INTRODUCTION TO RANDOM NETWORKS ANALYSIS

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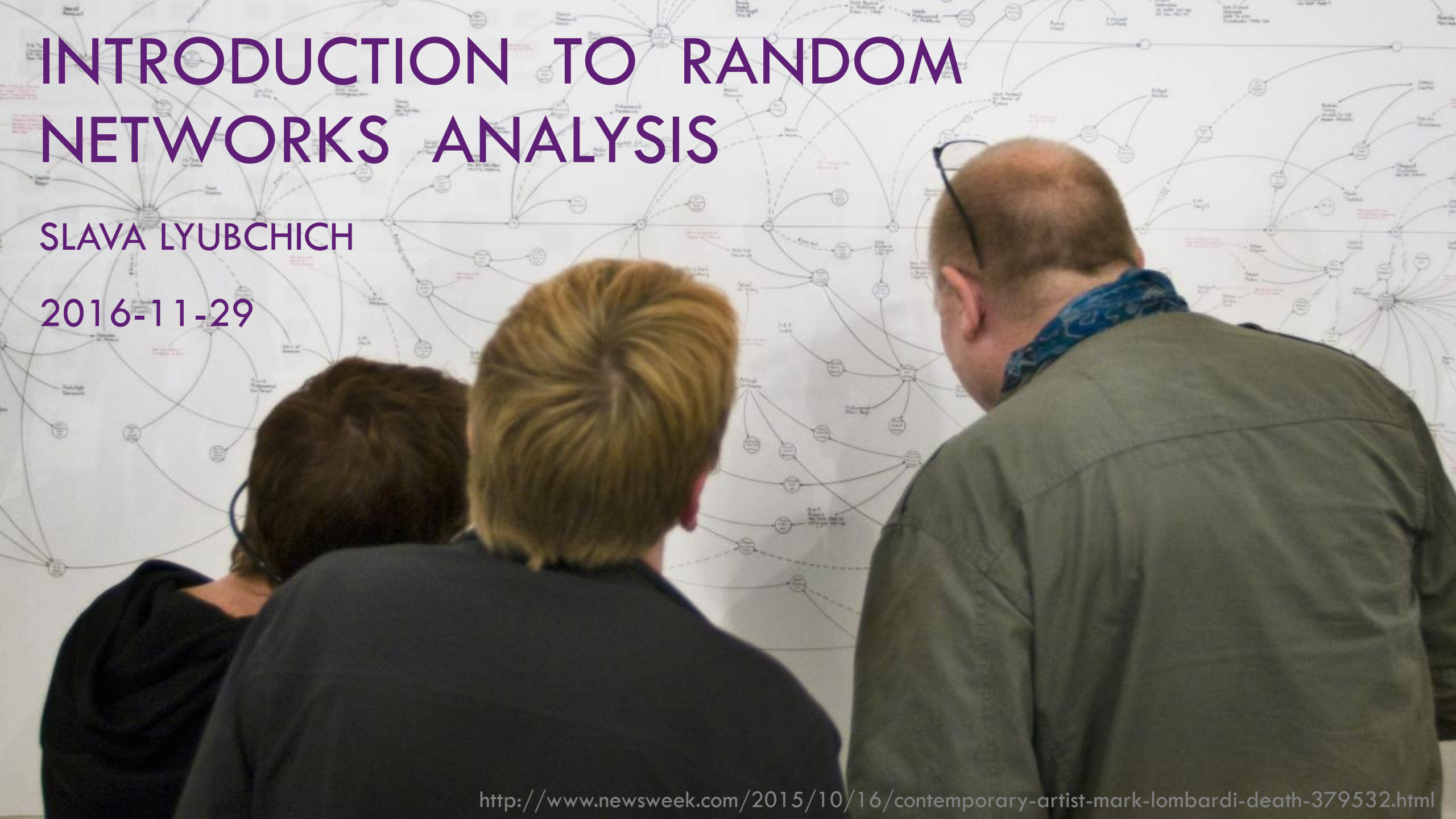
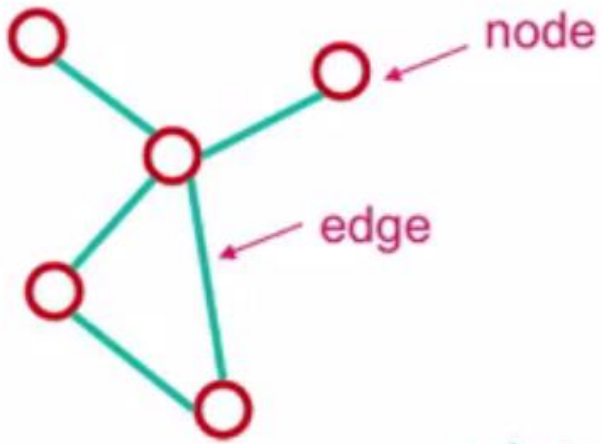
2016-11-29



http://www.newsweek.com/2015/10/16/contemporary-artist-mark-lombardi-death-379532.html

- Networks are sets of nodes connected by edges.

"Network" ≡ "Graph"

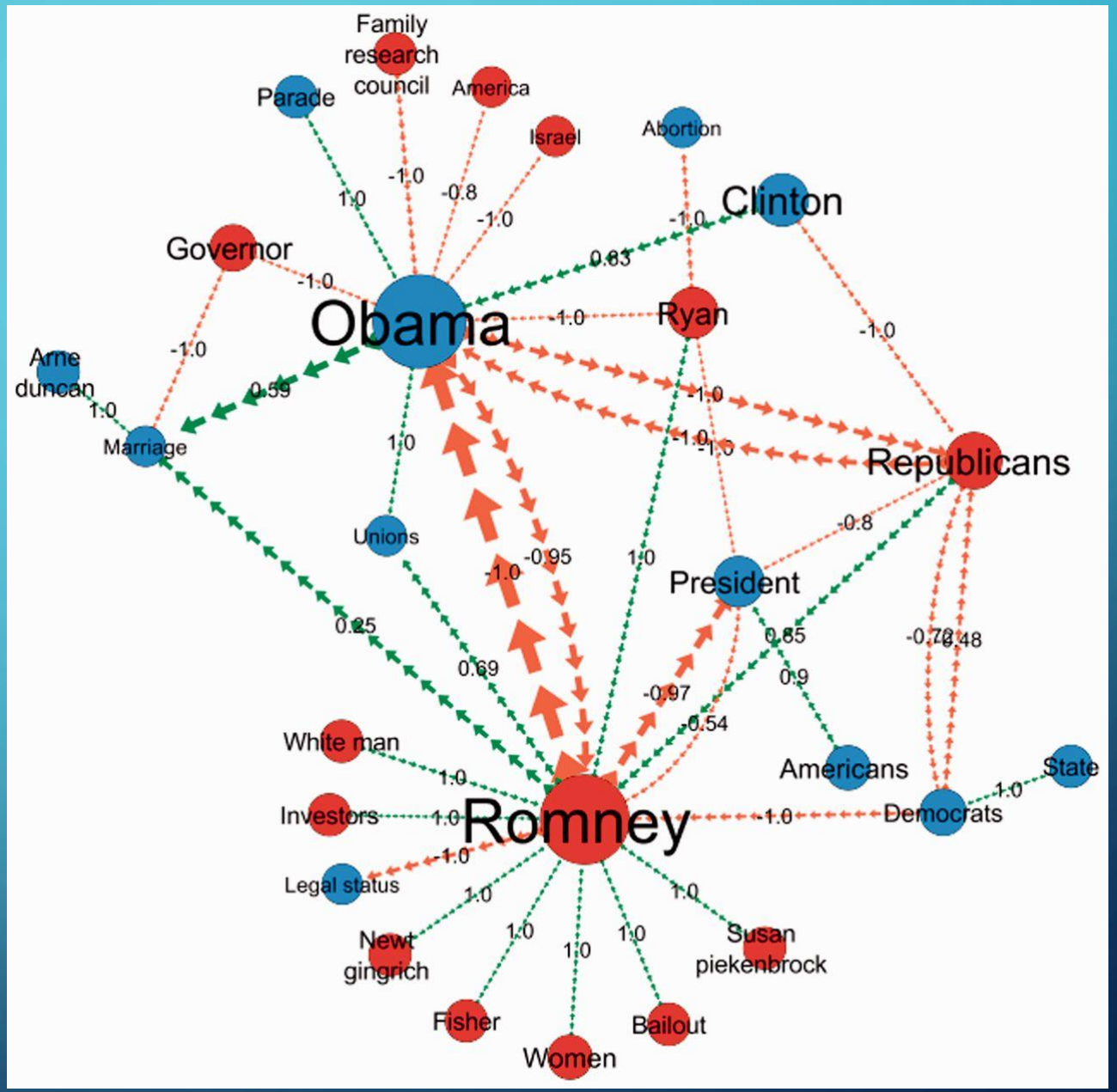


points	lines	
vertices	edges, arcs	math
nodes	links	computer science
sites	bonds	physics
actors	ties, relations	sociology

Source: Lada Adamic's presentation slides.

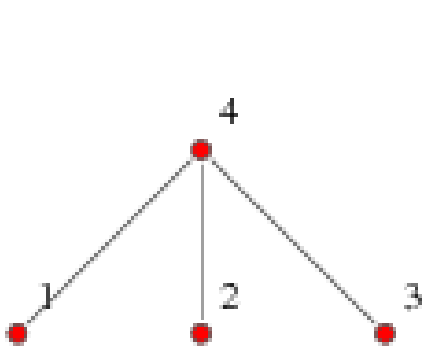
A SUBSET OF THE ELECTION NETWORK

(directed)

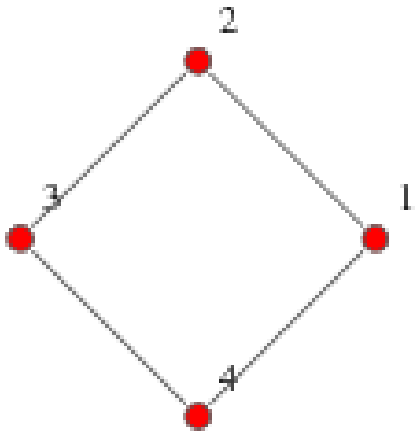


DOI: 10.1177/2053951715572916, Mar 2015

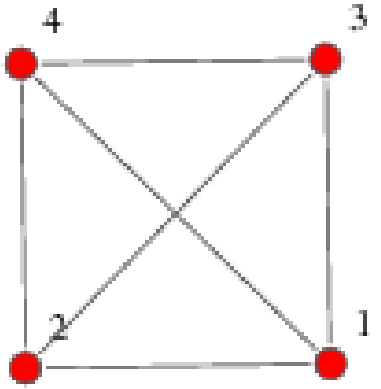
ADJACENCY MATRIX



$$\begin{pmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{pmatrix}$$



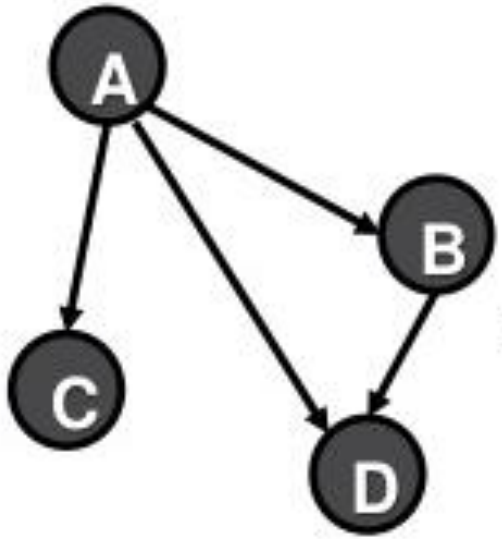
$$\begin{pmatrix} 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 \end{pmatrix}$$



$$\begin{pmatrix} 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{pmatrix}$$

ALTERNATIVE REPRESENTATIONS

Graph



Edge List

A	B
A	C
A	D
B	D

Adjacency Matrix

	A	B	C	D
A	-	1	1	1
B	0	-	0	1
C	0	0	-	0
D	0	0	0	-

Adjacency List

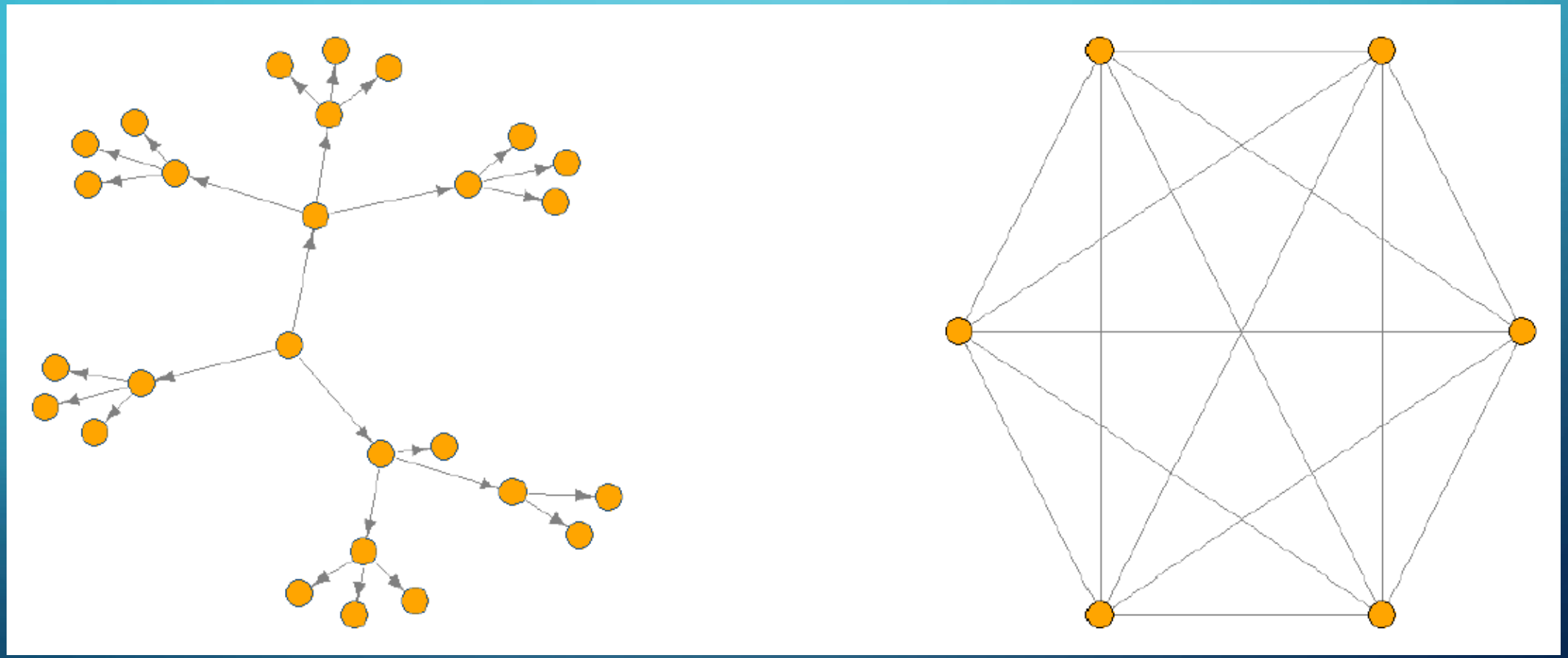
A	B, C, D
B	D

XML

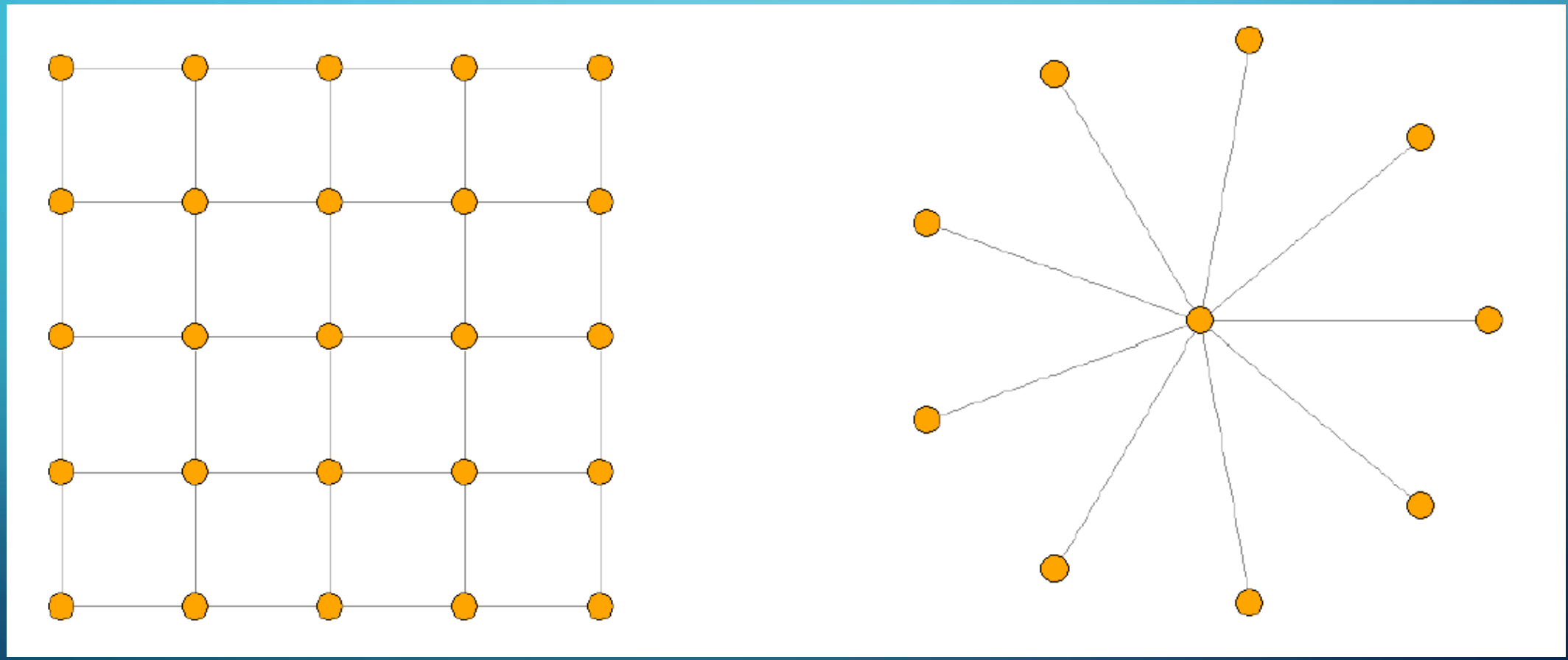
```
<Node>
    <Label>A</Label>
    <Connection>B</Connection>
    <Connection>C</Connection>
    <Connection>D</Connection>
</Node>
<Node>
    <Label>B</Label>
    <Connection>D</Connection>
</Node>
```

http://www.slideshare.net/daveking63/mining-and-analyzing-social-media-part-1-hicss47-tutorial-dave-king

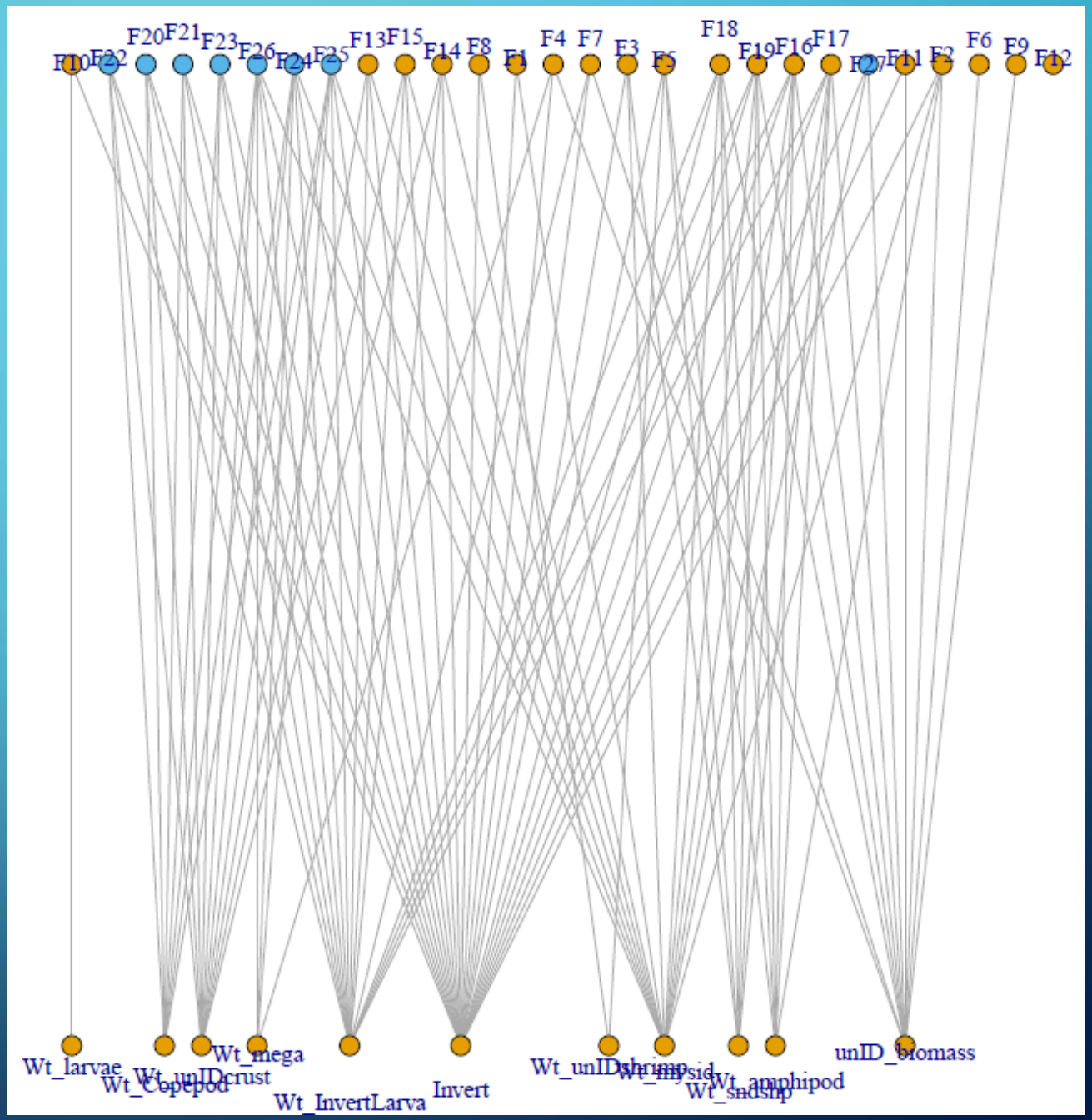
STANDARD STRUCTURES (TREE AND CLIQUE)



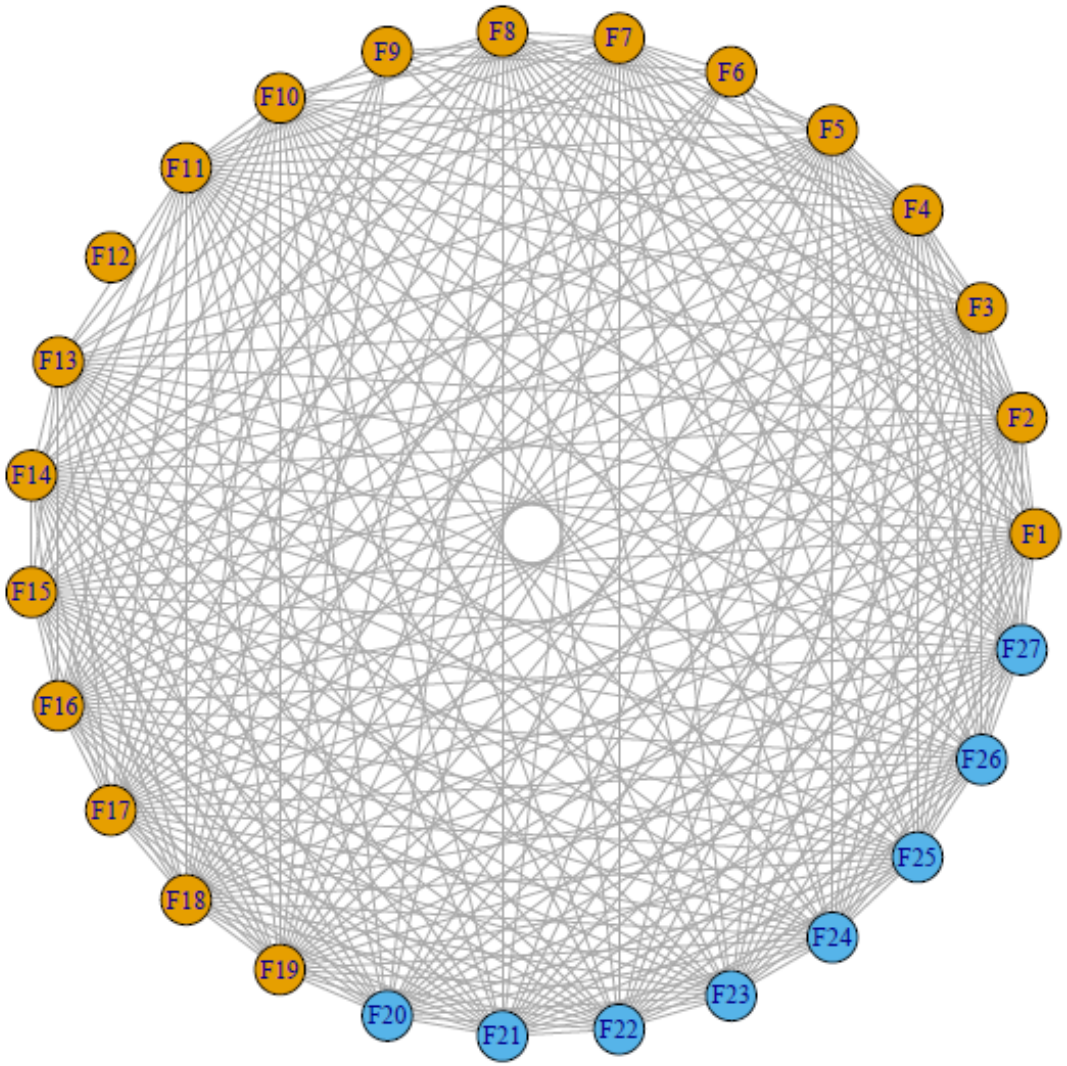
STANDARD STRUCTURES (LATTICE AND STAR)

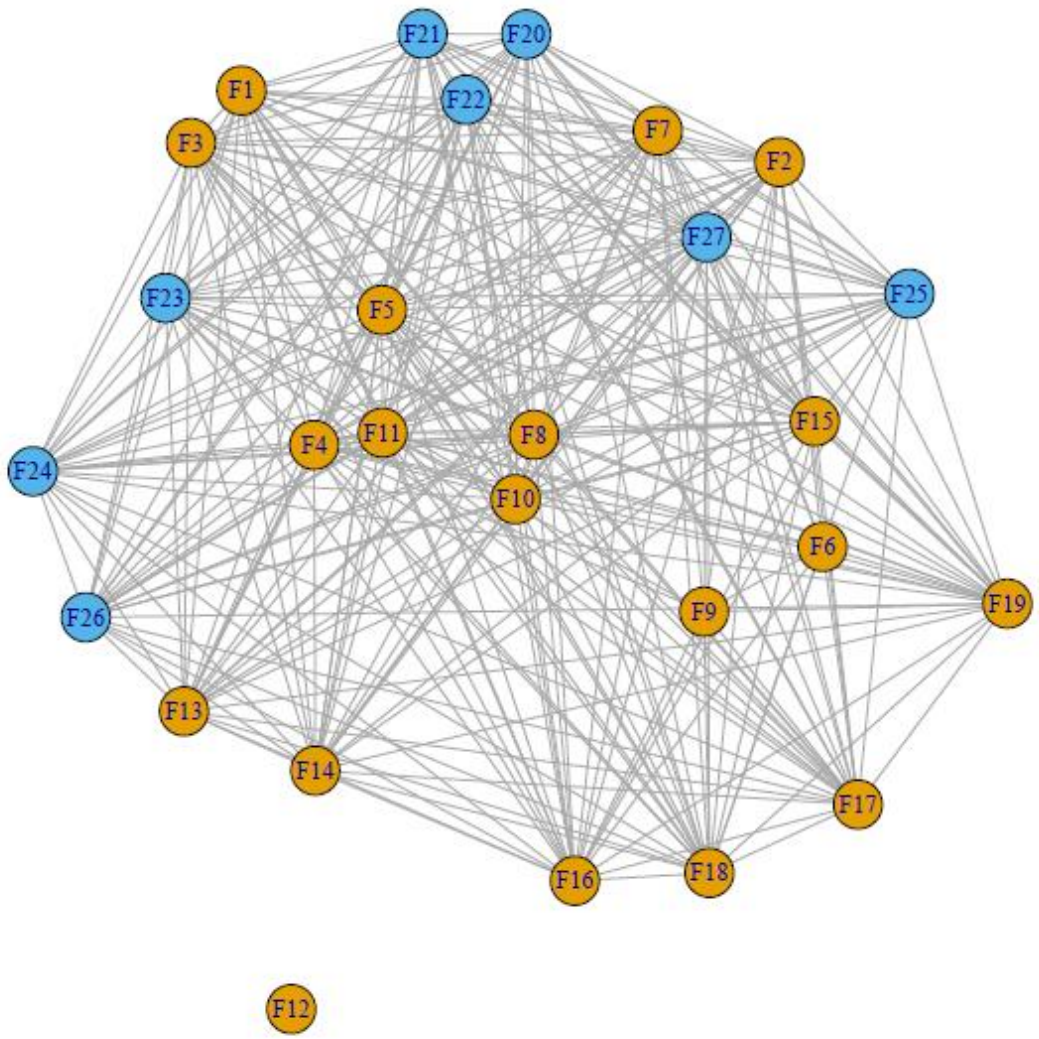


BIPARTITE GRAPH

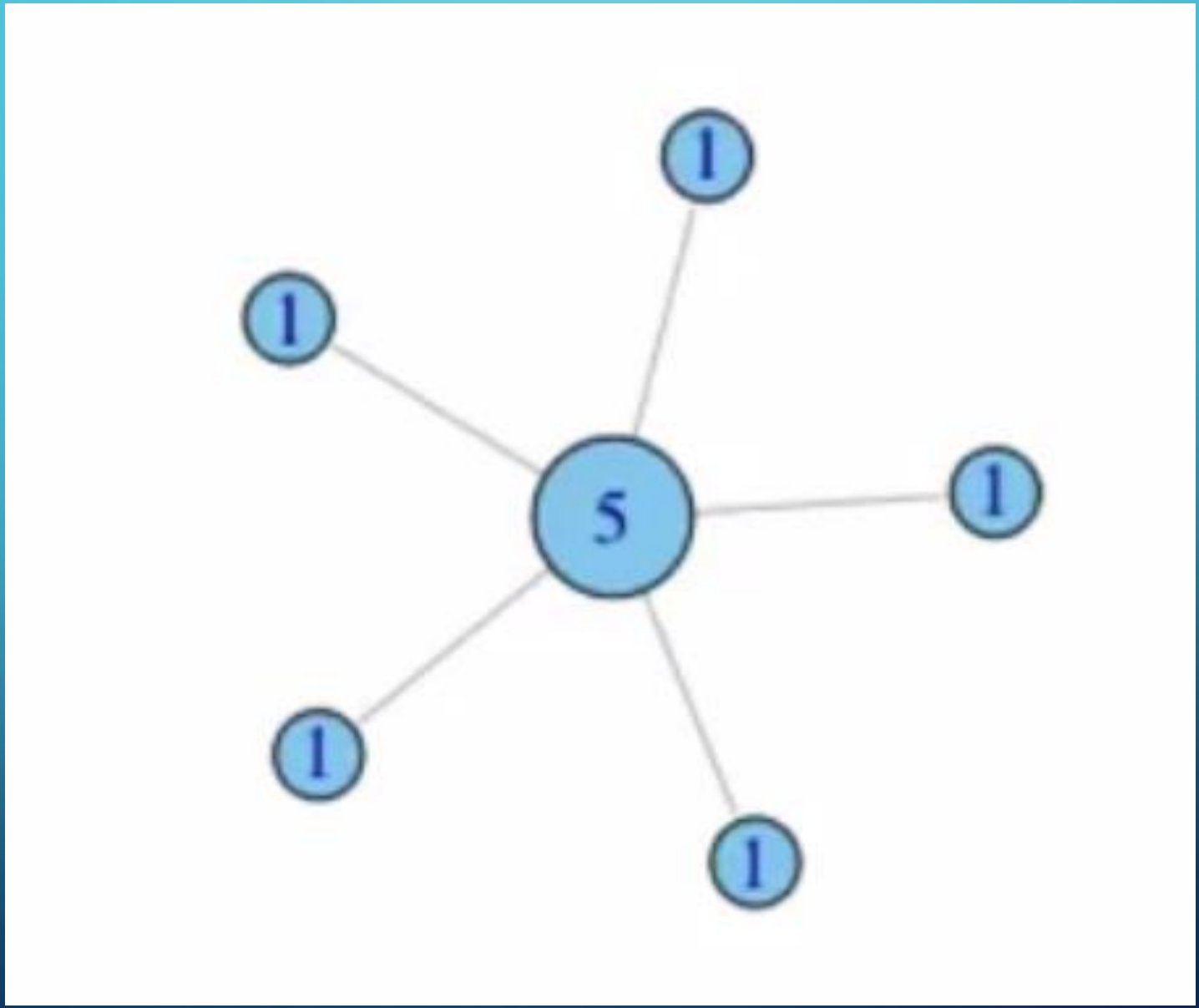


DIFFERENT LAYOUTS (AFFILIATION GRAPH)

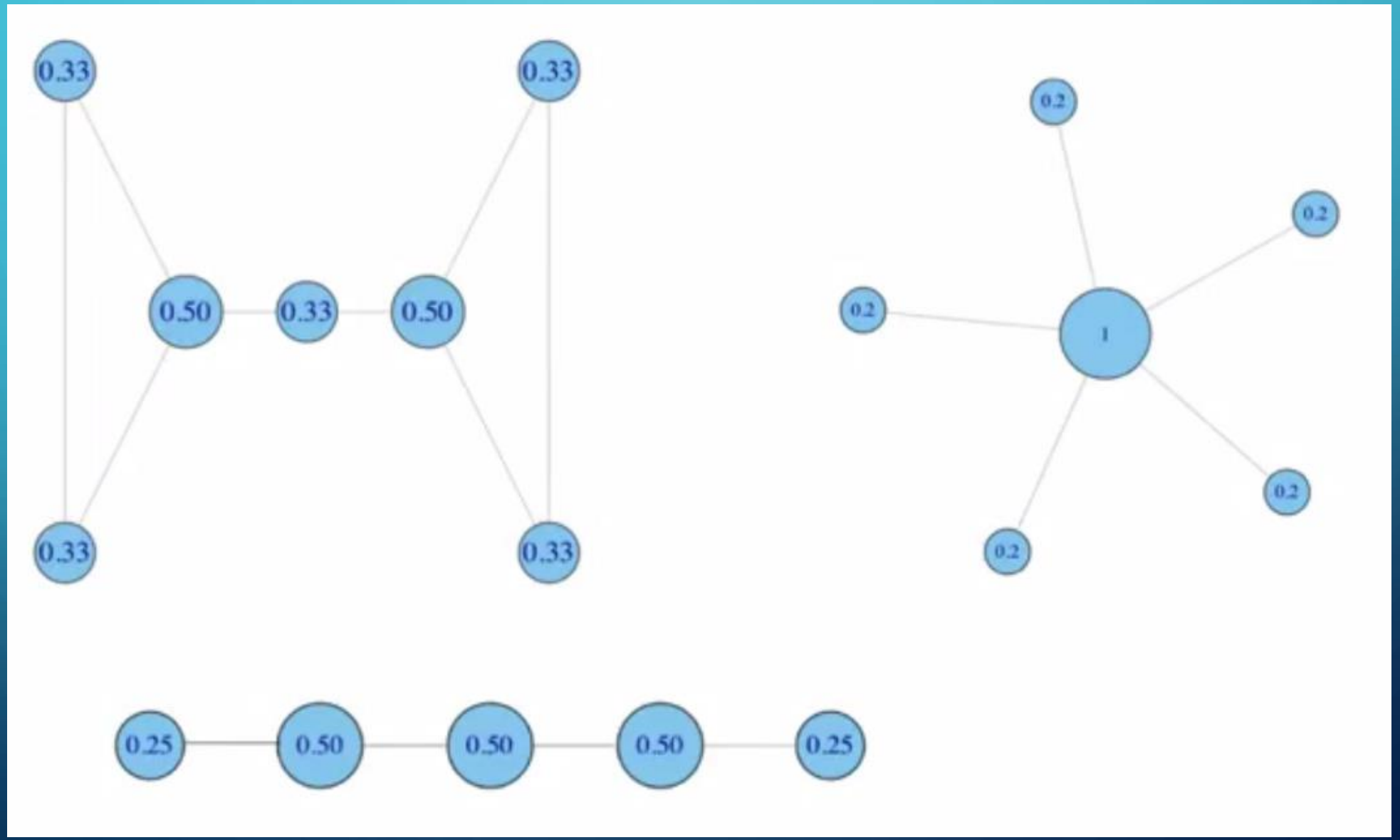




NODE CENTRALITY (DEGREE CENTRALITY)



NORMALIZE BY THE MAX POSSIBLE, I.E., (N-1)

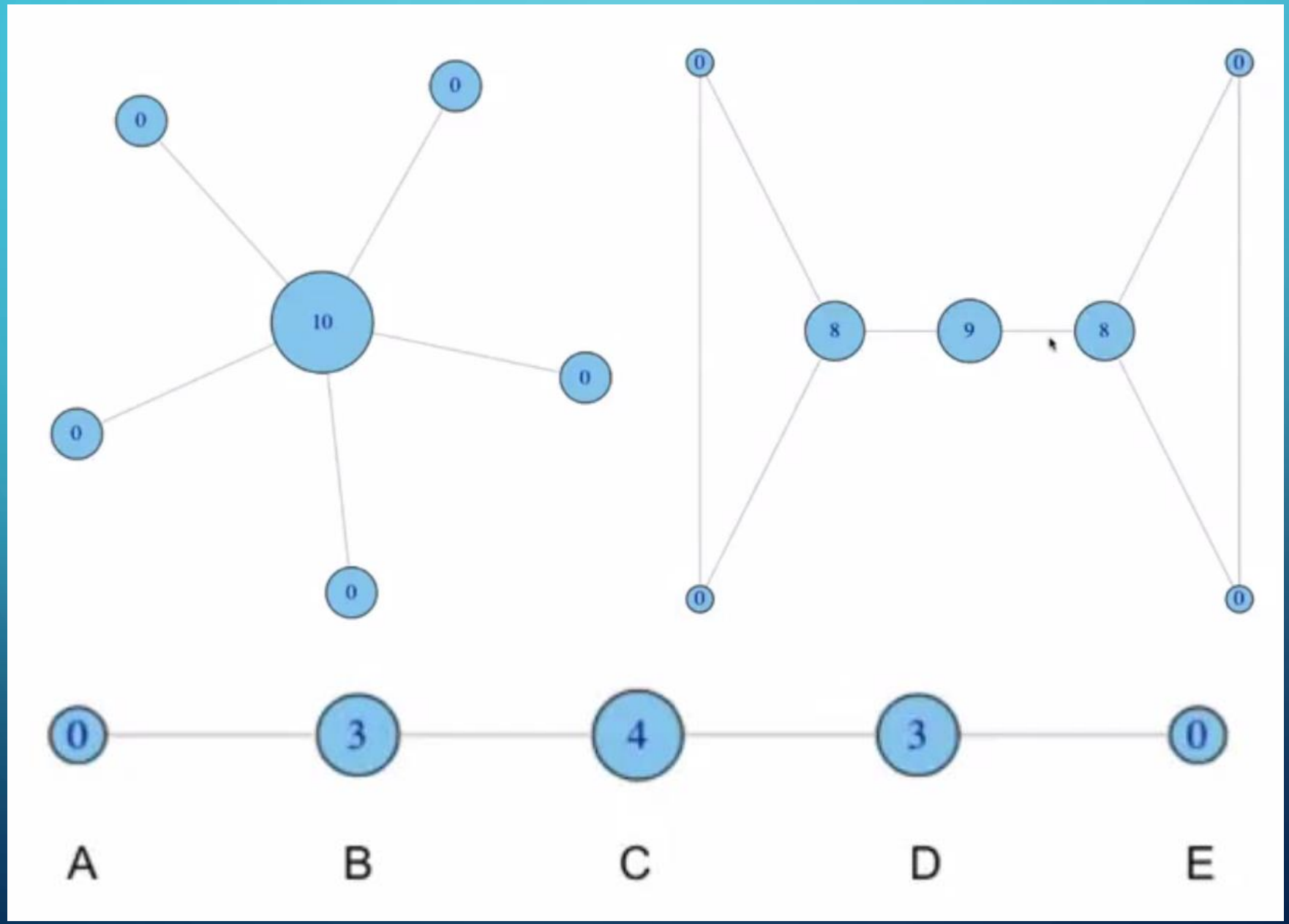


BETWEENNESS CENTRALITY

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

Where g_{jk} = the number of shortest paths connecting *jk*
$g_{jk}(i)$ = the number that actor *i* is on.

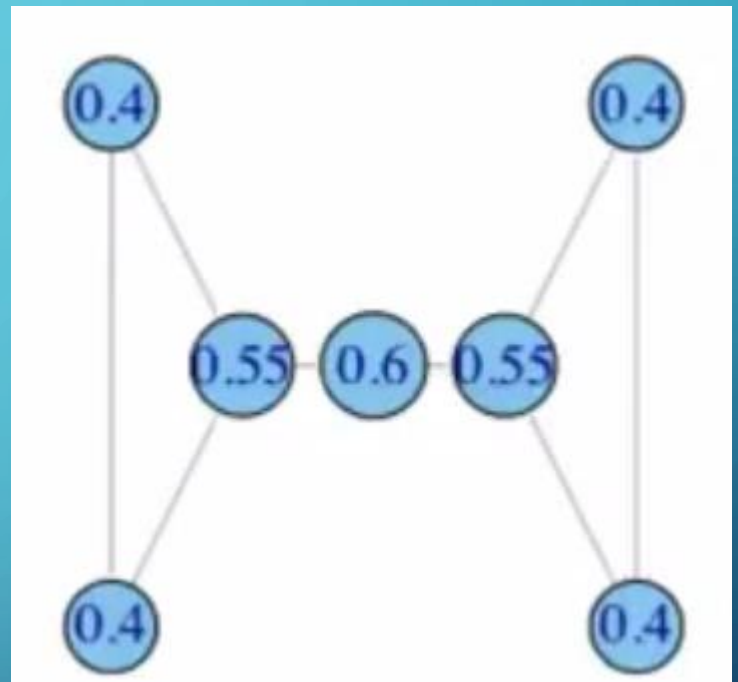
BETWEENNESS

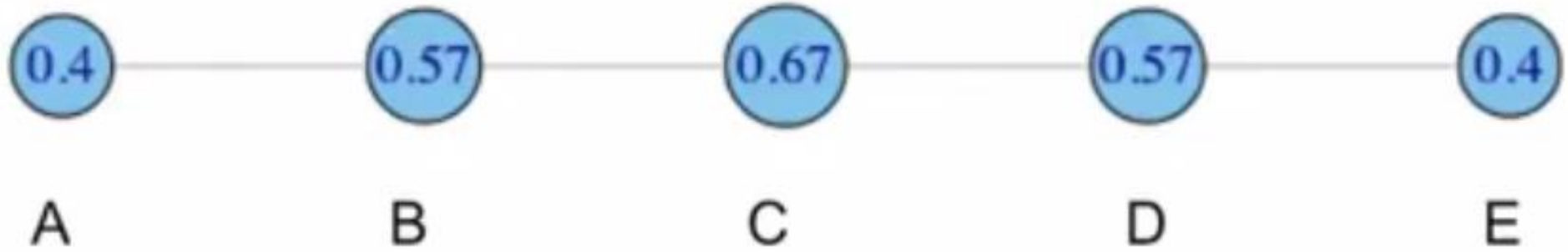


CLOSENESS

- Based on the average shortest path between a node and all other nodes in the network

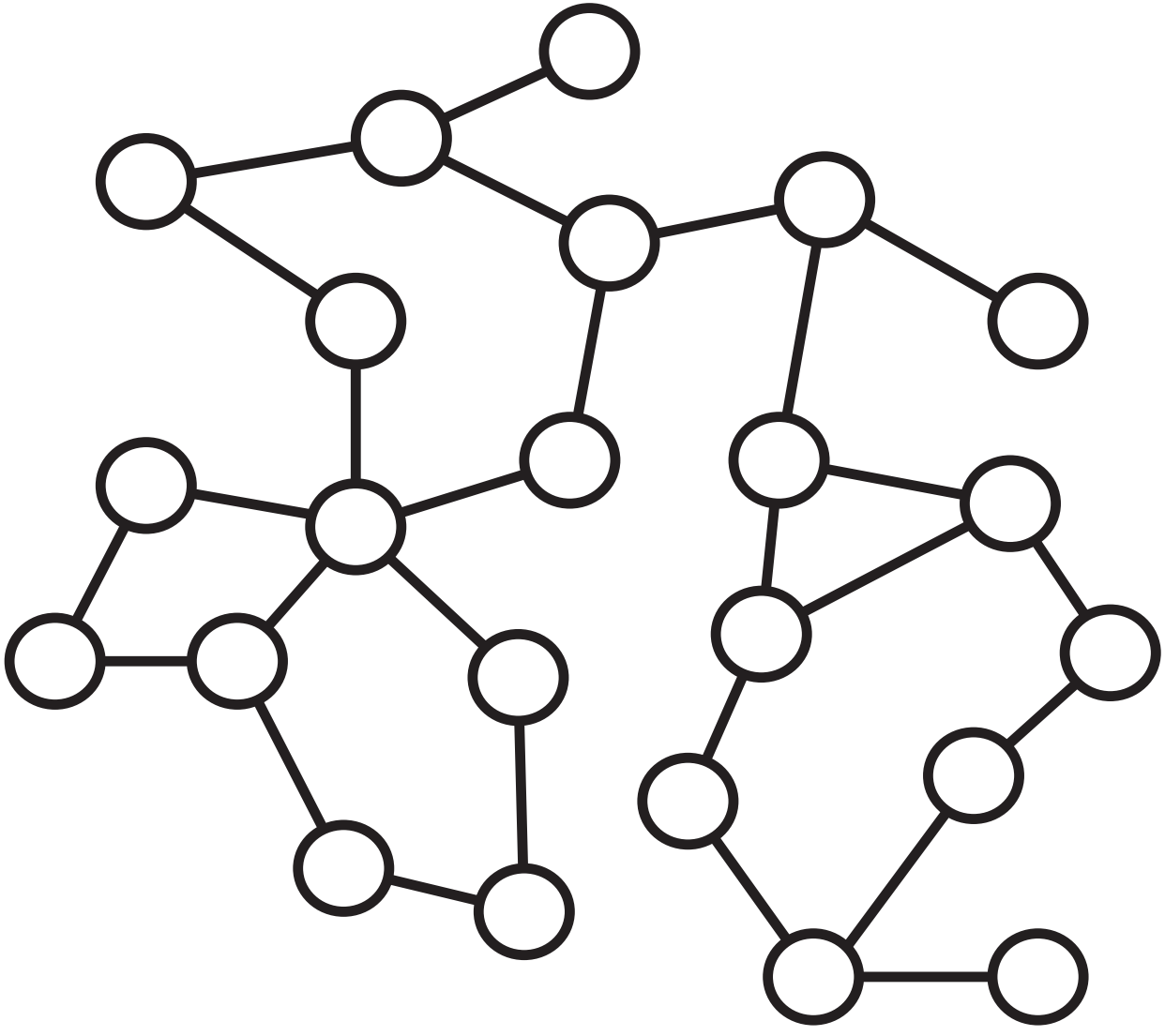
$$C_c(i) = \left[\sum_{j=1}^{N} d(i,j)\right]^{-1}$$



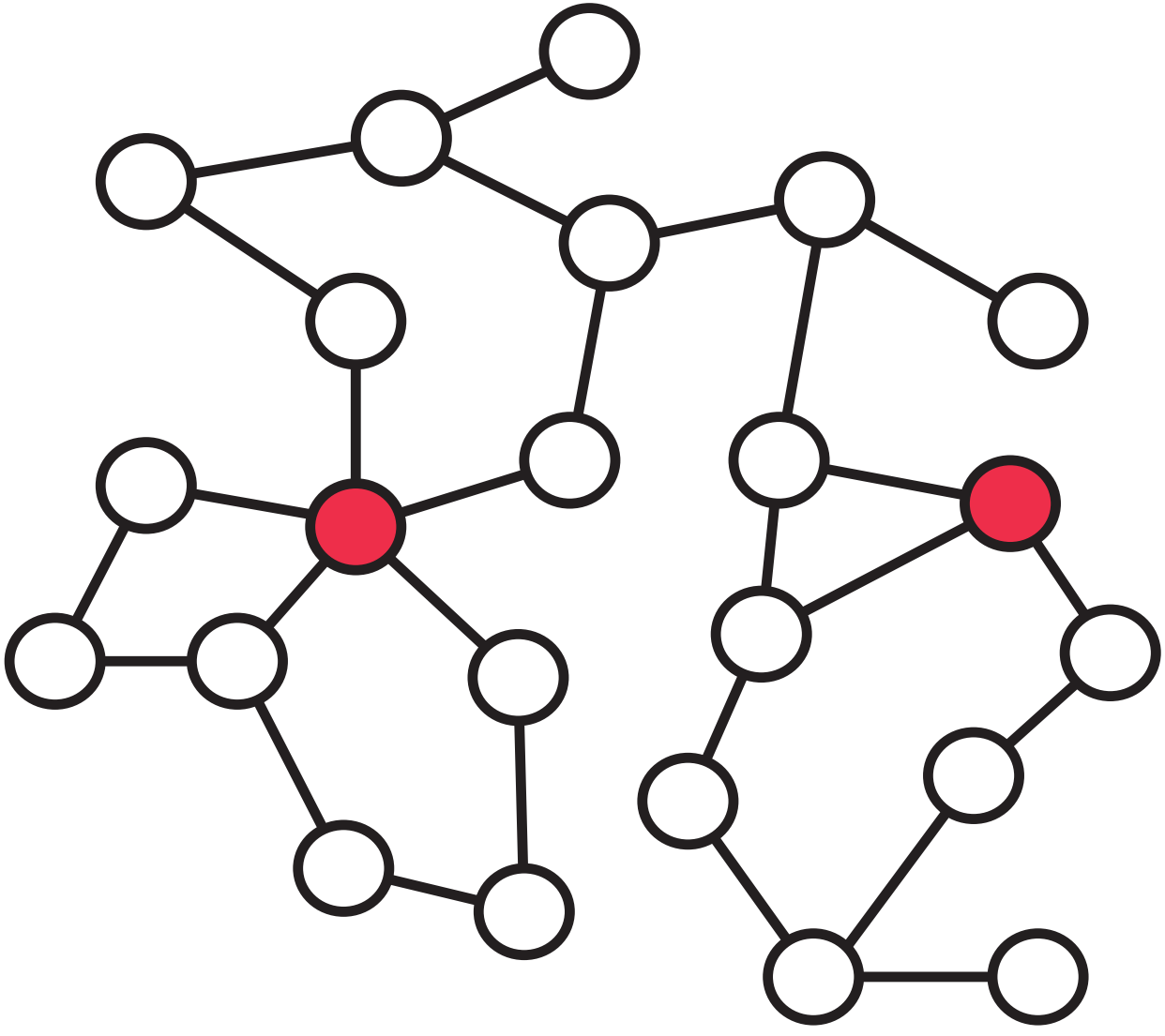


LABELED SNOWBALL WITH MULTIPLE INCLUSIONS (LSMI)

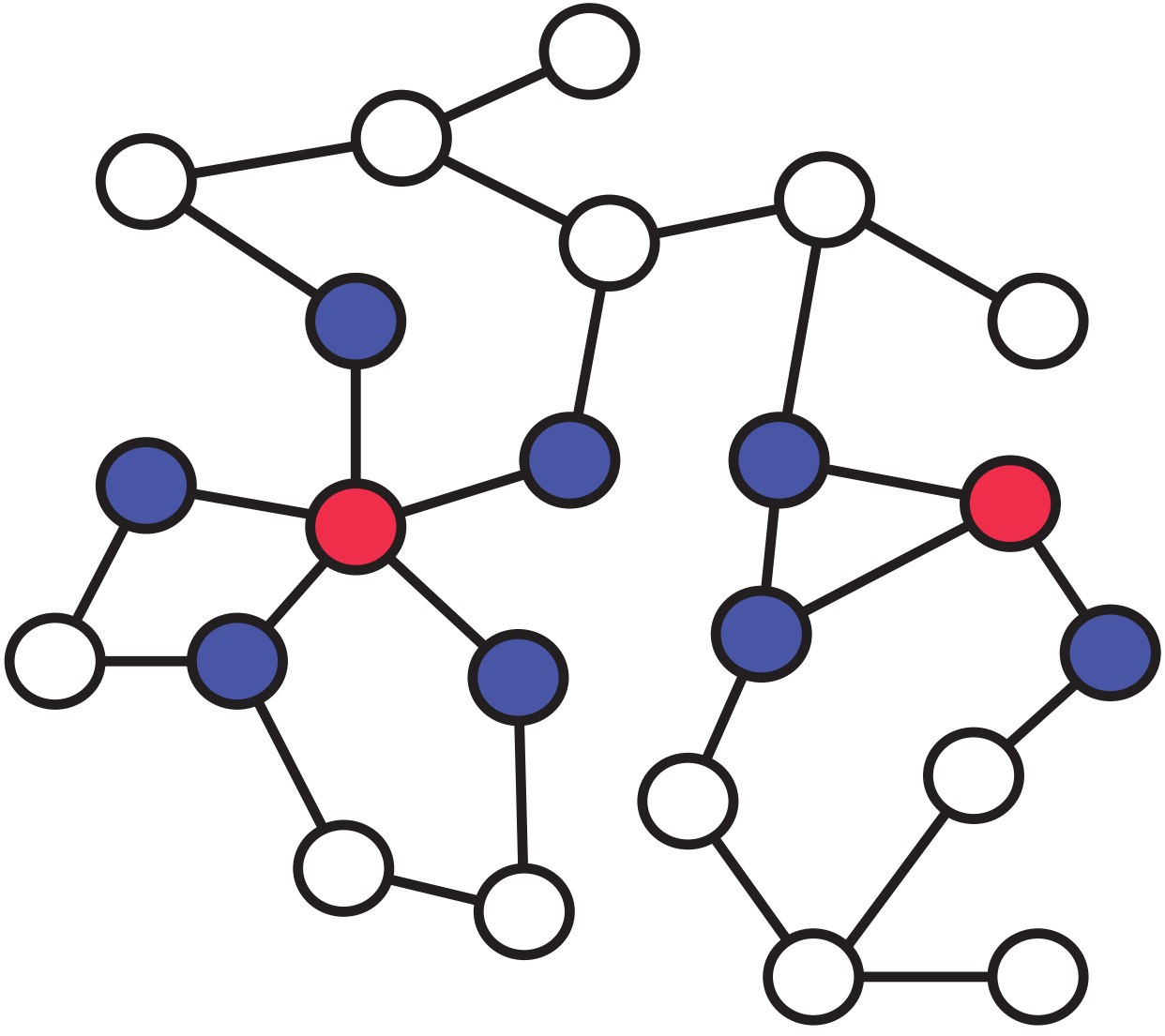
LSMI: Step 1



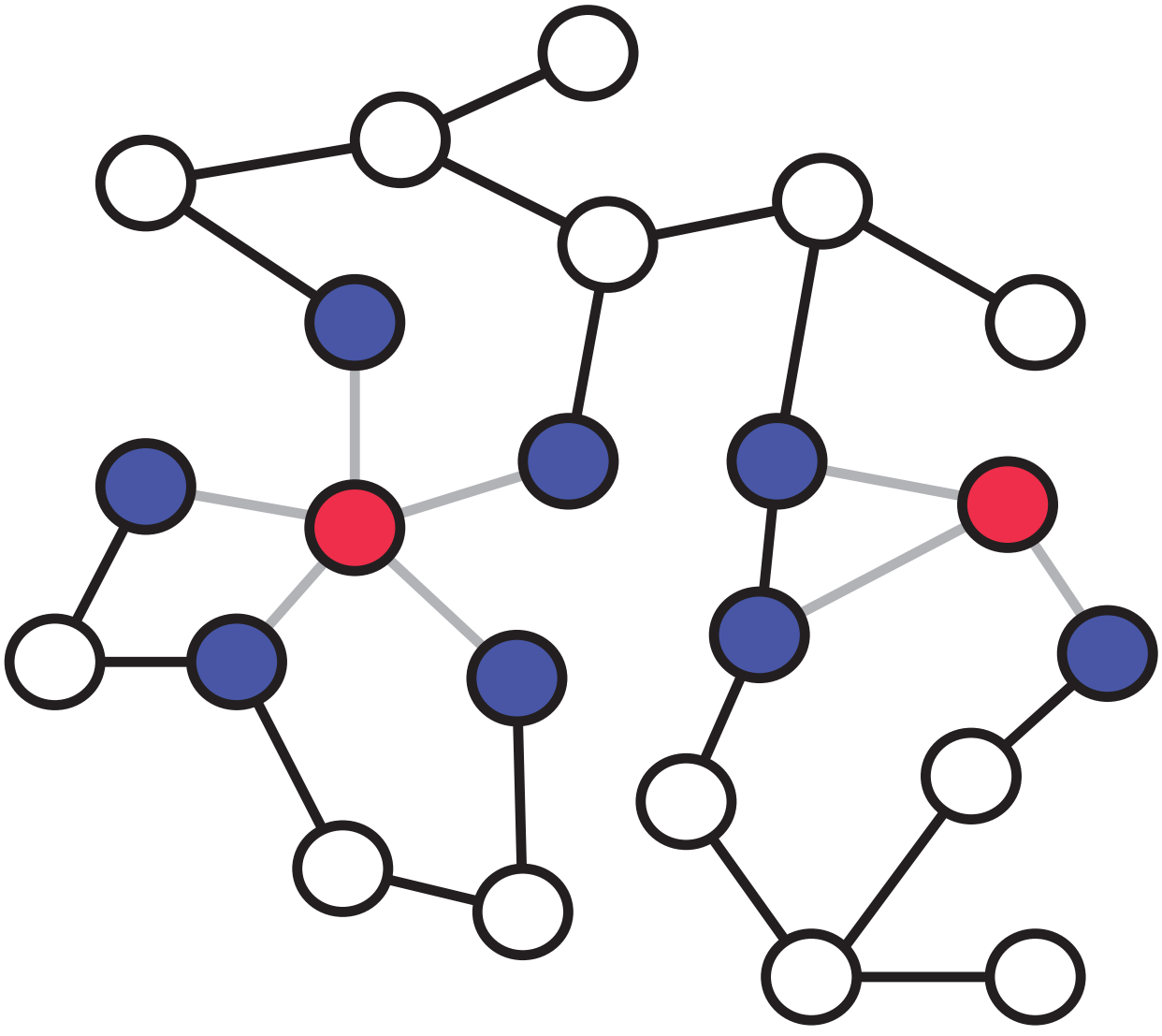
LSMI: Step 2



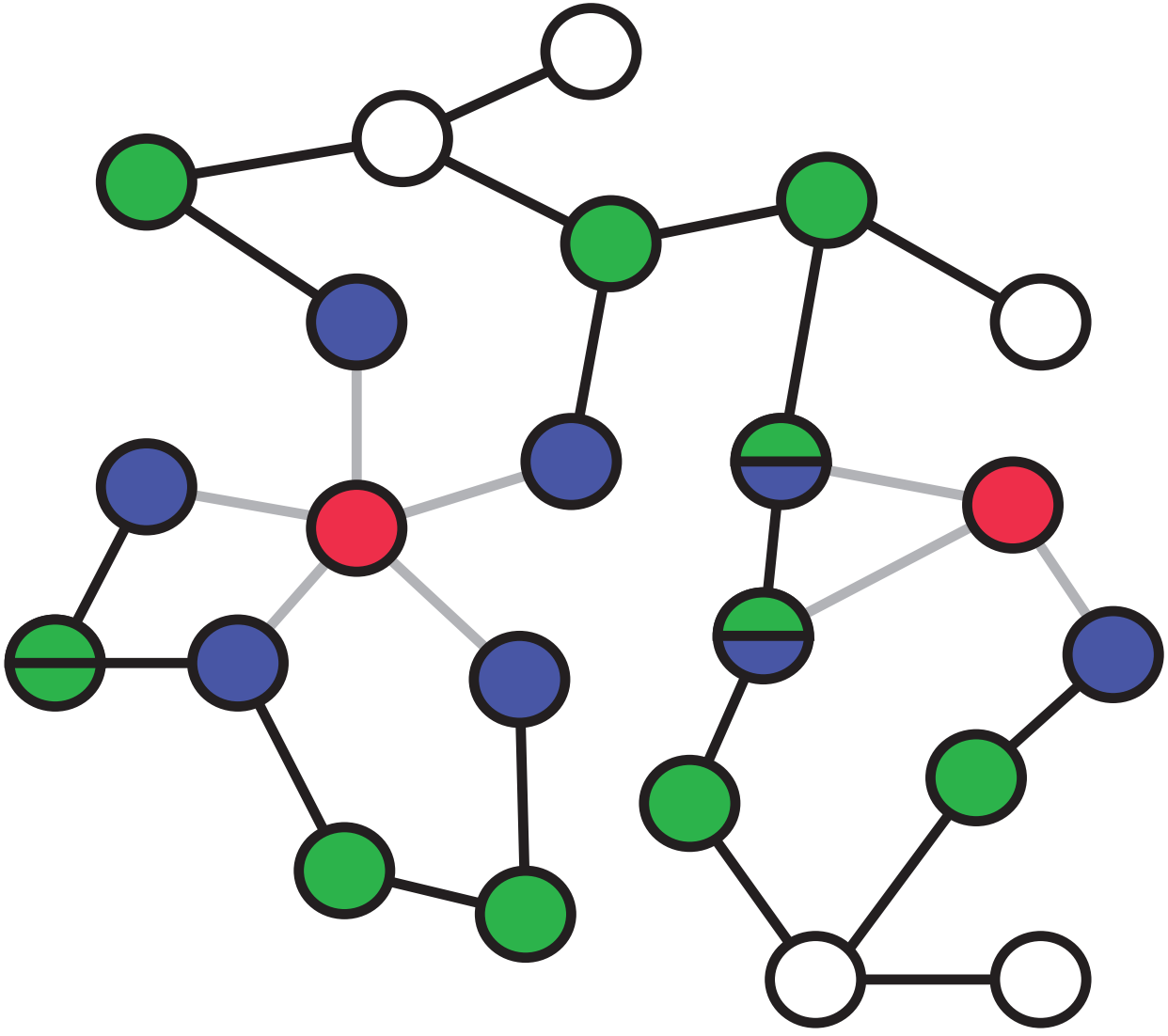
LSMI: Step 3



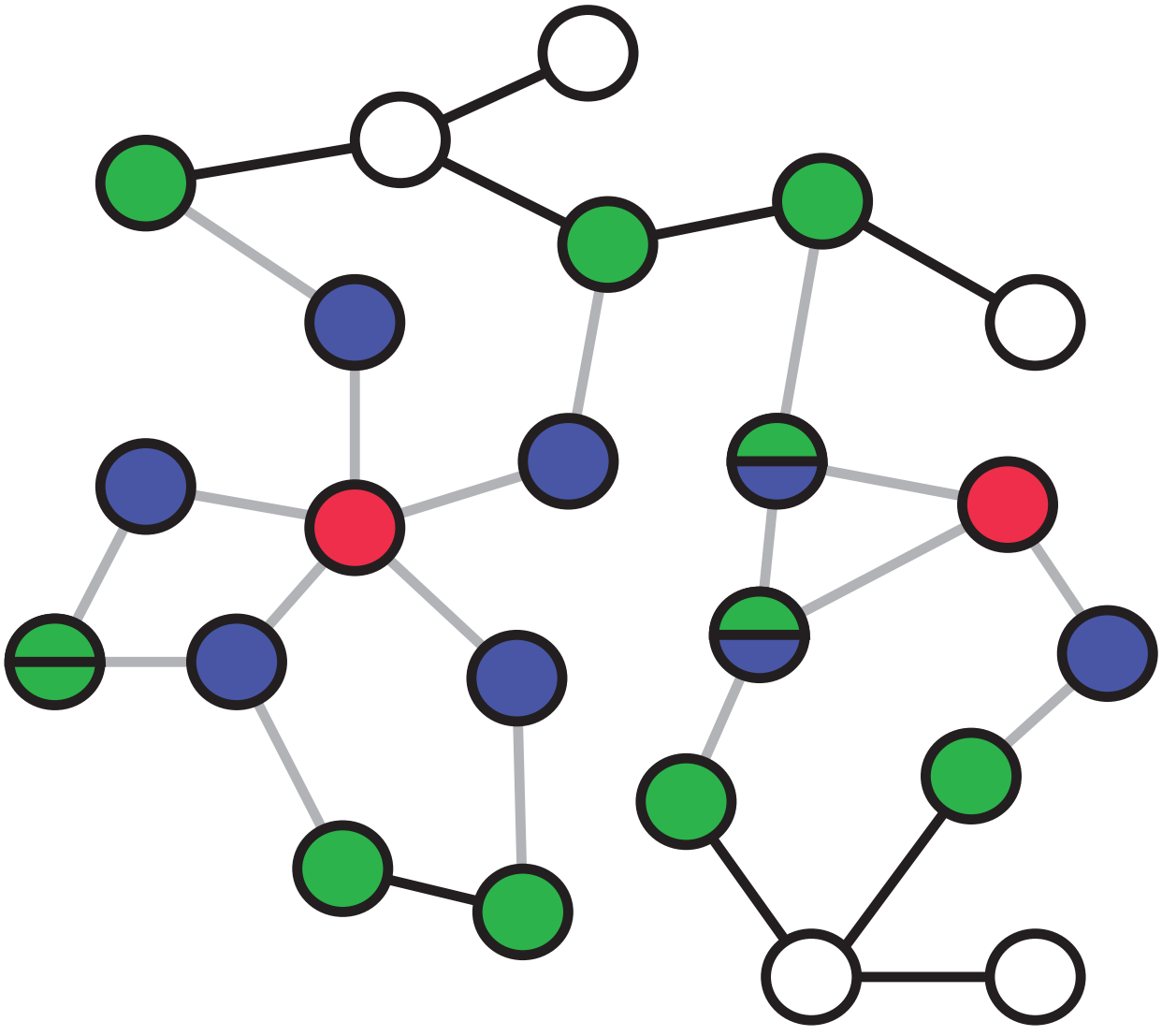
LSMI: Step 4



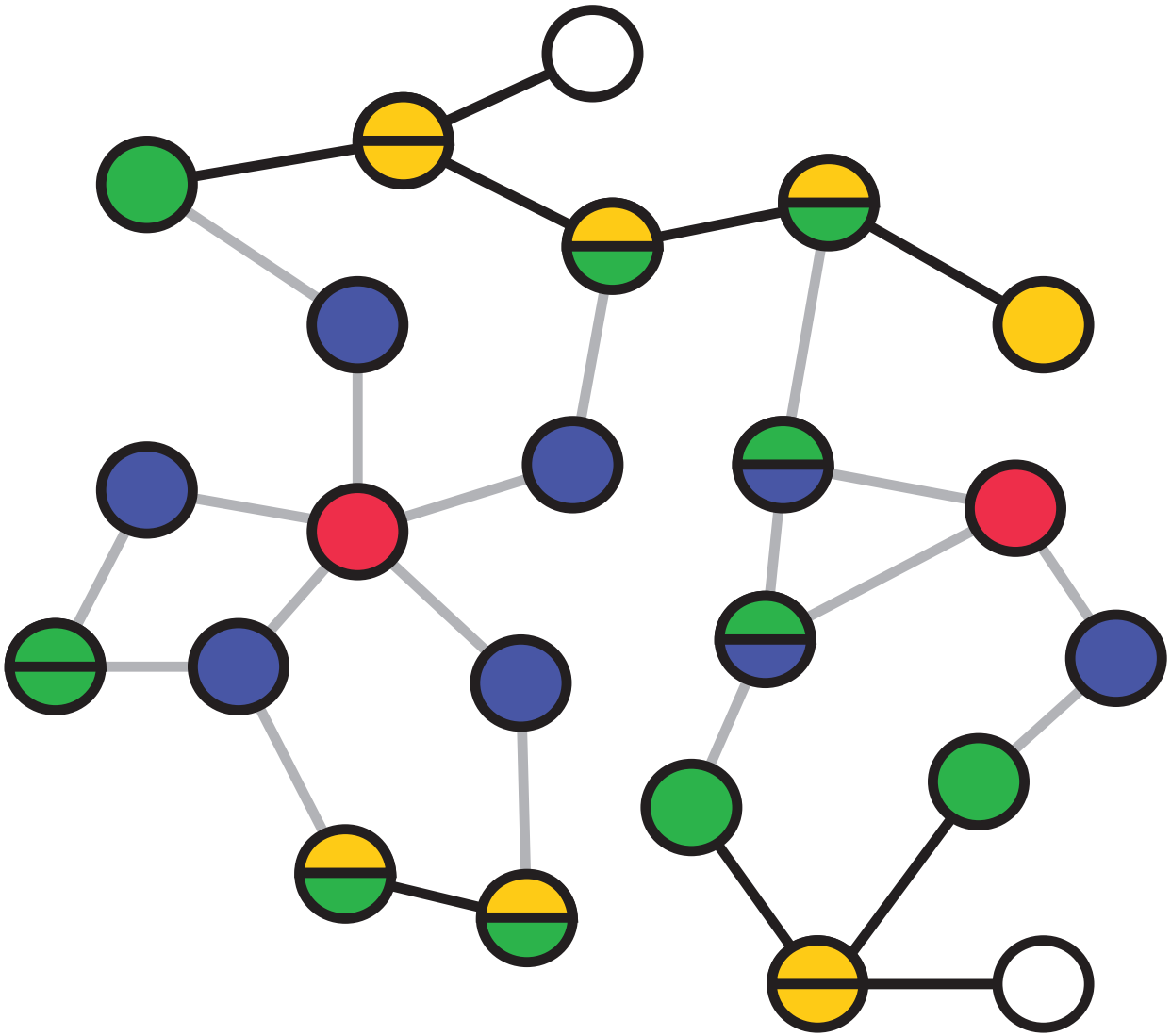
LSMI: Step 5



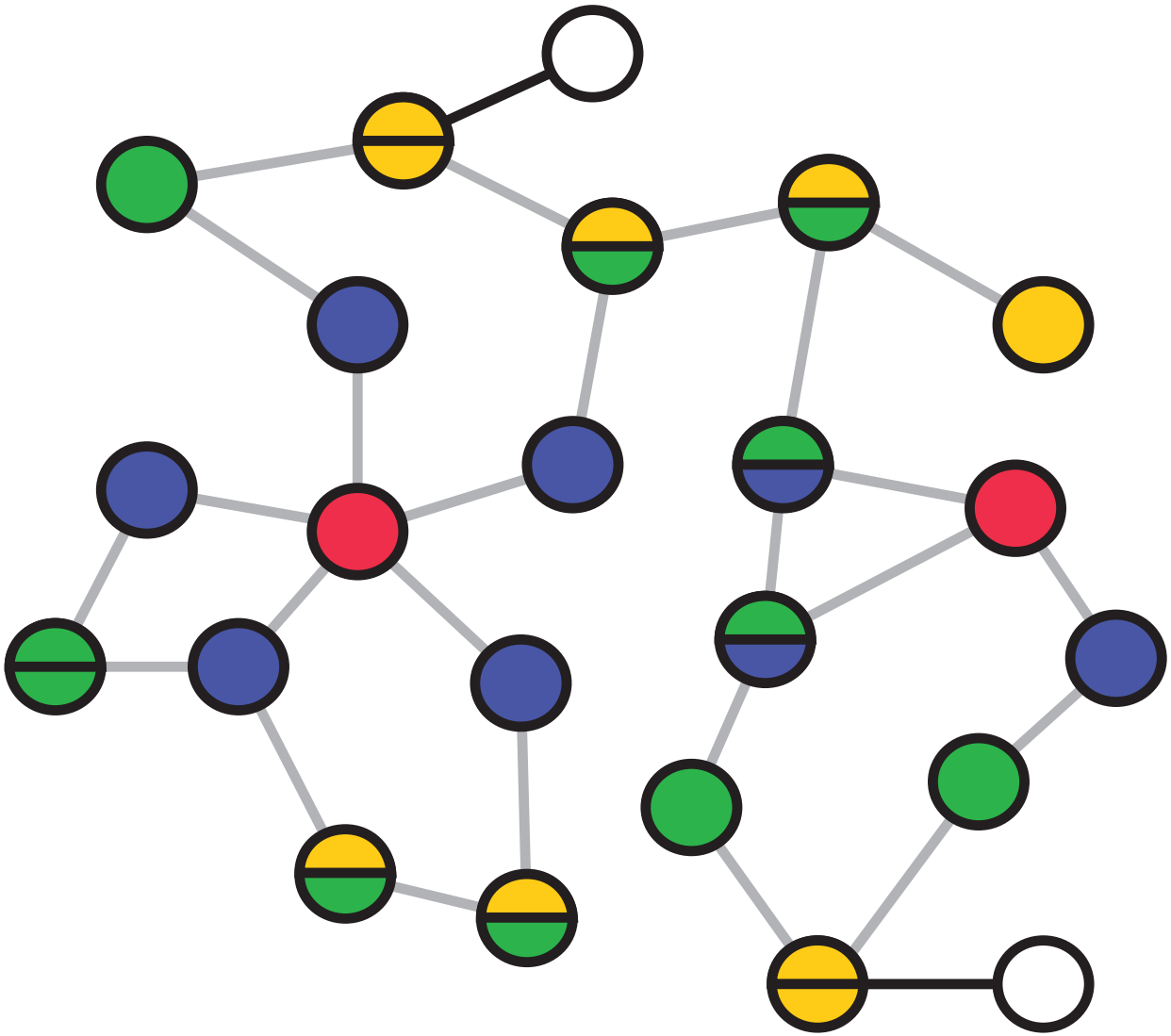
LSMI: Step 6



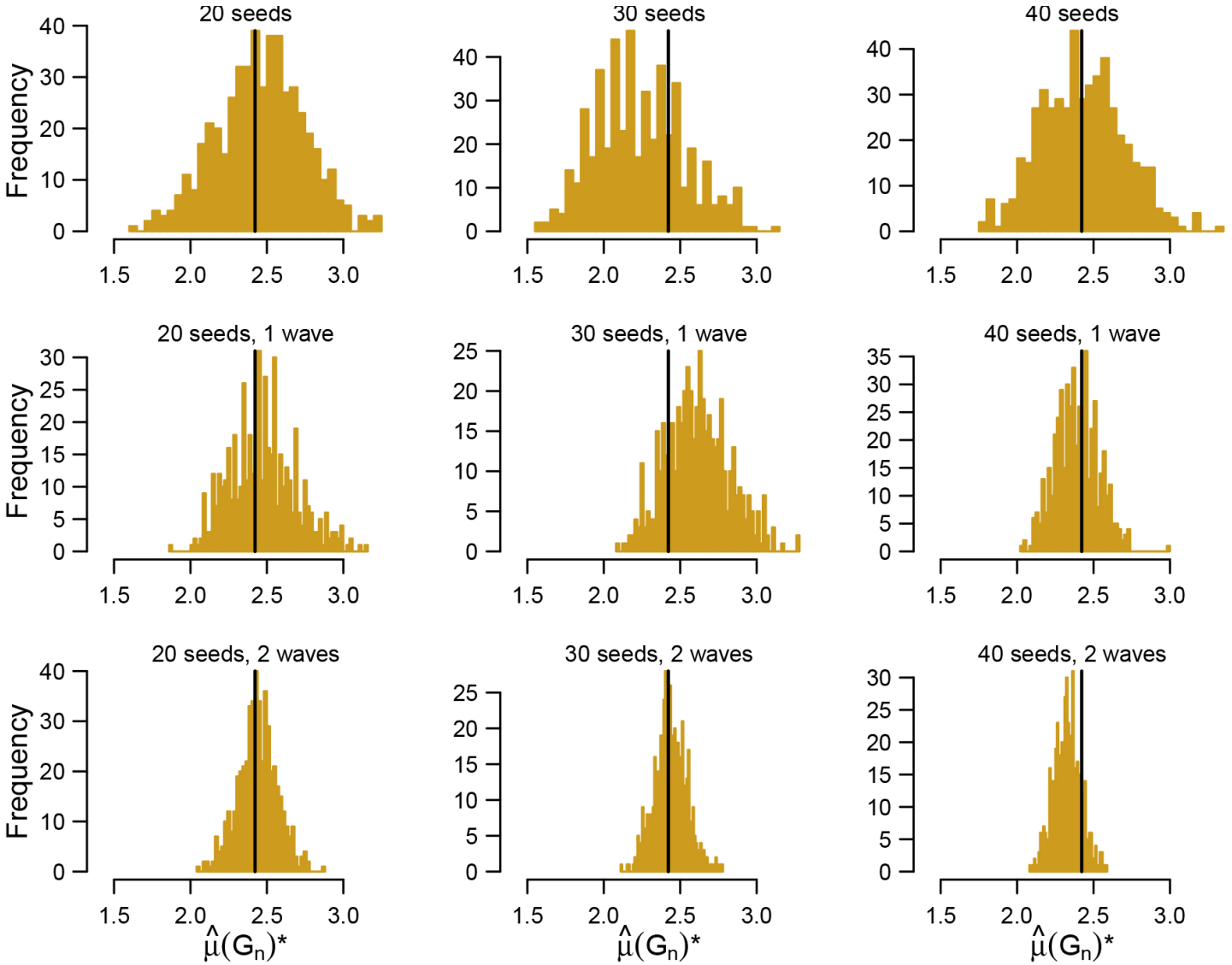
LSMI: Step 7



LSMI: Step 8



Bootstrap Mean Degrees $\hat{\mu}(G_n)^*$ for One Simulated Network; $\mu(G) = 2.42$ (Black Lines)



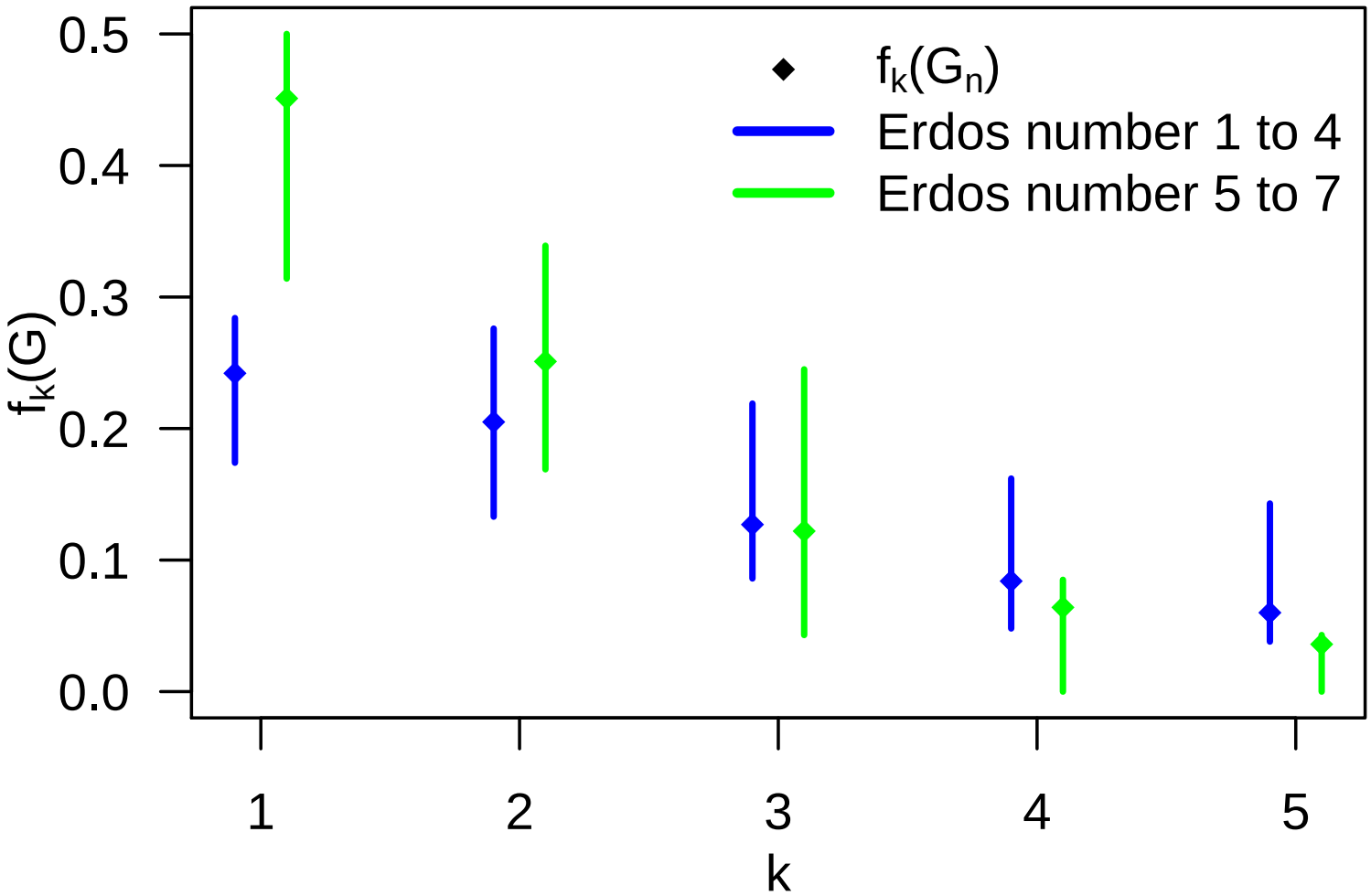
Erdos Networks

Define subnetworks based on Erdos number.

"Senior" researchers: Erdos number 1–4, $n = 94{,}766$, $\hat{\mu} = 5.53$.

"Junior" researchers: Erdos number 5–7, $n = 80{,}607$, $\hat{\mu} = 2.44$.

Erdos Subnetworks



Observed frequencies $f_k(G_n)$ (points)
and FPB 95% intervals (lines) for $f_k(G)$

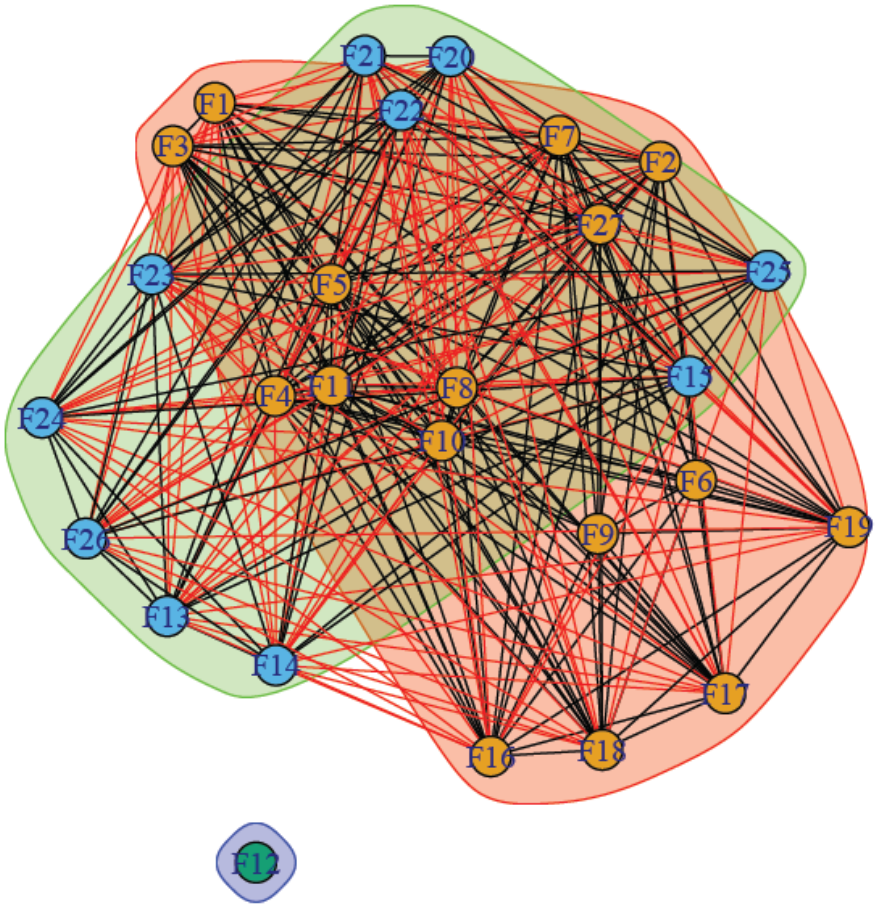
OTHER TOPICS:

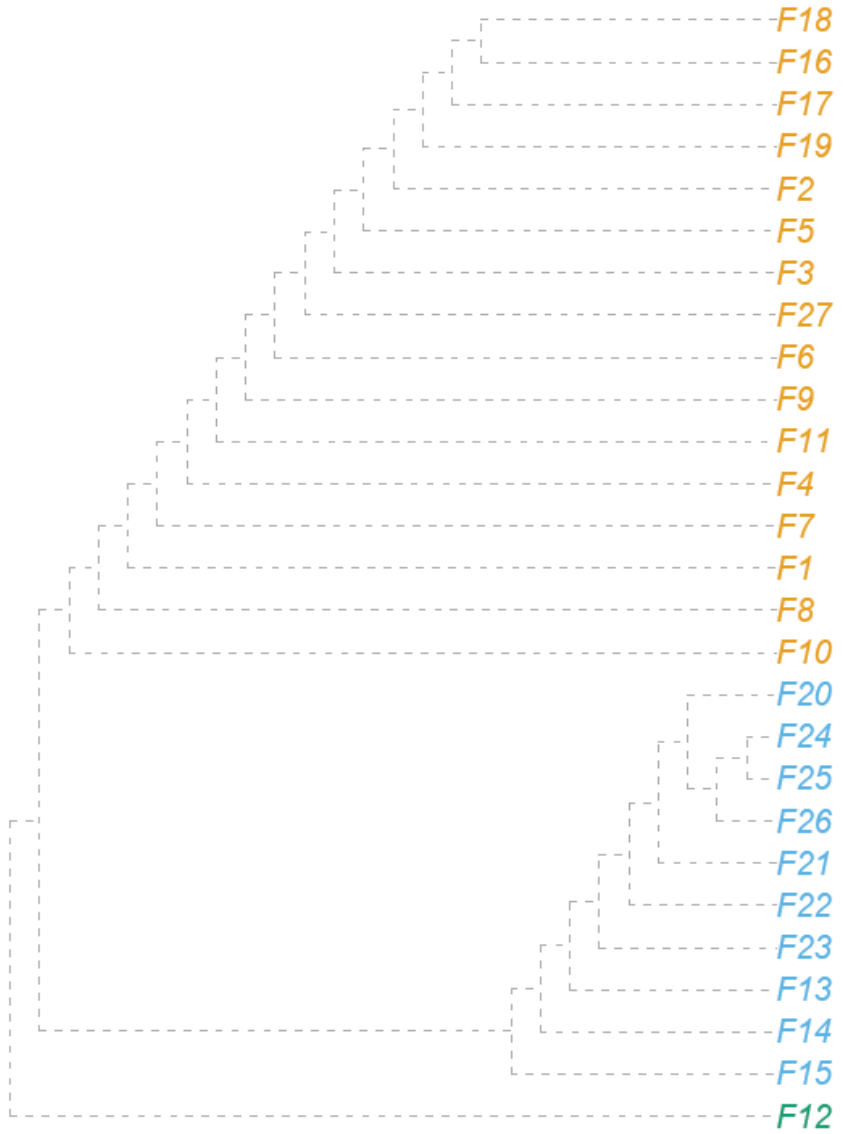
- Motifs (e.g., #of stars or wheels/loops)
- Communities
- Outliers (terrorists, fraud)
- Processes on networks (diffusion, percolation, information/idea/energy flows; complex contagion [buy red pants only if few friends have bought already], cascades, thresholds; collective action; innovation; problem solving)
- Resilience (to failures or attacks --- edge or node removal)
- Prediction of [missing/future] nodes or edges

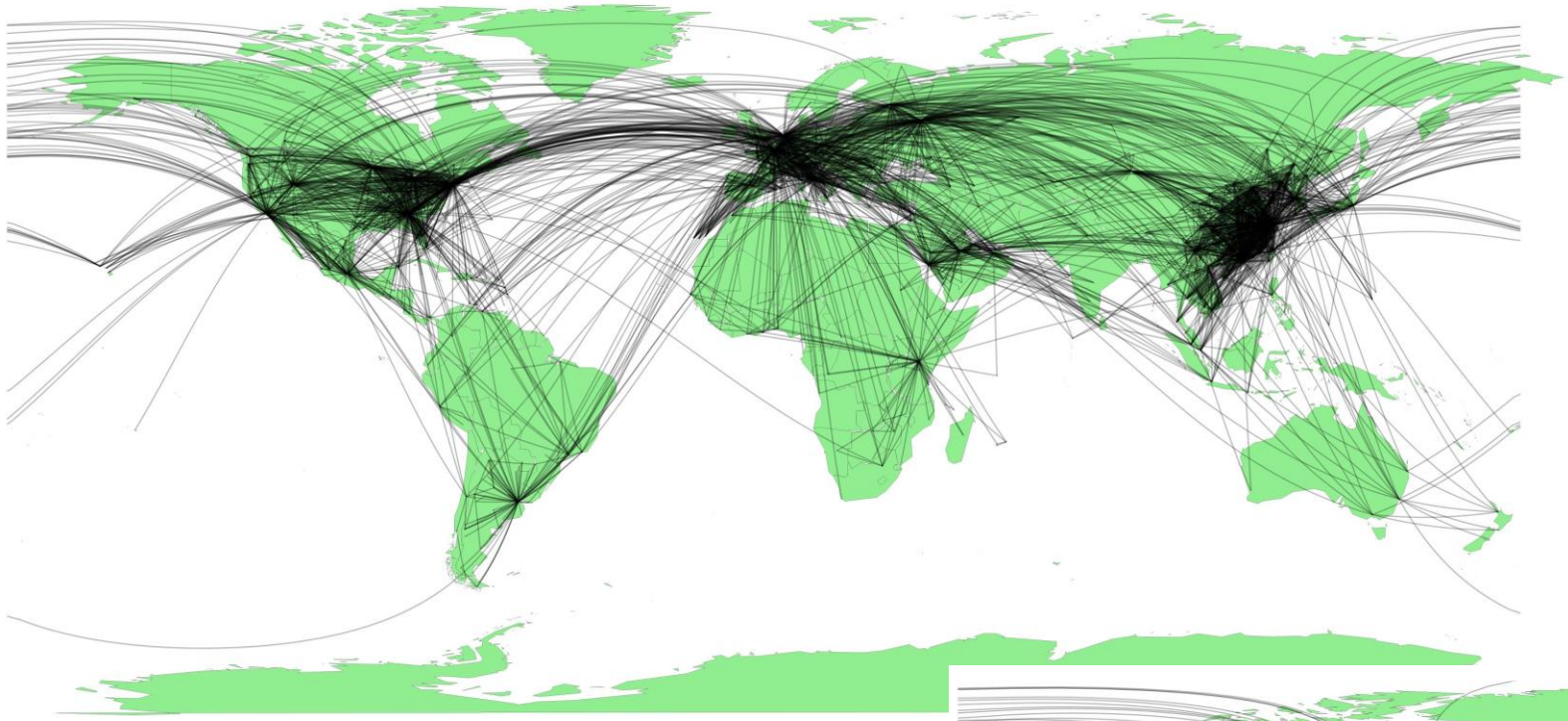
APPLICATIONS:

- Power grid, Internet (physical and not), Political nets, Social media (FB, LinkedIn, Google, Wiki, etc), Customer nets, Transport (roads, flights), Protein interactions, Food pairing, Movie actors, Business leaders, Epidemiology, Co-authors, Citations, Novel heroes, Words, Climate teleconnections, Food webs, etc.

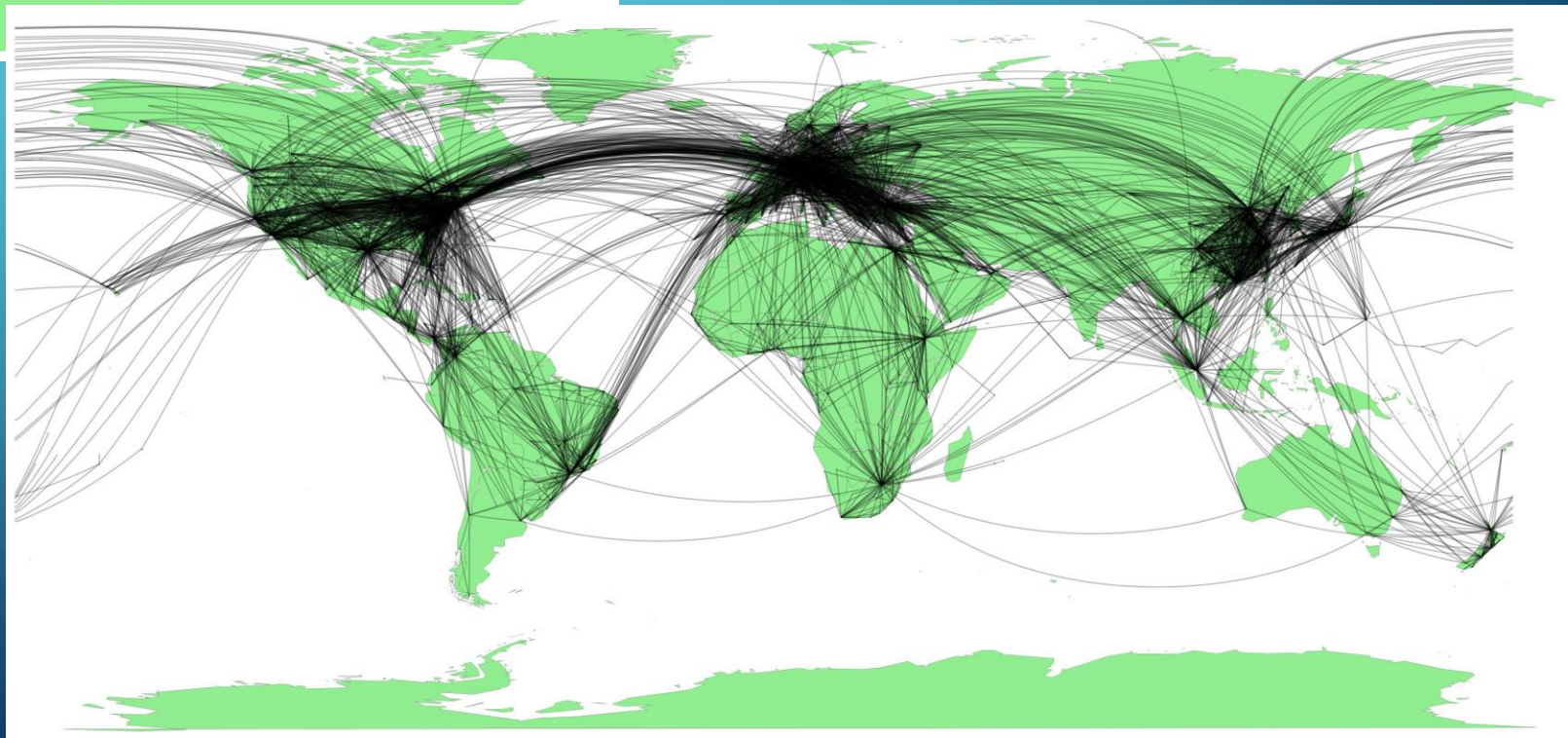
Affilitaton Network, with communities highlighted





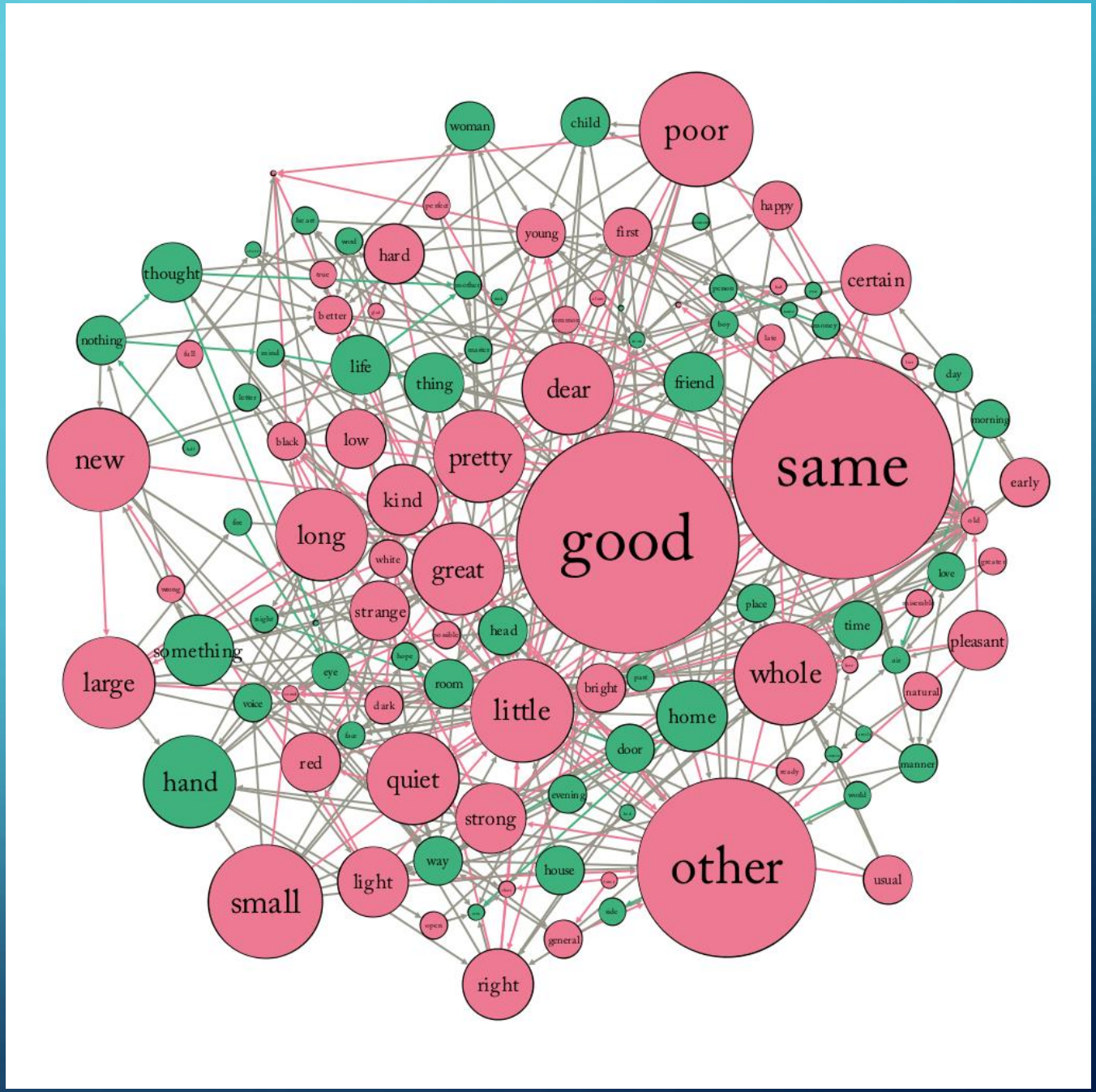


SKY TEAM

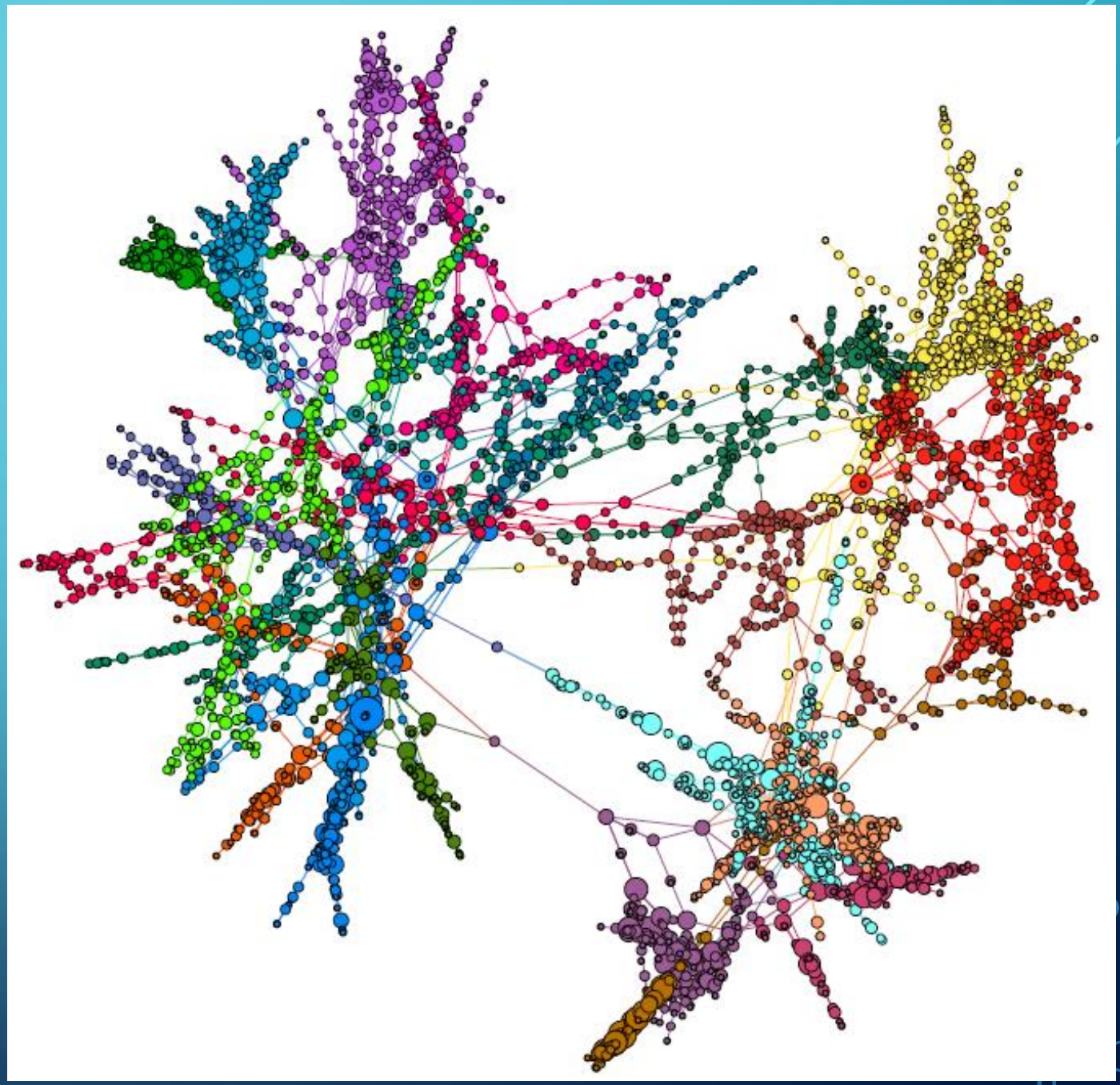


STAR ALLIANCE

NOUNS AND ADJECTIVES FOUND IN THE NOVEL DAVID COPPERELD



US WESTERN STATES POWER GRID



R PACKAGES:

- igraph
- snowboot
- statnet
- network

OTHER SOFTWARE:

- Gephy
- Pajek
- EgoNet
- NetMiner
- Statnet
- …

http://www.kdnuggets.com/2015/06/top-30-social-network-analysis-visualization-tools.html

Thank you!