Triadic closure
Strength of Weak Ties
Structural Holes

CS 322: (Social and Information) Network Analysis
Jure Leskovec
Stanford University

Networks: Flow of information

- How information flows through the network?
- How different nodes can play structurally distinct process in roles in this process?
- How different links (short range vs. long range) play different roles in diffusion?
- How this shapes the evolution of the network over time?

[Granovetter '73]

Strength of weak ties

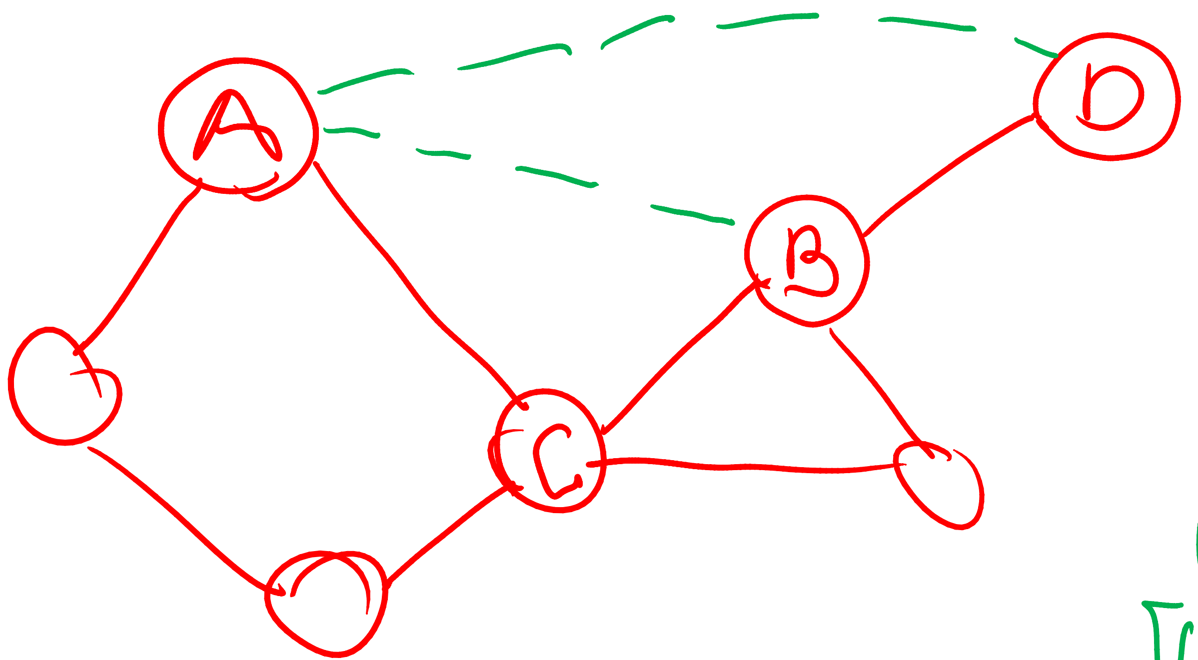
- How people find out about new jobs?
- Mark Granovetter, part of his PhD in 1960s
- People found the information through personal contacts
- But: contacts were often acquaintances rather than close friends
  - This is surprising:
    - One would expect your friends to help you out more than casual acquaintances when you are between the jobs
- Why is it that distance acquaintances are most helpful?

Granovetter's answer

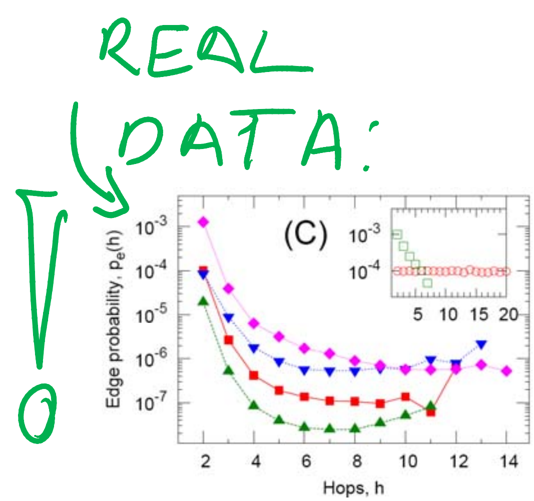
- Two perspectives on friendships
  - Structural:
    - Friendships span different portions of the network
  - Interpersonal:
    - Friendship between two people is either strong or weak

Triadic closure

- Which edge is more likely A-B or A-D?



- Triadic closure: If two people in a network have a friend in common there is an increased likelihood they will become friends themselves



Triadic closure

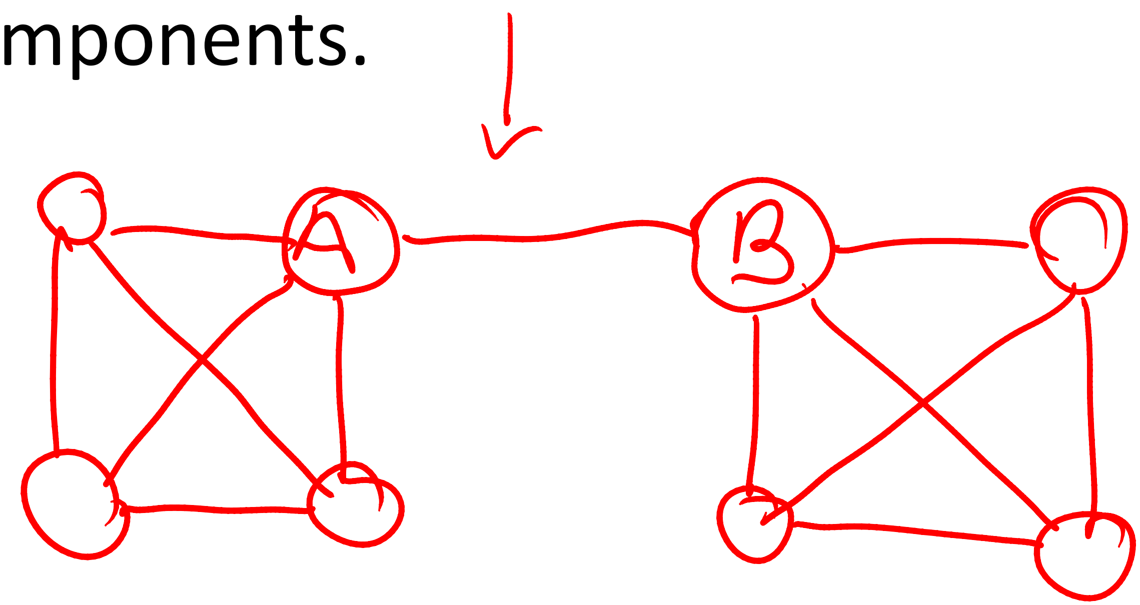
- Triadic closure == High clustering coefficient

Reasons for triadic closure:

- If B and C have a friend A in common, then:
  - B is more likely to meet C (since they both spend time with A)
  - B and C trust each other (since they have a friend in common)
  - A has incentive to bring B and C together (as it is hard for A to maintain two disjoint relationships)
- Empirical study by Bearman and Moody:
  - Teenage girls with low clustering coefficient are more likely to contemplate suicide)

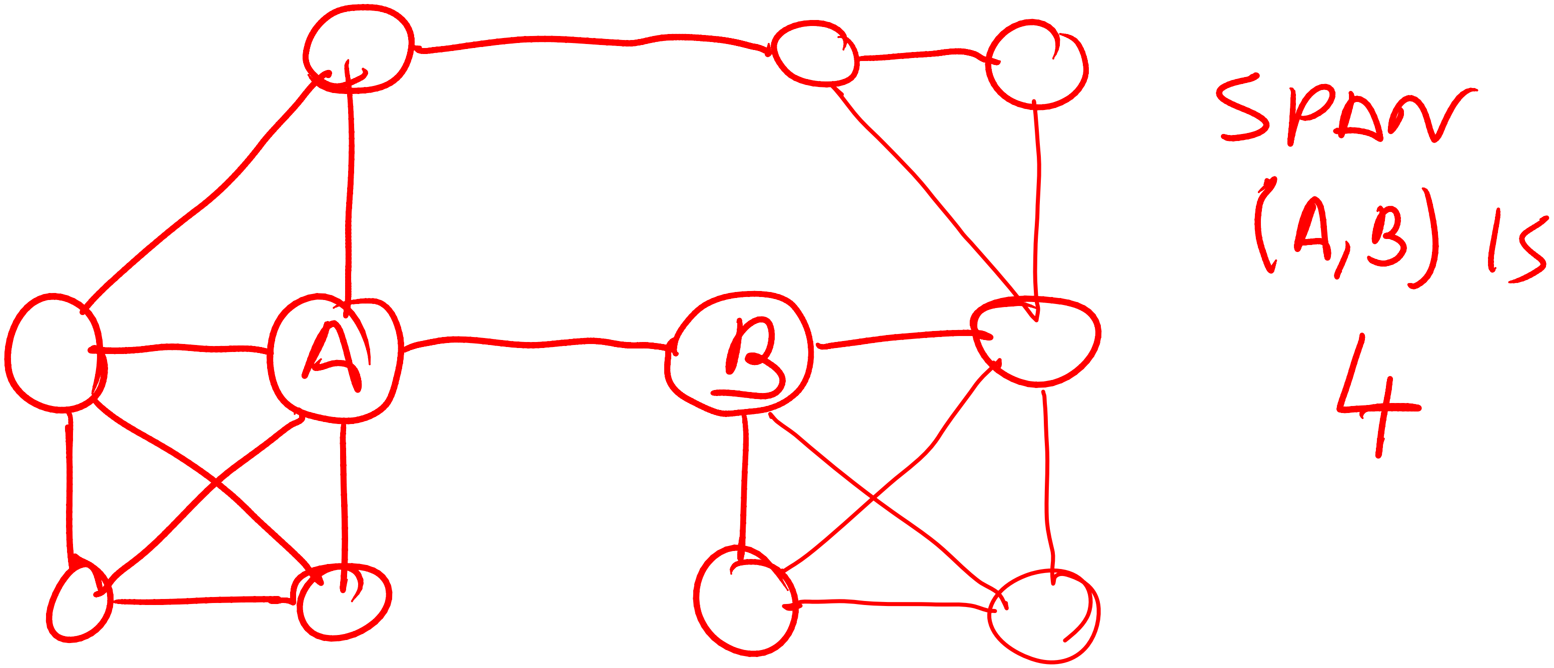
Bridges and Local Bridges

- Edge (A,B) is a bridge if deleting it would make A and B in be in two separate connected components.



Bridges and Local Bridges

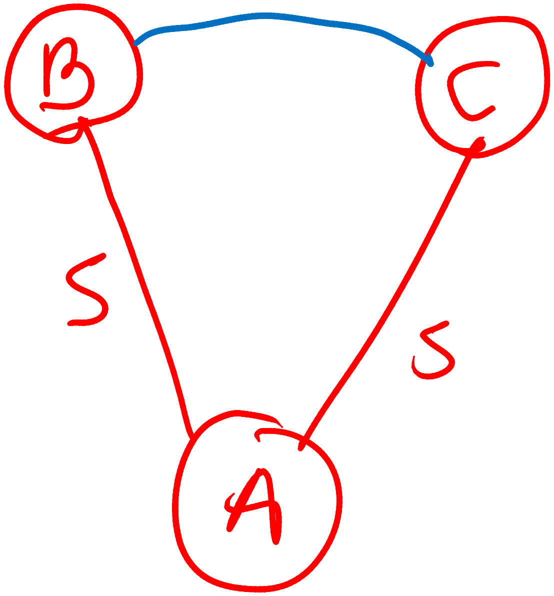
- Edge (A,B) is a local bridge A and B have no friends in common.
- Span of a local bridge is the distance of the edge endpoints if the edge is deleted.



(local bridges with long span are like bridges)

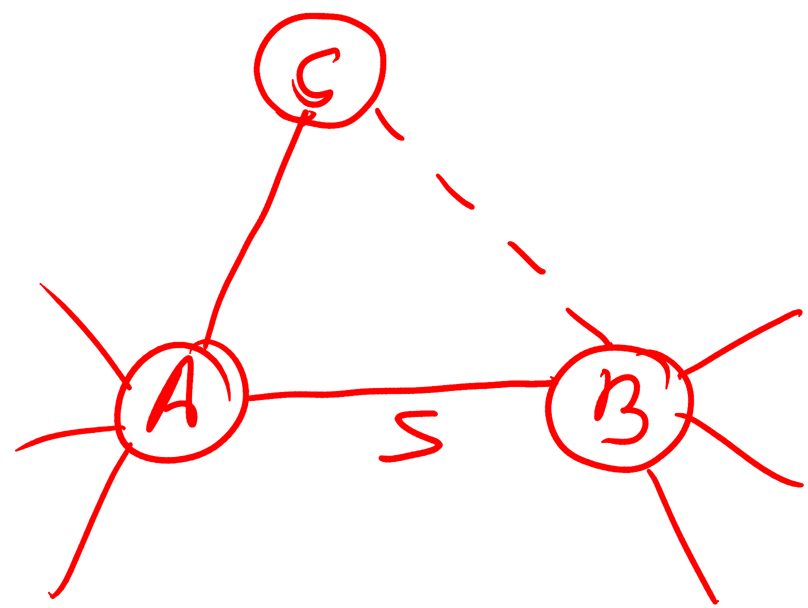
Strong Triadic Closure

- Links in networks have strength:
  - Friendship
  - Communication
- We characterize links as either Strong (friends) or Weak (acquaintances)
- Strong **Triadic Closure** Property: If A has strong links to B and C, then there must be a link (B,C) (that can be strong or weak)



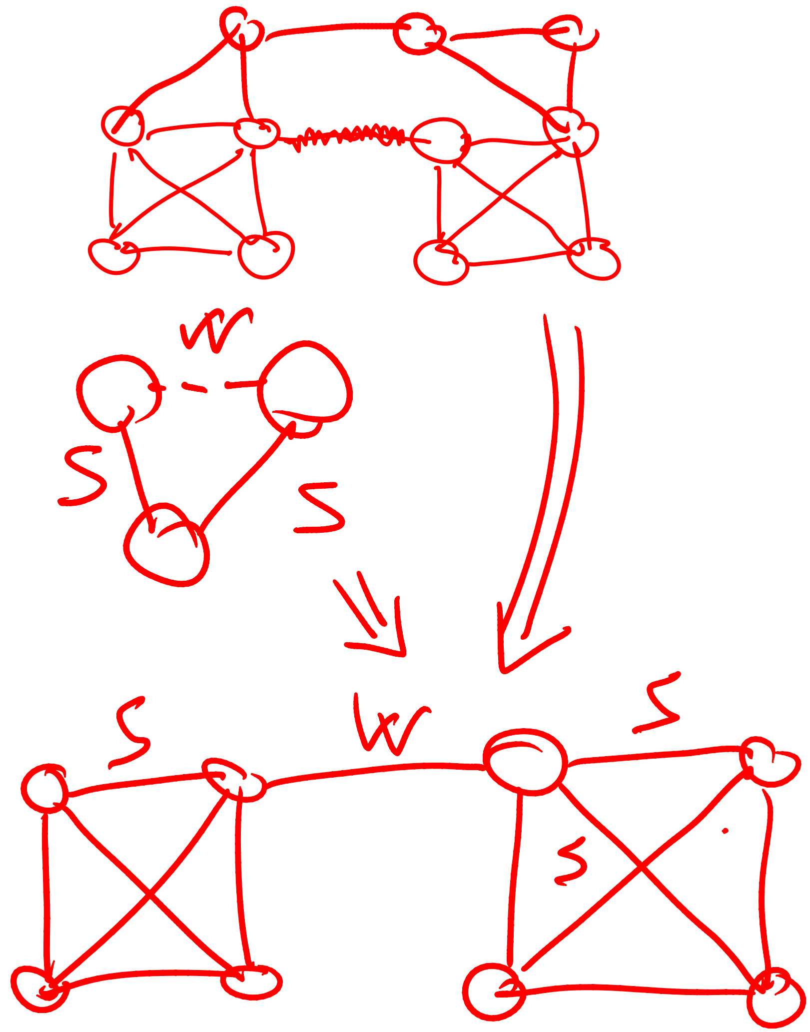
Local Bridges and Weak ties

- If node A satisfies Strong Triadic Closure and is involved in at least two strong ties, then any local bridge adjacent to A must be a weak tie.
- Proof by contradiction:
  - A satisfies Strong Triadic Closure
  - Let A-B be local bridge and a strong tie
  - Then B-C must exist because of Strong Triadic Closure
  - But then (A,B) is not a bridge



Summary of what we just did

- Defined Local Bridges:
  - Edges not in triangles
- Set two types of edges:
  - Strong and Weak Ties
- Defined Strong Triadic Closure:
  - Two strong ties imply a third edge
- ➔ Local bridges are weak ties



Tie strength and structure in real data

- For many years the Granovetter's theory was not tested
- But, today we have large who-talks-to-whom graphs:
  - Email, Messenger, Cell phones, Facebook
- Onnela et al. 2007:
  - Cell-phone network of 20% of country's population

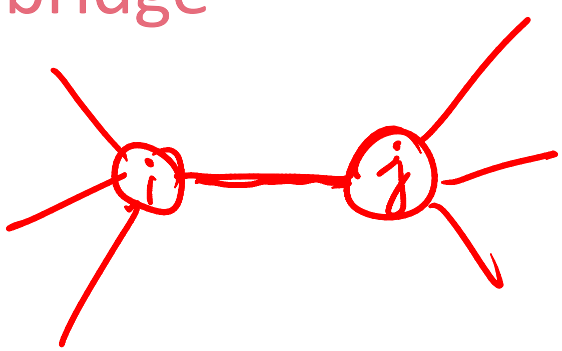
Neighborhood Overlap

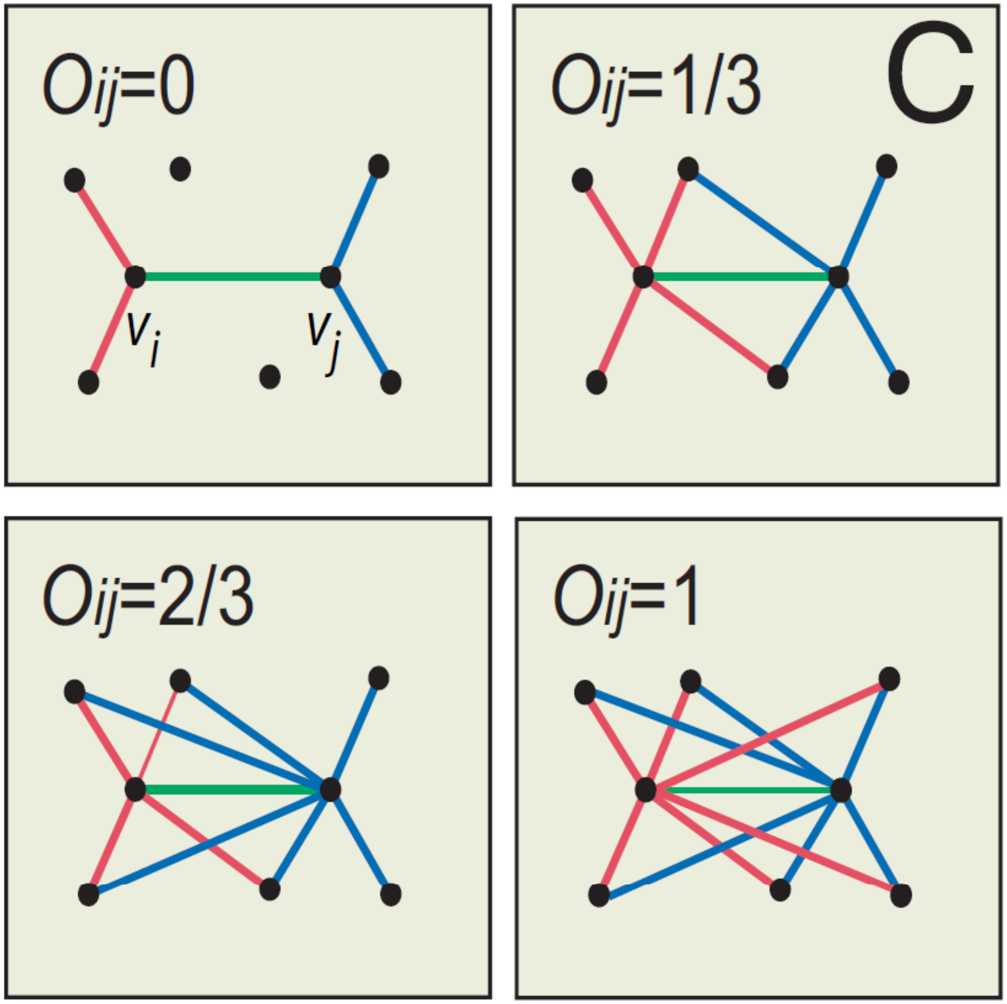
- Overlap:

  $$O_{ij} = \frac{n(i) \cap n(j)}{n(i) \cup n(j)}$$

  - n(i) … set of neighbors of A

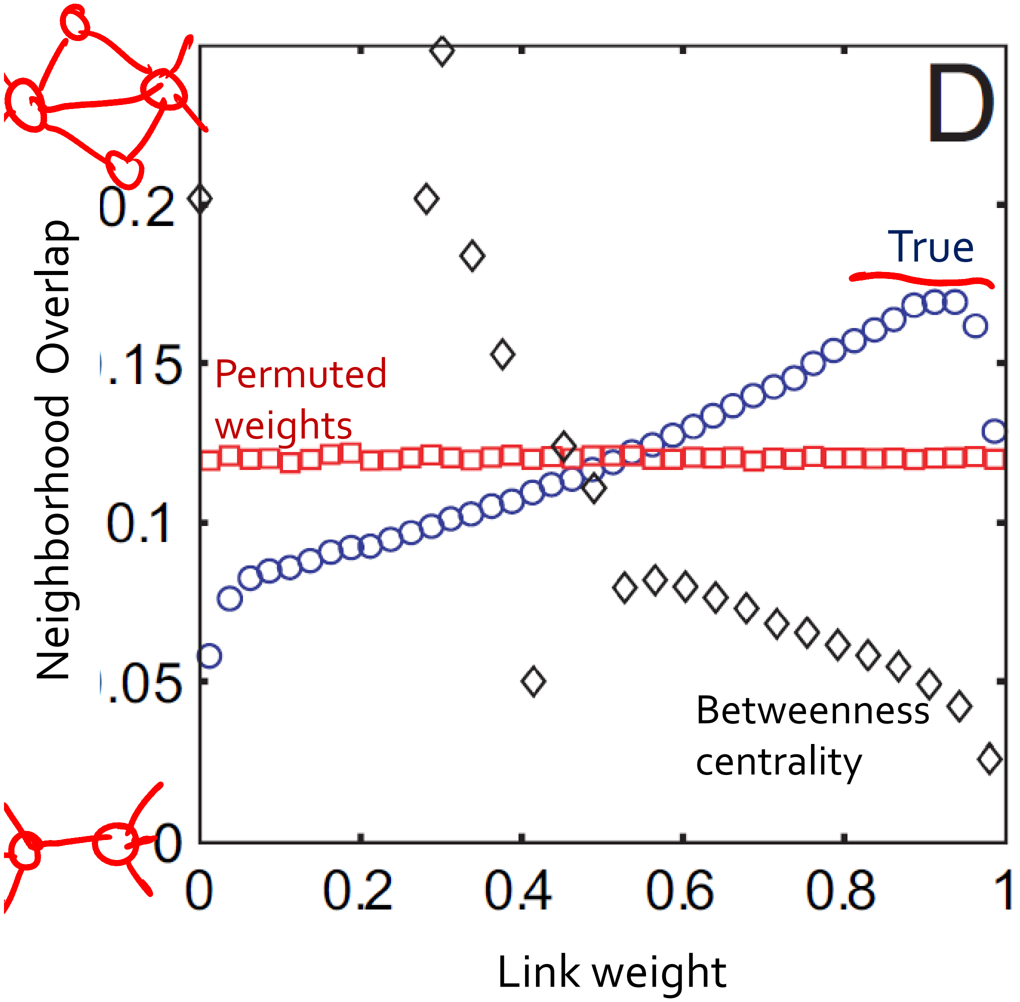
- Overlap = 0 when an edge is a local bridge





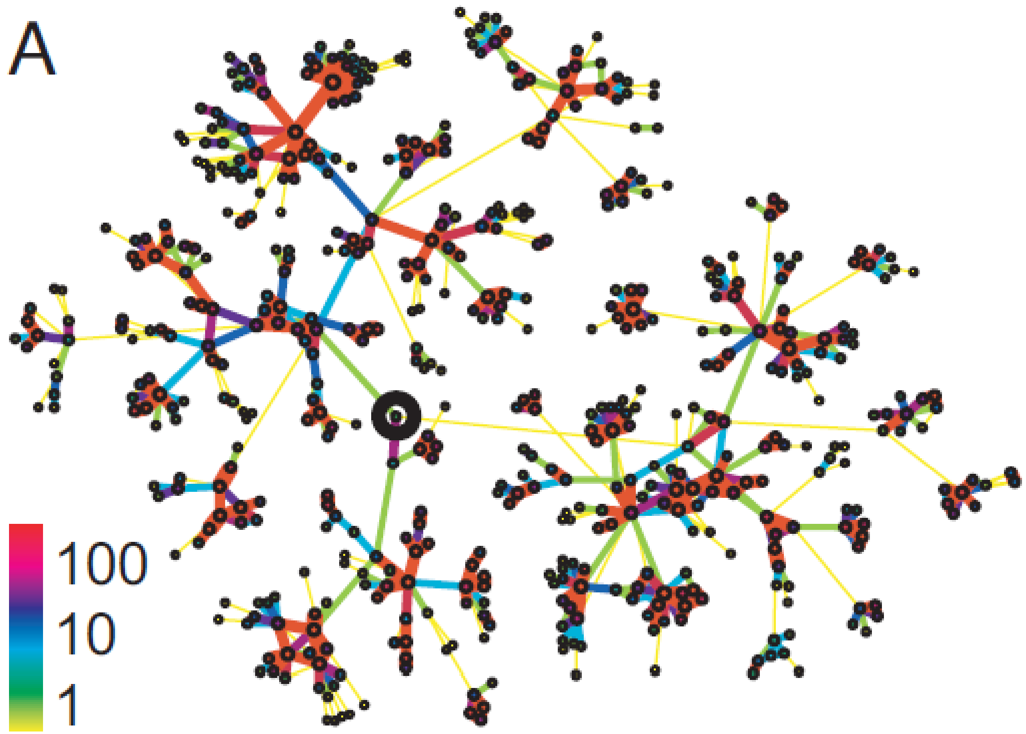
[Onnela et al. '07]

Mobile phones: Overlap vs. Weight



- Permuted weights: keep the structure but randomly reassign edge weights
- Betweenness centrality: number of shortest paths going through an edge

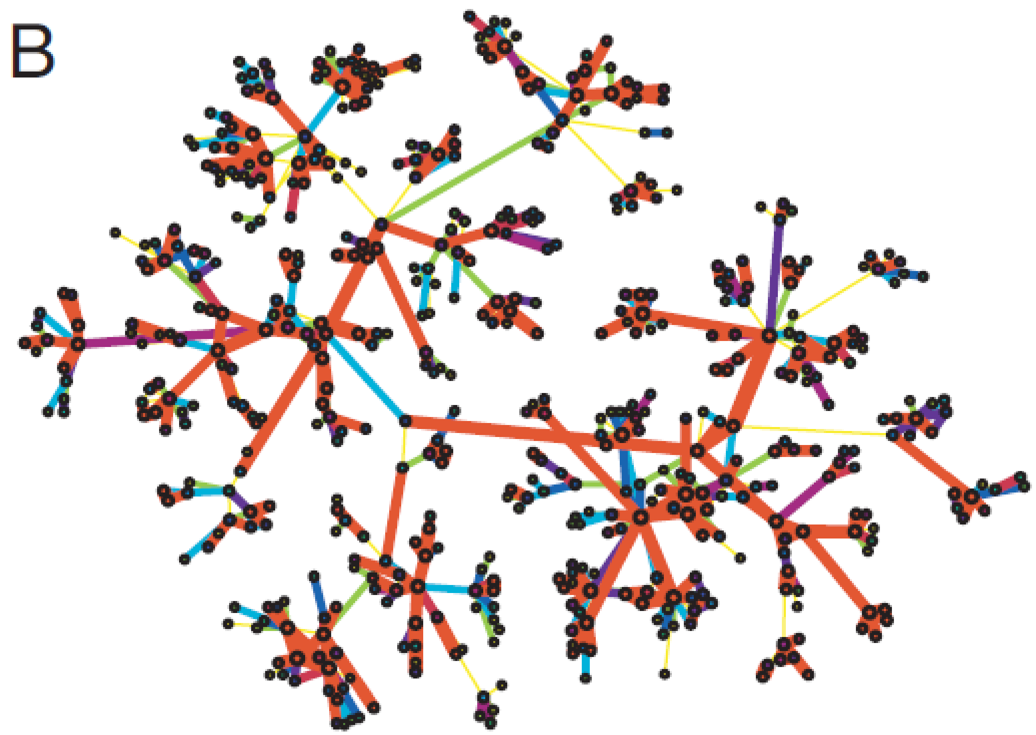
Real network tie strengths



- Real edge strengths in mobile call graph

[Onnela et al. '07]

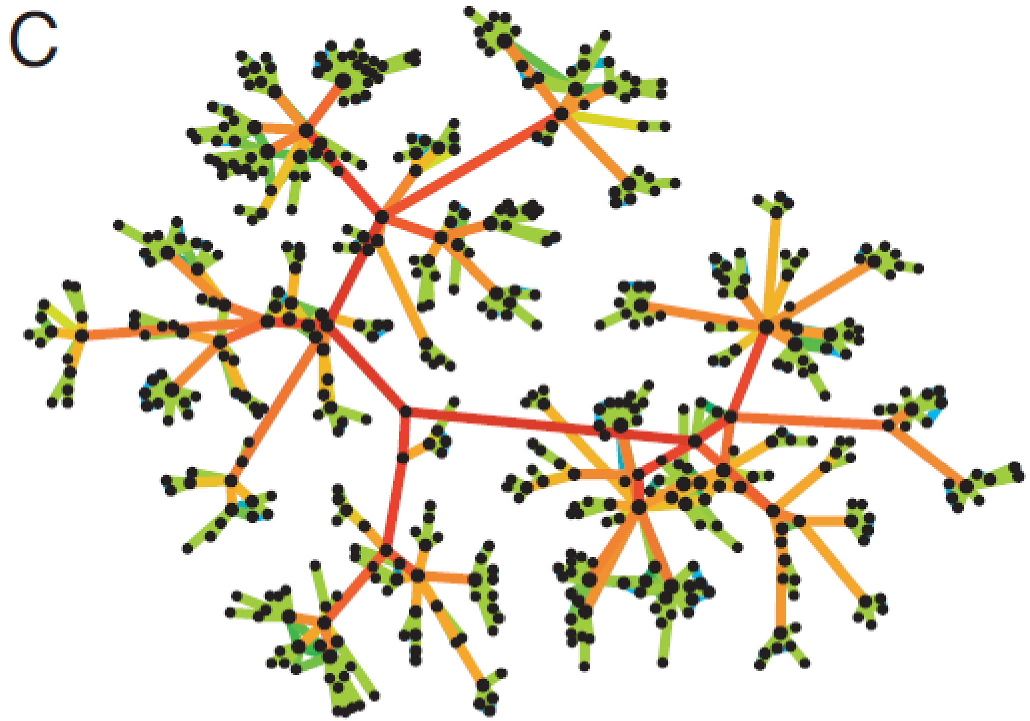
Permuted tie strenghts



- Same network, same set of edge strengths
- But now strengths are randomly shuffled over the edges

[Onnela et al. '07]

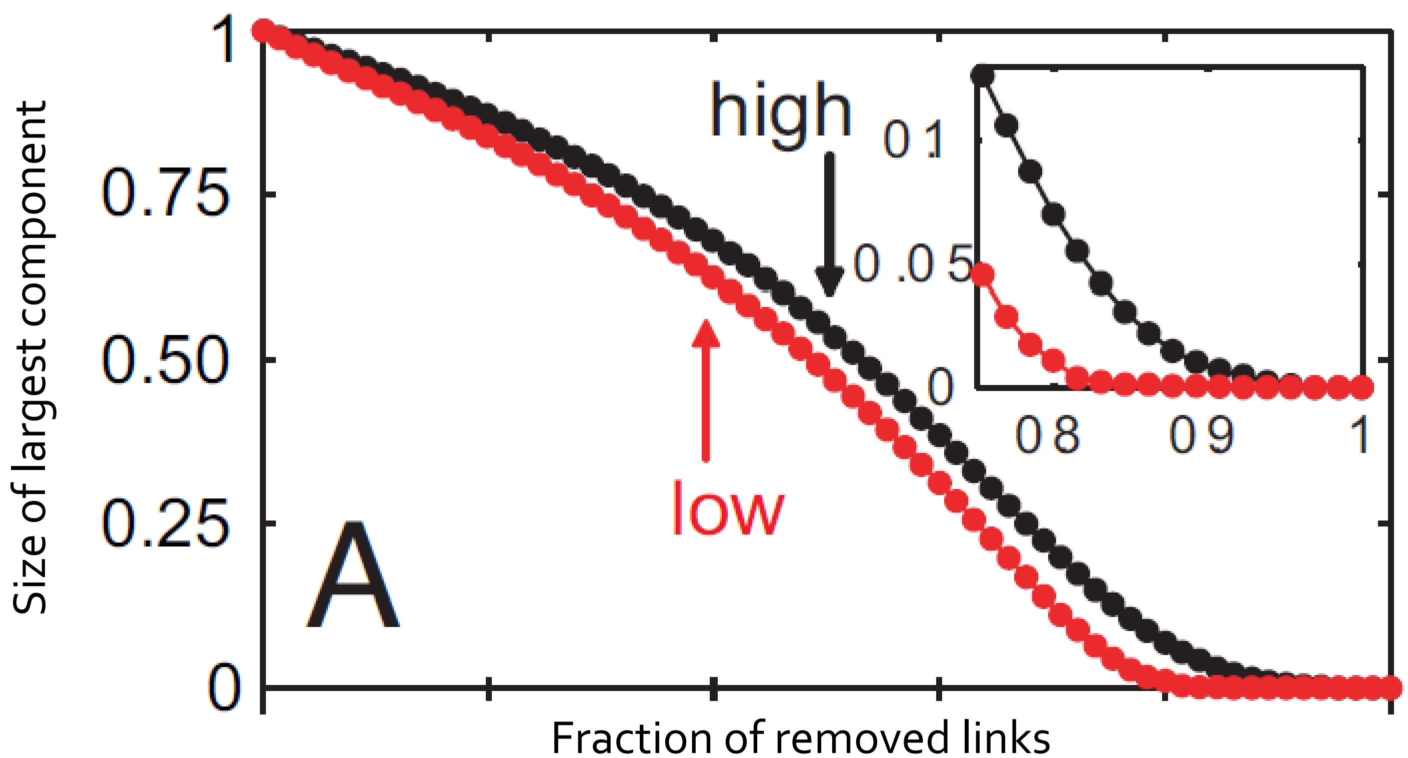
Edge betweenness centrality



- Edges labeled based on betweenness centrality (number of shortest paths going through an edge)

Link removal: Weight

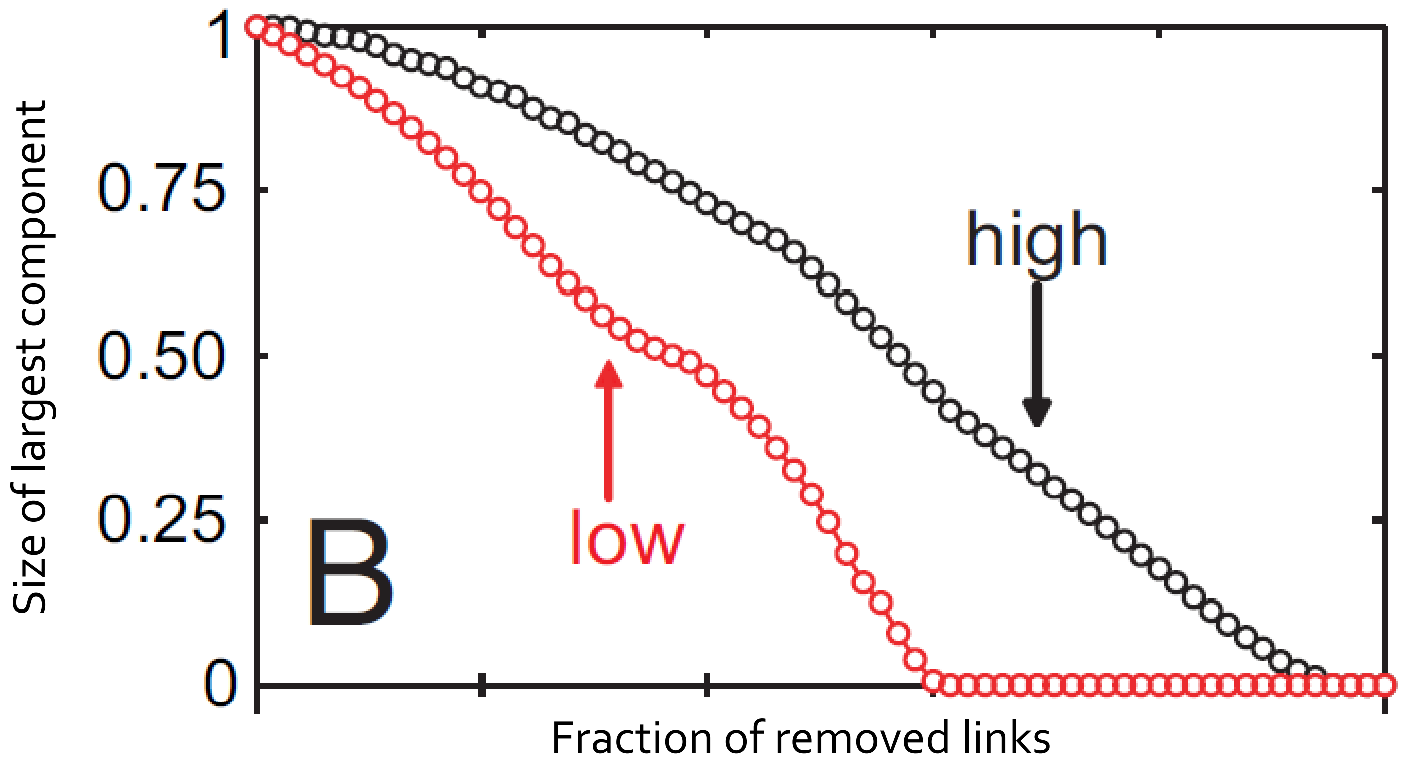
[Onnela et al. '07]



- Removing links based on **strength**
  - Low to high
  - High to low

[Onnela et al. '07]

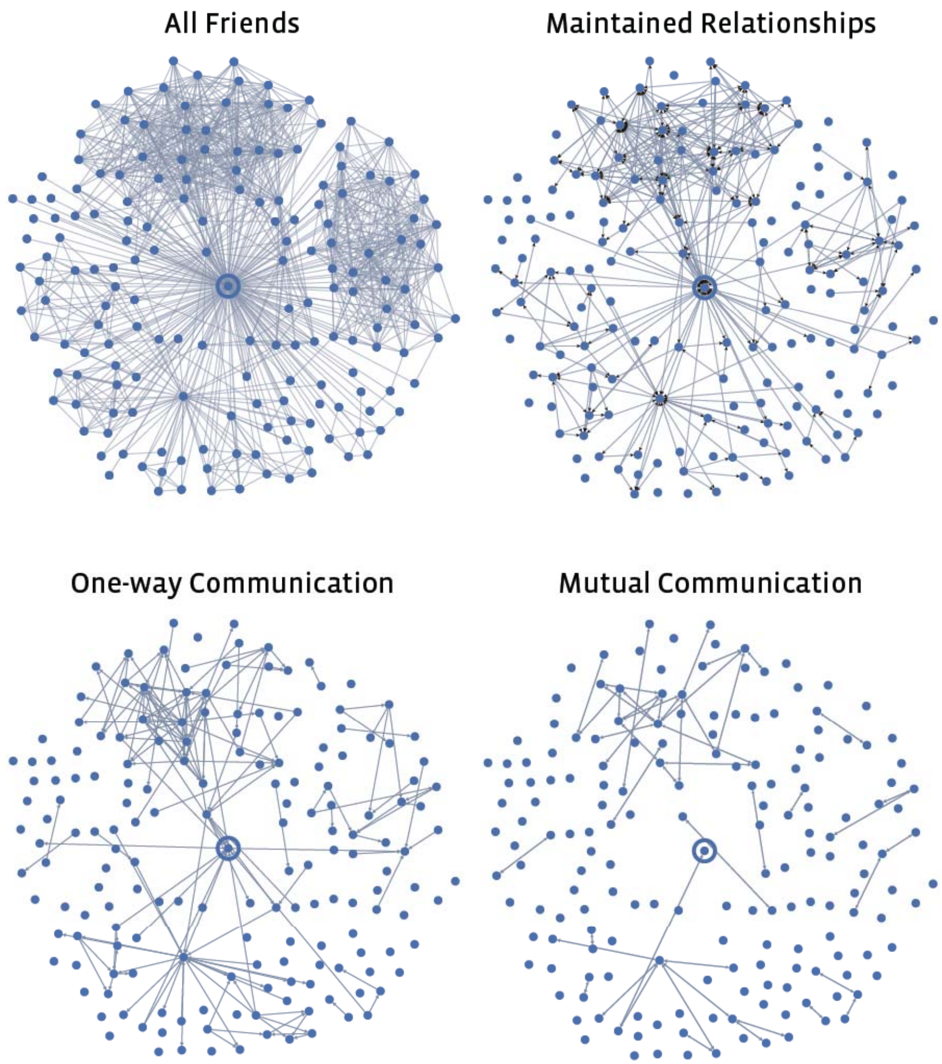
Link removal: Overlap



- Removing links based on **overlap**
  - Low to high
  - High to low

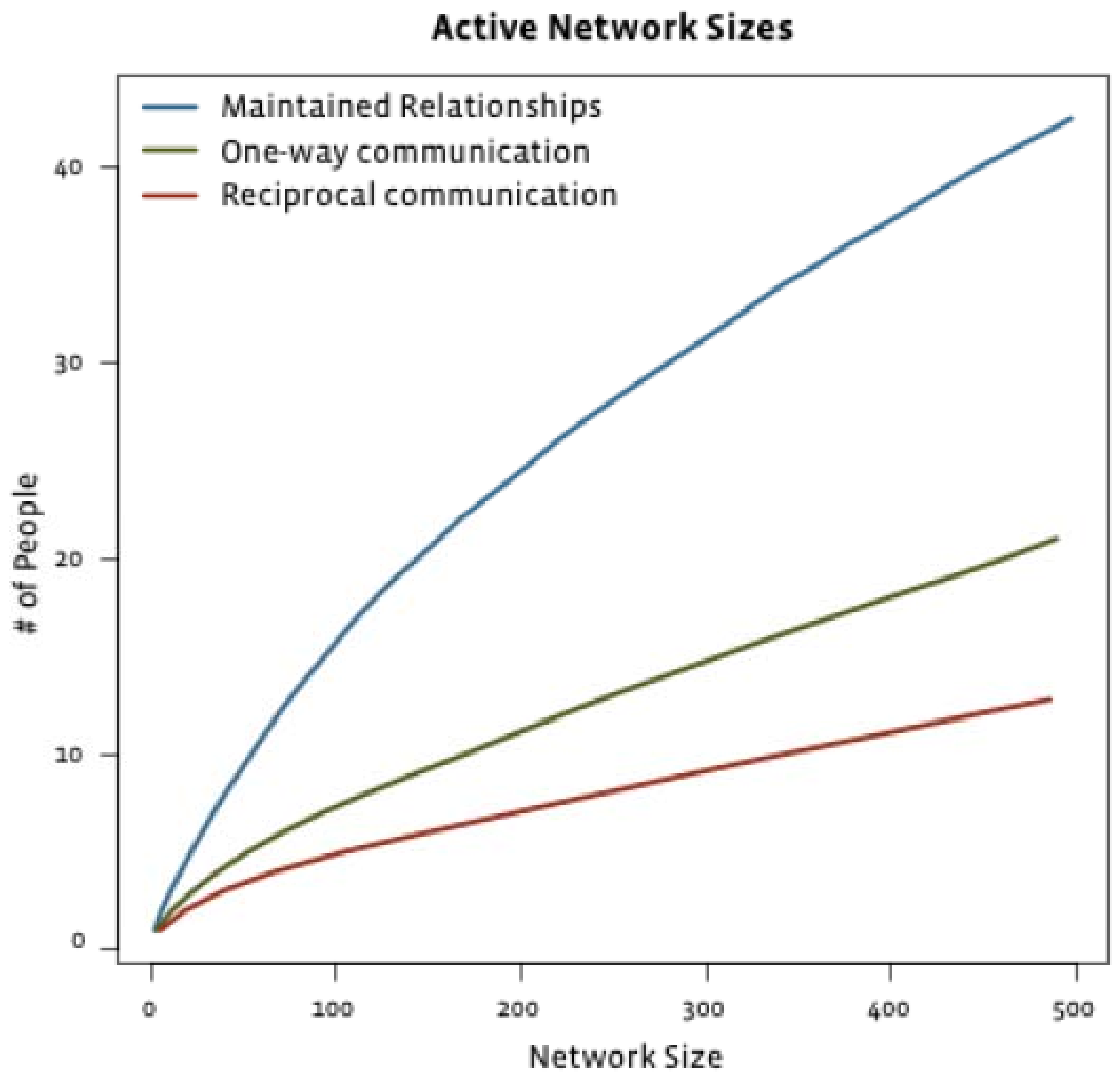
[Marlow et al. '09]

Another example: Facebook



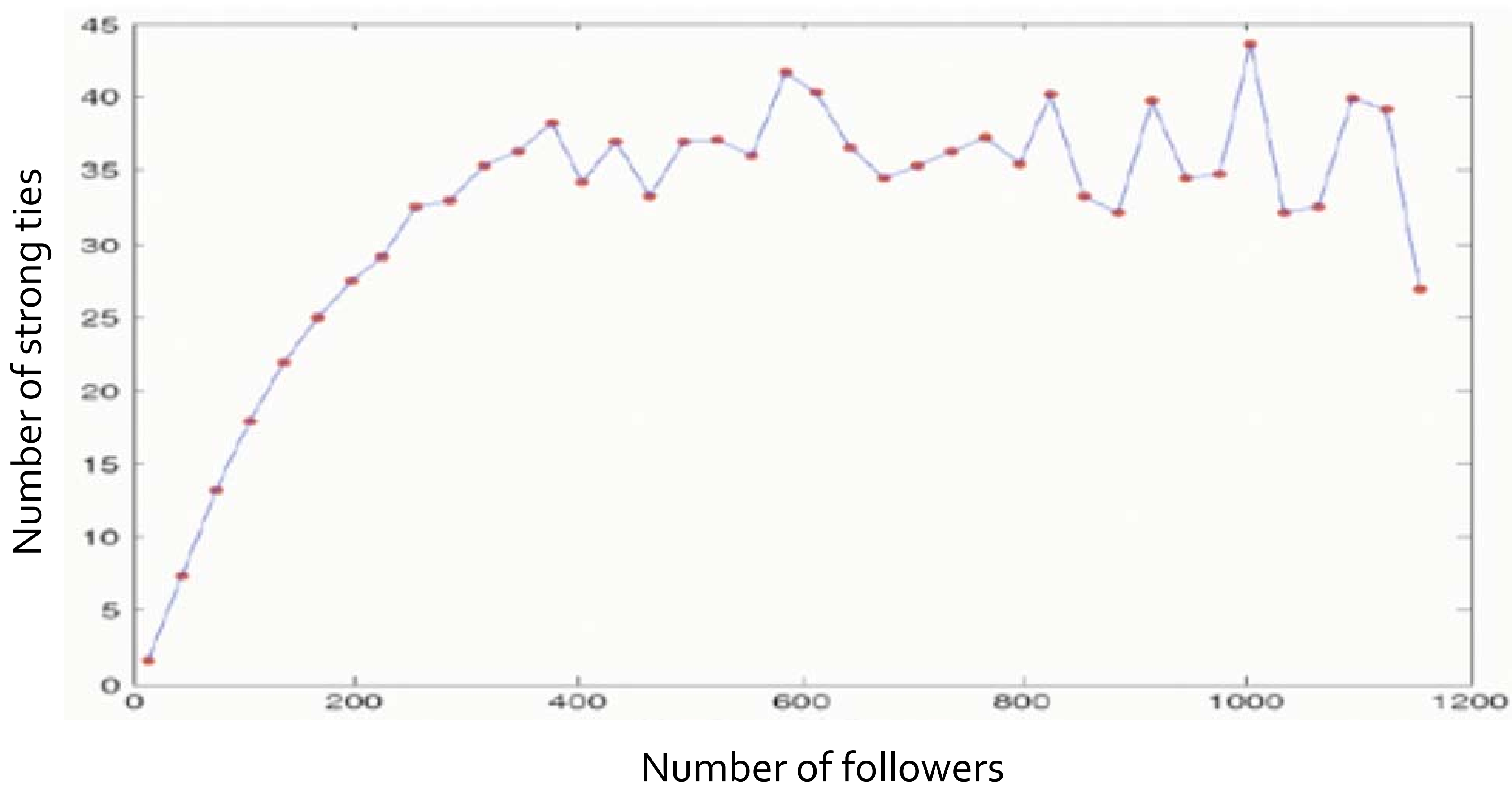
[Marlow et al. '09]

Facebook: Number of ties



[Huberman et al. '09]

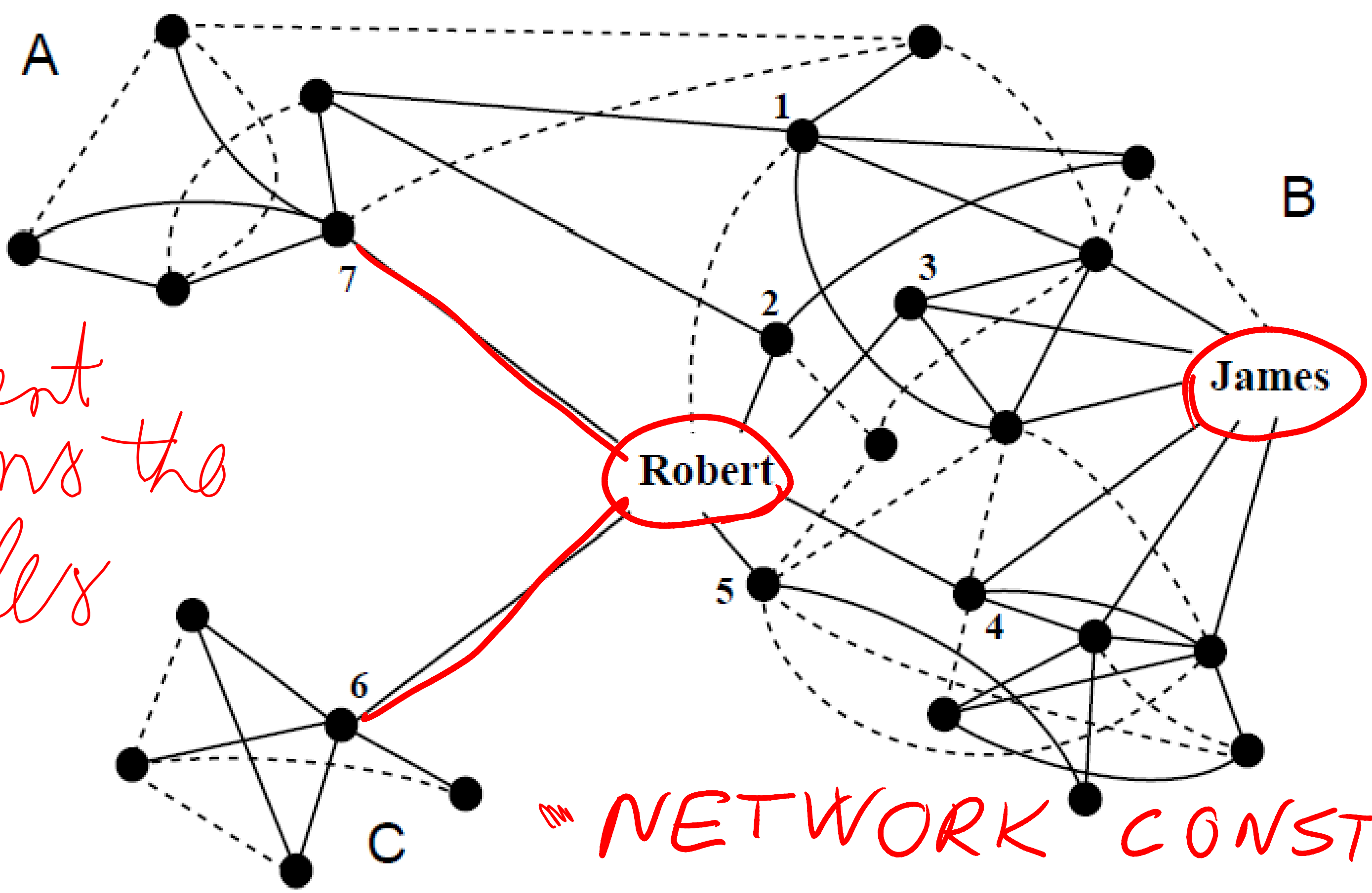
Twitter: Strong ties vs. Followers



[Ron Burt]

Structural Holes

Robert spans the holes



- NETWORK CONSTRAINT
- CLUSTERING COEFFICIEN

[Ron Burt]

Social Capital Matters