POIR 613: Computational Social Science

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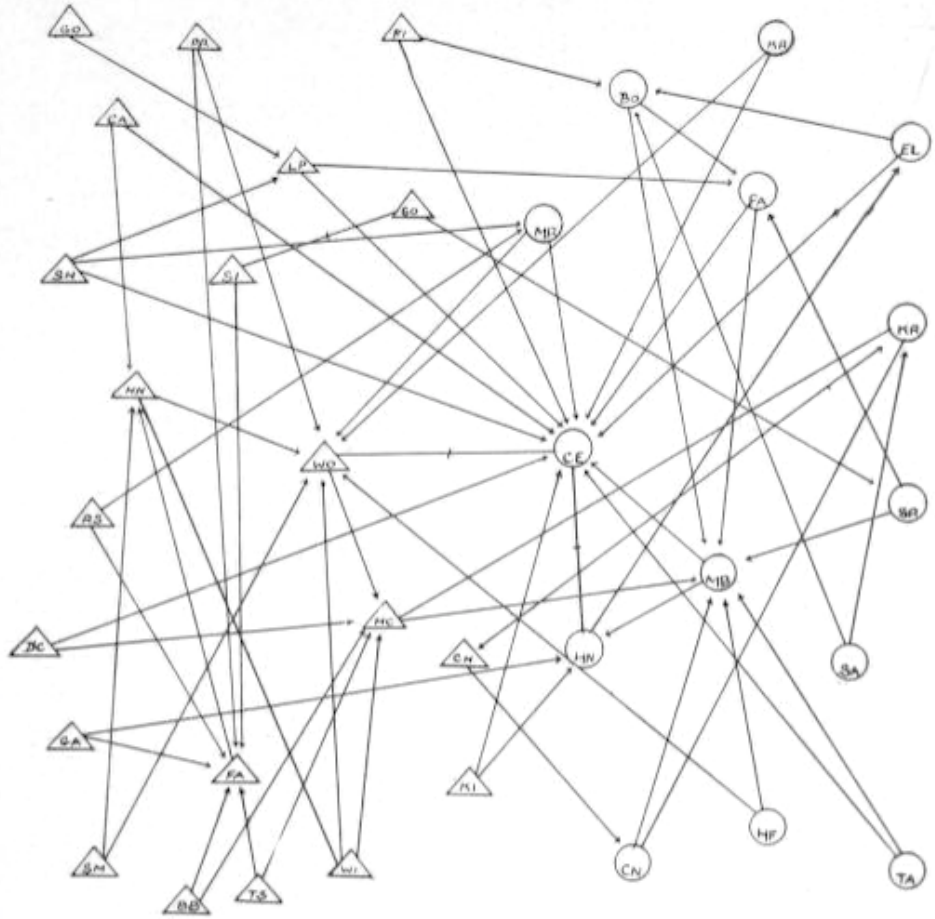
Introduction to
social network analysis

Human behavior is characterized by connections to others

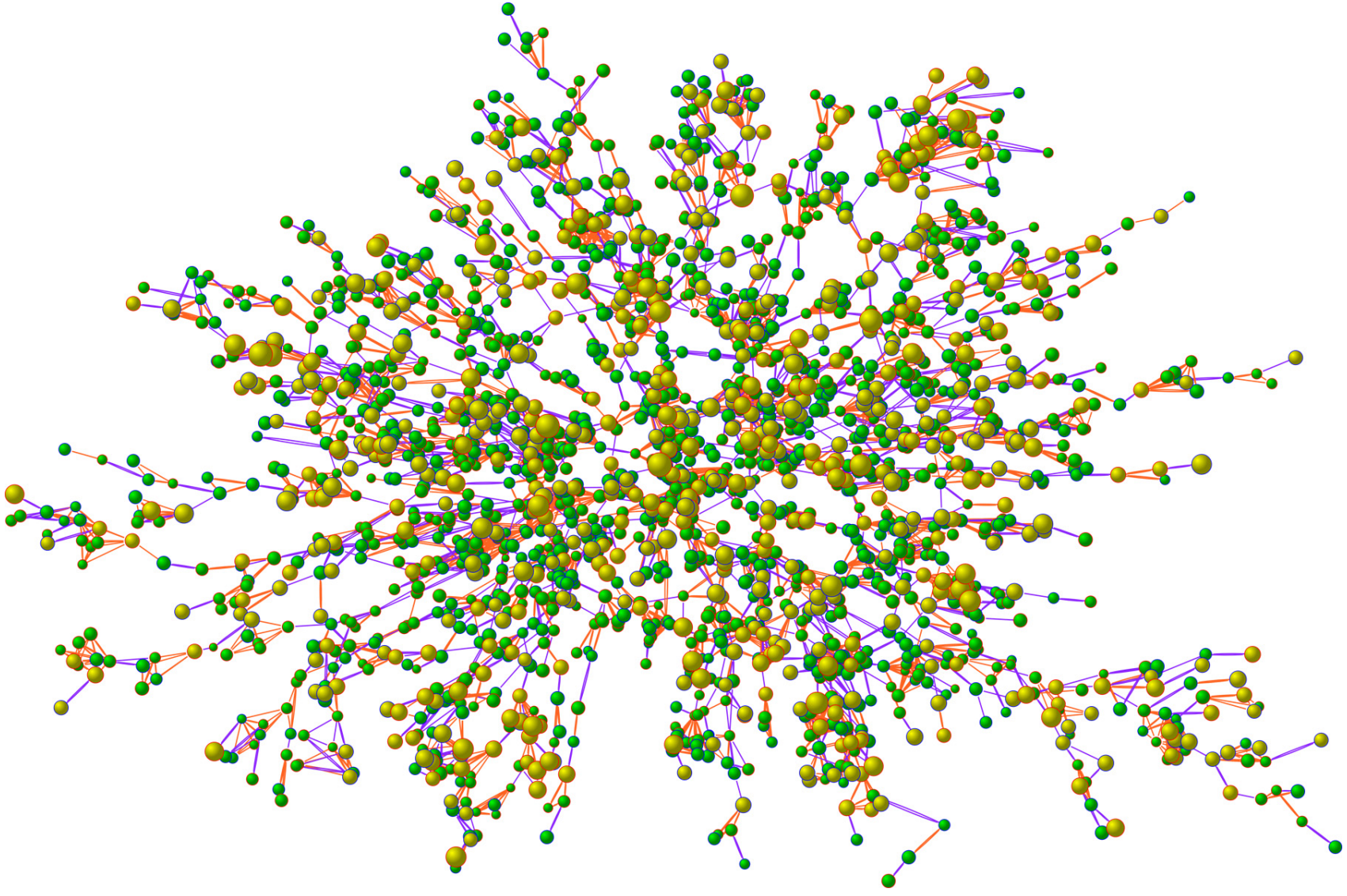
Digital technologies have led to an explosion in the availability of network data



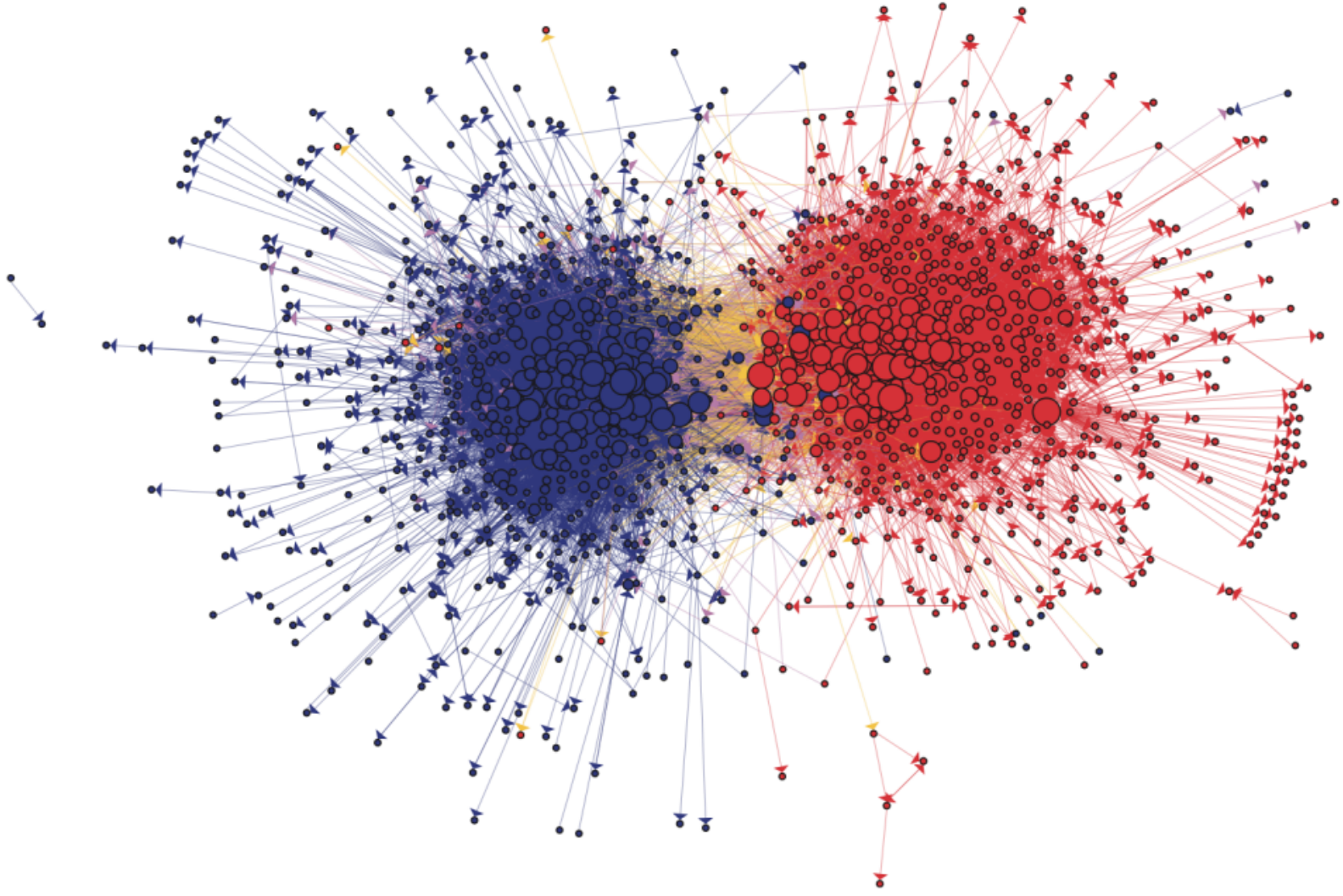
CLASS STRUCTURE, 1ST GRADE

21 boys and 14 girls. *Unchosen,* 18, GO, PR, CA, SH, FI, RS, DC, GA, SM, BB, TS, WI, KI, TA, HF, SA, SR, KR; *Pairs,* 3, EI-GO, WO-CE, CE-HN; *Stars,* 5, CE, WO, HC, FA, MB; *Chains,* 0; *Triangles,* 0; *Inter-sexual Attractions,* 22.

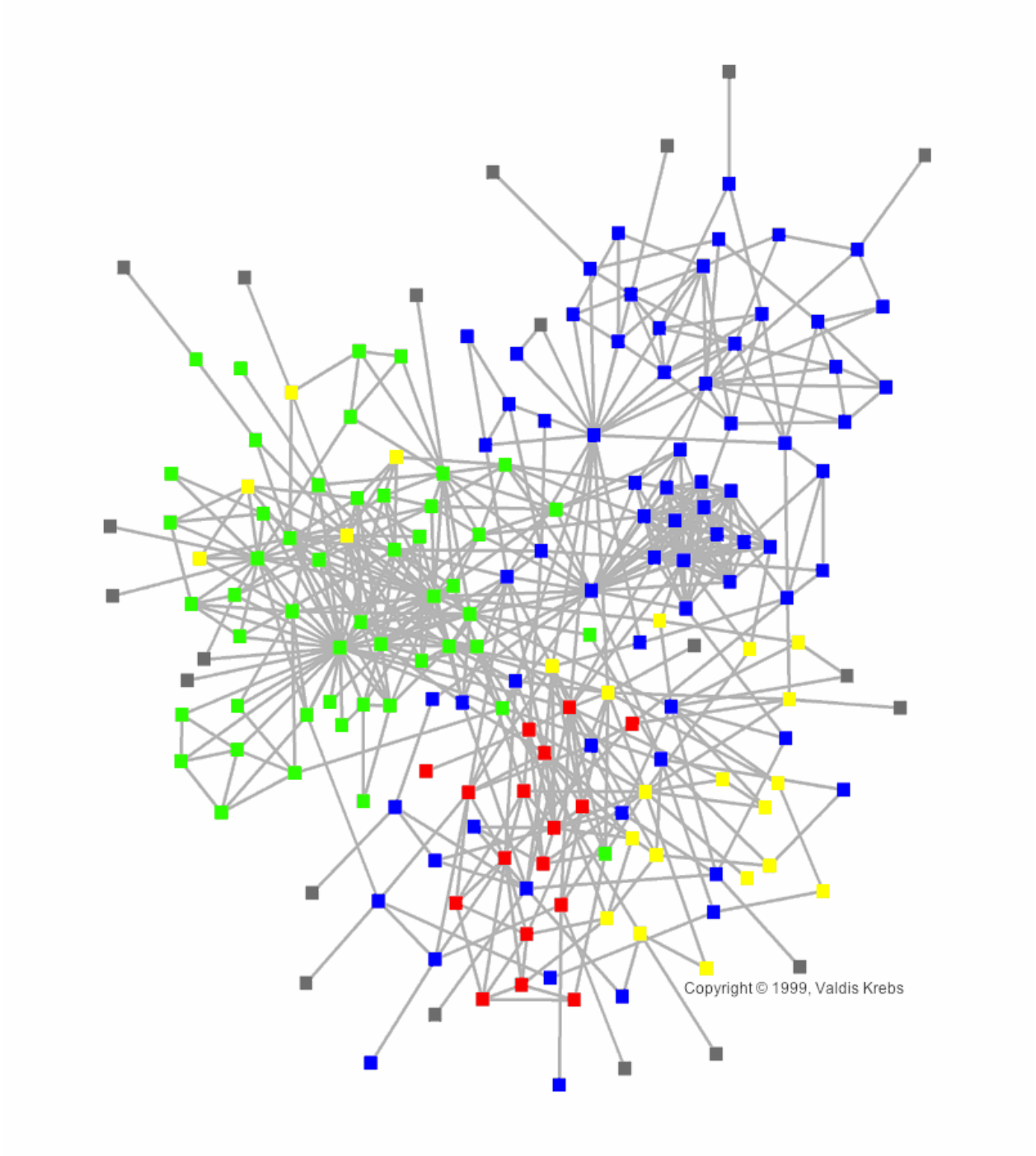
EVOLUTION OF GROUPS



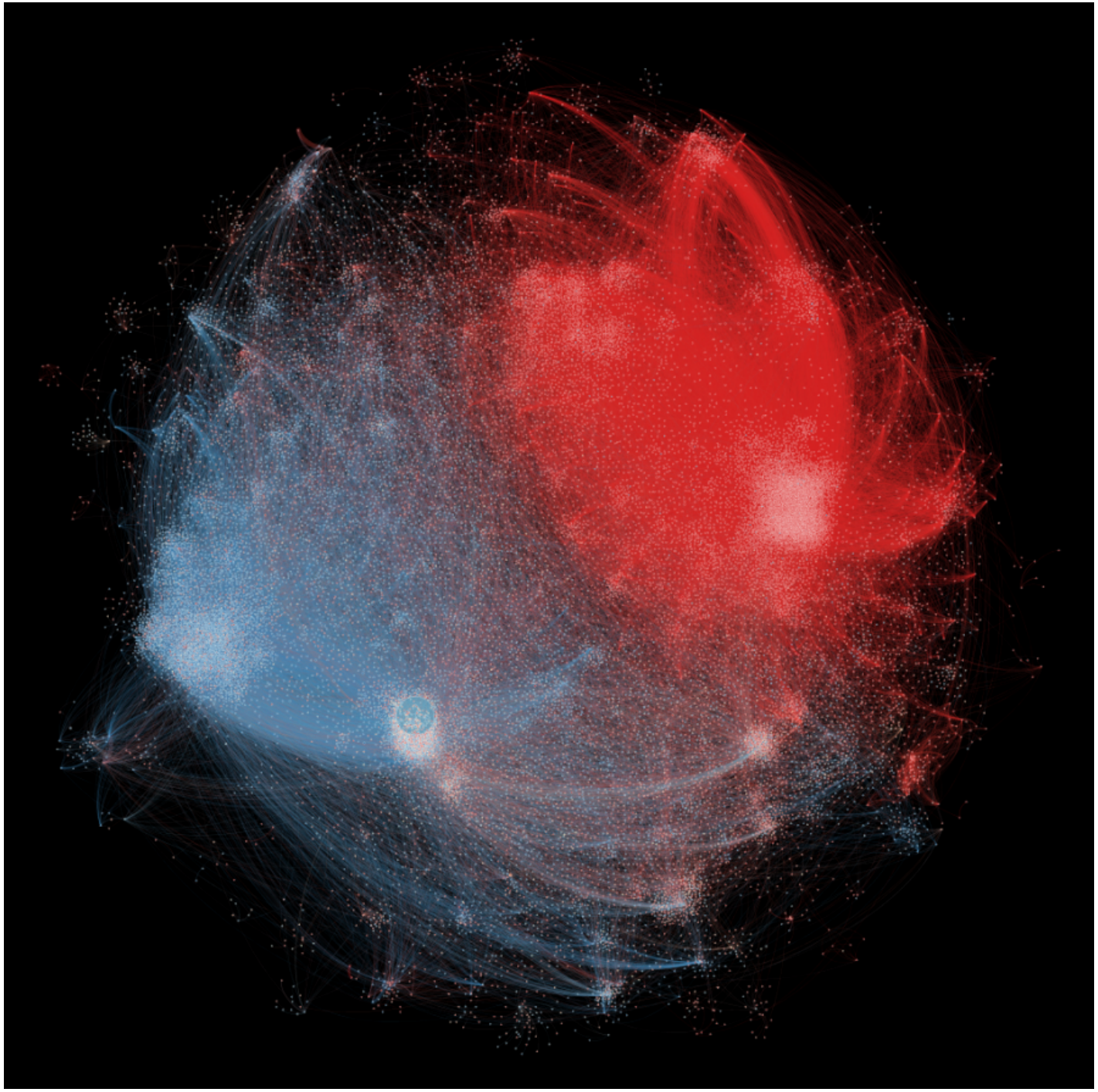
Christakis & Fowler, NEJM, 2007



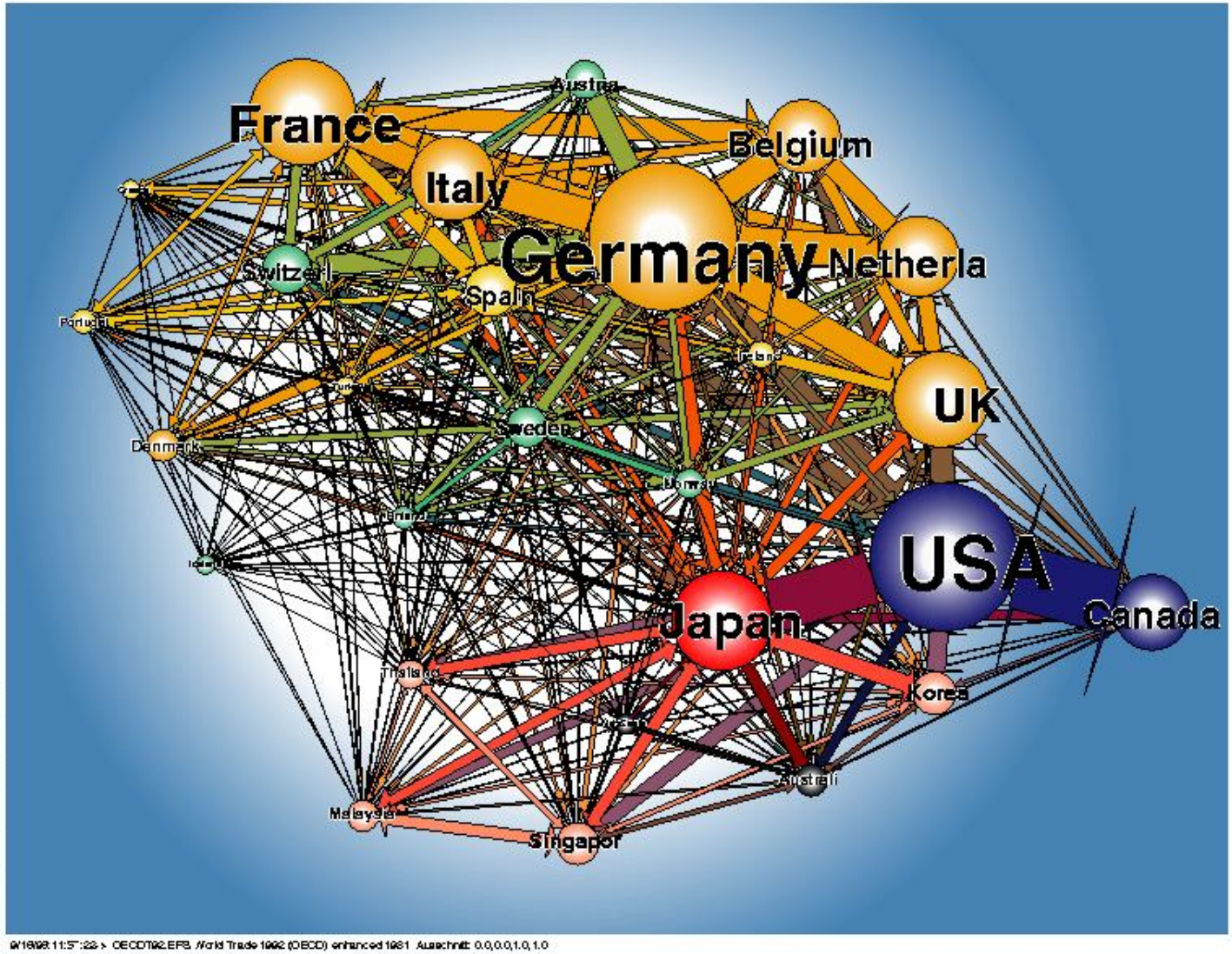
Adamic & Glance, 2004, IWLD



Email network of a company



Barbera et al, 2015, Psychological Science



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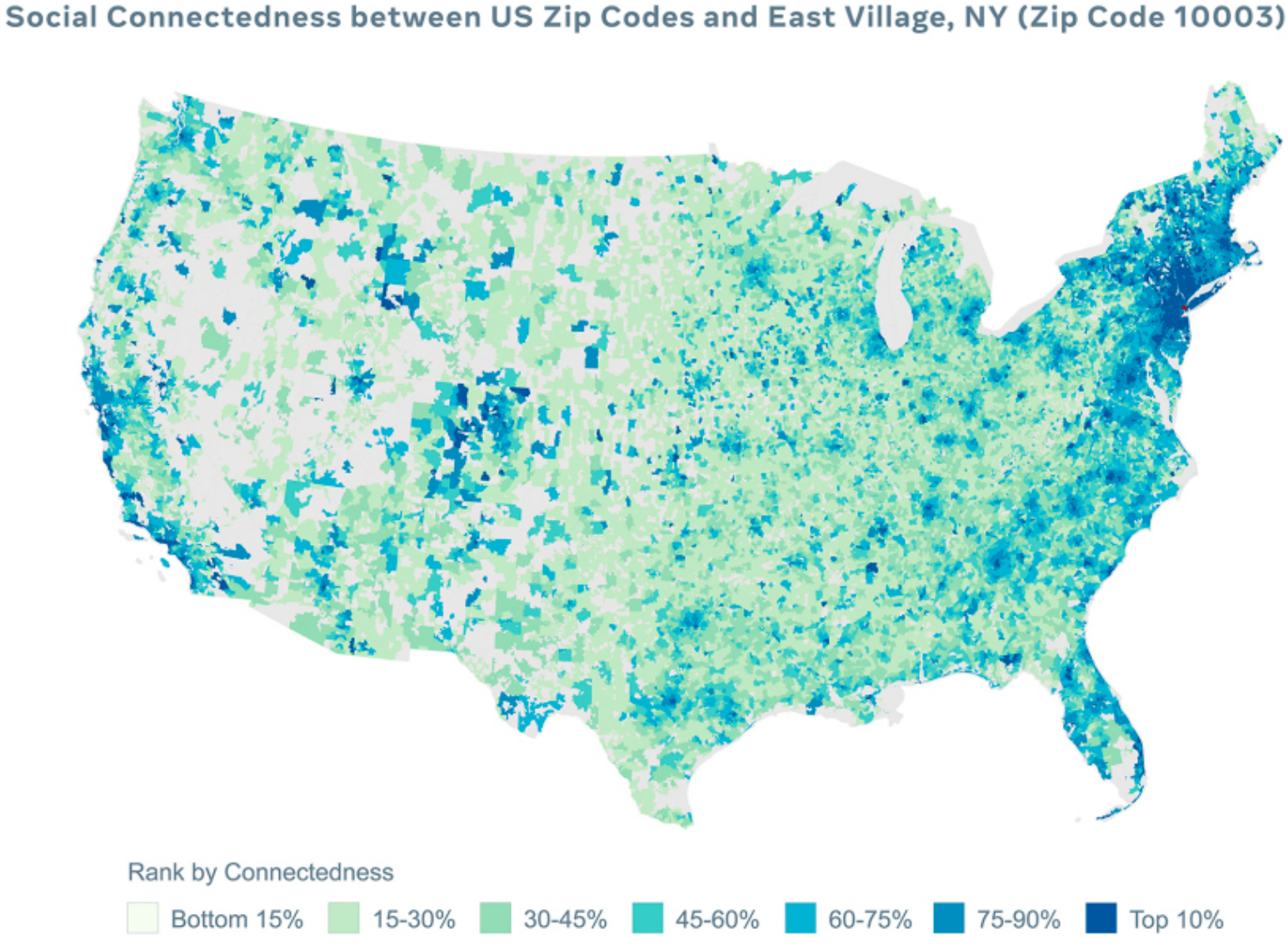


Facebook's Social Connectedness Index

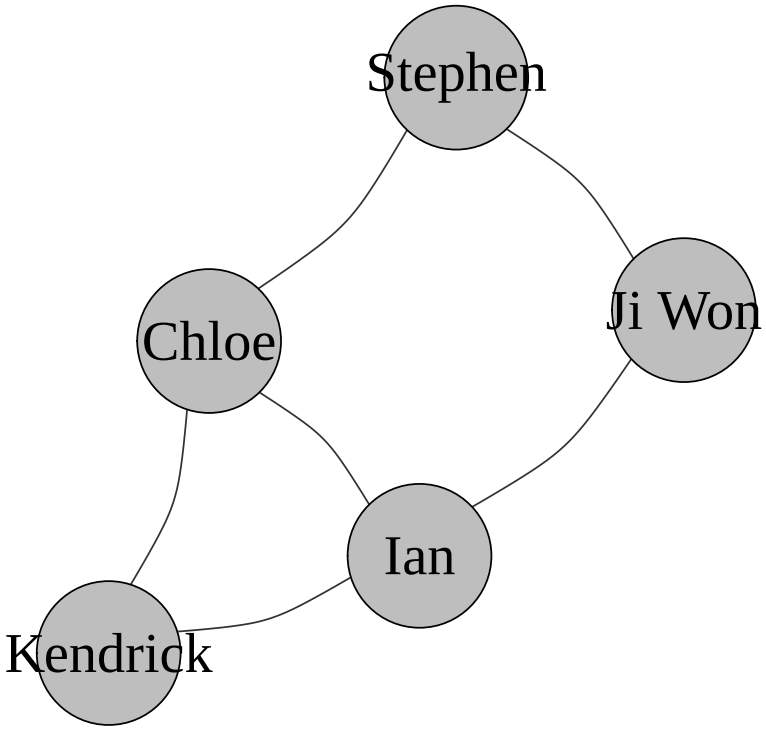
Basic concepts

- Node (vertex): each of the units in the network
- Edge (tie): connection between nodes
  - Undirected: symmetric connection, represented by lines
  - Directed: imply direction, represented by arrows
  - Unweighted: all edges have same strength
  - Weighted: some edges have more strength than others
- A network consists of a set of nodes and edges

  i.e. a set of actors and their relationships

Basic concepts

Network Visualization

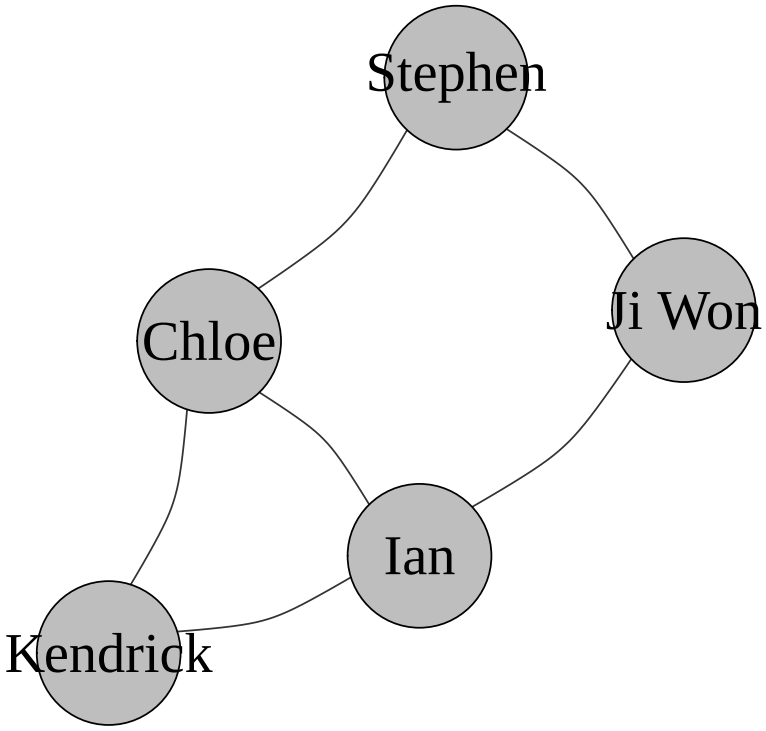


Adjacency Matrix

	S	C	J	I	K
Stephen	0	1	1	0	0
Chloe	1	0	0	1	1
Ji Won	1	0	0	1	0
Ian	0	1	1	0	1
Kendrick	0	1	0	1	0

Basic concepts

Network Visualization



Edgelist

	Node1	Node2
1	Stephen	Chloe
2	Stephen	Ji Won
3	Chloe	Ian
4	Chloe	Kendrick
5	Ian	Kendrick
6	Ji Won	Ian

Networks everywhere

- Academic literature: papers / citations
- Internet: websites / hyperlinks
- Twitter: users / retweets
- Power grid: plants, transformers / cables
- Biology: neurons / connections
- Text: documents / cosine similarity
- Hollywood: actors / playing in same movie
- Connectedness: zipcodes / connected people

Intellectual and societal impact of networks

Why do networks matter?

- **Economic impact**: most successful companies in 21st century base their technology and business model on networks
- **Health**: importance of networks in molecular biology, spread of human diseases, pharmacology
- **Fighting terrorism**: network-centric warfare can disrupt the financial networks of terrorist organizations and map adversarial networks
- **Epidemics**: role of transportation networks in the spread of viruses
- **Political behavior**: voting is contagious; opinion formation as a social process

Social network analysis: key dimensions of analysis

Node centrality

How to measure actor influence or importance in a network?

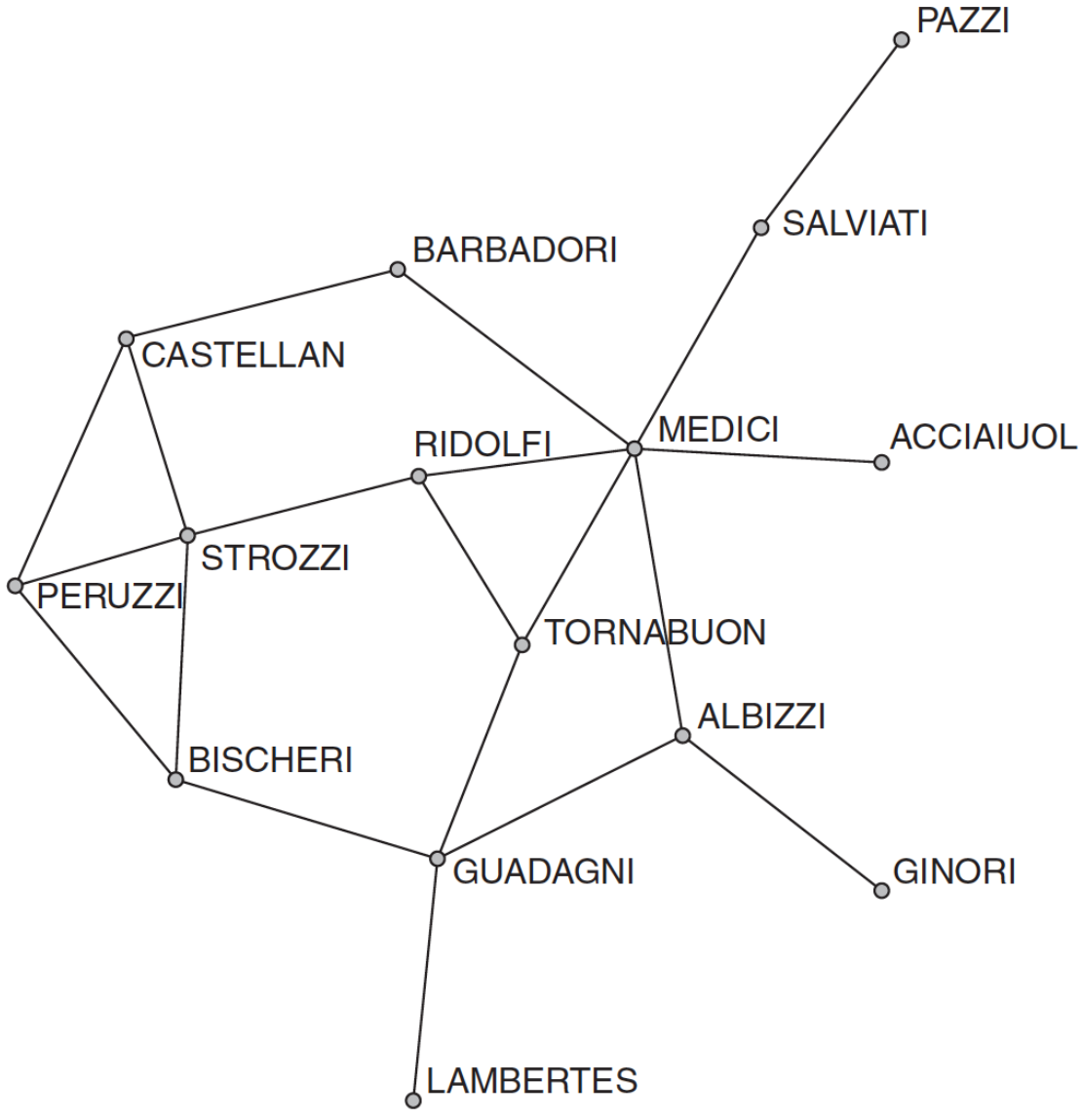
Two main conceptual definitions of centrality:

1. **Degree centrality**: number of connections for each node (potential for direct reach)
   - Indegree: incoming connections
   - Outdegree: outgoing connections
2. **Betweenness centrality**: gatekeeping potential
   - How well a node connects different parts of the network
   - Fraction of shortest paths between any two nodes on which a particular node lies

→ Other measures:

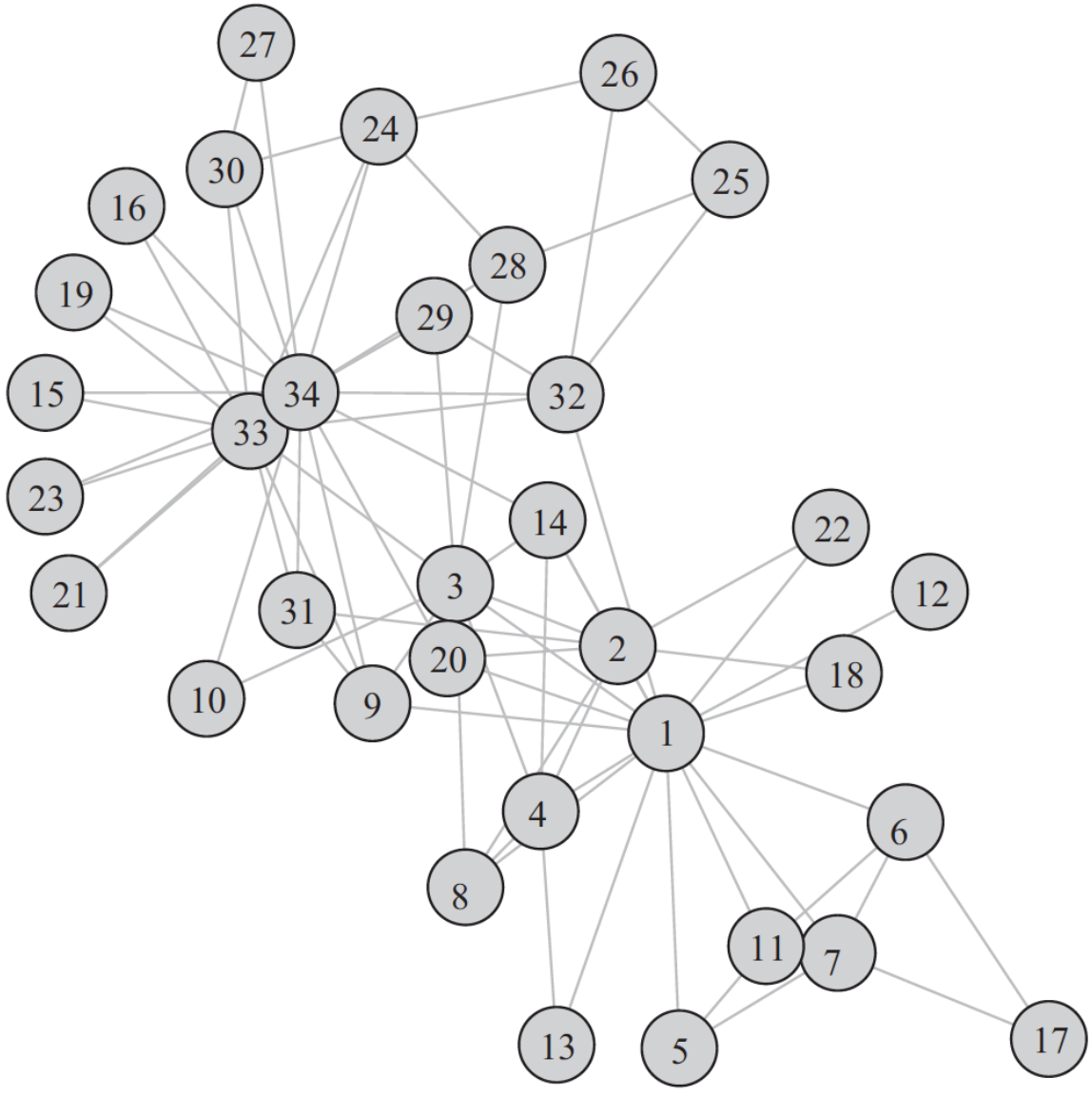
- **Closeness centrality**: broadcasting potential
- **Eigenvector centrality and coreness**: centrality measured as being connected to other central neighbors

Florentine family marriages in the 15th century



Source: Padgett (1993) and Sinclair (2016)

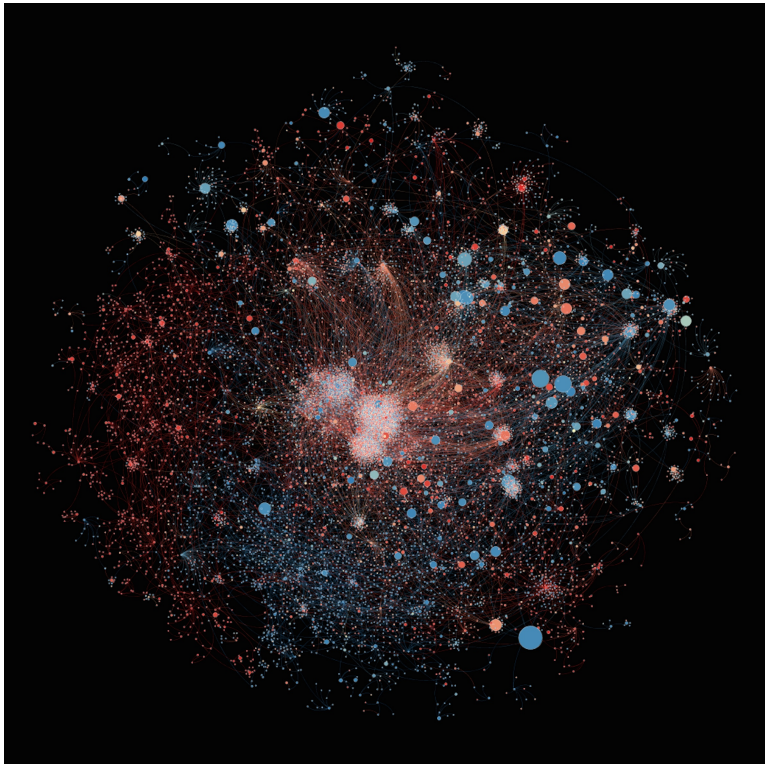
Social activities in a Karate club



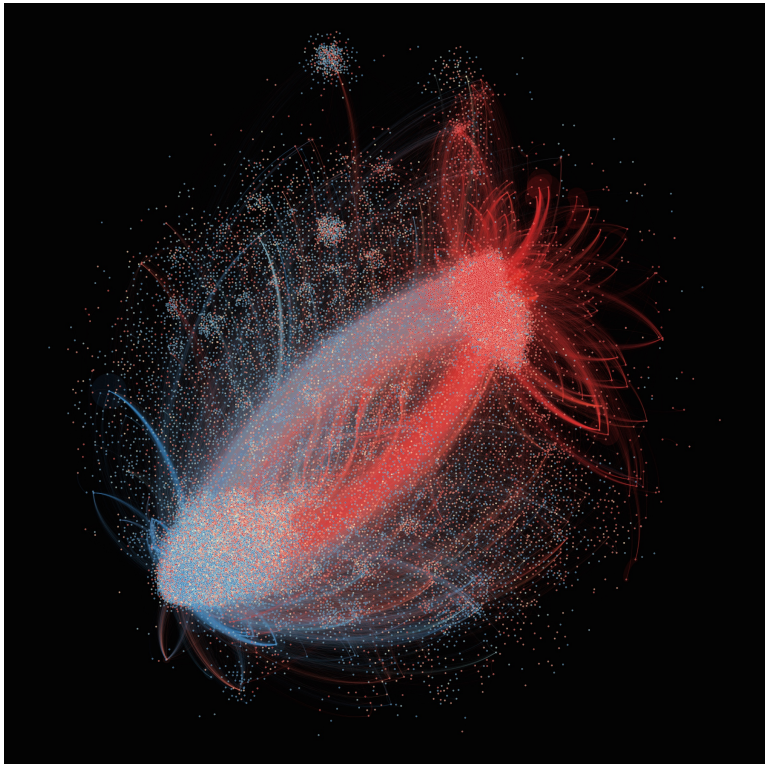
Source: Zachary (1997) and Sinclair (2016)

Social network analysis:
network properties

Mechanisms explaining network structure



2013 SuperBowl



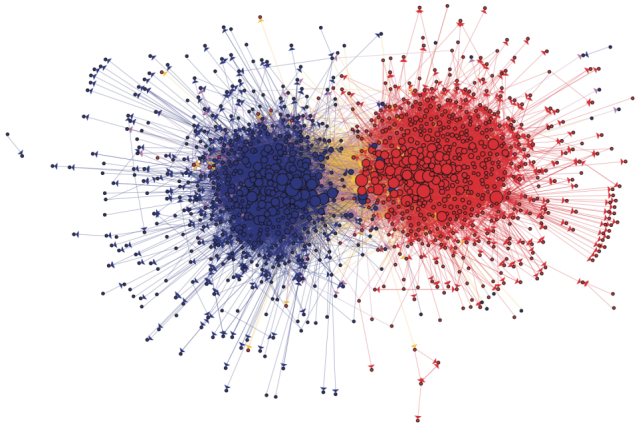
2012 Election

Barberá et al (2015) “Tweeting From Left to Right: Is Online Political Communication More Than an Echo Chamber?” *Psychological Science*

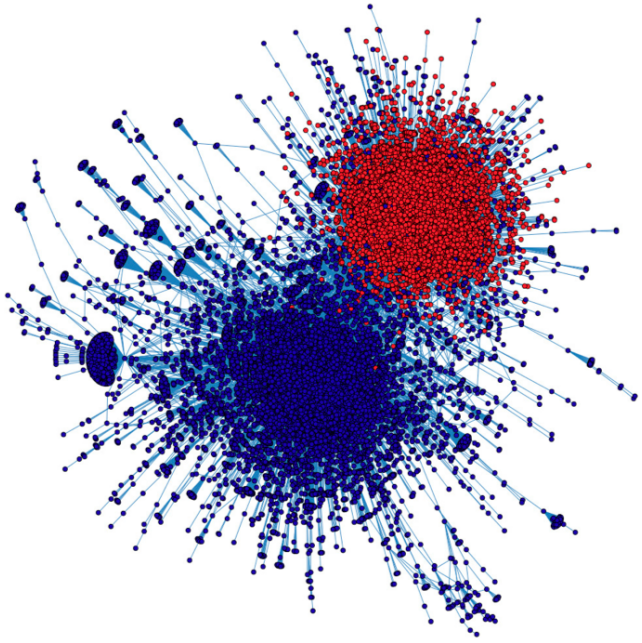
Mechanisms explaining network structure

Three key mechanisms behind tie formation:

1. **Homophily**: propensity to form ties based on shared traits (age, gender, ideology, location...)



Adamic and Glance (2005)



Conover et al (2012)

2. **Reciprocity**: propensity of directed ties to be mutual
   e.g. in holiday gifts exchanges, if you observe A giving a gift to B, then you're also likely to see B giving a gift back to A.
3. **Clustering** (aka *transitivity*): propensity of triads to close
   e.g. friendship networks grow via introductions: if James is