

Prominence



Center for Public Health
Systems Science

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Prominence

Understanding a network through analysis of individual positions of actors

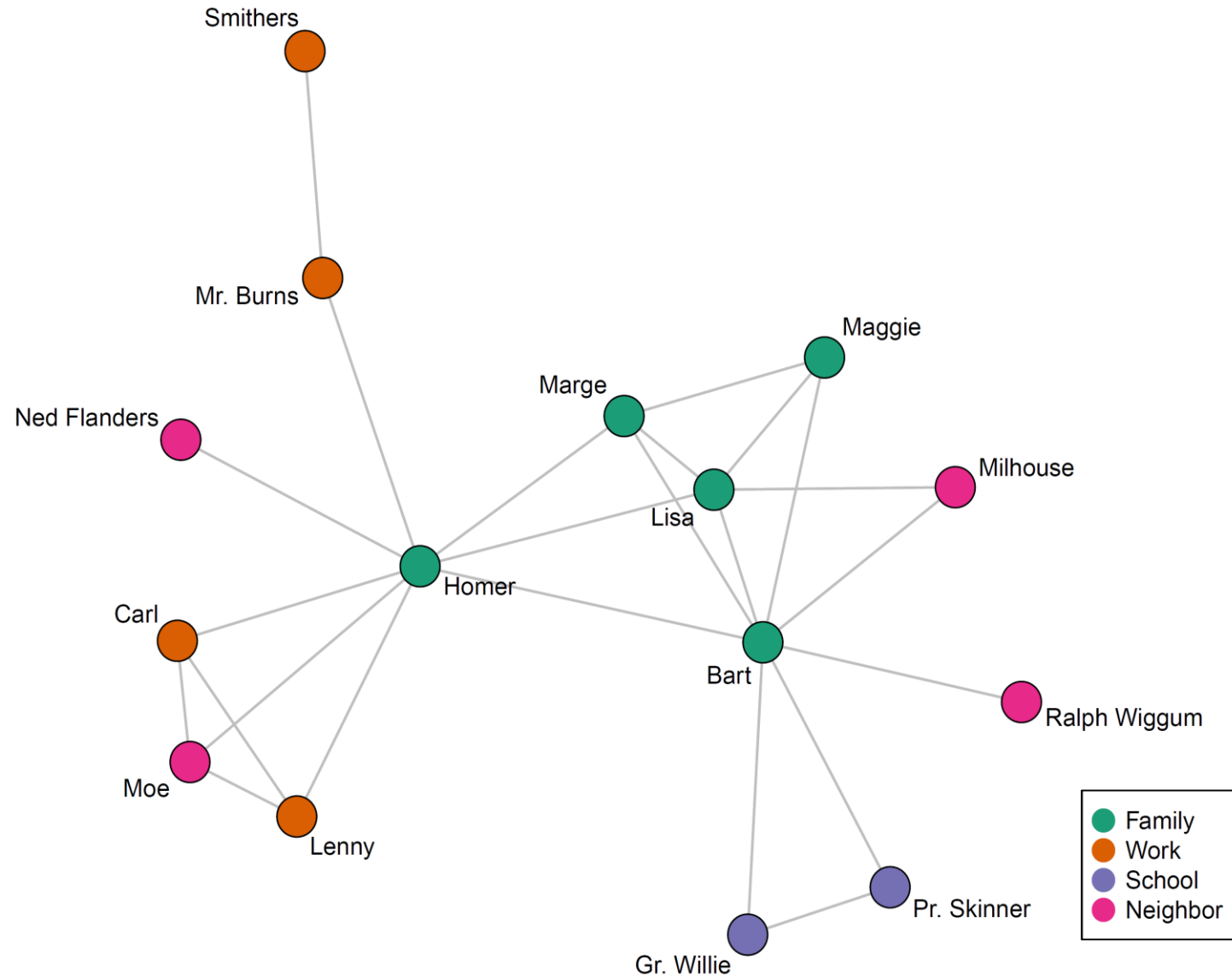


Prominence - centrality & prestige

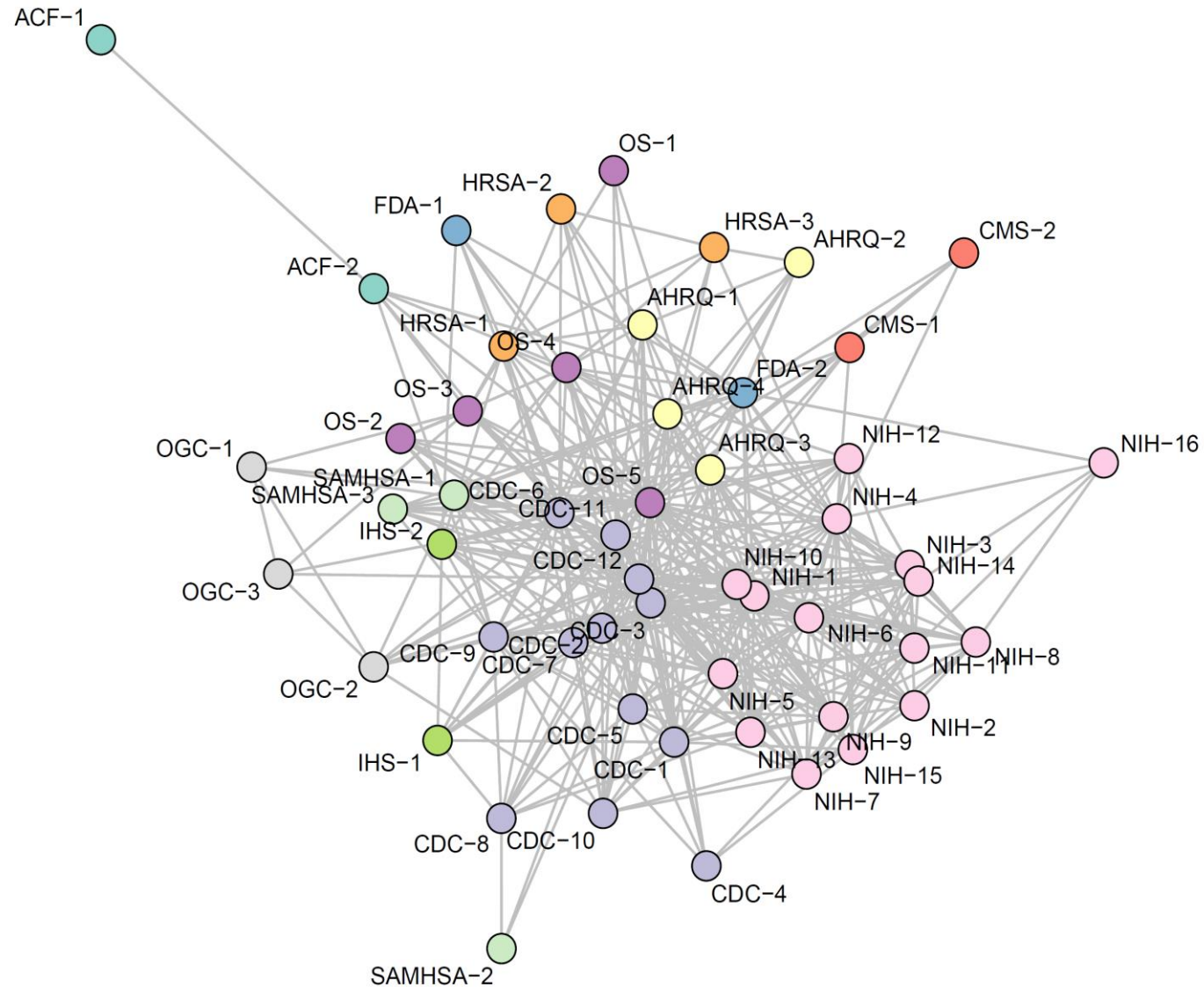
- An actor is *prominent* if the ties of the actor make that actor visible to the other actors in the network (Knoke & Burke, 1983).
 - Central actor - one involved in many ties (direct and indirect)
 - Prestigious actor - an actor who is the object of extensive ties
- Actor level measures and network level indices



Who is most prominent?



Now who is most prominent?



Definitions of Prominence

- Local vs. global conceptions of actor prominence
- Normalization (standardization) of prominence measures
 - Allows measures to be compared
 - Typically done so that the measures vary from 0 to 1



Centrality

Prominence for non-directed graphs



Centrality - node level characteristic

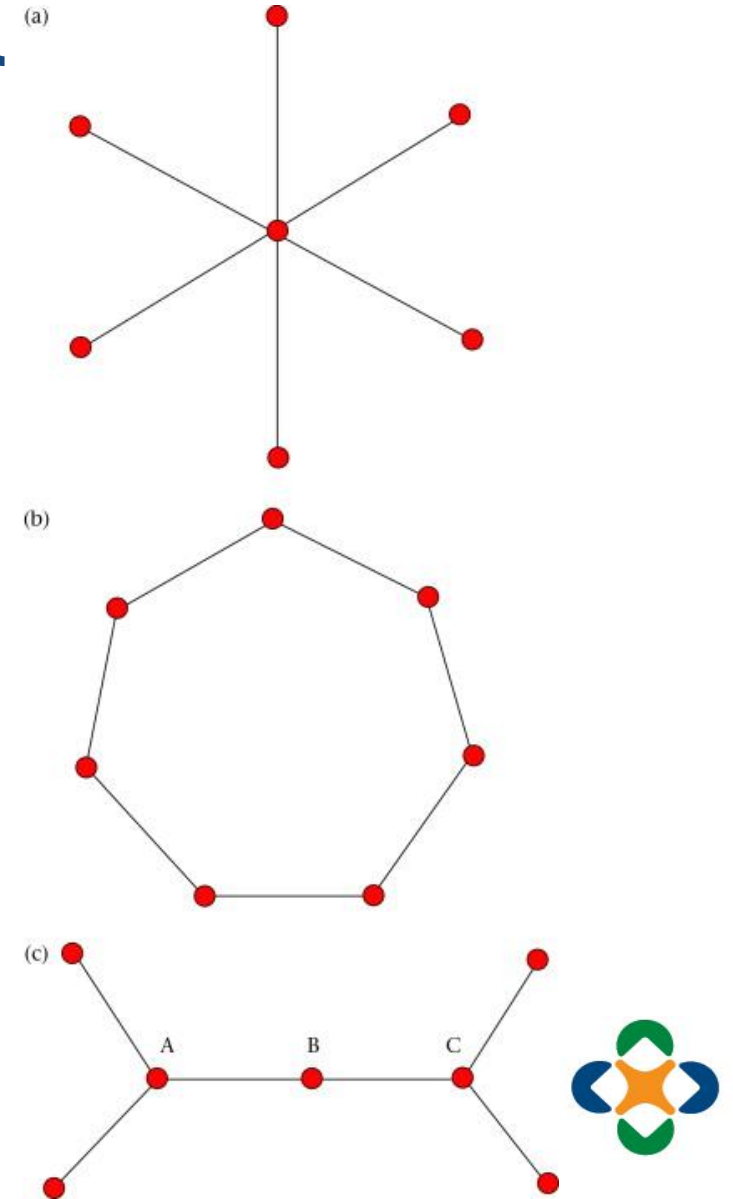
- For non-directed graphs, we talk about the *centrality* of individual nodes
- Can be defined in a number of ways
- Most common
 - Degree centrality
 - Closeness centrality
 - Betweenness centrality



Centralization - network level

- By definition, measures of prominence are node level characteristics
- Can examine the variability of centrality scores to come up with a network level measure of centrality variability - this is called *centralization*
 - Higher levels of centralization indicate a more hierarchical network structure
 - Centralization scores most useful in comparing different networks

<http://www.sciencedirect.com/science/article/pii/S0003347207004393>



Common measures of prominence

- Degree centrality -
 - degree of the node; number of ties
- Closeness centrality -
 - An actor is central if he or she is close to other actors; small distance between the actor and all other actors
 - Based on the inverse of the sum of the distances
- Betweenness centrality
 - An actor is central if it is involved with many communication/connection paths in a network, the person 'in the middle'
 - More specifically, an actor is central if it lies between other actors on their geodesics



Degree centrality

- Prominent actors are directly connected to many other actors
- Simply equal to the degree of the node
- A local measure of centrality (only looks at direct ties)
- Group degree centralization
 - Dispersion index (W&F 5.5)
 - Variance index (W&F 5.6)

$$C_D = d(n_i)$$



Closeness centrality

- Prominent actors are close to all other actors in the network
- A global measure of centrality

$$C_C(n_i) = \left[\sum_{j=1}^g d(n_i, n_j) \right]^{-1}$$

- Where $d(n_i, n_j)$ is the distance of the geodesic between two actors
- Closeness centralization measures variability of individual node-level closeness centrality scores



Betweenness centrality

- Prominent actors are involved in (*i.e.*, between) interaction of other pairs of actors
- Importance of geodesics
- A global measure of centrality
- Often interpreted as control over communication or information flow

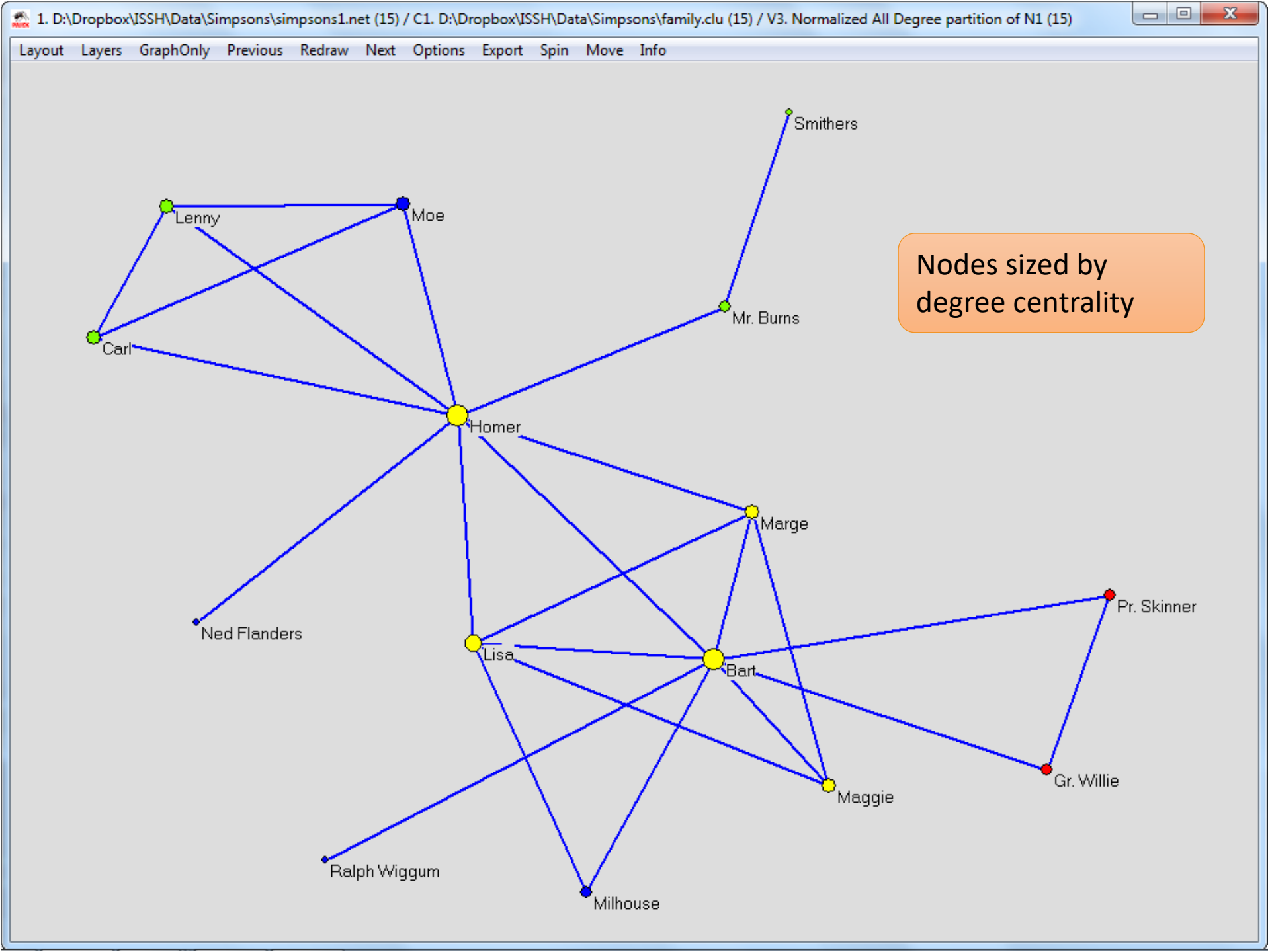
$$C_B(n_i) = \sum_{j < k} g_{jk}(n_i) / g_{jk}$$

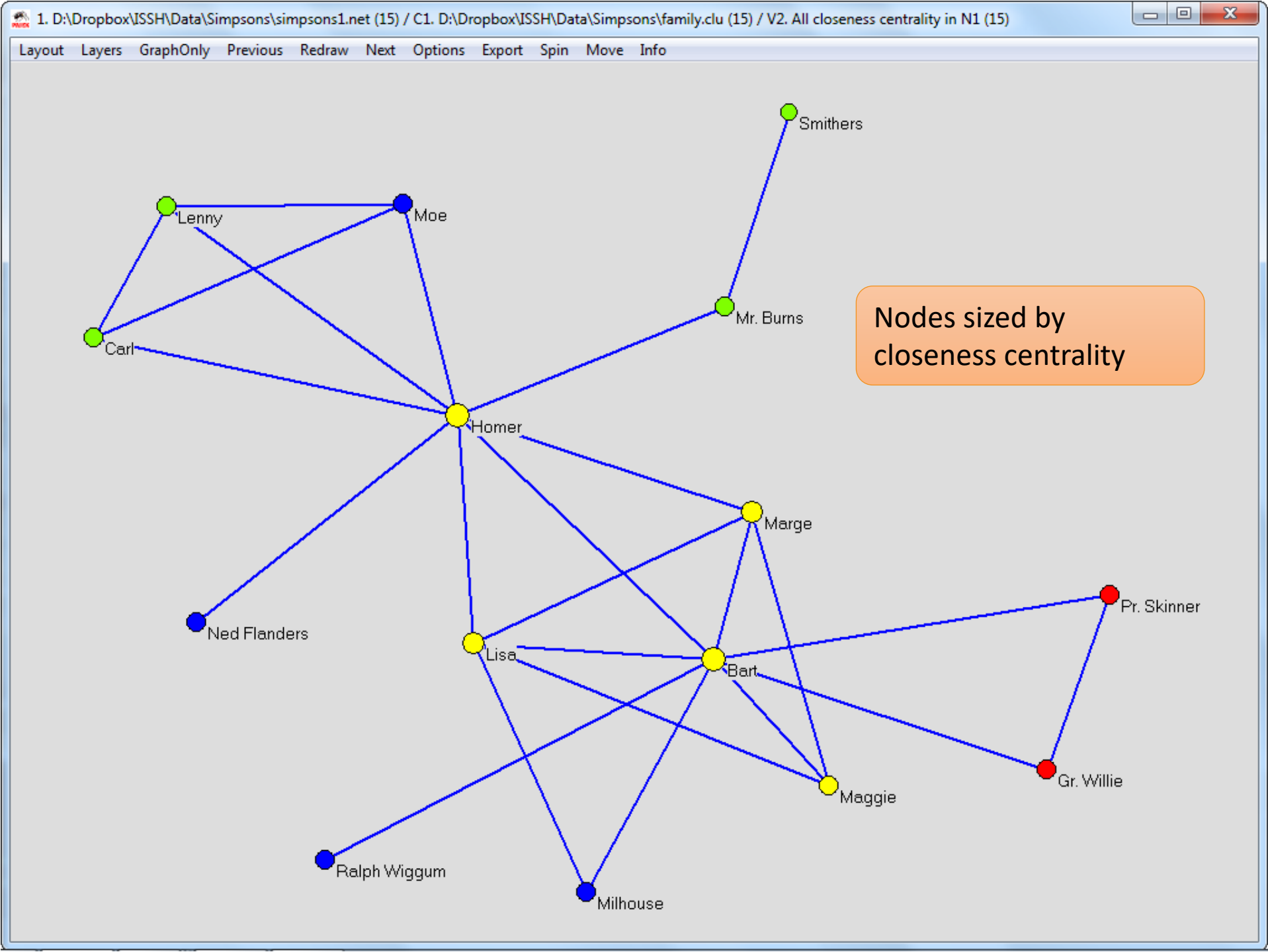


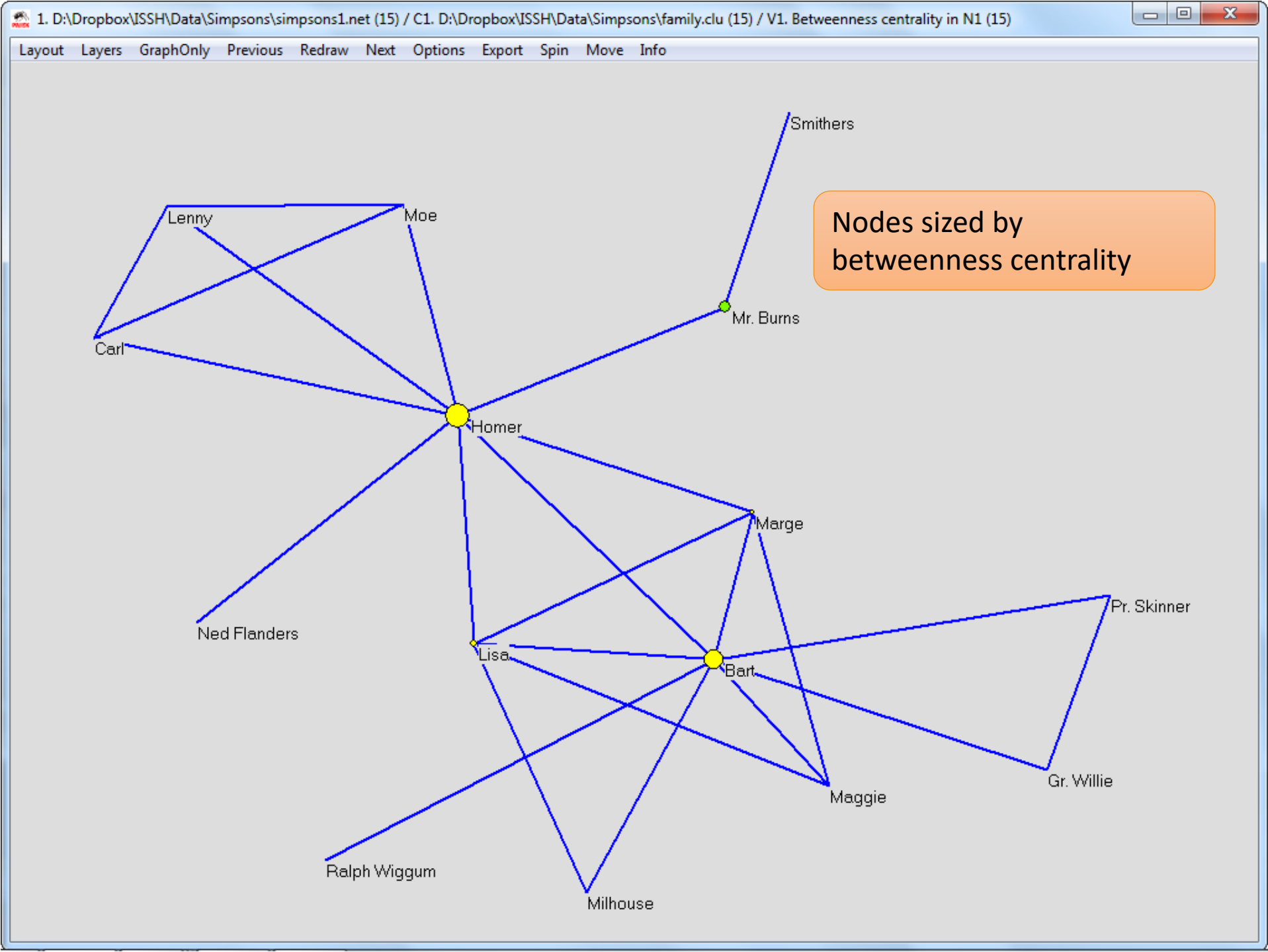
Simpsons' prominence

Actor	Degree	Closeness	Betweenness
Homer	8	.70	.65
Marge	4	.56	.02
Bart	8	.67	.46
Lisa	5	.58	.08
Maggie	3	.44	.00
Mr. Burns	2	.45	.14
Smithers	1	.32	.00
Pr. Skinner	2	.42	.00
Gr. Willie	2	.42	.00
Carl	3	.45	.00
Lenny	3	.45	.00
Moe	3	.45	.00
Milhouse	2	.42	.00
Ralph Wiggum	1	.41	.00
Ned Flanders	1	.42	.00
Centralization	0.40	0.49	0.60

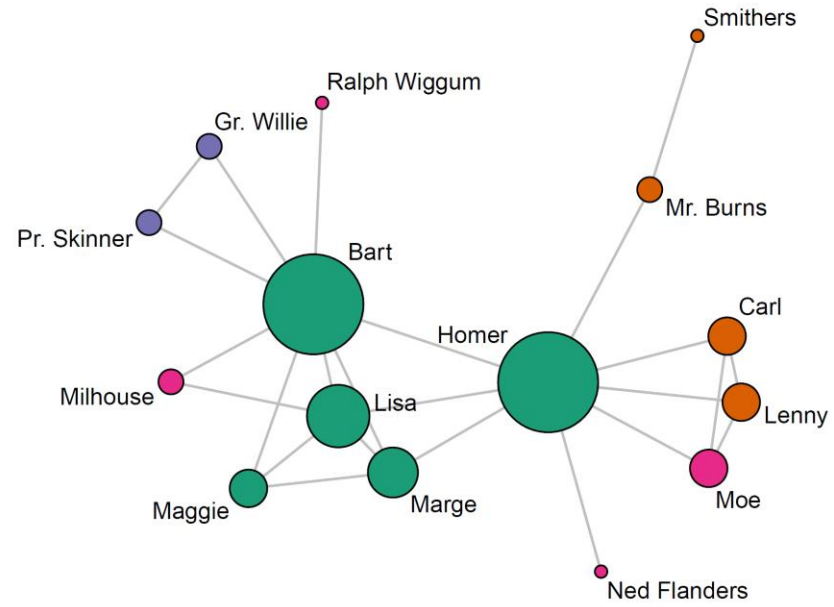




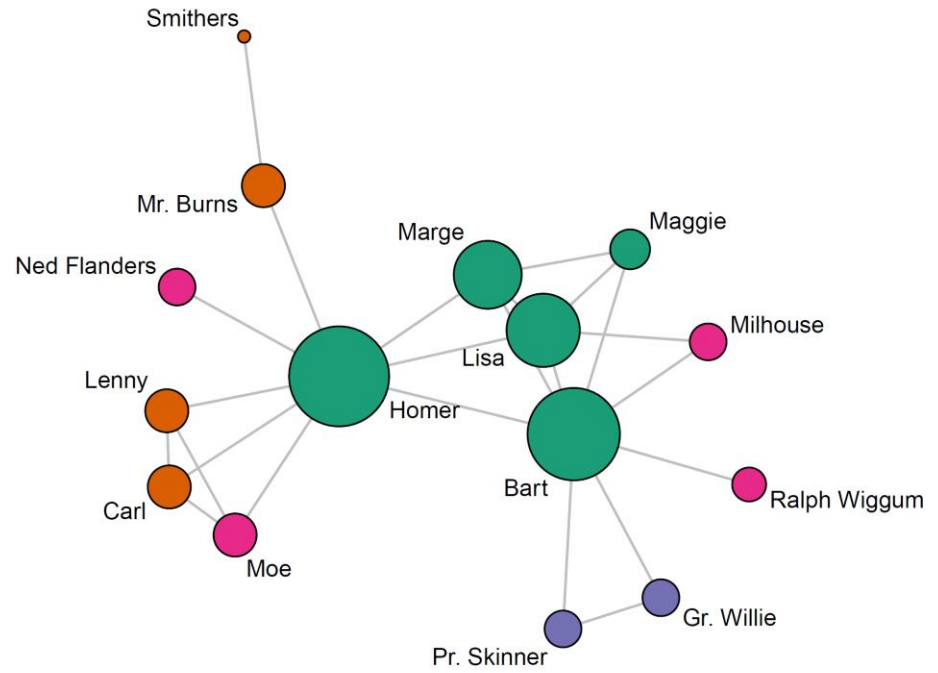




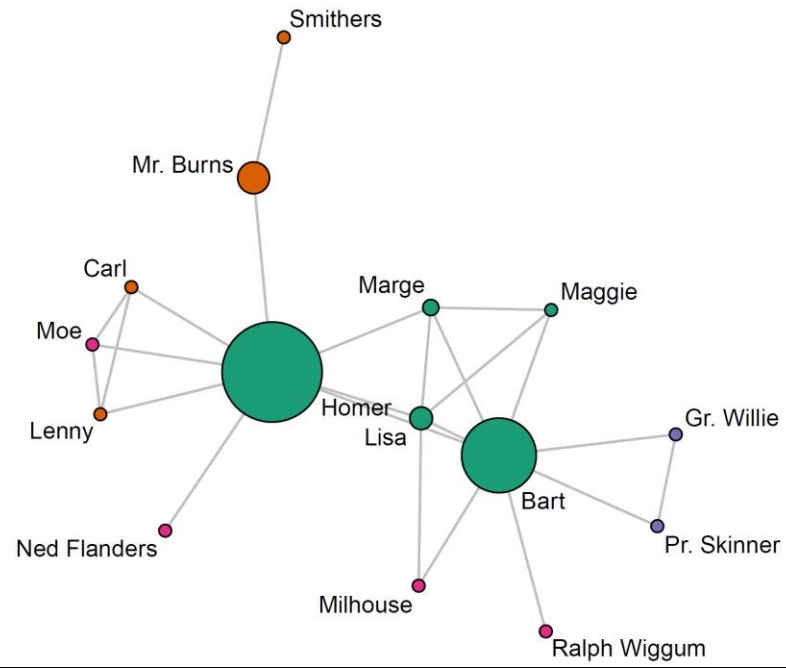
Degree



Closeness



Betweenness



Other centrality measures

- Information centrality - use all paths (weighted by path length) to calculate betweenness, instead of just the geodesics
- Flow betweenness - based on concept of information flow. Particularly useful for valued graphs. (Also see Borgatti, 2005, for a sophisticated discussion of flow concepts and centrality.)
 - Interesting paper based on this concept: <http://www.axonpotential.com/the-new-soccer-metric-flow-centrality/>
- Eigenvector centrality - global measure of centrality based on factor analysis of the sociomatrix
- PageRank - recursive measure of prominence which depends on the number and PageRank metric of all pages that link to it ("incoming links").

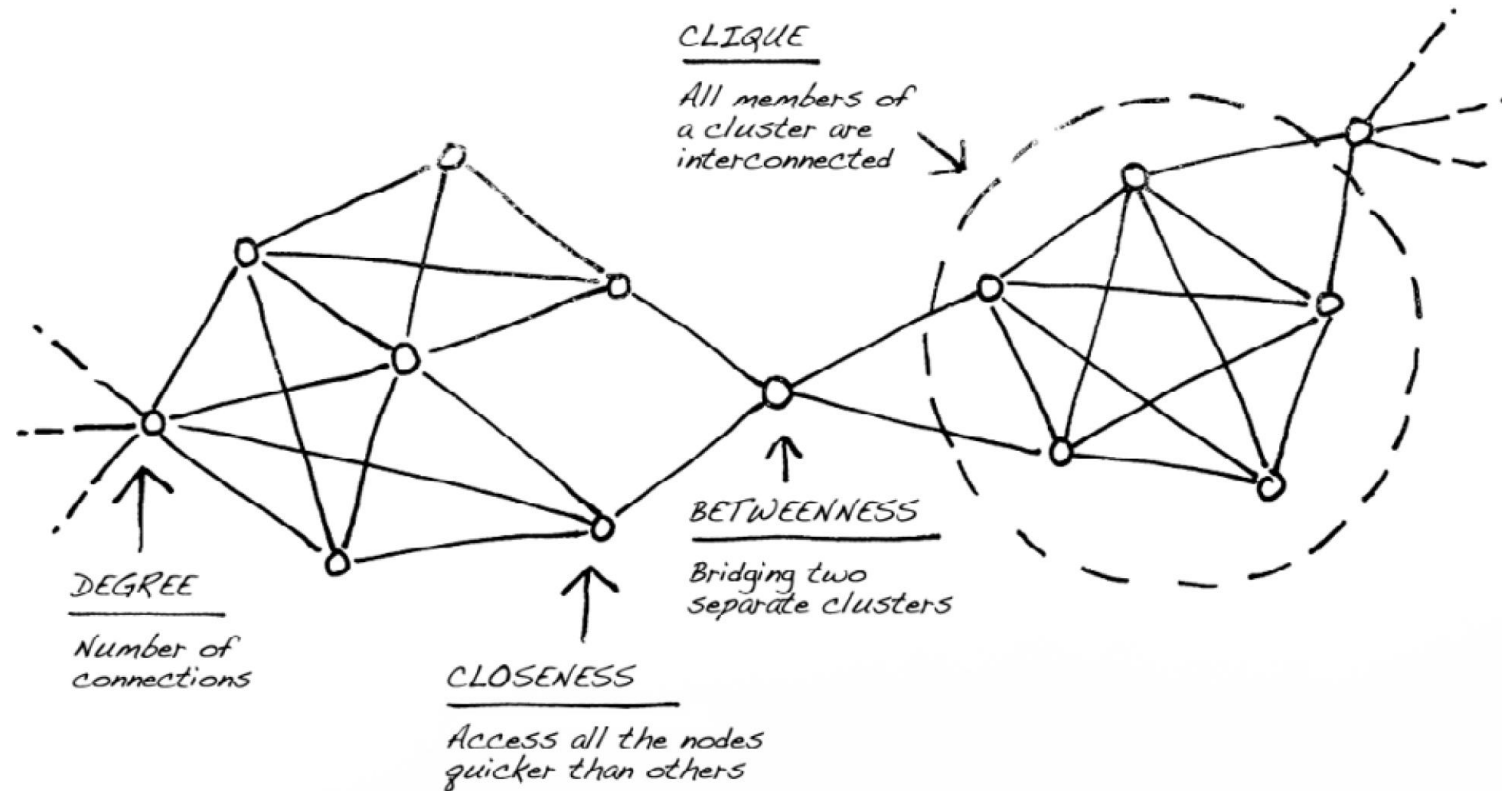


Thinking about centrality

- How to choose appropriate centrality measure
 - Think carefully about the meaning of the tie in the network, and what you think prominence should be for that network
 - See Borgatti (2005) for a good example of this
- Recent work and extensions
 - Extending concepts of centrality to groups of actors (Everett & Borgatti, 2005; Newman, 2006)
 - Random walk model of centrality (Newman, 2005)

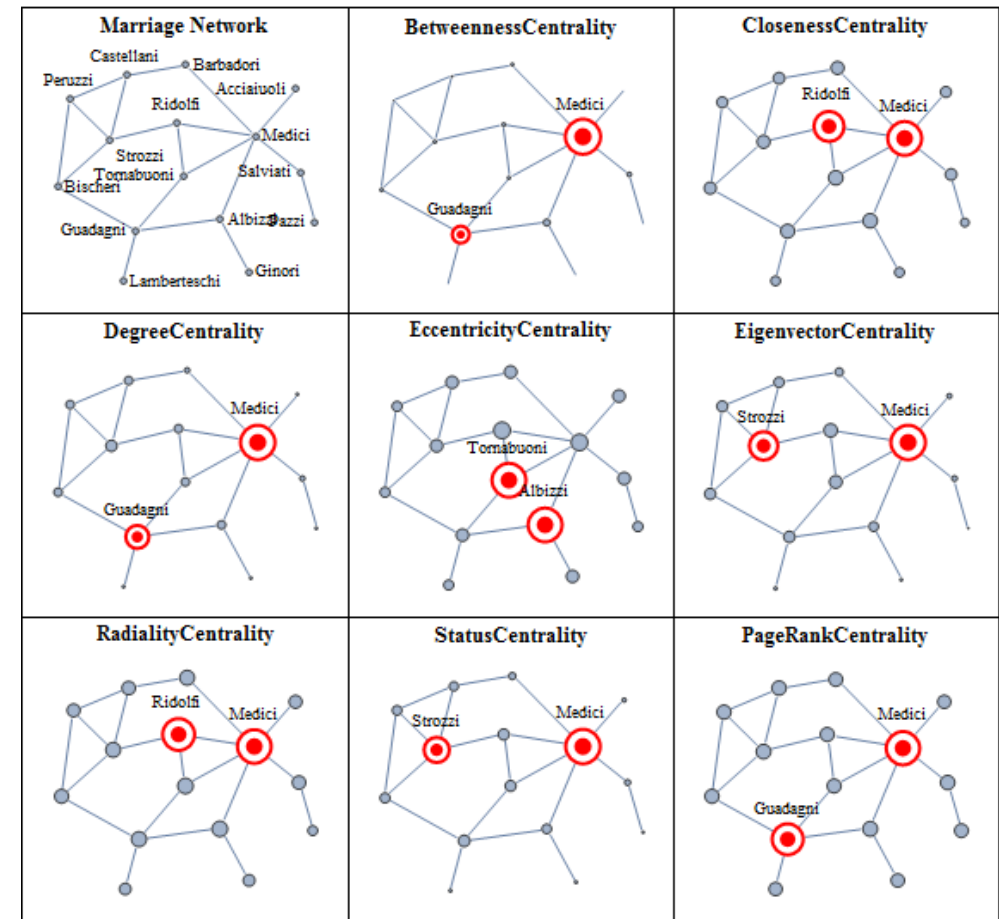
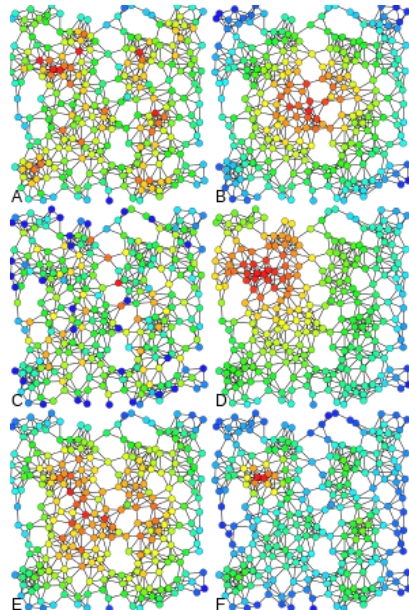


Prominence is a property of individual nodes, but must be interpreted within the context of overall network structure

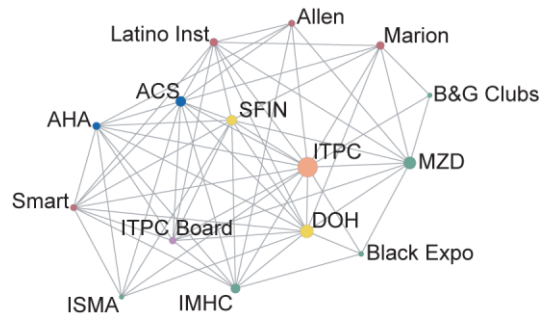


Comparing measures of centrality

- Each measure of centrality will give different types of information about prominence
 - See <http://en.wikipedia.org/wiki/Centrality>

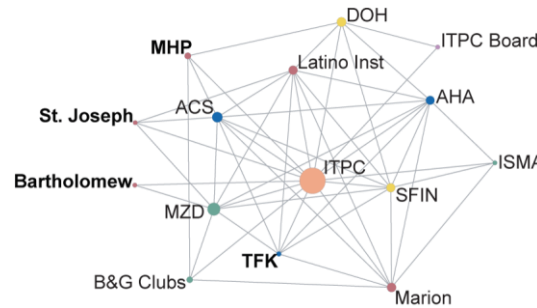


Example of Prominence: Change in Indiana Tobacco Control Program after cuts in funding



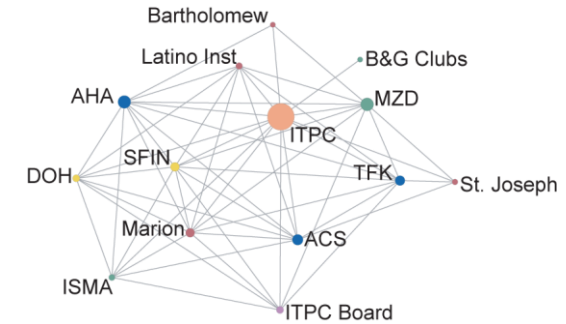
FY03

Stability	--
Density	0.61
Betweenness	0.14



FY04

Stability	--	73%
Density	▼	0.48
Betweenness	▲	0.30



FY05

Stability	▲	97%
Density	▲	0.59
Betweenness	▼	0.23

\$33.8M Tobacco Control Funding

\$850M State Budget Deficit

\$595M State Budget Deficit

\$300M State Budget Deficit

\$18.2M Tobacco Control Funding

\$12.4M Tobacco Control Funding



Prestige

Prominence for directed graphs



Prominence for directed graphs

- Basic idea is the same (want to understand the importance of individual nodes based on their location and ties)
- For directed graphs, prominence = prestige
 - Actors are prestigious to the extent that they are the object of choices from other actors



Degree prestige

- Simply count the indegrees for each node
- Indegrees reflect direct choices
- Local measure of prestige

$$P_D(n_i) = d_I(n_i)$$



Proximity prestige

- Extends degree prestige to include indirect choices
 - *Influence domain* of an actor is the set of actors who directly and indirectly choose the actor (called input domain in Pajek)
 - Can restrict the influence domain to a certain distance (e.g., two steps)
- The proximity prestige of a node is the proportion of all vertices in its influence domain divided by the mean distance from all nodes in its influence domain
- Global measure of prestige

$$P_P = \frac{I_i / (g - 1)}{\sum d(n_j, n_i) / I_i}$$



Tips

- Always examine prominence
- Use multiple centrality measures, compare to one another
- Use centrality scores to size nodes in network graphics
- Pick appropriate centrality measure for research purpose

