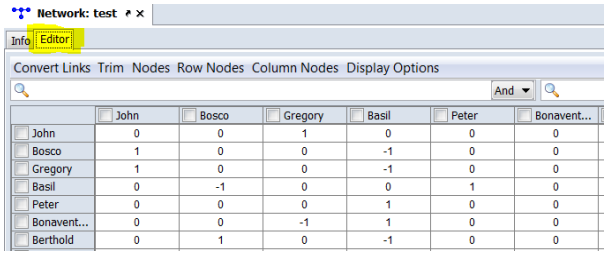
6. Click on Editor, to manipulate the data



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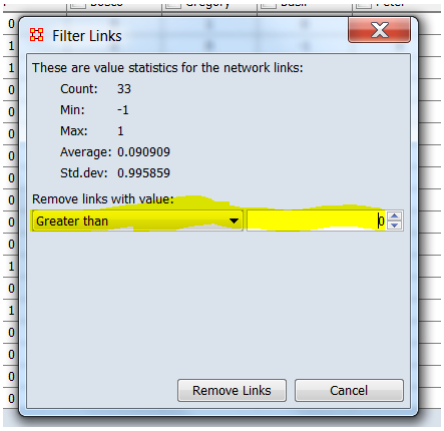
7. Click Trim -> Remove links by value
8. Select Greater than, 0
9. Click Remove Links

Now we only have links where one monk didn't like the other



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10. Click Convert Links -> Binarize link values

Now we're sure that all links have value 1, completing our data cleaning

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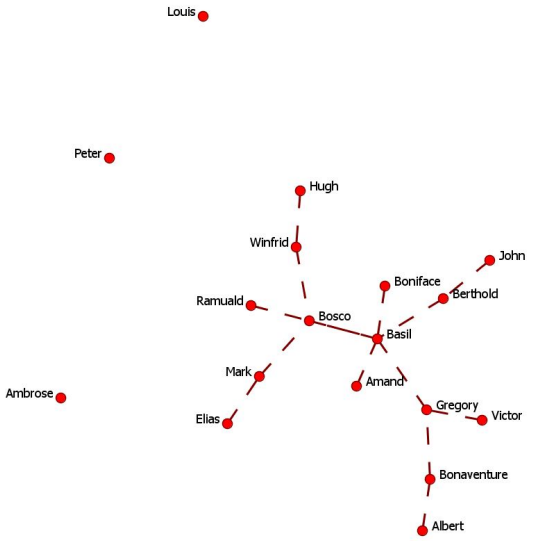
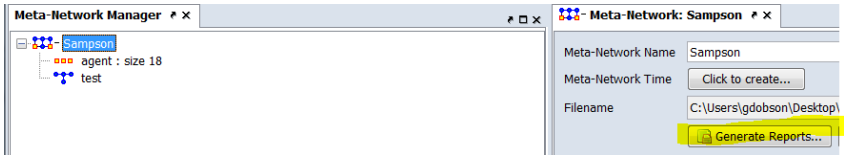
11. Visualize

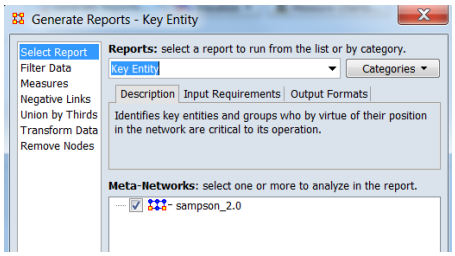


ORA Walkthrough 2

12. Select Sampson Meta Network, Click Generate Reports



13. Select Key Entity Report



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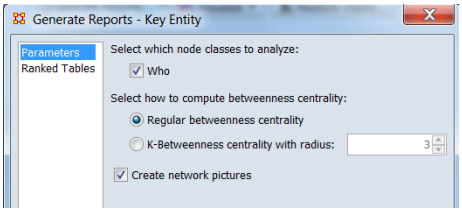
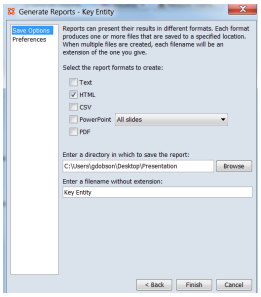
14. Leave the Defaults



15. Leave the Defaults, click Finish



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16. Click on Key Agent - Who Analysis

KEY ENTITY REPORT

Input data: Sampson

Start time: Mon Jun 4 21:42:26 2018

Data Description

Table of Contents

Key Agent - Who Analysis

Performance Indicators - measures performance of the organization(s) as a whole

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Total Degree Centrality

Individuals or organizations who are 'in the know' are those w
the know' are identified by degree centrality in the relevant so
is total degree centrality and it is calculated on the agent by ag

If the node of interest has a higher than normal value (greater
Finally, the row is colored blue if the node has a lower than nc

Input network: Does not Like (size: 18, density: 0.0490196)

Show 10 entries

Rank	Agent
1	Basil
2	Bosco
3	Gregory
4	Berthold
5	Bonaventure
6	Mark
7	Winfrid
8	Albert
9	Amand
10	Boniface

Basil and Bosco most disliked…John not disliked!

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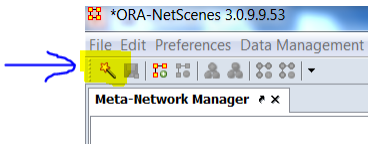
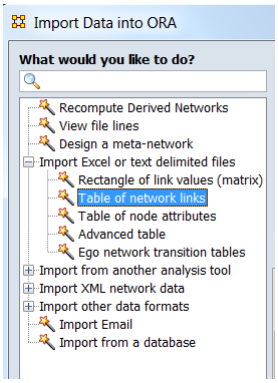
1. Click Import Wizard Button



2. Click Table of Network Links



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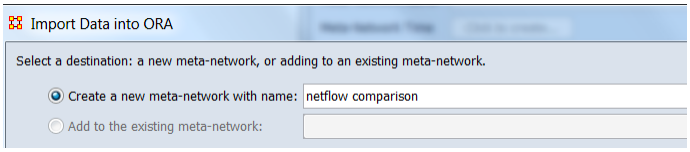
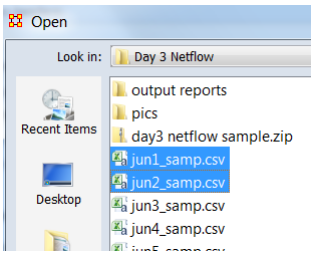
3. Create new meta-network, named “Netflow comparison”



4. Browse, select BOTH of jun1_samp.csv and jun2_samp.csv



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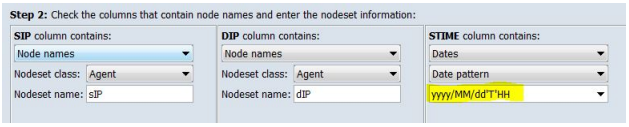
5. Set the Step 2 options like so:



6. Set the Step 3 options like so, and then “Next”:

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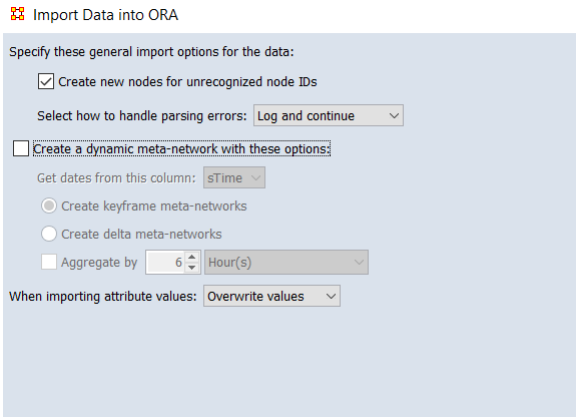
7. Uncheck “Create a dynamic meta-network” and click “Finish”



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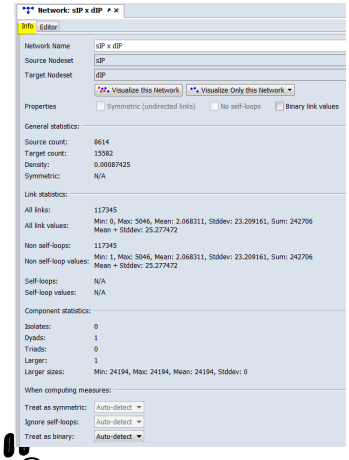
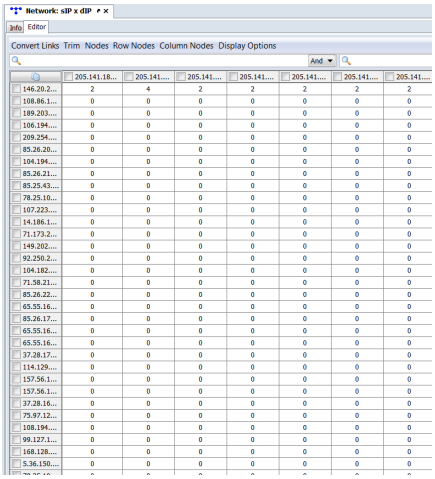
8. Inspect data in the Info and Editor:





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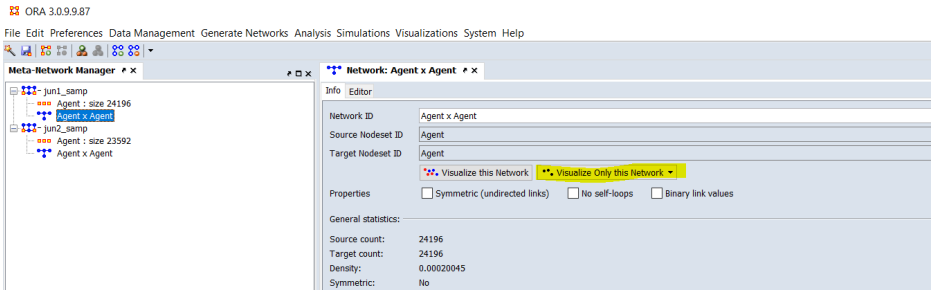
9. Visualize the network (one of them), select “Load Normally”



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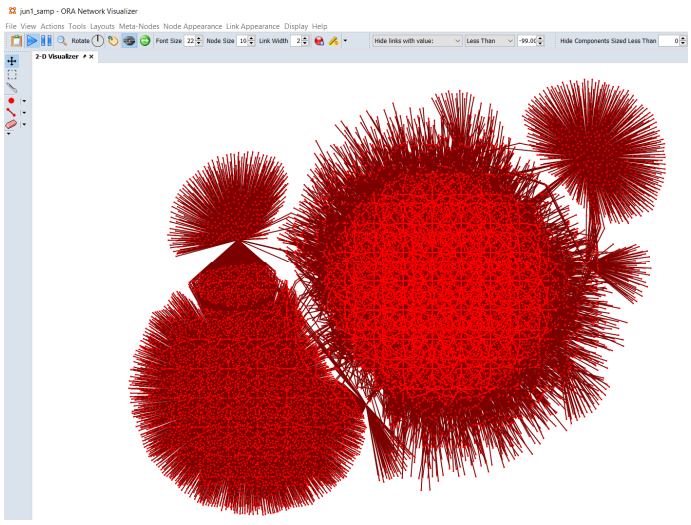

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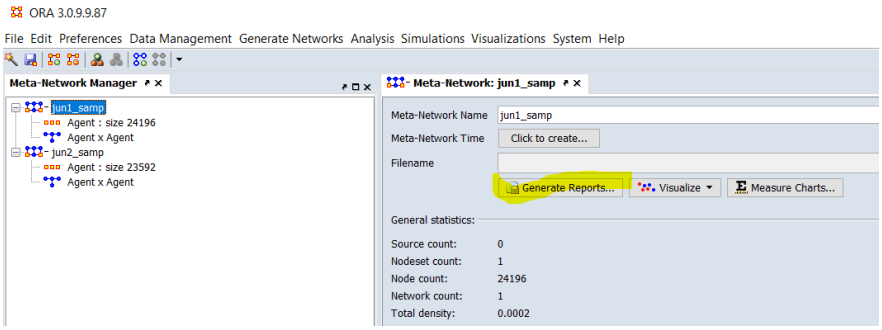
10. Select jun1_samp network and Click “Generate Reports”



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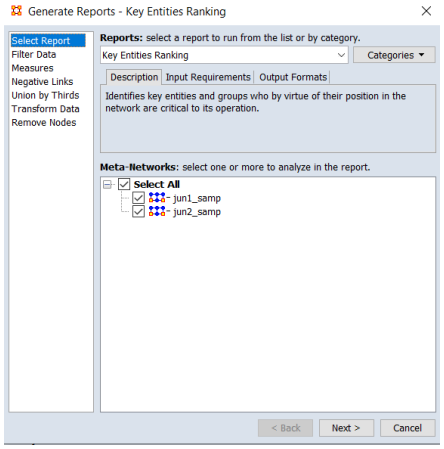
11. Select “Key Entities Rankings” and select both jun1_samp and jun2_samp and click “Next”



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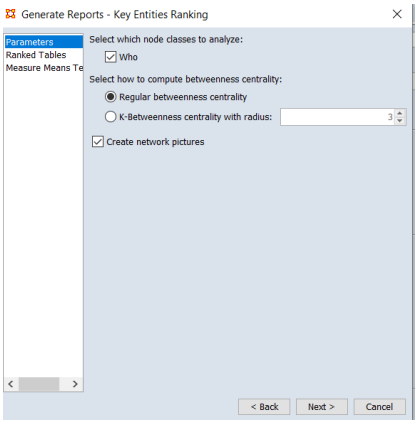
12. Leave defaults and click “Next”



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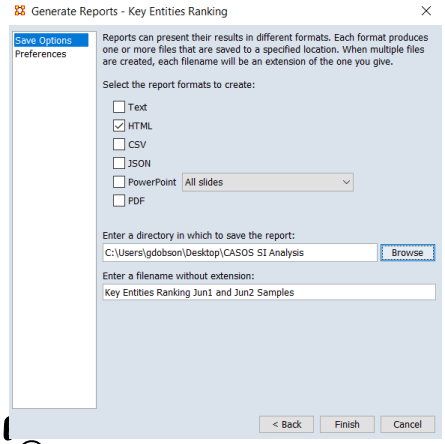
13. Select a folder and name of report, click Finish and browse report



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