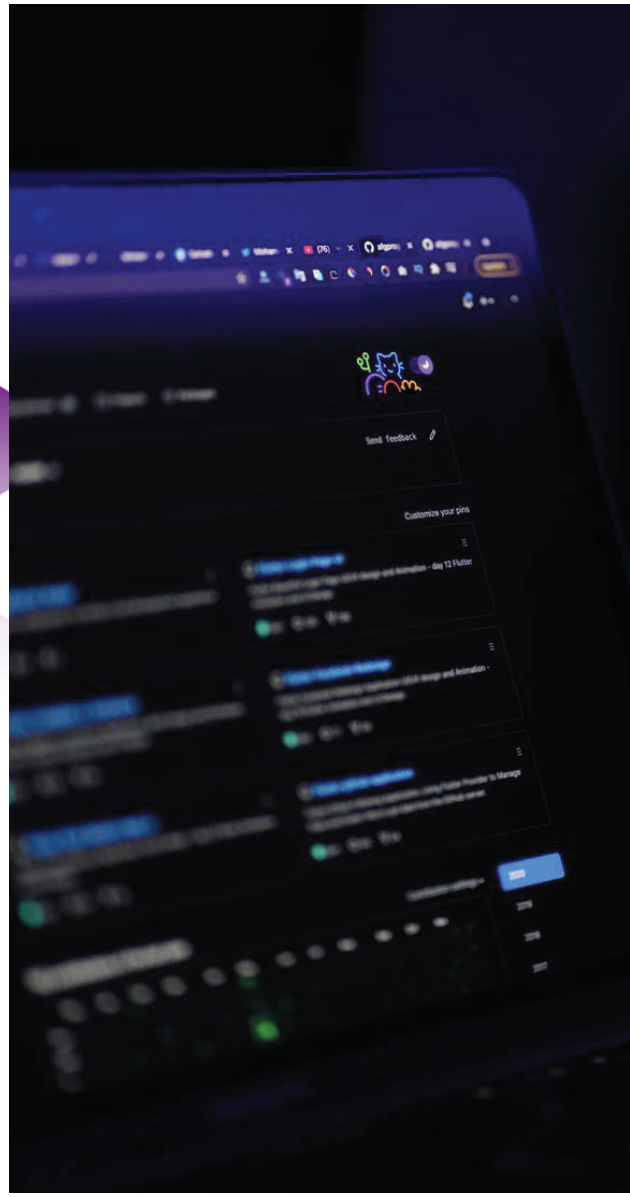
UK Data Service

Introduction to Social Network Analysis



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Economic and Social Research Council

Content

1. What is Social Network Analysis?
2. Real-world applications
3. Core concepts
4. Key metrics for analysis
5. Hands-on example
6. Data formats
7. Q&A

What is Social Network Analysis?

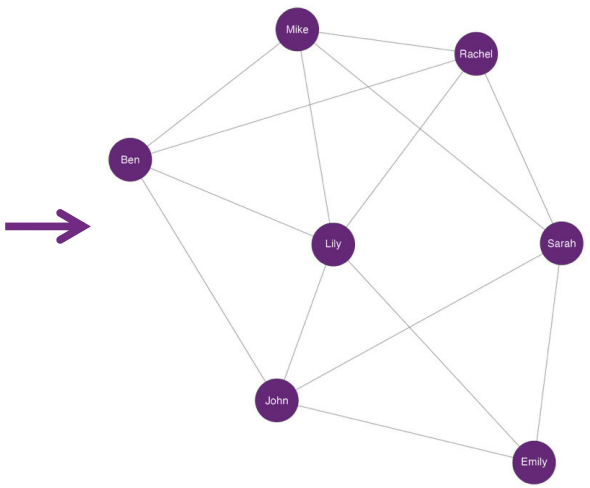
"One of the most potent ideas in the social sciences is the notion that individuals are embedded in thick webs of social relations and interactions."

(Borgatti et al, 2009)

Social Network Analysis is:

- A method for studying **relationships** between entities
- A way to **visualize** complex social structures
- A toolkit for **measuring** patterns of connection

Team
Ben
Emily
Sarah
Mike
John
Rachel
Lily



The Network Perspective

"Networks are a way of thinking about social systems that focus our attention on the relationships among the entities that make up the system, which we call actors or nodes."

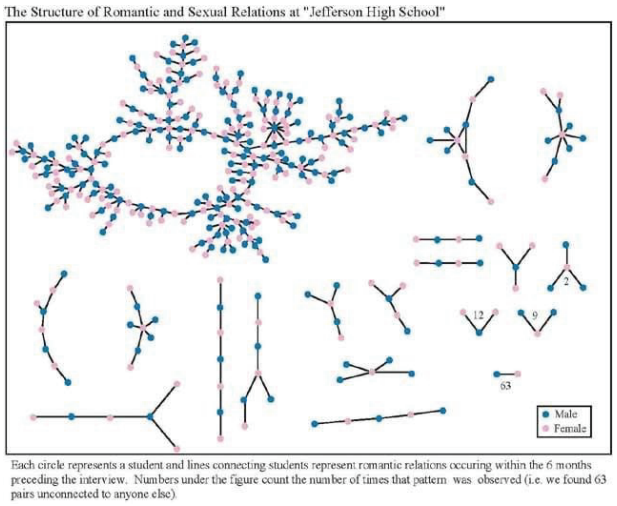
(Borgatti et al, 2018)

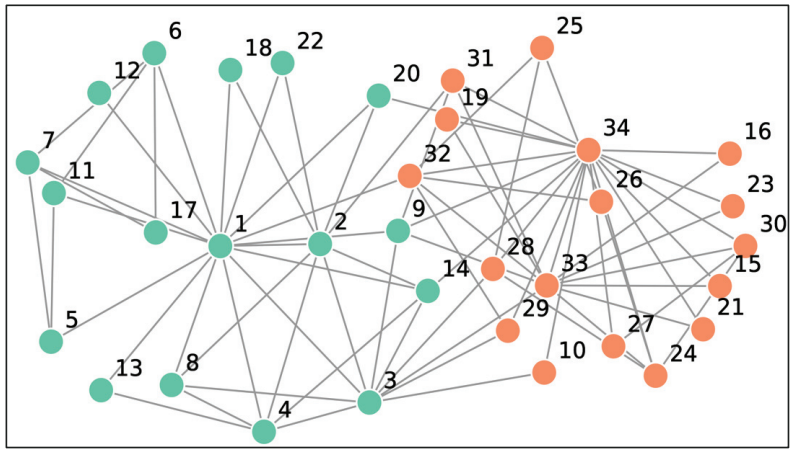
Traditional Approach	Network Approach
Emphasises individual attributes	Emphasises relational patterns and attributes
Individuals as independent	Individuals as interdependent
"What characteristics predict behaviour?"	"How does position in the network affect behaviour?"
Attributes primary, relationships secondary	Relationships primary, attributes contextualised

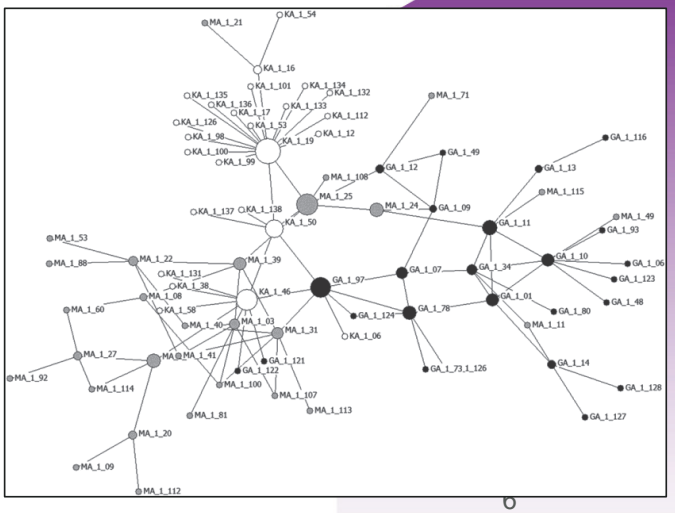
Networks Are Everywhere

"…much of culture and nature seems to be structured as networks – from brains (e.g., neural networks) and organisms (e.g., circulatory systems) to organizations (e.g., who reports to whom), economies (e.g., who sells to whom) and ecologies (e.g., who eats whom)."

(Borgatti et al, 2018)







What Questions Can SNA Answer?

Common social network research questions broadly come under a few categories:

1. How do things spread through networks?
2. Does where you sit in the network affect you?
3. How do people choose their connections?
4. What does the overall structure look like?
5. How do networks evolve?
6. What makes a network work well?

Core Concepts

The basic elements include:

Nodes (or Vertices)

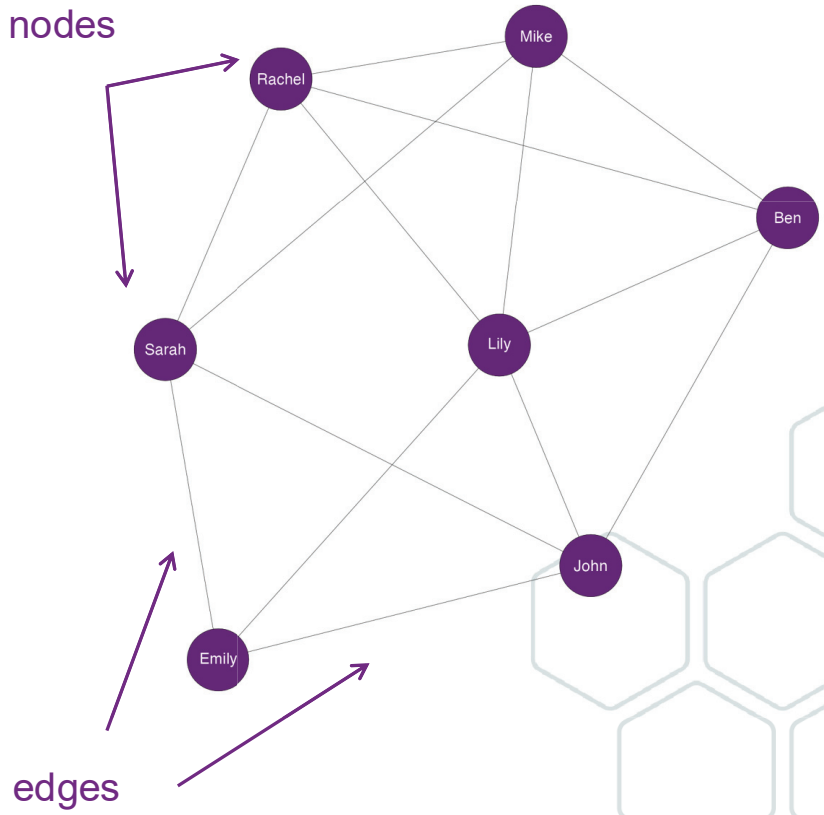
- The entities in your network
- Examples: people, organisations, countries, websites

Edges (or Ties)

- The connections between nodes
- Examples: friendship, collaboration, trade, hyperlinks

Network (or Graph)

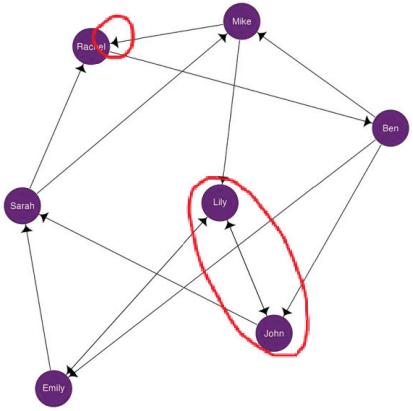
- The complete set of nodes and their edges

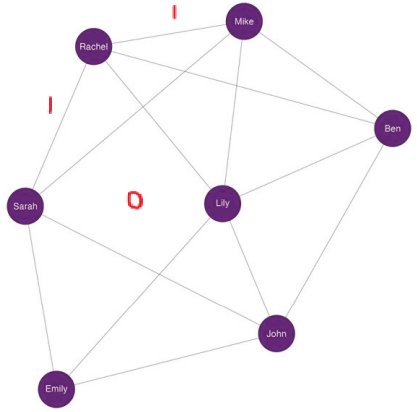


Types of networks

<u>Directed vs Undirected</u>

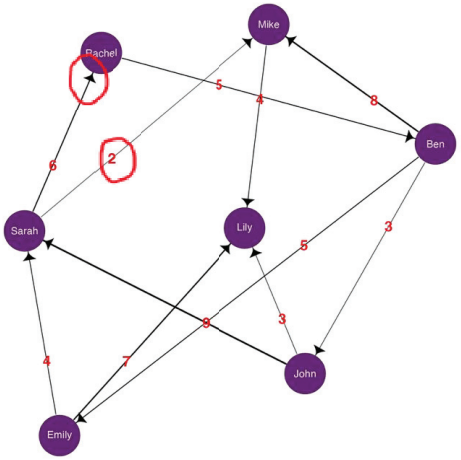
- Undirected: Friendship (usually mutual)
- Directed: Twitter follows (can be one-way)

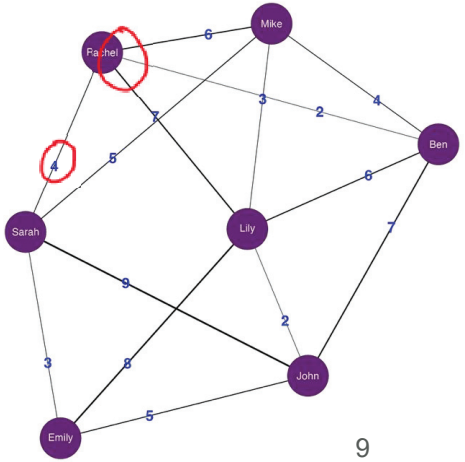




<u>Weighted vs. Unweighted</u>

- Unweighted (binary): Friends or not friends
- Weighted (valued): Number of emails sent

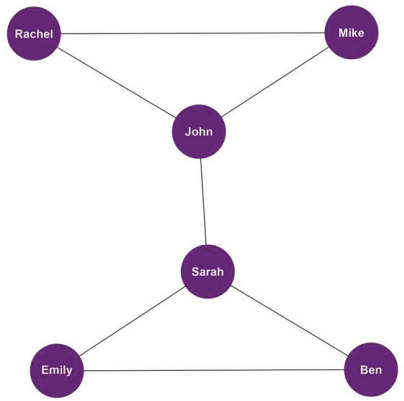




Types of networks

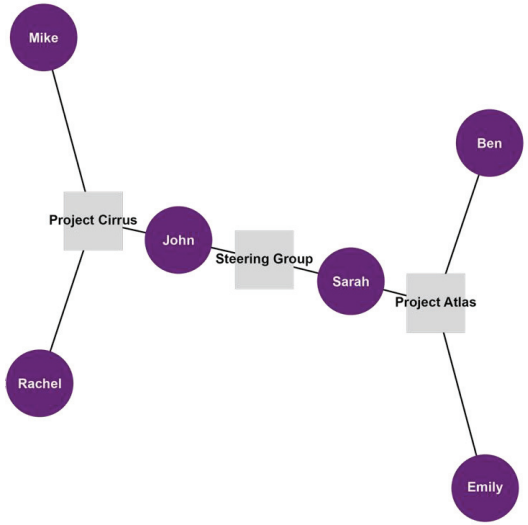
One-Mode

Model the relationships between similar units e.g. people, computers, organisations



Two-Mode (or 'affiliation networks')

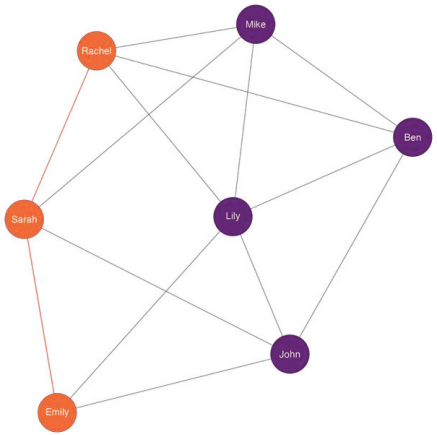
Model the relationship between two different units e.g. elites and corporations, actors and movies, students and clubs



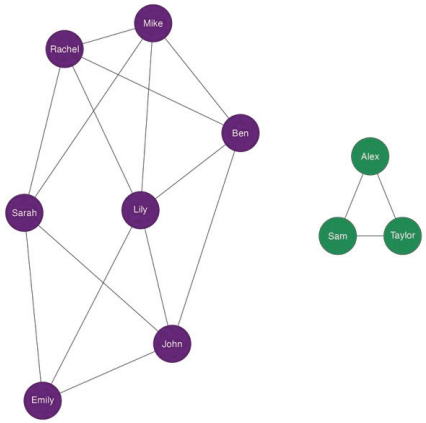
Network Structure

"…a fundamental axiom of social network analysis is the concept that structure matters. For example, teams with the same composition of member skills can perform very differently depending on the patterns of relationships among the members."
(Borgatti et al, 2009)

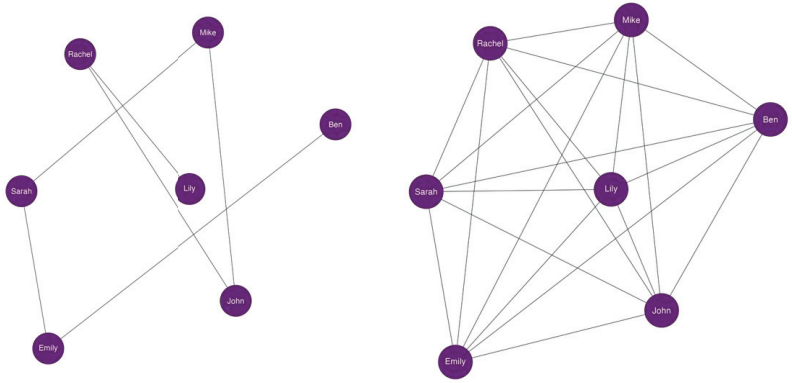
Paths



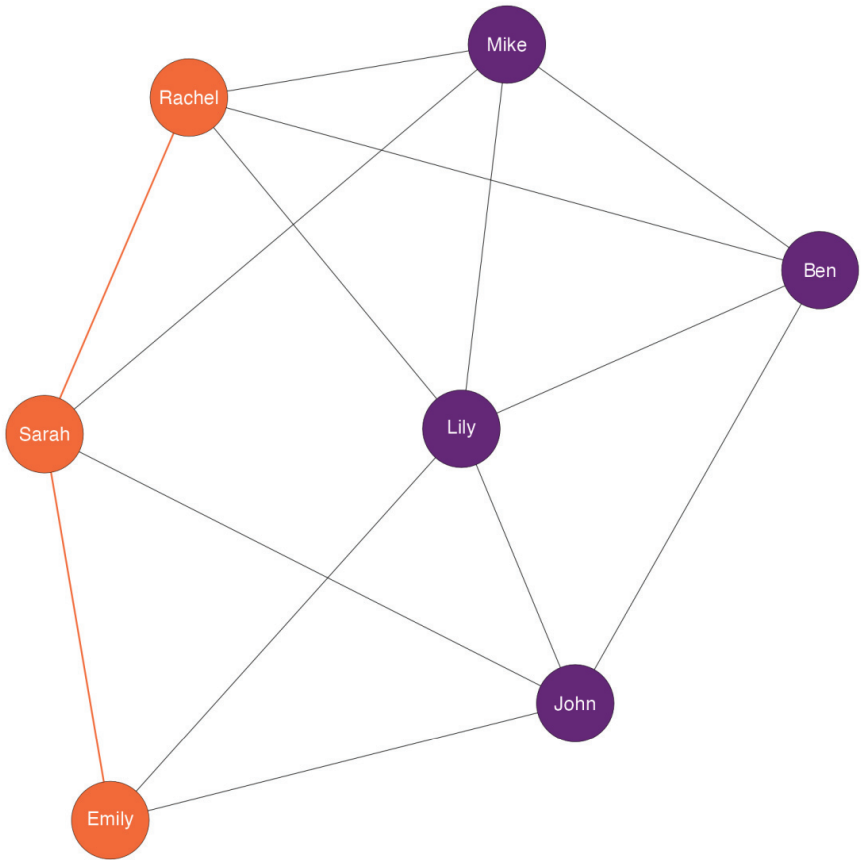
Components



Density

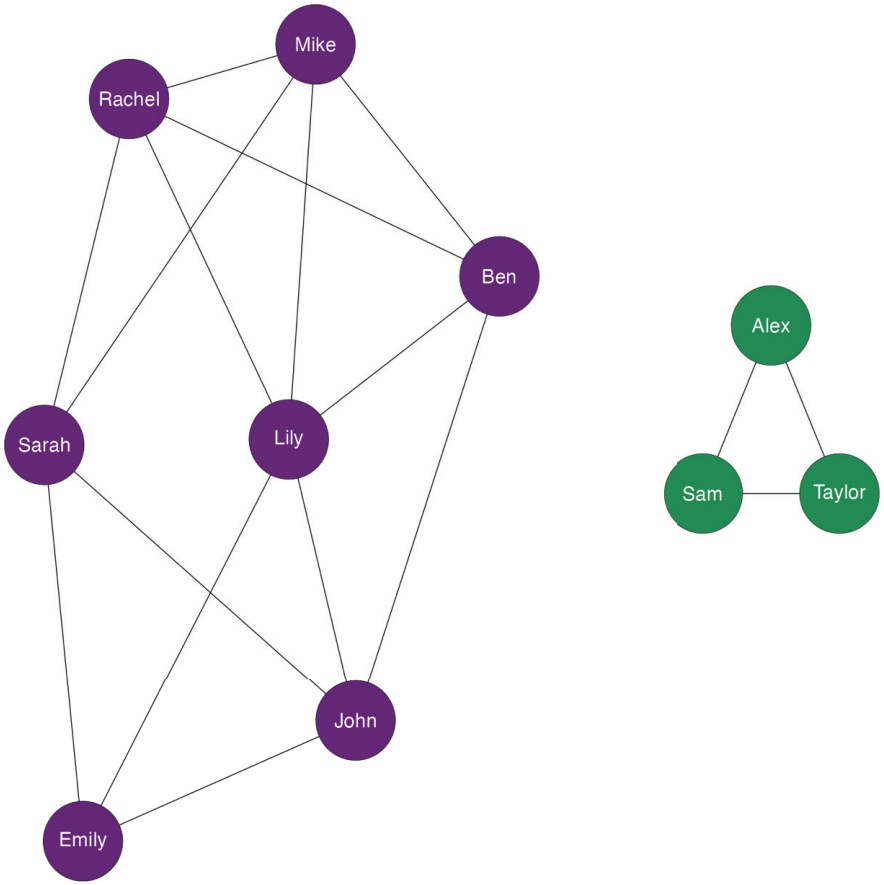


Paths



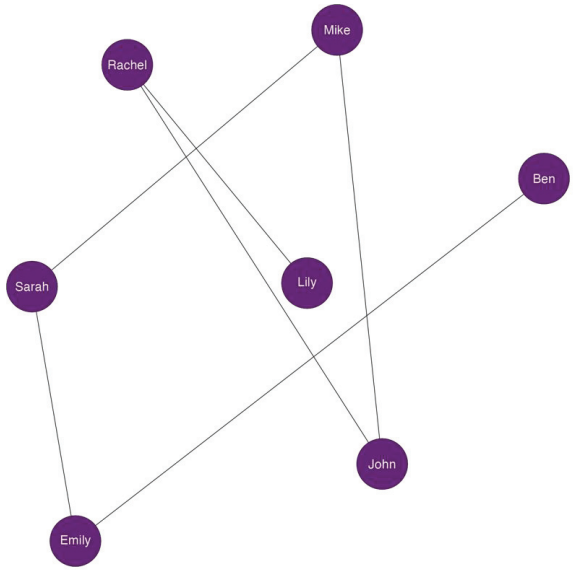
- A path is a **route** linking one person to another in a network
- Paths show **how information, influence, or resources travel** through connections
- The **shortest path** highlights the most efficient route for communication or coordination

Components



- A component is a group of nodes that are all connected to each other **but not connected to anyone outside the group**
- Components reveal **where communication and influence flow**, and where they stop.
- Understanding components helps identify **disconnected parts of a network**

Density



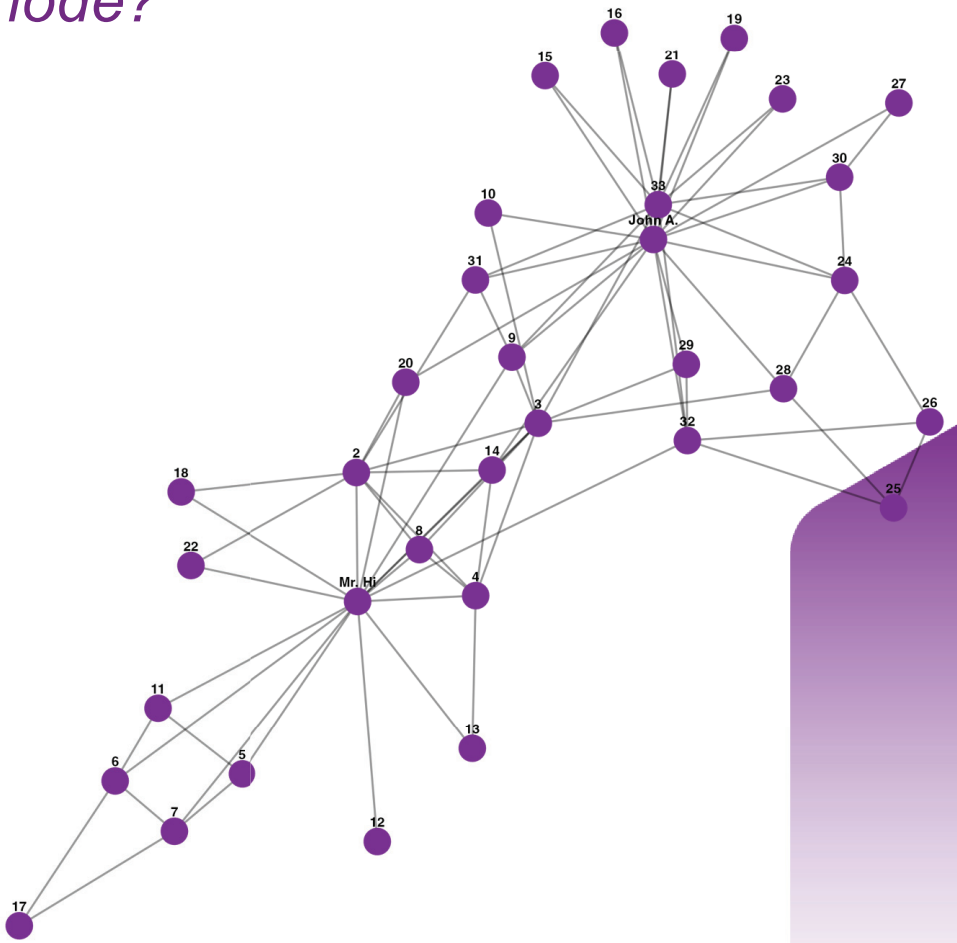
Low density networks have fewer links but can be **more efficient** and focus on **stronger connections**

High density networks spread information quickly but can lead to **echo chambers**

Measuring Networks: Node-level metrics

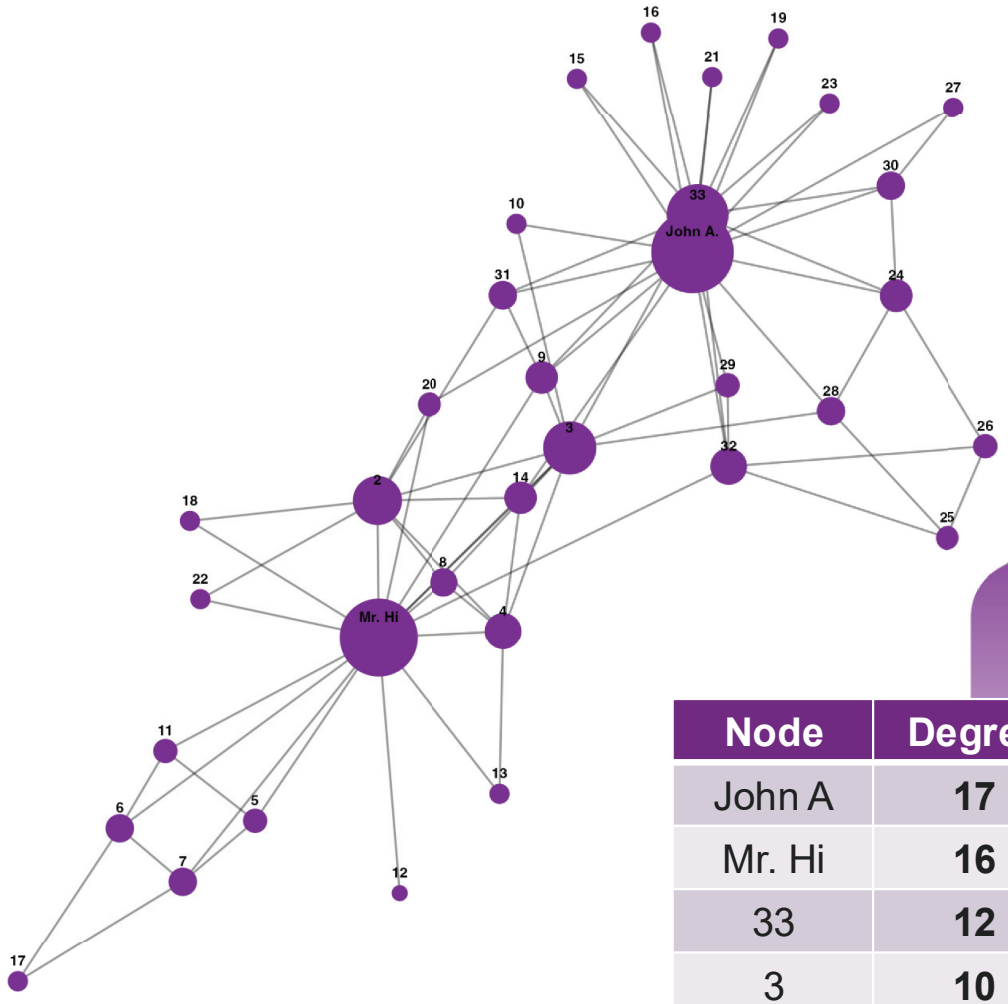
How important is a node?

Metric	Description
Degree Centrality	Number of direct connections (e.g. Sales 1 = 2)
Betweenness Centrality	Role in connecting others
Closeness Centrality	Distance to all other nodes



Degree centrality

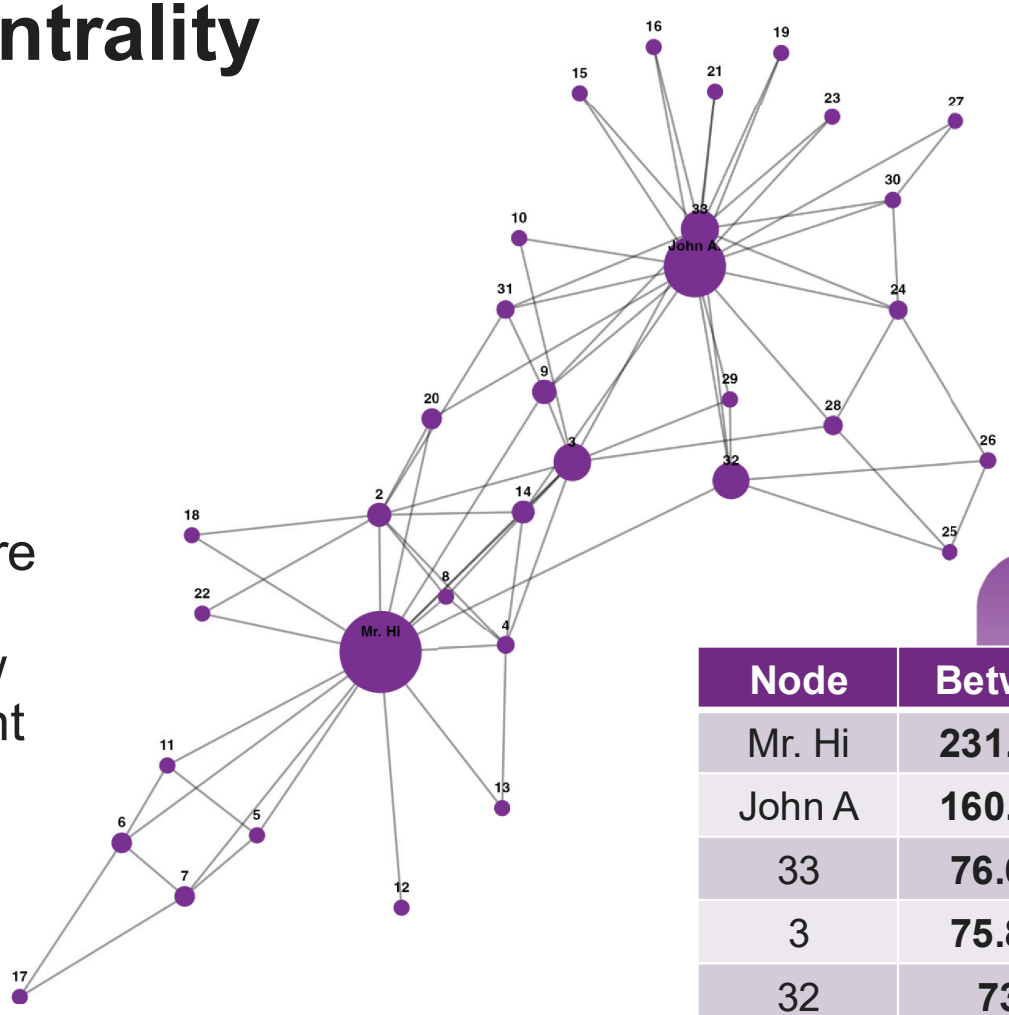
- Who has the most connections?
- Calculated by counting a nodes connections (its degree)
- High degree nodes are known as ‘hubs’, and they have a big influence on the networks structure and function, e.g. spread of information, or disease.



Node	Degree
John A	**17**
Mr. Hi	**16**
33	**12**
3	**10**

Betweenness Centrality

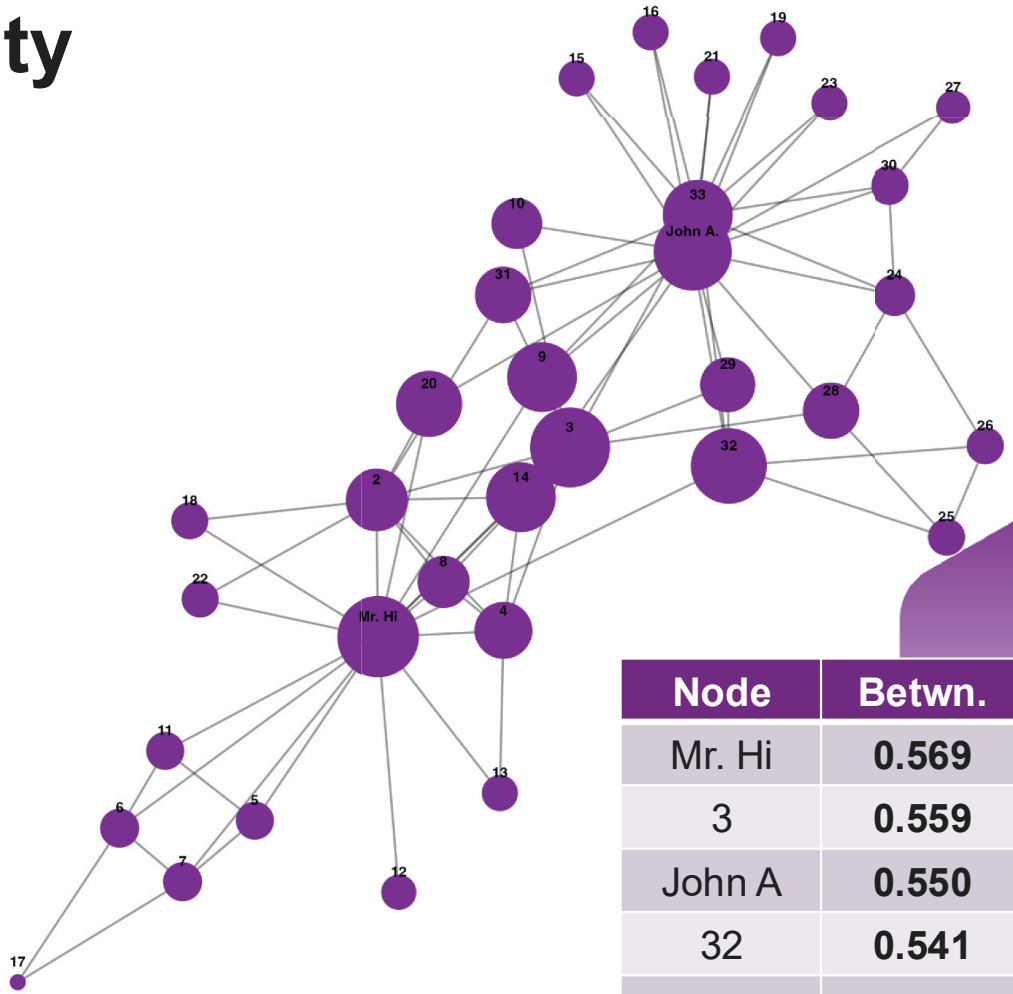
- Who are the bridges?
- Calculated by counting how often a node lies on the shortest path between all other pairs of nodes
- High betweenness nodes are brokers and gatekeepers who control information flow and can connect or fragment the network



Node	Betwn.
Mr. Hi	**231.07**
John A	**160.55**
33	**76.69**
3	**75.85**
32	**73**

Closeness Centrality

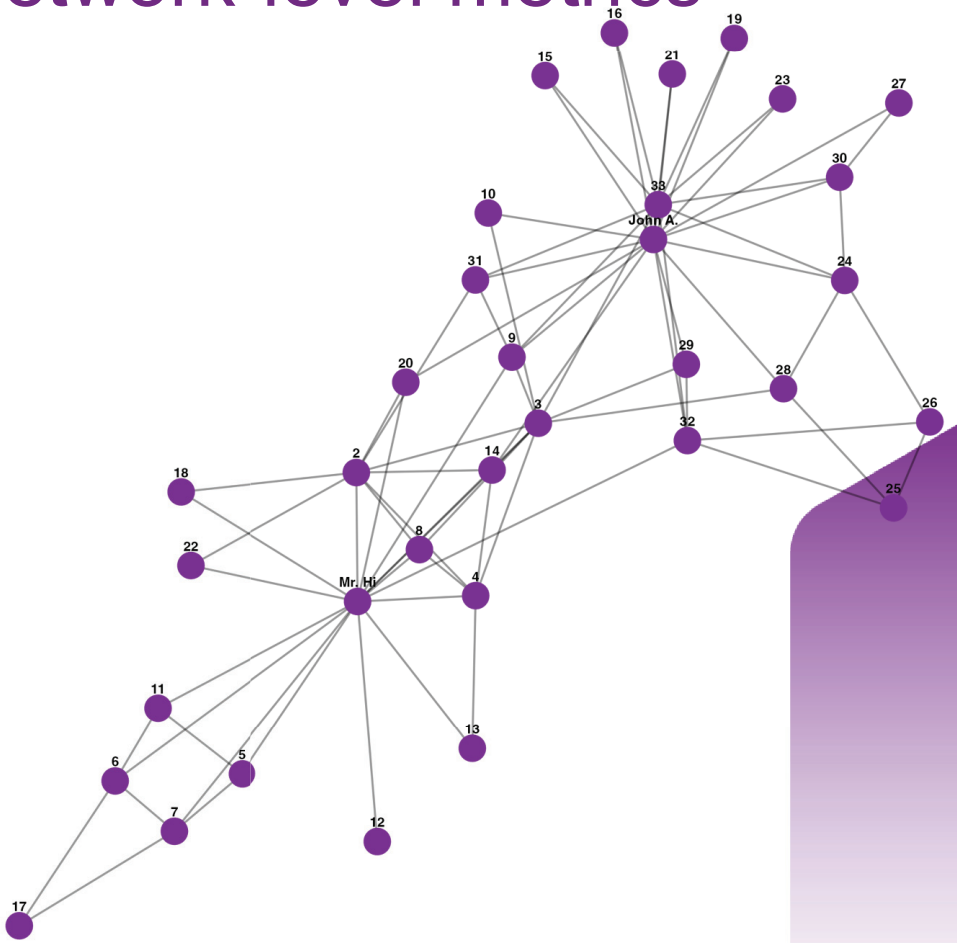
- Who can reach everyone quickly?
- Calculated by finding the average shortest path from a node to all other nodes in the network
- High closeness nodes are optimally positioned for rapid information dissemination or gathering feedback from the entire network



Node	Betwn.
Mr. Hi	**0.569**
3	**0.559**
John A	**0.550**
32	**0.541**
9	**0.516**

Measuring Networks: Network-level metrics

Metric	Description
Density	How connected the overall network is
Clustering Coefficient	Tendency of nodes to form tightly knit groups
Average Path Length	Avg number of steps it takes to reach one node from across the network

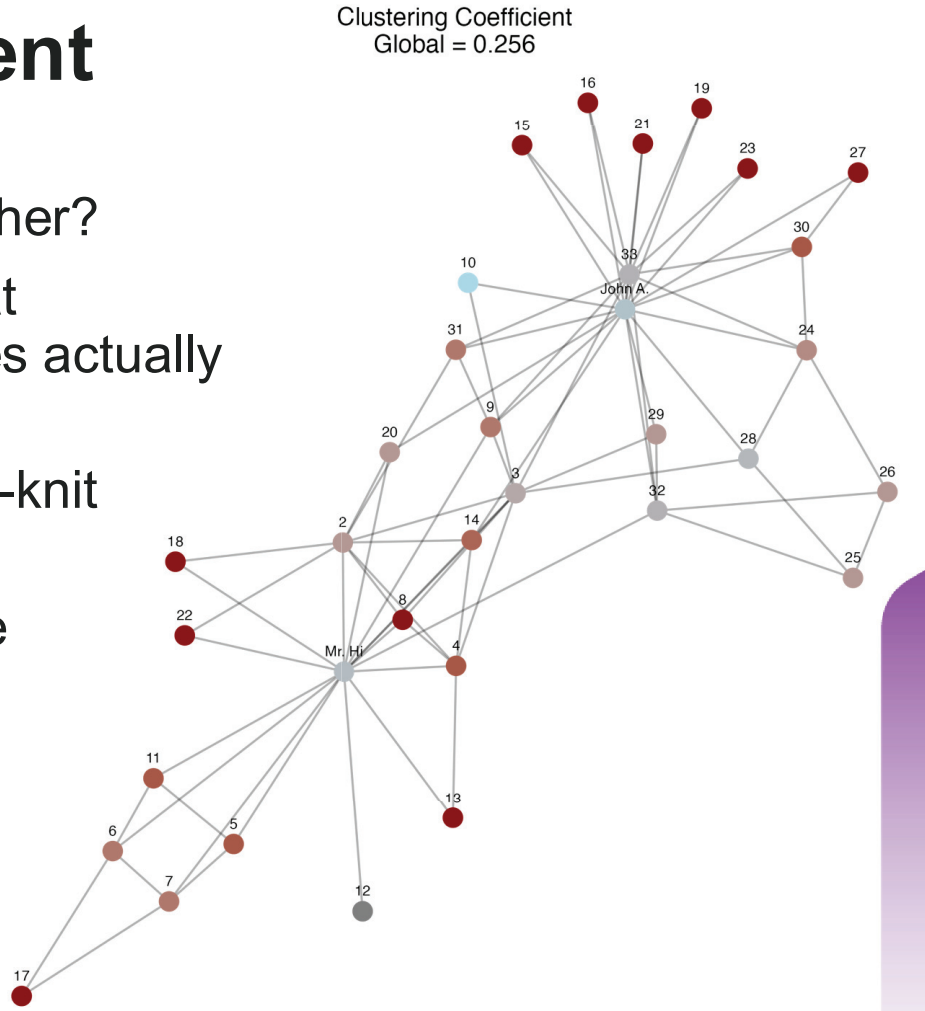


Density

- How connected is the overall network?
- Calculated by dividing actual edges by possible edges
- Low density creates **structural holes** and need for bridges.
- High density means everyone knows everyone.

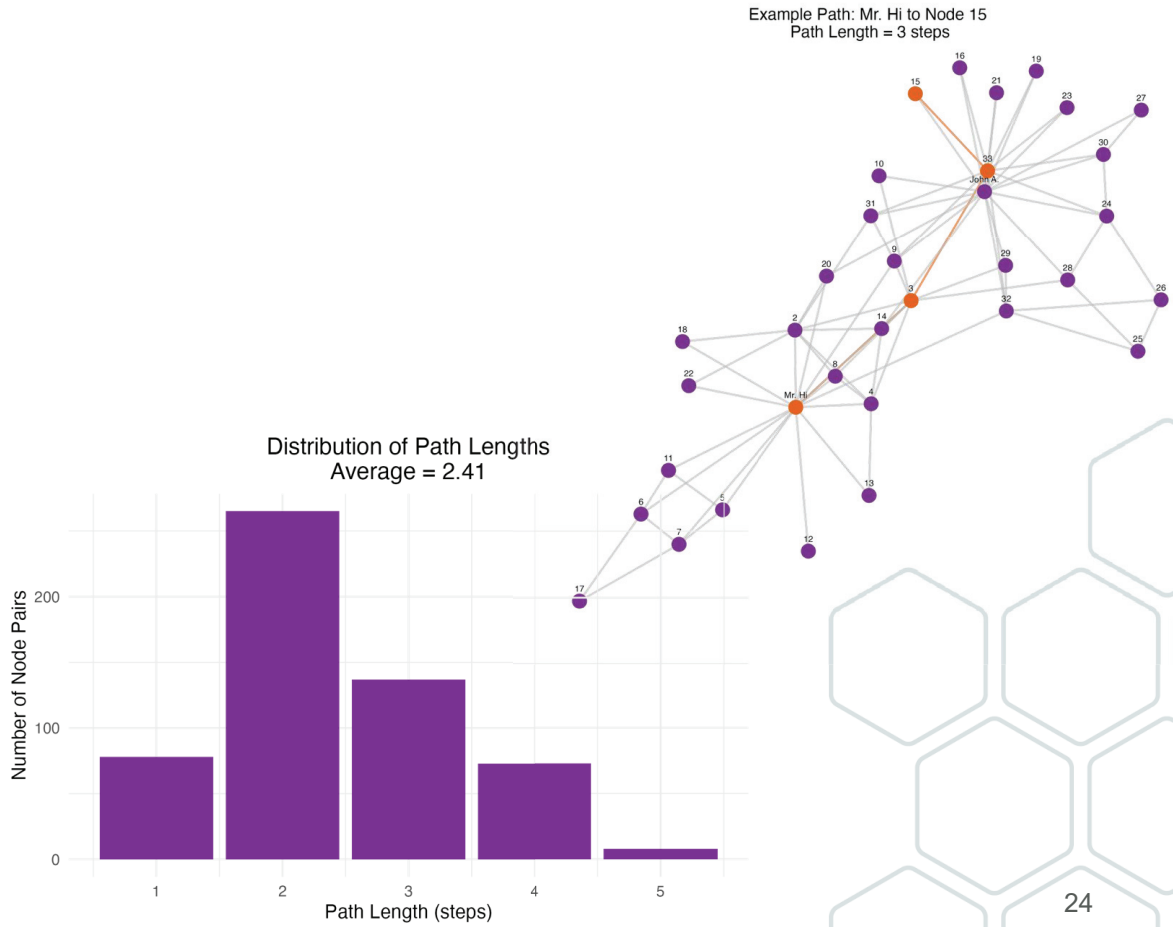
Clustering Coefficient

- Do your friends know each other?
- Calculated by measuring what proportion of possible triangles actually exist
- High clustering indicates tight-knit groups and cliques.
- Low clustering suggests more scattered connections.



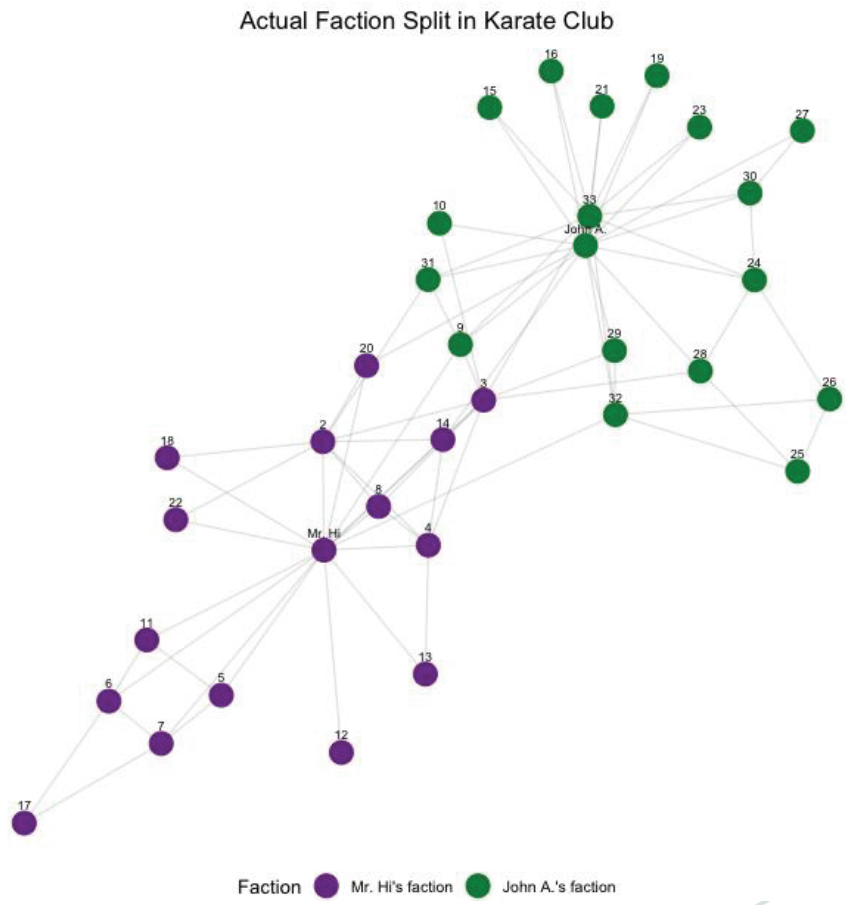
Average Path Length

- How many steps separate any two people?
- Calculated by finding shortest paths between all pairs and taking the average
- Short paths enable rapid information spread. When combined with high clustering this creates **“small word”** networks



Identifying Communities

- How do we find communities?
- Look for many connections WITHIN GROUPS, few BETWEEN GROUPS
- Algorithms score different divisions to find the best split
- Can reveal hidden structures and predict social outcomes

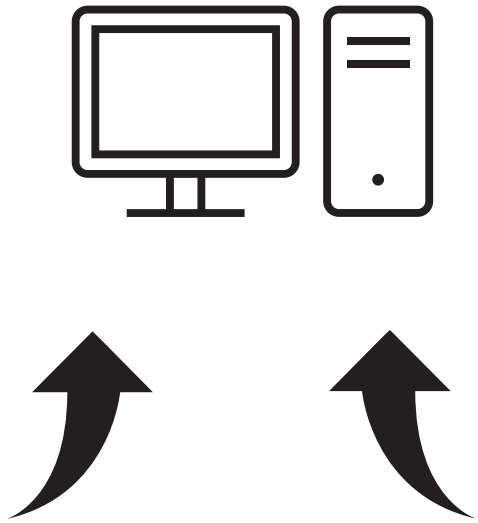


Representing Network Data

- Networks are made up of nodes (entities) and edges (connections)
- Network data can be stored in different formats, but the two most common are:

1. Edge list

Source	Target
1	2
1	3
1	4
1	5
1	6
1	7
1	8
…	…
32	34
33	34



2. Adjacency matrix (34 x 34)

	1	2	3	4	5	6	7	8	9	10	11
1	0	1	1	1	1	1	1	1	1	0	1
2	1	0	1	1	0	0	0	1	0	0	0
3	1	1	0	1	0	0	0	1	1	1	0
4	1	1	1	0	0	0	0	1	0	0	0
5	1	0	0	0	0	0	1	0	0	0	1
6	1	0	0	0	0	0	1	0	0	0	1
7	1	0	0	0	1	1	0	0	0	0	0
8	1	1	1	1	0	0	0	0	0	0	0
9	1	0	1	0	0	0	0	0	0	0	0
10	0	0	1	0	0	0	0	0	0	0	0

Getting Started with SNA Software

No code options:

- UCINET – Comprehensive analysis suite
- Gephi – Free, visual network exploration
- NodeXL – Excel plugin for spreadsheet users

Programming options:

- R (igraph) – Comprehensive analysis
- Python (NetworkX) – Also provides comprehensive analysis

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Thank you.

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