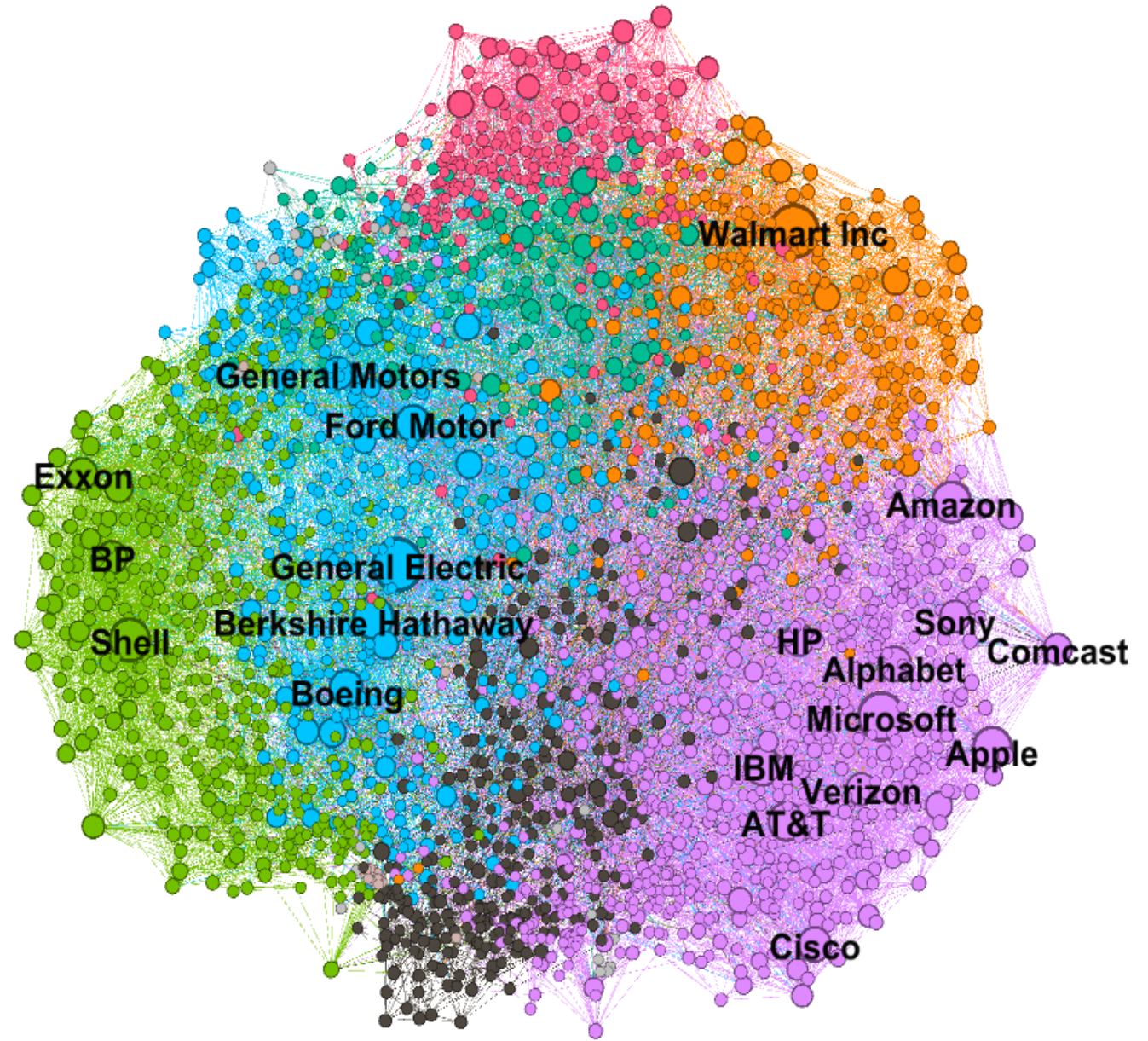


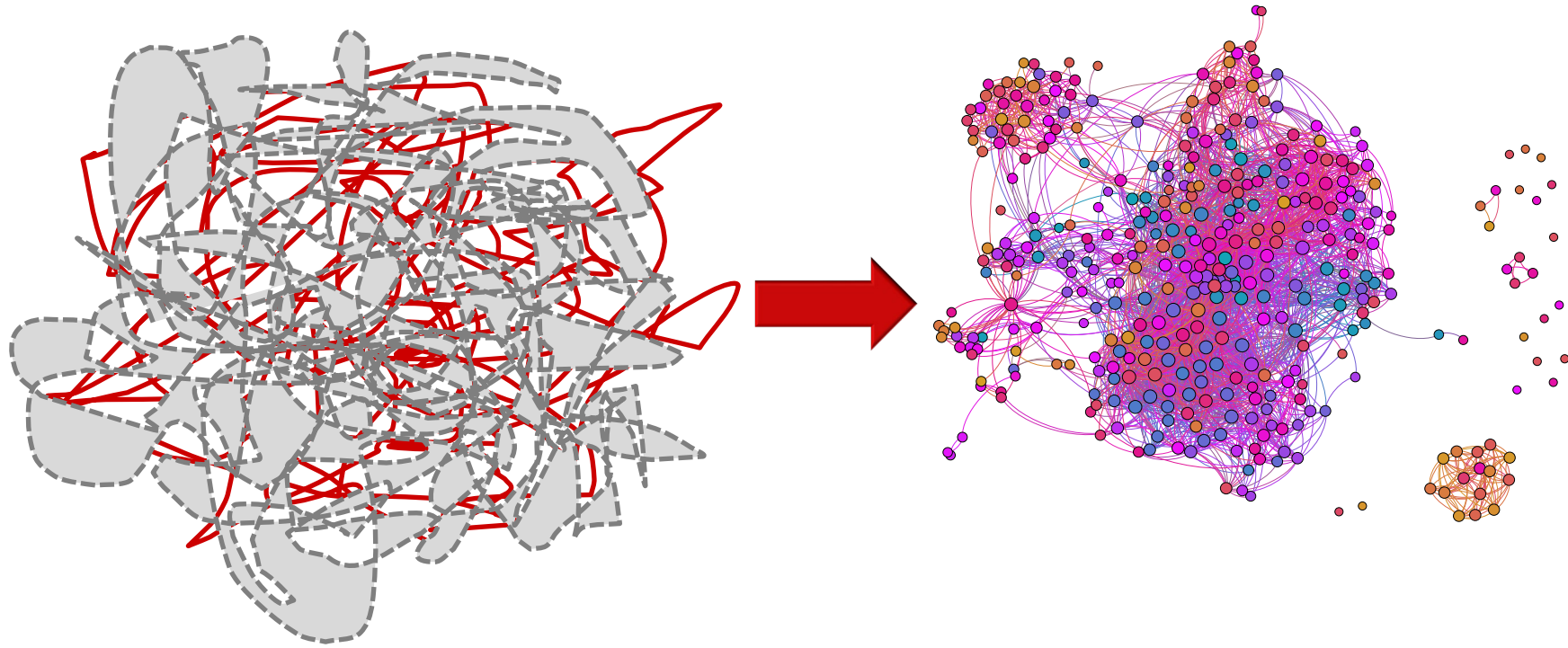
Social Network Analysis

Business Intelligence



Terry College of Business
UNIVERSITY OF GEORGIA

Why should we study systems as networks?



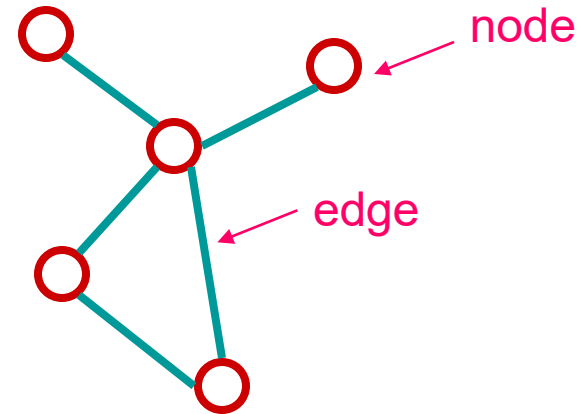
- Six Degrees of Separation

What are networks?

- Networks are sets of nodes connected by edges.
- “Network” \equiv “Graph”

Nodes: entities

Edges: relationships

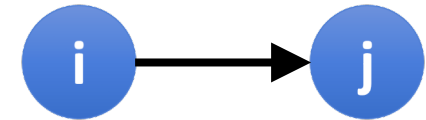


points	lines	
vertices	edges, arcs	math
nodes	links	computer science
sites	bonds	physics
actors	ties, relations	sociology

Adjacency matrices

- Representing edges (who is adjacent to whom) as a matrix

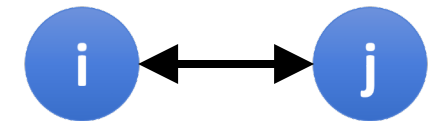
- $A_{ij} = 1$ if node i has an edge to node j
= 0 if node i does not have an edge to j



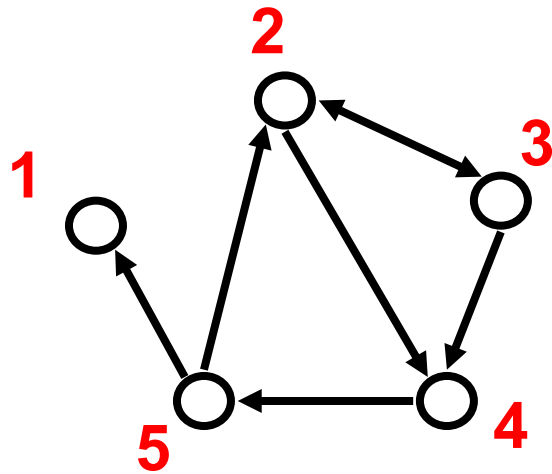
- $A_{ii} = 0$ unless the network has self-loops



- $A_{ij} = A_{ji}$ if the network is undirected,
or if i and j share a reciprocated edge (symmetric)



Example: Adjacency matrix



$$A = \begin{matrix} & \begin{matrix} \text{Nodes} & 1 & 2 & 3 & 4 & 5 \end{matrix} \\ \begin{matrix} \text{Nodes} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{matrix} & \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 1 & 1 & 0 & 0 & 0 \end{bmatrix} \end{matrix}$$

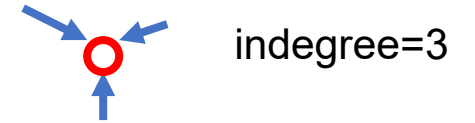
Node Importance (Centrality)

- Node network properties

- from immediate connections

- indegree

how many directed edges (arcs) are incident on a node



- outdegree

how many directed edges (arcs) originate at a node



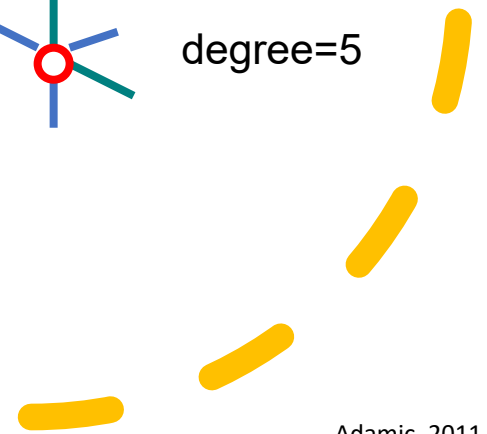
- degree (in or out)

number of edges incident on a node

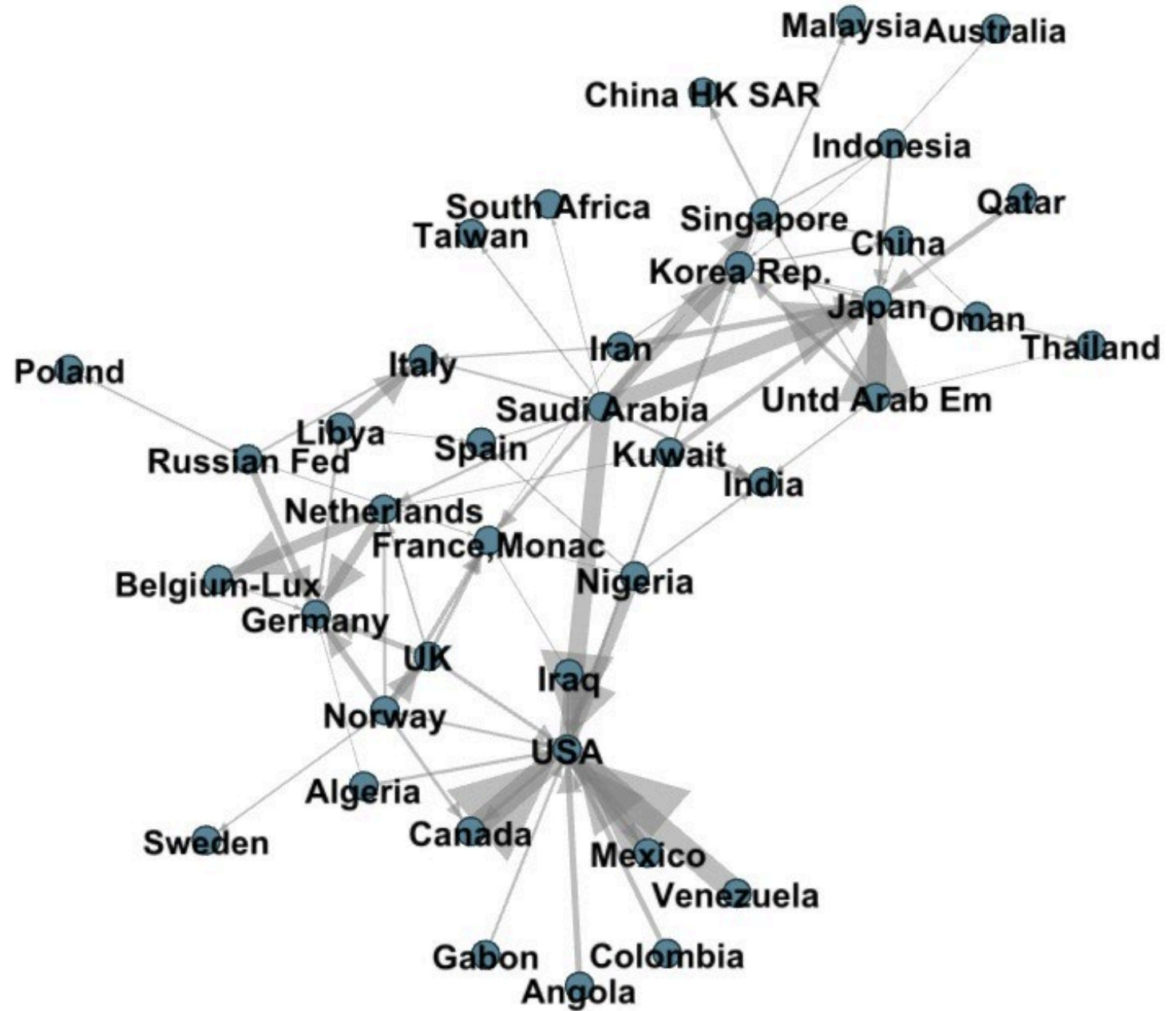


- from the entire graph

- centrality (betweenness, closeness)



Trade in petroleum
and petroleum
products, 1998,
source: NBER-United
Nations Trade Data



Adamic, 2011

Question

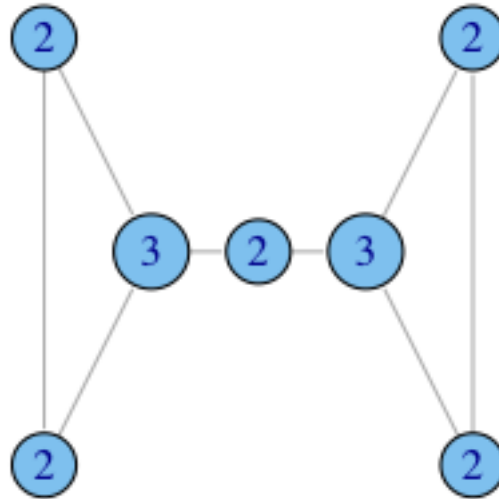
- Which countries have high indegree (import petroleum and petroleum products from many others)
 - a) Saudi Arabia
 - b) Japan
 - c) Iraq
 - d) USA
 - e) Venezuela

Question

- Which country has a high outdegree (exports a significant amount of petroleum and petroleum products)?
 - a) Saudi Arabia
 - b) Japan
 - c) Iraq
 - d) USA
 - e) Venezuela

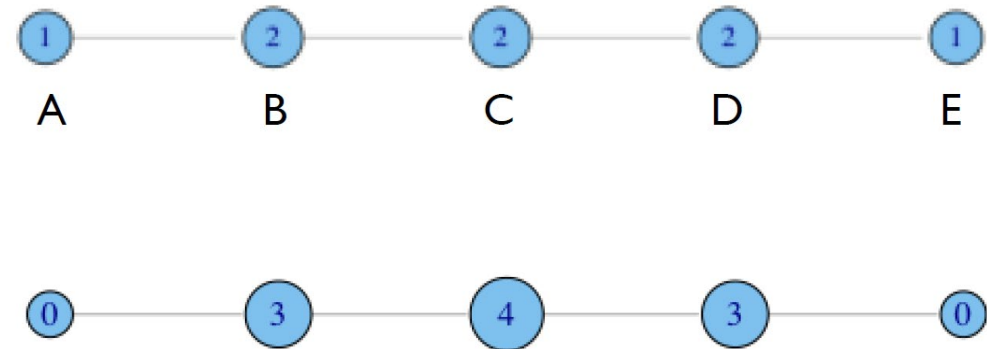
What does degree not capture?

- In what ways does degree fail to capture centrality in the following graphs?

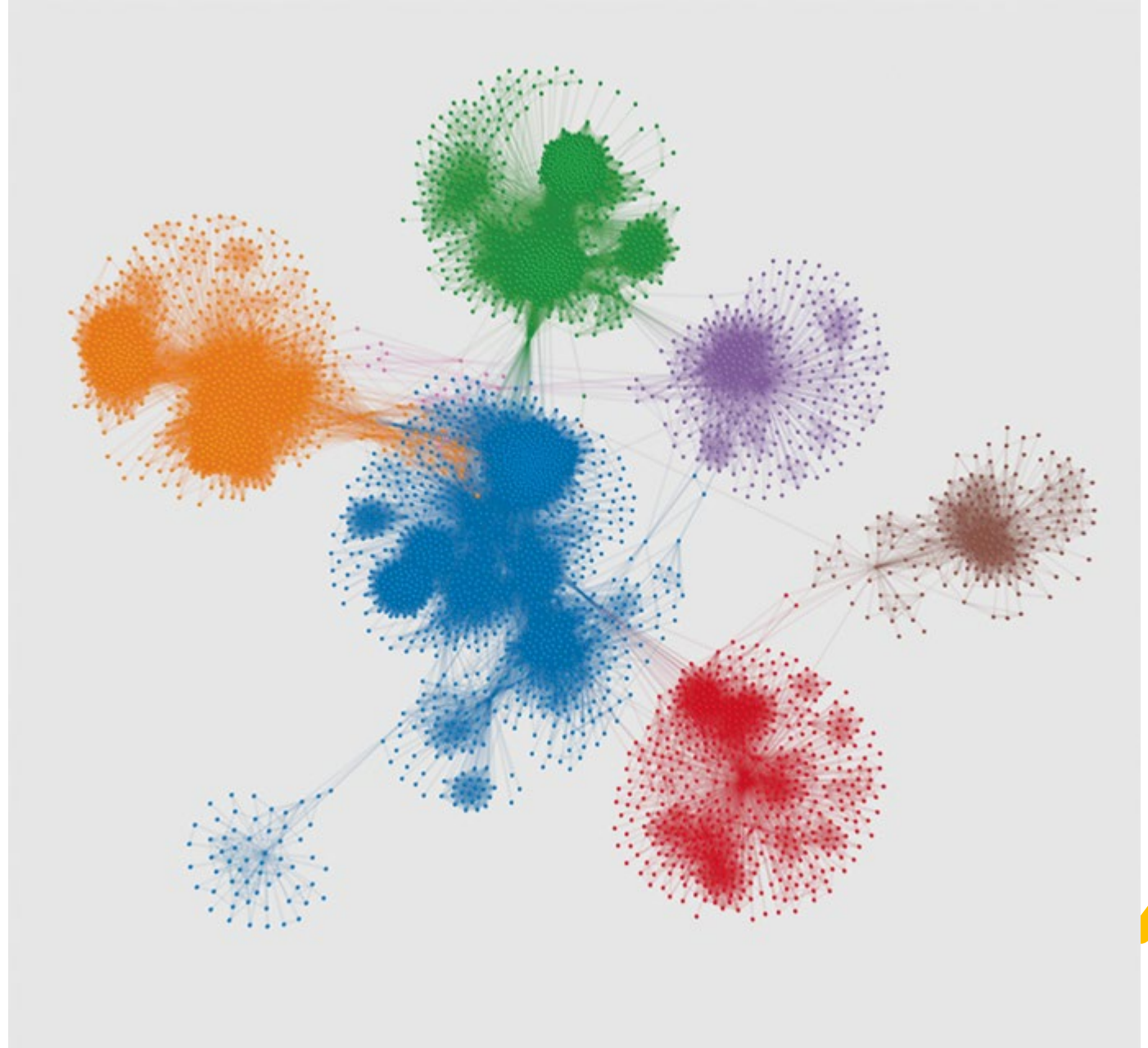


Betweenness captures brokerage

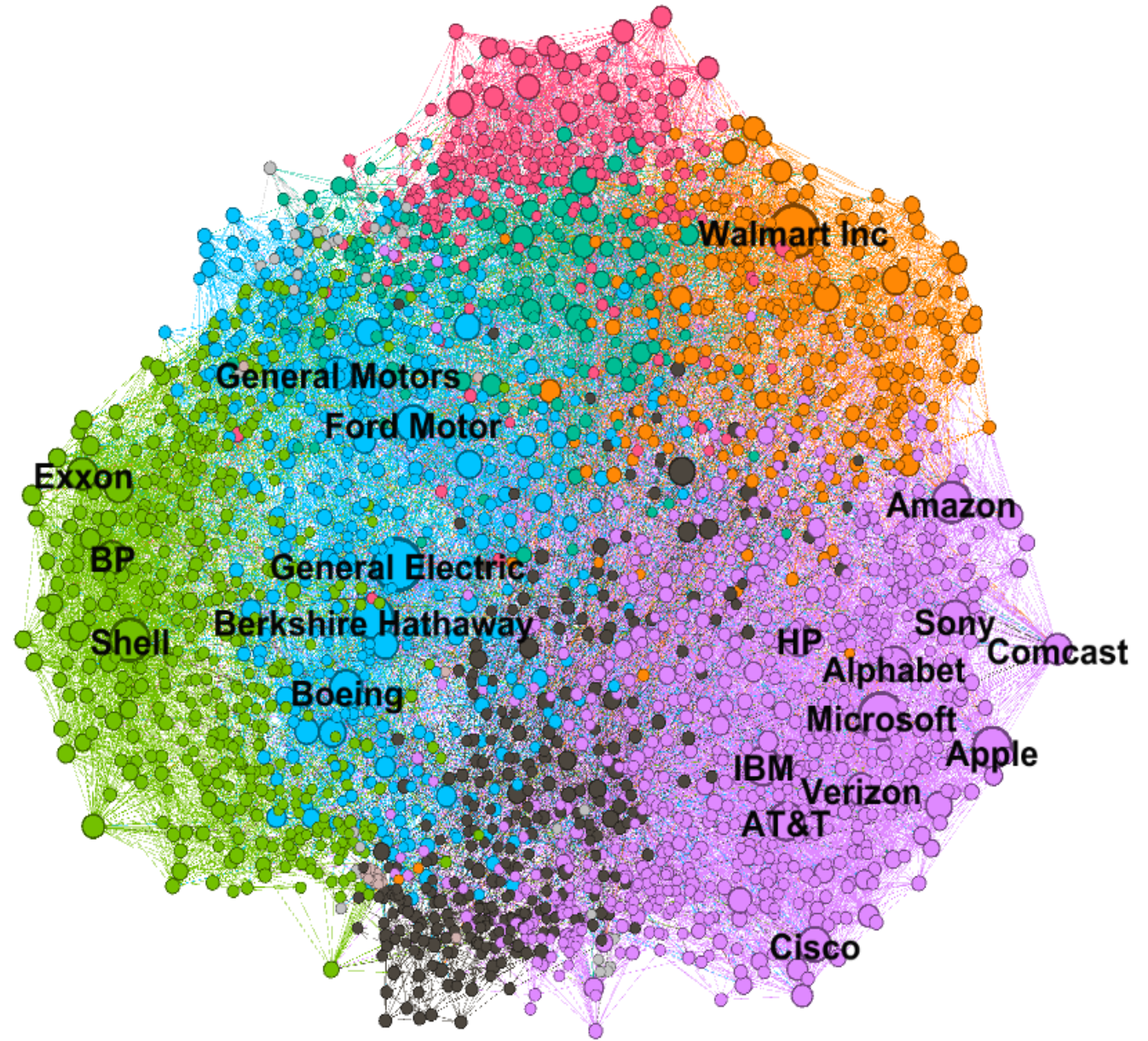
- Intuition: how many pairs of individuals would have to go through you in order to reach one another in the minimum number of hops?



Network Communities



Network Communities



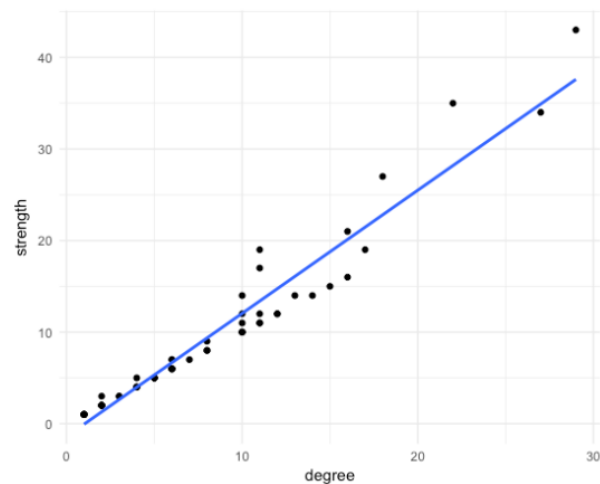
Network Features

Id	Label	..	Degree	Eccentricity	Closeness Centrality	Harmonic Closeness Centrality	Betweenness Centrality	Modularity Class
0.0	Myriel		10	4.0	0.429379	0.491228	504.0	0
2.0	MlleBaptistine		3	4.0	0.413043	0.445175	0.0	0
3.0	MmeMagloire		3	4.0	0.413043	0.445175	0.0	0
11.0	Valjean		36	3.0	0.644068	0.732456	1624.4688	2
12.0	Marguerite		2	4.0	0.413043	0.440789	0.0	1
16.0	Tholomyes		9	4.0	0.391753	0.457237	115.793642	1
17.0	Listolier		7	5.0	0.340807	0.396272	0.0	1
18.0	Fameuil		7	5.0	0.340807	0.396272	0.0	1
19.0	Blacheville		7	5.0	0.340807	0.396272	0.0	1
20.0	Favourite		7	5.0	0.340807	0.396272	0.0	1
21.0	Dahlia		7	5.0	0.340807	0.396272	0.0	1
22.0	Zephine		7	5.0	0.340807	0.396272	0.0	1
23.0	Fantine		15	4.0	0.460606	0.539474	369.486942	1
24.0	MmeThenardier		11	4.0	0.460606	0.520833	82.656893	4
25.0	Thenardier		16	3.0	0.517007	0.58114	213.468481	4
26.0	Cosette		11	4.0	0.477987	0.533991	67.819322	2
27.0	Javert		17	3.0	0.517007	0.585526	154.844945	2
28.0	Fauchelevant		4	4.0	0.402116	0.438596	75.5	2
29.0	Bamatabois		8	4.0	0.426966	0.480263	22.916667	3
30.0	Perpetue		2	5.0	0.317992	0.349561	0.0	2
31.0	Simplice		4	4.0	0.417582	0.453947	24.624841	2
33.0	Woman1		2	4.0	0.395833	0.423246	0.0	2
34.0	Judge		6	4.0	0.404255	0.449561	0.0	3
35.0	Champmathieu		6	4.0	0.404255	0.449561	0.0	3
36.0	Brevet		6	4.0	0.404255	0.449561	0.0	3
37.0	Chenildieu		6	4.0	0.404255	0.449561	0.0	3
38.0	Cochepaille		6	4.0	0.404255	0.449561	0.0	3

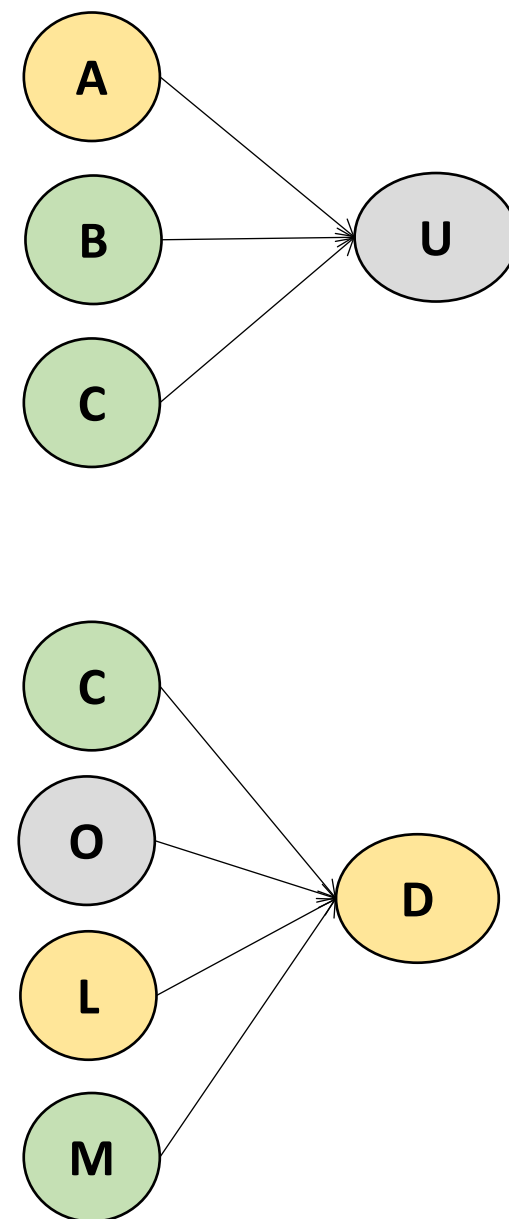
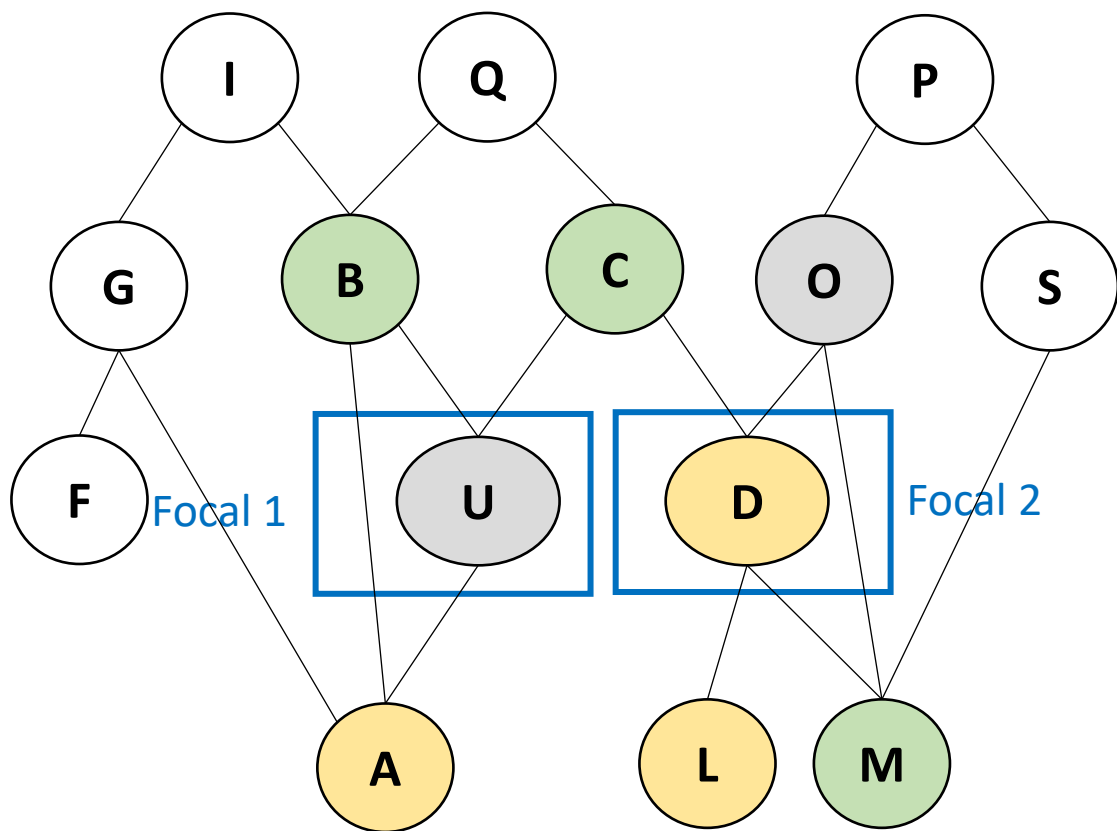
Visualizing correlation

```
# scatterplot of degree and strength
```

```
ggplot(data = nodes, mapping = aes(x = degree, y = strength)) +  
  geom_point() +  
  geom_smooth(method = "lm", se = FALSE)
```



Neighborhood



Rios, 2021