Strong and Weak Ties

Objectives

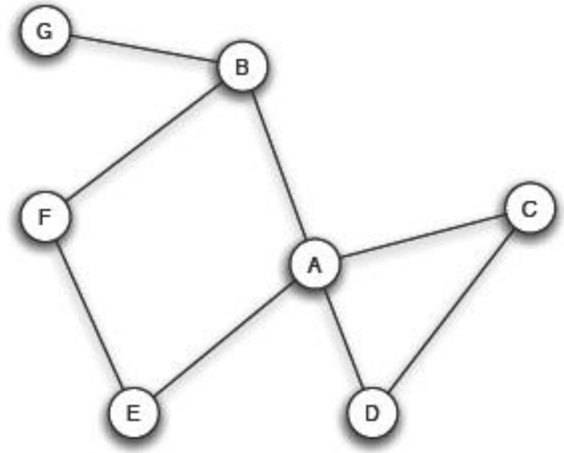
- How information flows through a social network
- How different nodes can play structurally distinct roles in this process
- How these structural considerations shape the evolution of the network itself over time

“Finding a job”

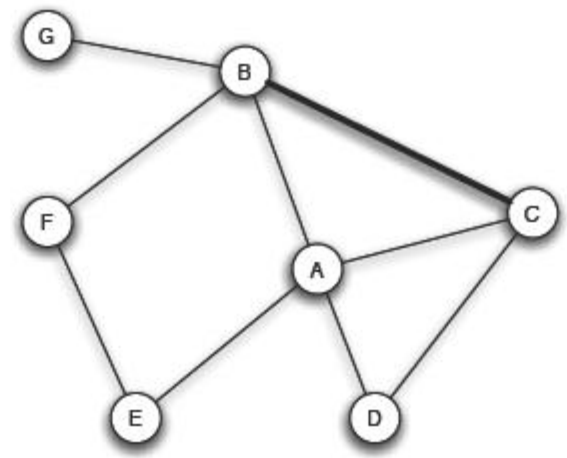
- Mark Granovetter (1960s)
  - interviewed people who had recently changed employers
  - how they discovered their new jobs?
  - many learned information through personal contacts
  - these contacts often described as acquaintances (weak ties) rather than close friends (strong ties)
- A bit surprising:
  - your close friends have the most motivation to help
  - why more distant acquaintances who are to thank?

Triadic Closure

- If B and C have a friend A in common, then edge between B and C tends to be produced
  - a triangle



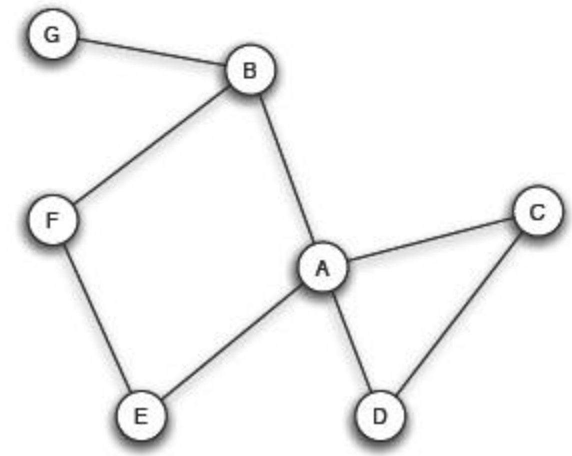
(a) *Before B-C edge forms.*



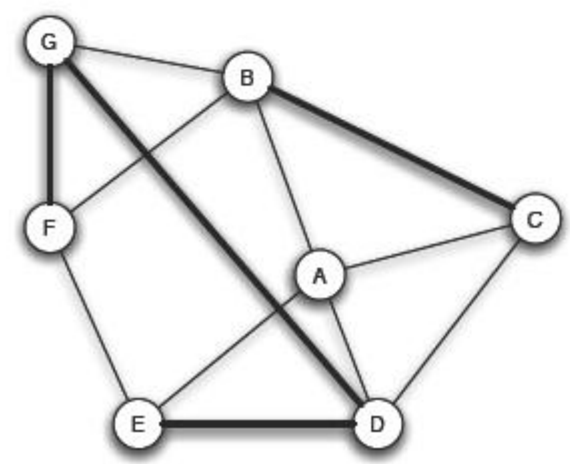
(b) *After B-C edge forms.*

Triadic Closure

- Observe snapshots of a social network at two distinct points in time
- Significant number of new edges form through this triangle-closing operation



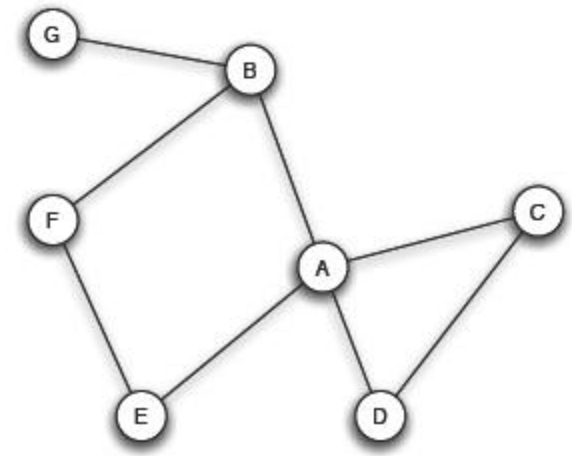
(a) *Before new edges form.*



(b) *After new edges form.*

The Clustering Coefficient

- Measure to capture triadic closure
- The clustering coefficient of a node A, CC(A), is the fraction of pairs of A's friends that are connected to each other by edges
- Ex:
  – Figure(a): CC(A) = 1/6
  – Figure(b): CC(A) = ½
- CC ranges from 0 (when none of the
- node's friends are friends with each other) to 1 (when all of the node's friends are friends with each other)



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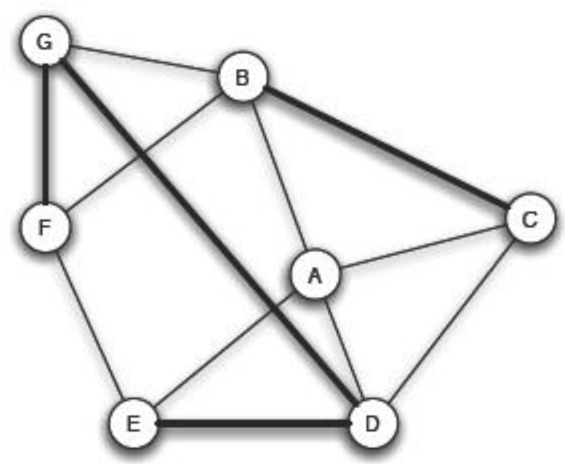


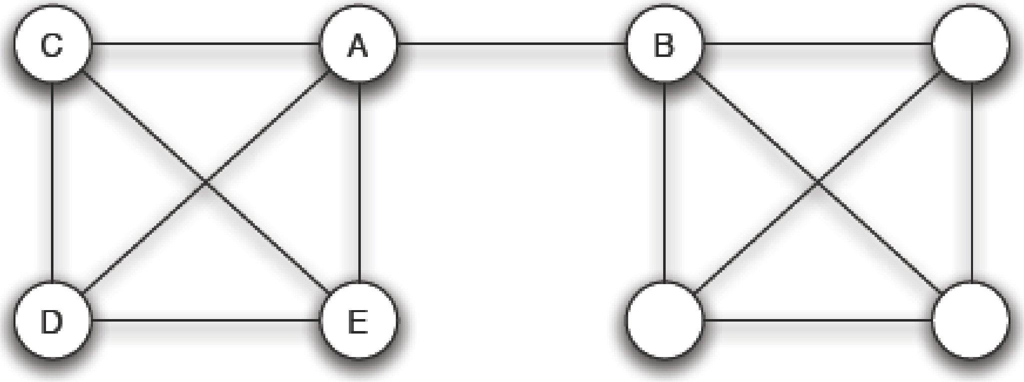
(b) *After new edges form.*

Reasons for Triadic Closure

- Why B and C more likely to become friends, when they have a common friend?
  - increased opportunity for B and C to meet
  - B and C trust each other
  - it becomes a source of latent stress in these relationships if B and C are not friends
    - teenage girls who have a low clustering coefficient in their network of friends are significantly more likely to contemplate suicide

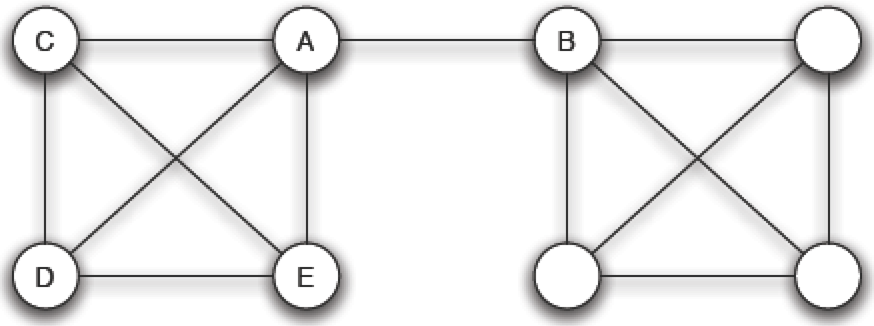
Bridges and Local Bridges

- A has 4 friends:
  - C, D, and E connected to a tightly-knit group
  - B reaches into a different part of the network
  - B offers access to new things



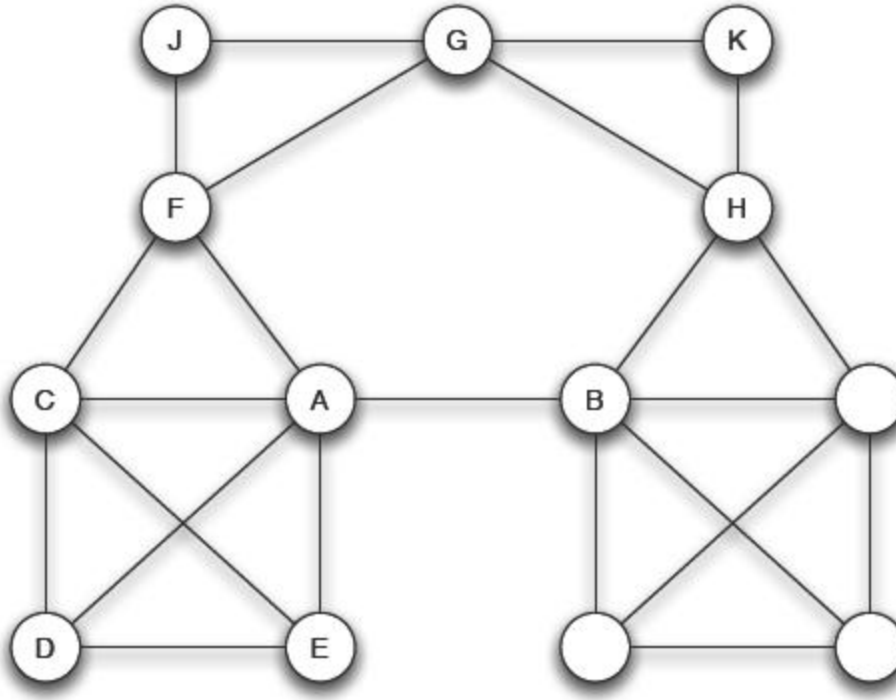
Bridges and Local Bridges

- Edge A-B is a bridge if deleting it causes A and B to be in different components
- Bridges are extremely rare in real social networks
  - giant component, many short paths



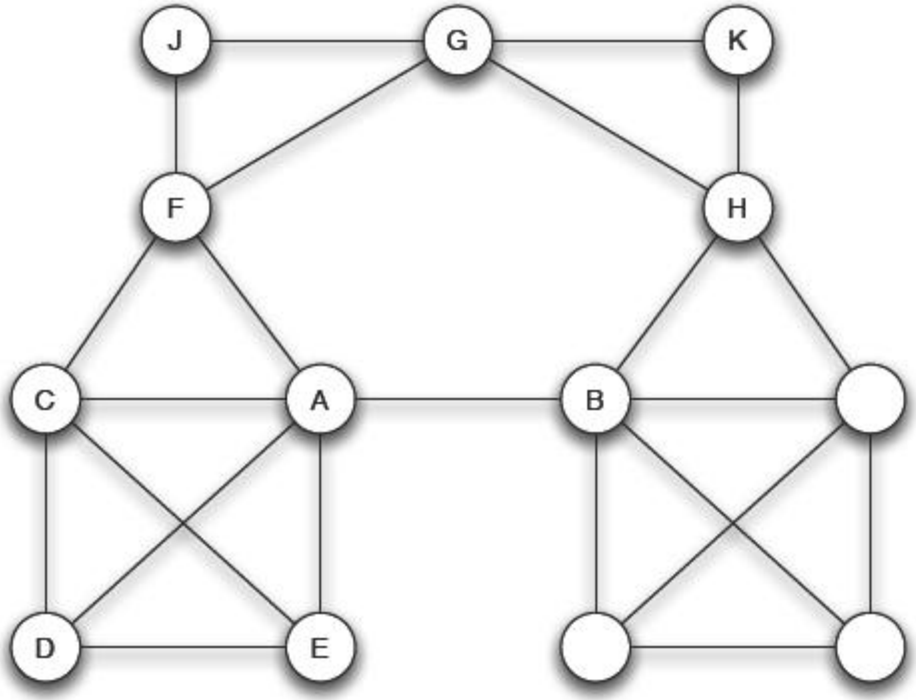
Bridges and Local Bridges

- Edge A-B is a local bridge if its endpoints A and B have no friends in common
  - deleting A-B => d(A,B) increases more than 2
- Relation with triadic closure:
  - a local bridge does not belong to any triangle
- Local bridges provide their endpoints with access to parts of the network that they would otherwise be far away from



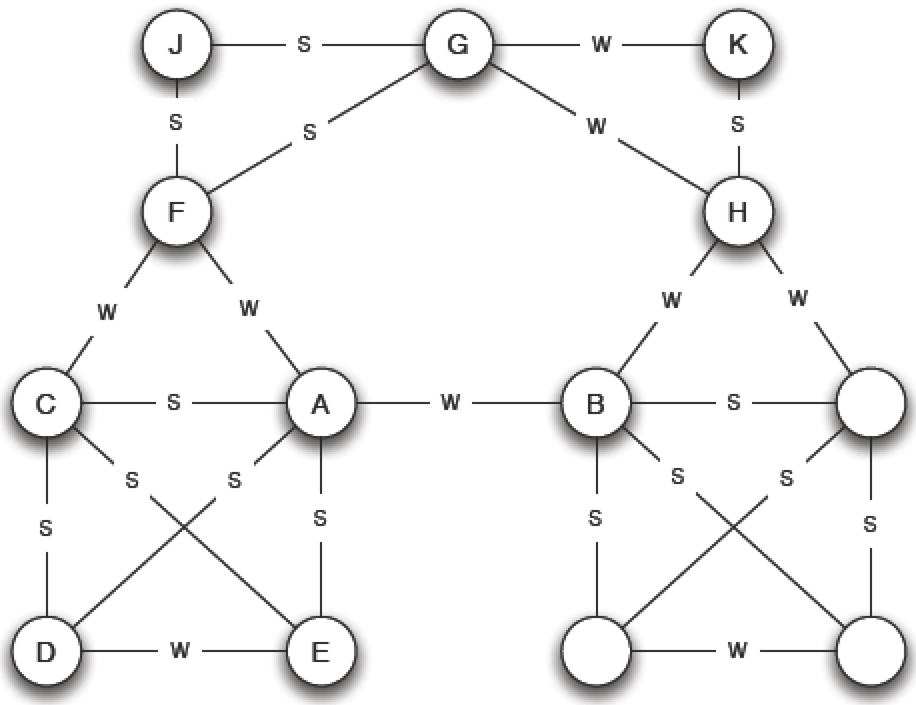
"Finding a job"

- if a node like A is going to get new information about a job, it might come often (not always) from a friend connected by a local bridge
- The closely-knit groups of close friends are eager to help, but they know roughly the same things with A
- **How to connect local bridges to acquaintances?**



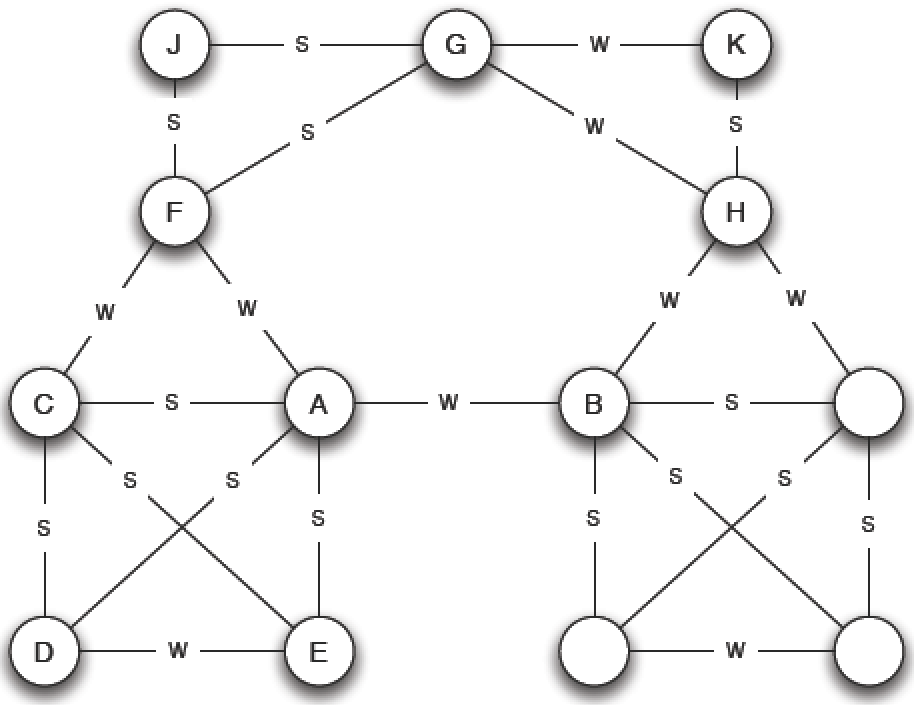
Strong vs. Weak Ties

- Classification of links in a social network:
  - strong ties (friends) vs. weak ties (acquaintances)
- Connection to triadic closure:
  - if A has edges to B and C, then edge B-C is especially likely to form if A's edges to B and C are both strong ties



The Strong Triadic Closure Property

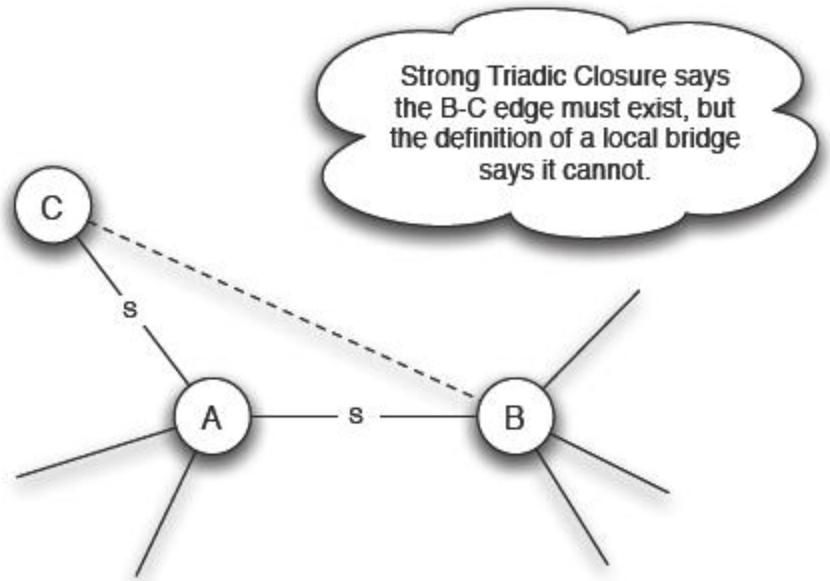
- A violates the Strong Triadic Closure Property if:
  - has strong ties to two other nodes B and C, and
  - there is no edge at all (either a strong or weak tie) between B and C
- A satisfies the Strong Triadic Closure Property if it does not violate it
- Ex (figure):
  - all nodes satisfy the Property
  - if edge A-F were strong tie, then A and F would both violate the Property (A-G is missing)
- Strong Triadic Closure Property is too extreme to hold across all nodes of a large social network
  - useful step as an abstraction to reality



Local Bridges and Weak Ties

- *If A satisfies the Strong Triadic Closure Property and is involved in at least two strong ties, then any local bridge it is involved in must be a weak tie.*

- *Proof.* Consider A that satisfies Strong Triadic Closure Property and is involved in at least two strong ties. Suppose A is involved in a local bridge to B that is a strong tie. Contradiction:
  - A-C the other strong tie
  - A-B local bridge => A and B must have no friends in common => B-C edge must not exist
  - A satisfies Strong Triadic Closure: A-B and A-C strong => B-C must exist (as weak or strong tie)



“Finding a job”

- The previous argument completes the connection between the weak ties (acquaintances) and local bridge (access to other parts of the network)
- But it is based on the assumptions of Strong Triadic Closure and is a simplification that:
  - holds approximately even when the assumption is relaxed
  - need to test on real-world data

Weak Ties and Local Bridges in Real Data

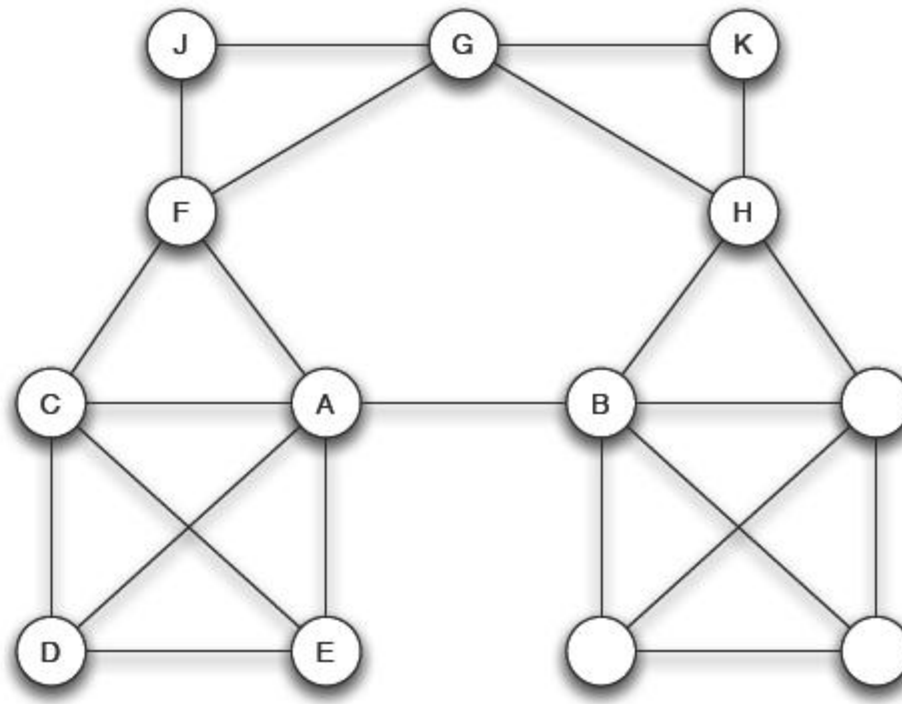
- Onnela et al.: traces of digital communication ("who-talks-to-whom" data)
  - cell phone records
  - 20% of a national population
  - 18-week observation period
  - a giant component (84%)
- How to measure weak ties and local bridges?
  - use the speaking time as strength
  - generalize definition of local bridge

Generalizing Weak Ties and Local Bridges

- So far sharp dichotomies:
  - an edge is either a strong tie or a weak tie, and
  - it is either a local bridge or it isn't
- For real data we need smoother gradations:
  - strength of an edge the total number of minutes between the two ends of the edge
  - neighborhood overlap of edge A-B:
    - N(A), N(B) are neighbors of A and B, resp.
    - $O(A\text{-}B) = |N(A) \cap N(B)| \,/\, |N(A) \cup N(B)|$
    - We don't count A or B themselves

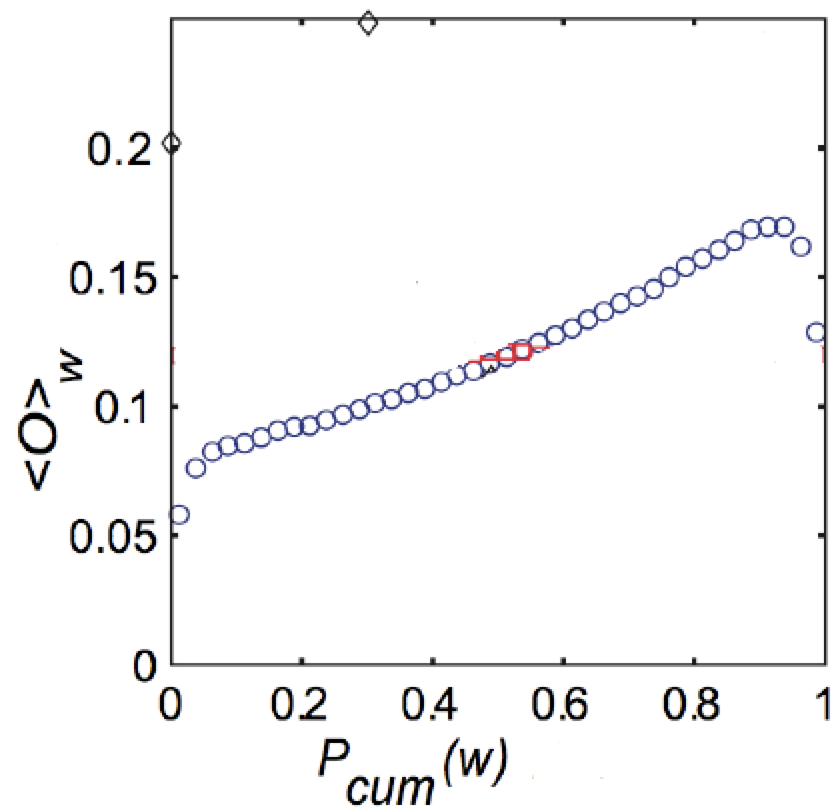
Generalizing Weak Ties and Local Bridges

- Ex(figure):
  - O(A-F) = 1/6
- Overlap(A-B) = 0 => A-B a local bridge
- Allows for "almost" local bridges
  - A-F vs. A-E
    - O(A-E) = 2/4



Weak Ties and Local Bridges in Real Data

- How the overlap of an edge depends on its strength?
- Lower overlap (almost local bridges) tend to have weaker strength
  - verifies theory
  - deviation at the end of the plot: people using cell-phones in unusual fashions



overlap as a function of strength (percentile)

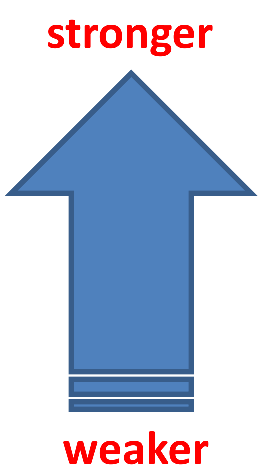
Weak Ties and Local Bridges in Real Data

- How to test whether weak ties link together different tightly-knit communities that each contain a large number of stronger ties?
- Onnela et al. provided an indirect analysis:
  - deleted edges one at a time, starting with strongest ties => the giant component shrank steadily
  - deleted edges one at a time, starting with weakest ties => the giant component shrank more rapidly
- Verifies the theoretical expectation:
  - weak ties provide the more crucial connective structure for holding together communities

Tie Strength and Social Media

- Large lists of friends in social-networking tools
- How many of these correspond to strong and weak ties?
- Tie strengths can provide an important perspective on on-line social activity

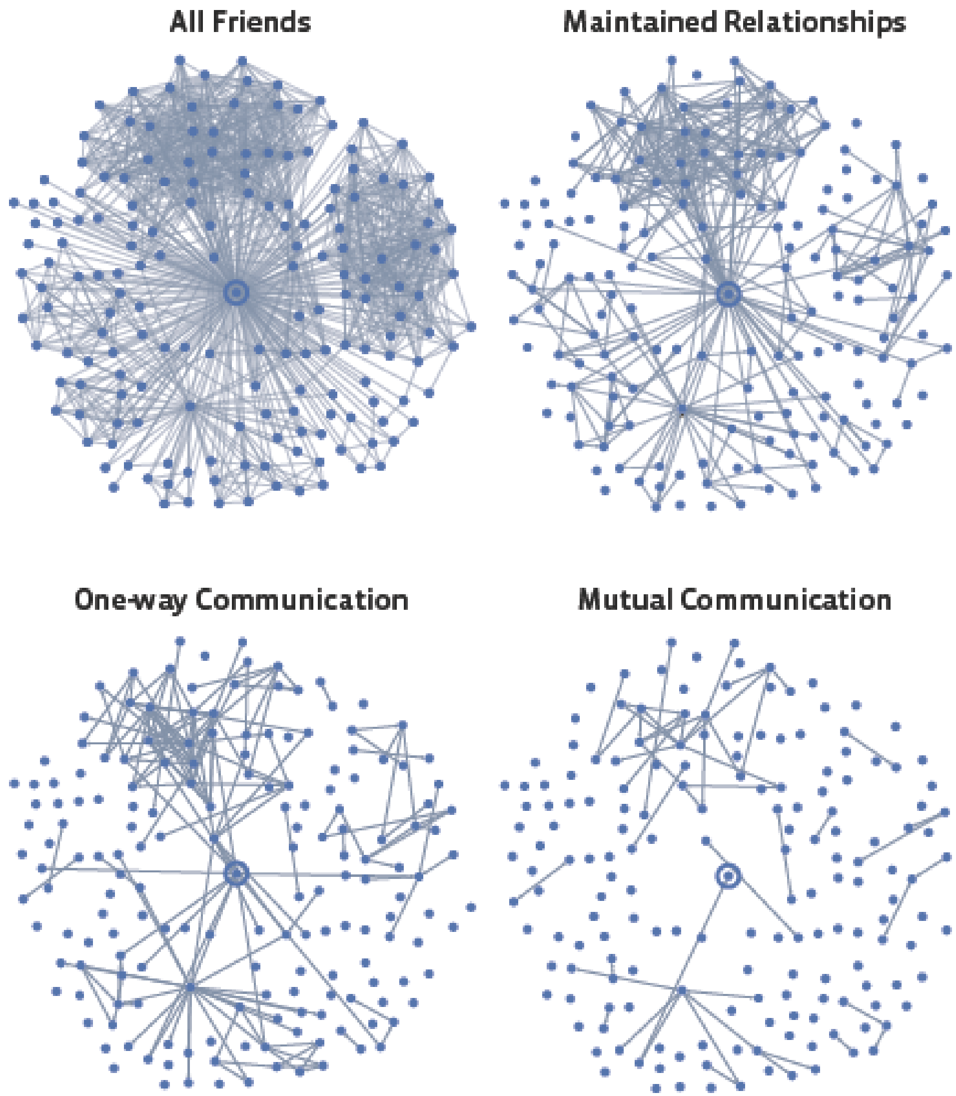
Tie Strength on Facebook



- Cameron and Marlow:
  - To what extent each social link is actually used for social interaction beyond being listed?
  - 3 categories of links (usage over a 1-month period)
    - mutual communication: user both sent and receive messages from the friend
    - one-way communication: user sent messages to the friend (regardless if replied)
    - maintained relationship: user followed information of the friend (regardless of messages)
      - "following information": clicking on content via Facebook's News Feed service or visiting the friend's profile
  - Categories not mutually exclusive:
    - mutual communication always belongs subset of one-way communication

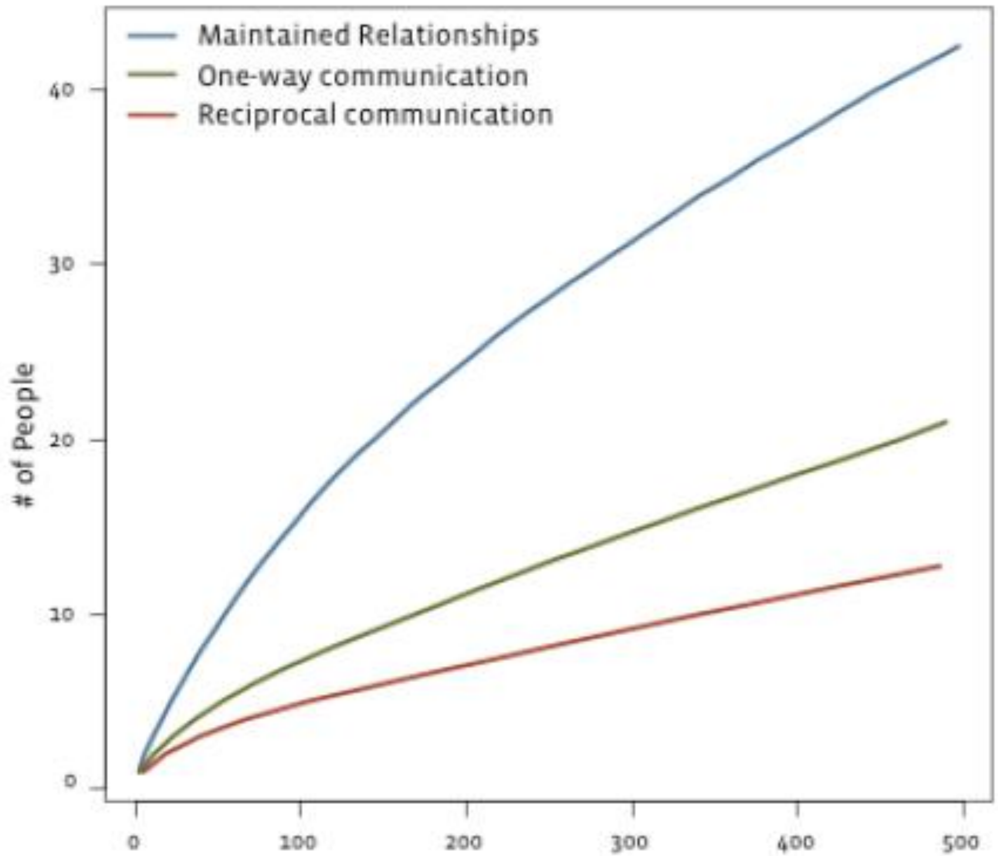
Example for a sample Facebook user

- Restricting to stronger ties thins out the network
- Triadic closure:
  - in upper and right part of “All Friends”
  - Maintained:
    - upper survives (current friends)
    - right hot (earlier friends, e.g., school)



Active Friendships in Facebook

- Users report large numbers of friends
  - up to 500
- Mutual communication (strong ties):
  - between 10 and 20
- Maintained (weak ties)
  - under 50



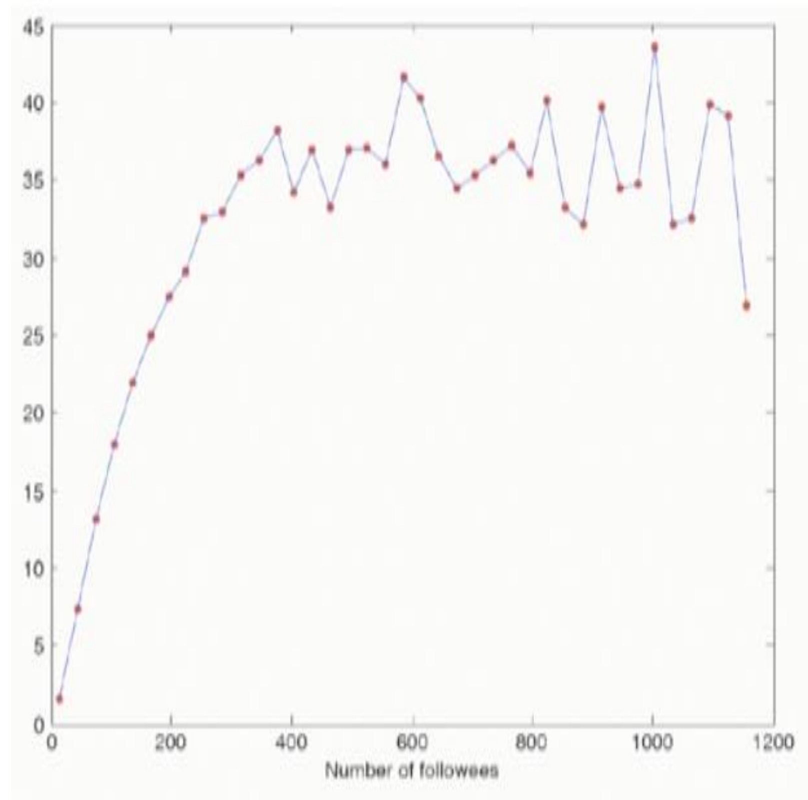
number of friends a user declares

Passive Engagement

- The power of media like Facebook:
  - maintained relationships (weak ties) enable passive engagement
    - keep up with friends by reading news about them (even) in the absence of communication
- Weak tie are middle ground between:
  - the strongest ties (mutual communication) and
  - inactive ties (friends only listed)
  - If only mutual communication allowed:
    - small list of friends (like those we call regularly)
- Weak ties maintain the social network highly connected:
  - everyone is passively engaged with each other and events/news propagate very quickly

Tie Strength on Twitter

- Huberman, Romero, and Wu:
  - Strong ties of a user A:
    - users that A directly communicates through tweets
  - Weak ties of a user A:
    - users that A follows without direct communication
- Below 50 strong ties even for over 1000 followees (weak ties)



number of a user’s strong ties vs. weak ties

Reasons for weak ties

- Strong ties require investment of time and effort
- Both are constrained => we reach a limit
- "Dunbar's number" = 150
  - Strong ties limited by the size of the human brain
- Weak ties pose milder constraints
  - they need to be established but not necessarily maintained continuously
  - easier accumulate large numbers of weak ties

Understanding how on-line media affect social networks is a complex research problem (still open)