# Online Social Networks and Media

## Strong and Weak Ties

Chapter 3, from D. Easley and J. Kleinberg book

# Issues

- How simple processes at the level of individual nodes and links can have complex effects at the whole population
- How information flows within the network
- How different nodes play structurally distinct roles

# The Strength of Weak Ties Hypothesis

Mark Granovetter, in the late 1960s

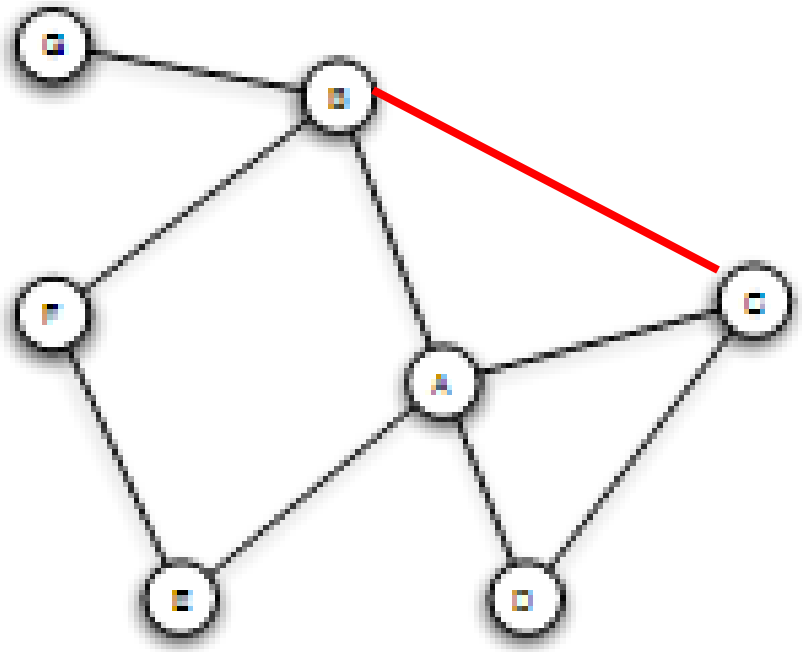
Many people learned information leading to their current job ***through personal contacts***, often described as ***acquaintances*** rather than closed friends

Two aspects

- Structural
- Local (interpersonal)

# Triadic Closure

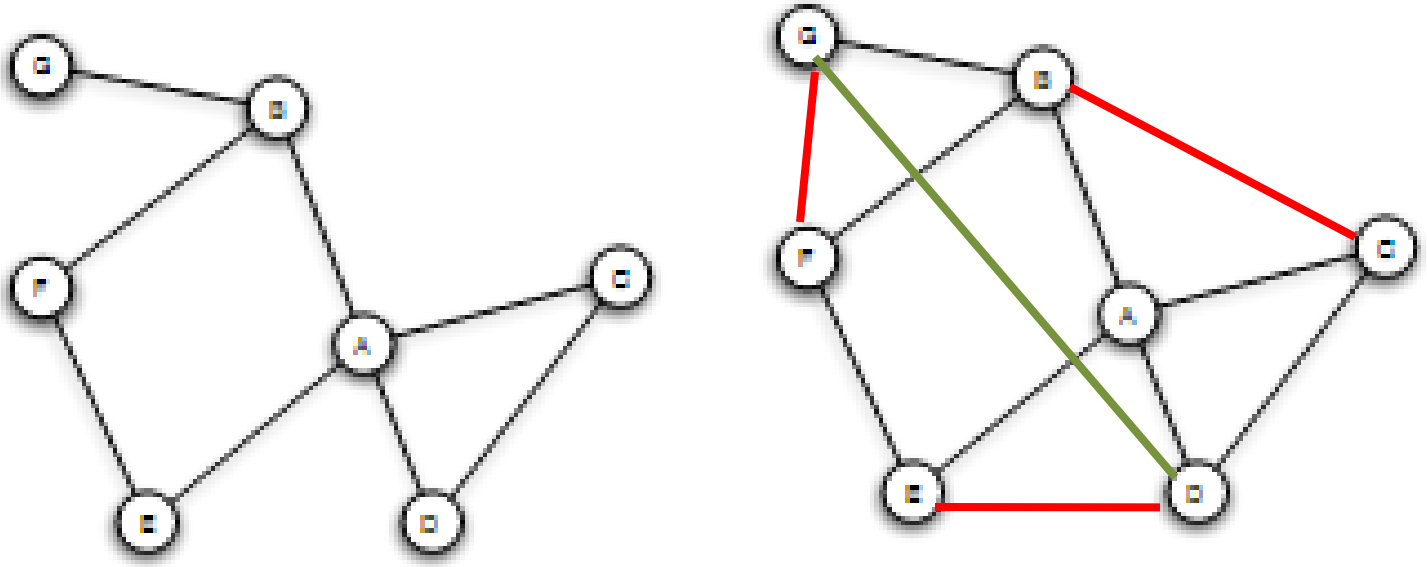
If two people in a social network have a friend in common, then there is an increased likelihood that they will become friends themselves at some point in the future




Triangle

# Triadic Closure

Snapshots over time:



# Clustering Coefficient

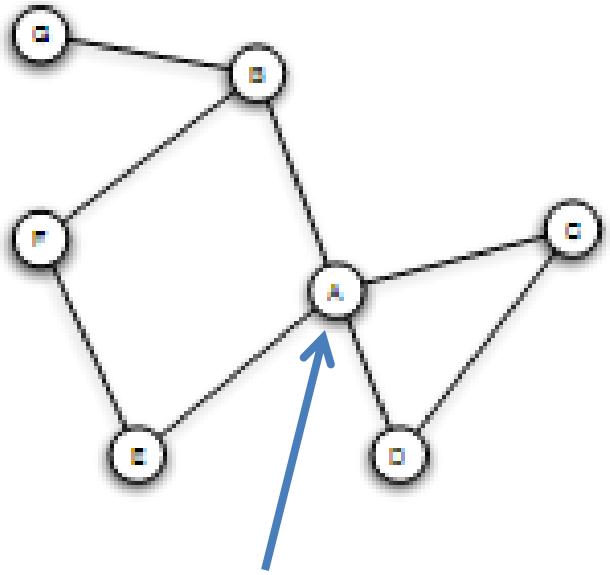
(Local) clustering coefficient for a node is the probability that two randomly selected friends of a node are friends with each other

$$C_i = \frac{2\,|\{e_{jk}\}|}{k_i(k_i - 1)}$$

$$e_{jk} \in E, u_i, u_j \in Ni, k \text{ size of } \mathrm{N_i}, \mathrm{N_i} \text{ neigborhood of } u_i$$

Fraction of the friends of a node that are friends with each other (i.e., connected)

# Clustering Coefficient



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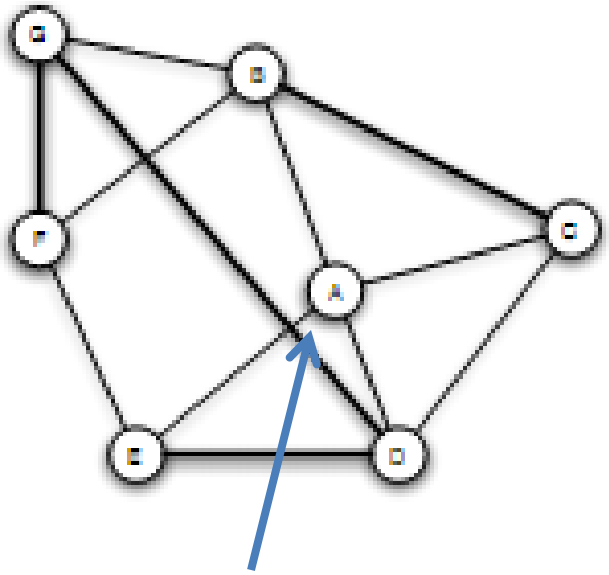

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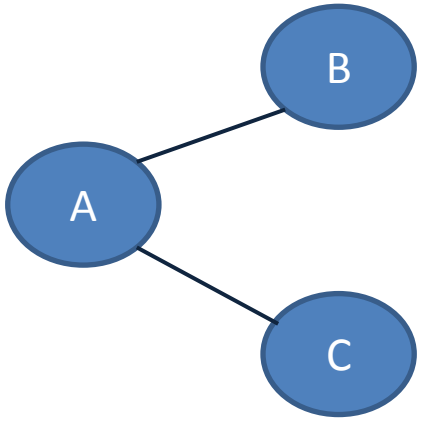
Ranges from 0 to 1

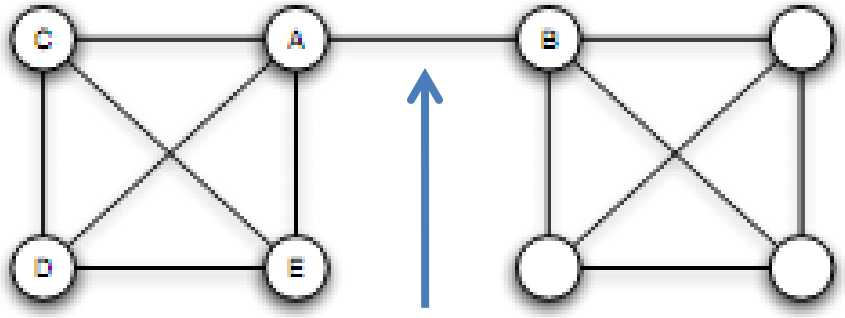
# Triadic Closure

If A knows B and C, B and C are likely to become friends, but WHY?




1. Opportunity
2. Trust
3. Incentive of A (latent stress for A, if B and C are not friends, dating back to social psychology)

# Bridges and Local Bridges



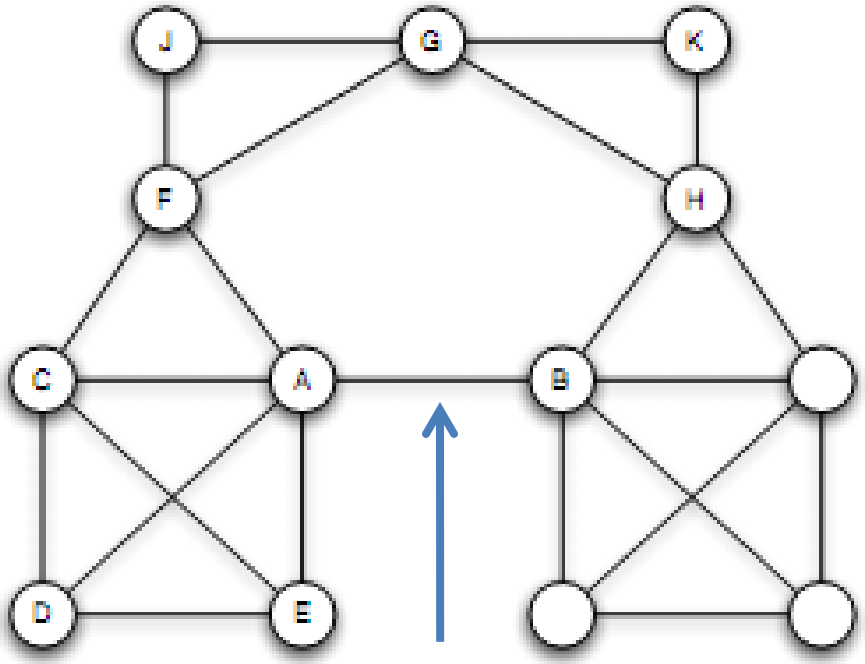

Bridge
(aka cut-edge)

An edge between A and B is a *bridge* if deleting that edge would cause A and B to lie in two different components

AB the only "route" between A and B

*extremely rare in social networks*

# Bridges and Local Bridges

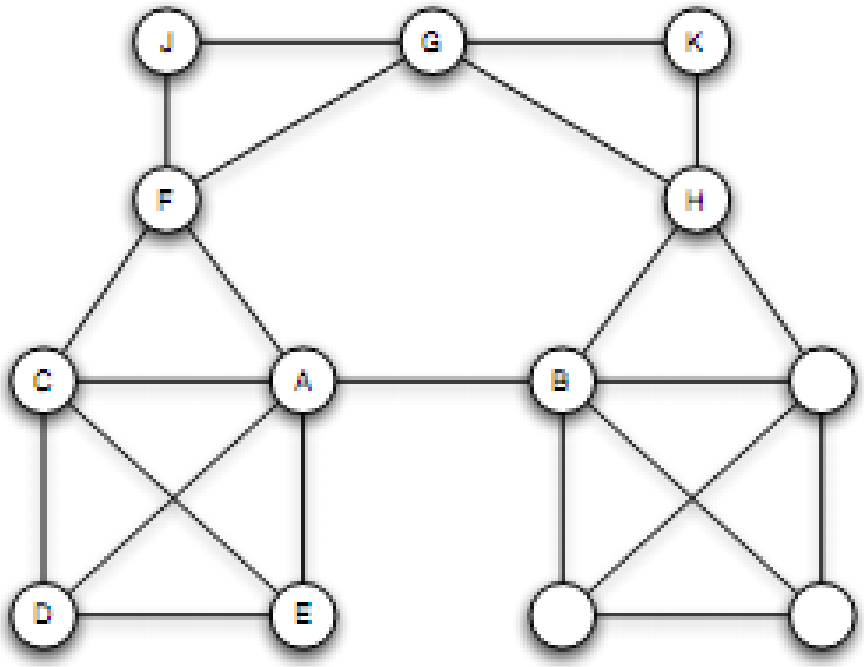



Local Bridge

An edge between A and B is a local bridge if deleting that edge would increase the distance between A and B to a value strictly more than 2

Span of a local bridge: distance of the its endpoints if the edge is deleted

# Bridges and Local Bridges




An edge is a local bridge, if an only if, it is not part of any triangle in the graph

*Back to job seeking:*

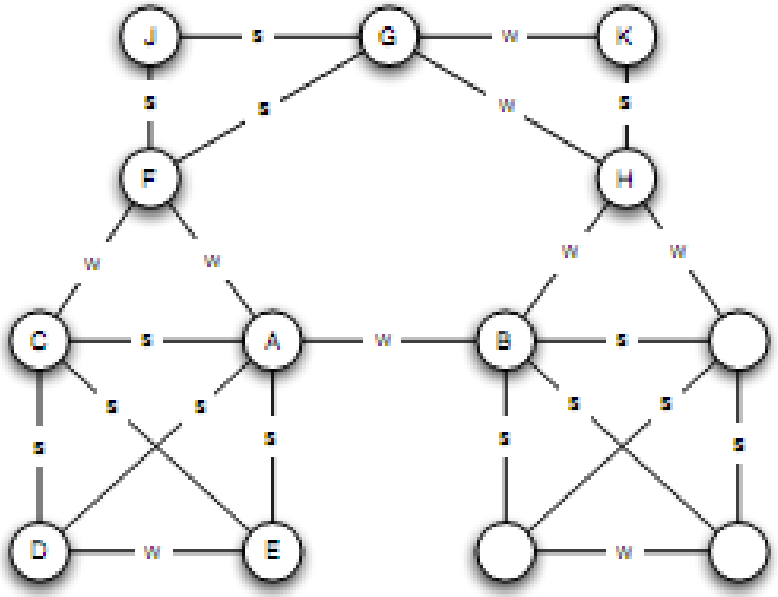
If you are going to get truly new information, it may come from a friend connected by a local bridge

*But why distant acquaintances?*

# The Strong Triadic Closure Property

- Levels of strength of a link
- Strong and weak ties
- Vary across different times and situations

Annotated graph

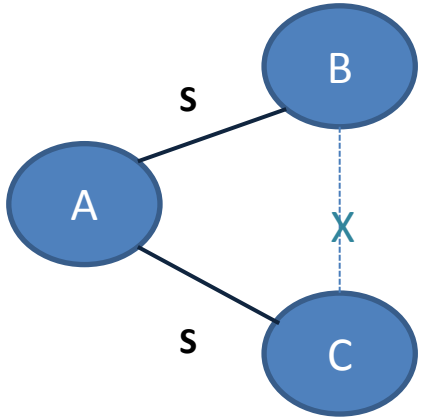


# The Strong Triadic Closure Property

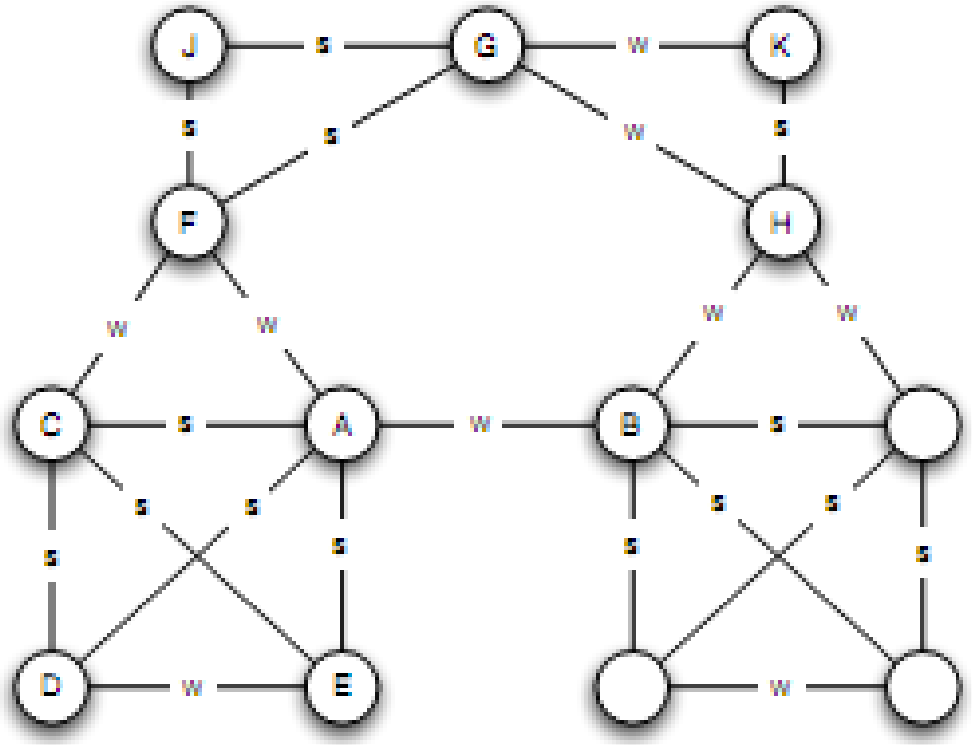
If a node A has edges to nodes B and C, then the B-C edge is especially likely to form if both A-B and A-C are strong ties

A node A violates the Strong Triadic Closure Property, if it has strong ties to two other nodes B and C, and there is no edge (strong or weak tie) between B and C.

A node A satisfies the Strong Triadic Property if it does not violate it



# The Strong Triadic Closure Property



# Local Bridges and Weak Ties

- ✓Local distinction: weak and strong ties
- ✓Global structural distinction: local bridges or not

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

**Proof:** by contradiction

*Relation to job seeking?*

*The role of simplifying assumptions:*

- *Useful when they lead to statements robust in practice, making sense as qualitative conclusions that hold in approximate forms even when the assumptions are relaxed*

- *Stated precisely, so possible to test them in real-world data*

- *A framework to explain surprising facts*

# Tie Strength and Network Structure in Large-Scale Data

How to test these prediction on large social networks?

# Tie Strength and Network Structure in Large-Scale Data

Communication network: “who-talks-to-whom”
Strength of the tie: time spent talking during an observation period

## Cell-phone study [Omnela et. al., 2007]

“who-talks-to-whom network”, covering 20% of the national population

- Nodes: cell phone users
- Edge: if they make phone calls to each other in both directions over 18-week observation periods

Is it a “social network”?
Cells generally used for personal communication + no central directory, thus cell-phone numbers exchanged among people who already know each other
Broad structural features of large social networks (giant component, 84% of nodes)

# Generalizing Weak Ties and Local Bridges

- ✓ Either weak or strong
- ✓ Local bridge or not

Tie Strength

From weak and strong -> Numerical quantity (= number of min spent on the phone)

Quantify “local bridges”, how?

# Generalizing Weak Ties and Local Bridges

## Bridges

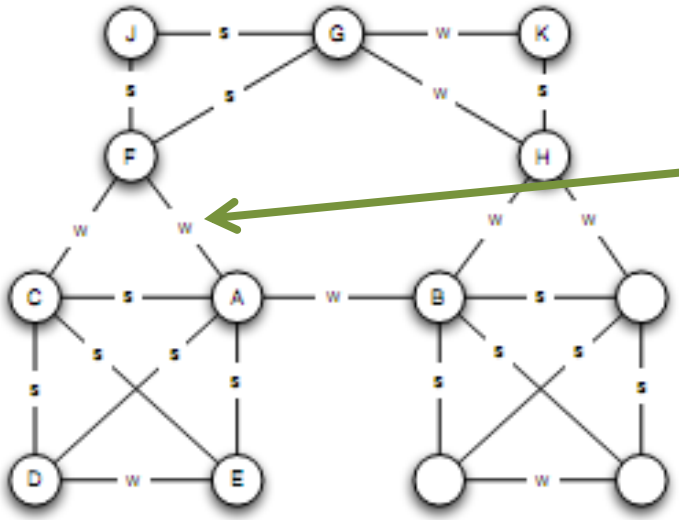
## "almost" local bridges

### Neighborhood overlap of an edge $e_{ij}$

$$\frac{|N_i \cap N_j|}{|N_i \cup N_j|}$$

Jaccard coefficient

*(*) In the denominator we do not count A or B themselves*




A: B, E, D, C
F: C, J, G

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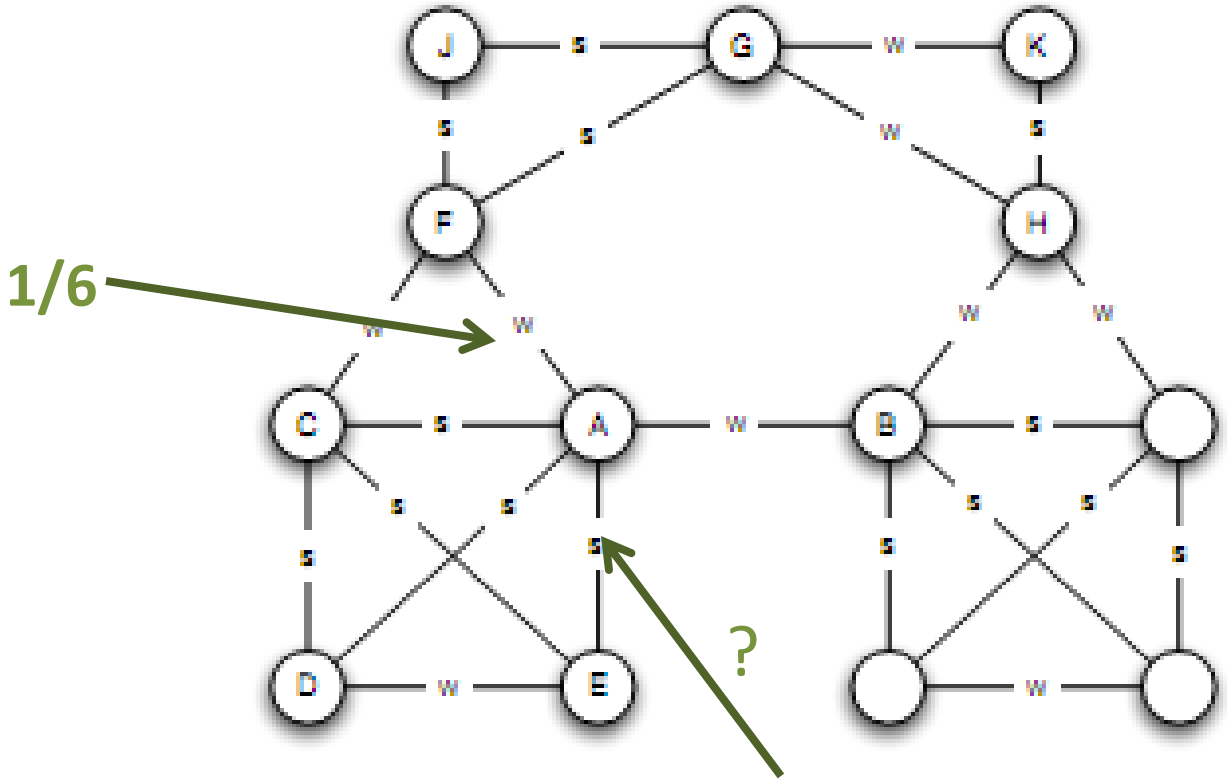
*When is this value 0?*

# Generalizing Weak Ties and Local Bridges

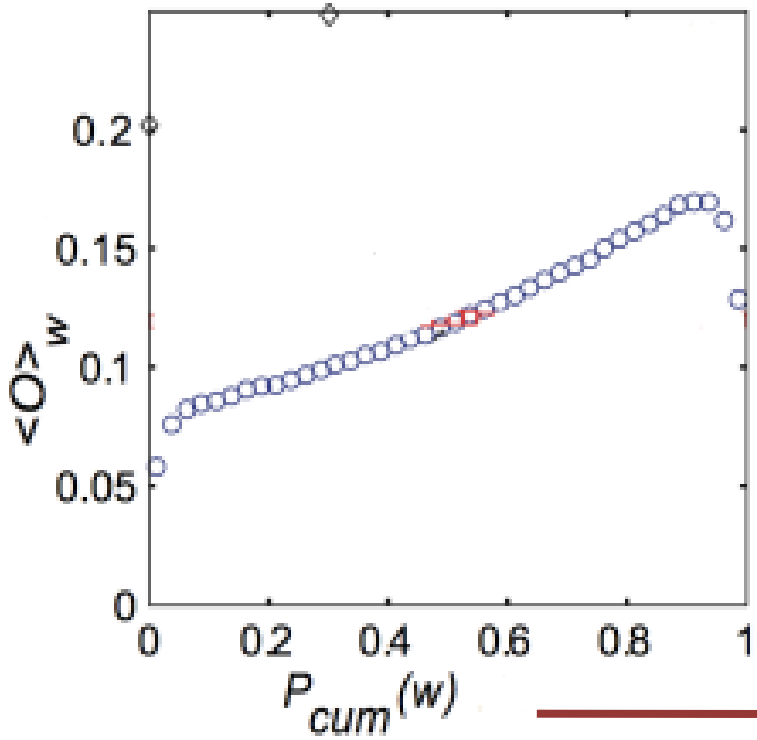
Neighborhood overlap = 0 : edge is a local bridge
Small value: “almost” local bridges



# Generalizing Weak Ties and Local Bridges:
## Empirical Results

*How the neighborhood overlap of an edge depends on its strength*

(Hypothesis: the strength of weak ties predicts that neighborhood overlap should grow as tie strength grows)




*(*) Some deviation at the right-hand edge of the plot*

sort the edges -> for each edge at which percentile

Strength of connection (function of the percentile in the sorted order)

*Local level -?-> global level: weak ties serve to link different tightly-knit communities that each contain a large number of stronger ties – How would you test this?*

# Generalizing Weak Ties and Local Bridges: Empirical Results

Hypothesis: weak ties serve to link different tightly-knit communities that each contain a large number of stronger ties

Delete edges from the network one at a time

- Starting with the strongest ties and working downwards in order of tie strength
    - giant component shrank steadily

-Starting with the weakest ties and upwards in order of tie strength
    - giant component shrank more rapidly, broke apart abruptly as a critical number of weak ties were removed

# Social Media and Passive Engagement

People maintain large explicit lists of friends

Test:
How online activity is distributed across links of different strengths

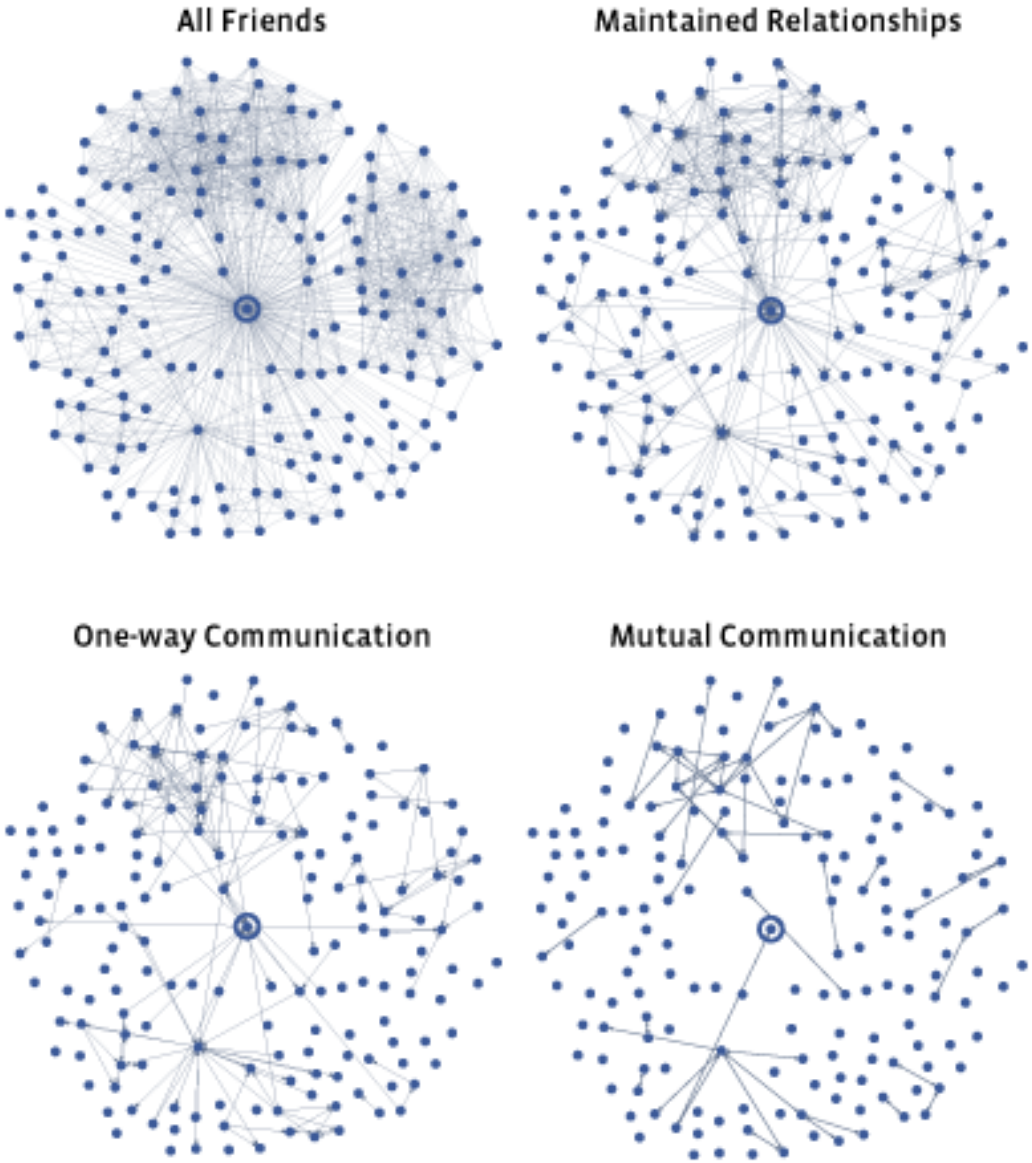
# Tie Strength on Facebook

Cameron Marlow, et al, 2009

At what extent each link was used for social interactions

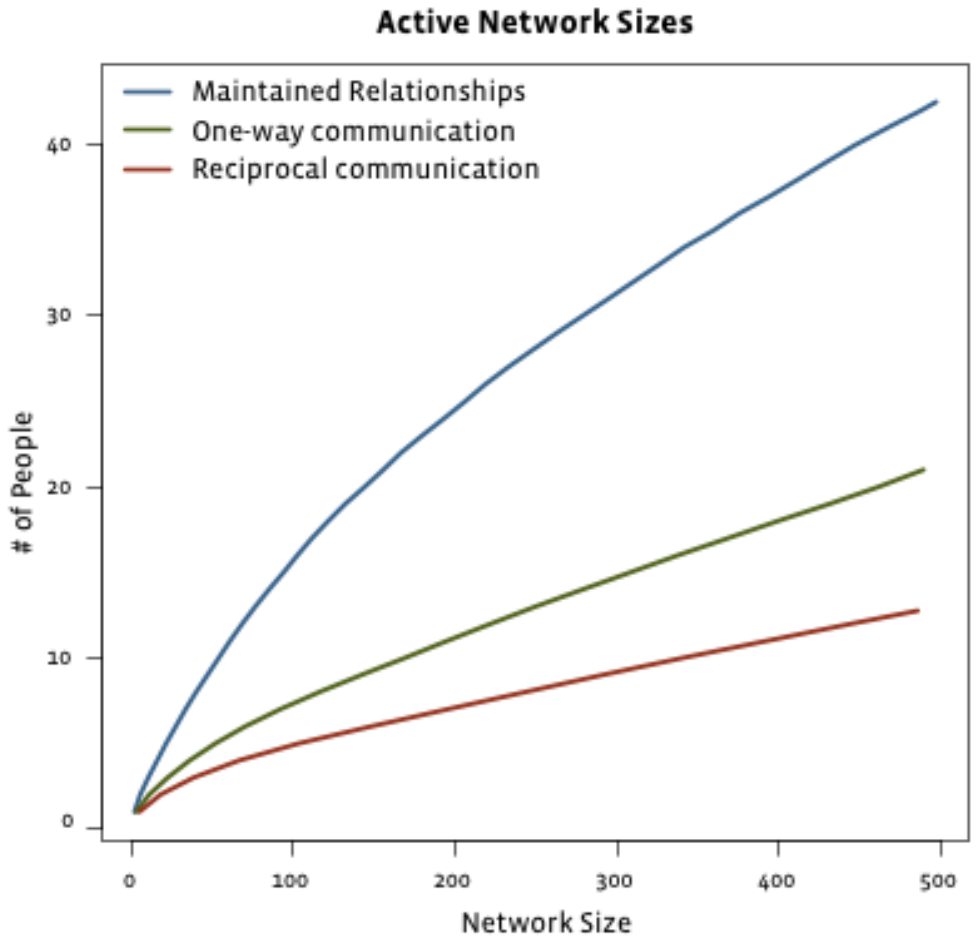
1. Reciprocal (mutual) communication: both send and received messages to friends at the other end of the link
2. One-way communication: the user send one or more message to the friend at the other end of the link
3. Maintained relationship: the user followed information about the friend at the other end of the link (click on content via News feed or visit the friend profile more than once)

# Tie Strength on Facebook




Two distinct regions

# Tie Strength on Facebook




Total number of friends

Even for users with very large number of friends

- actually communicate : 10-20
- number of friends follow even passively <50

**Passive engagement** (keep up with friends by reading about them even in the absence of communication)

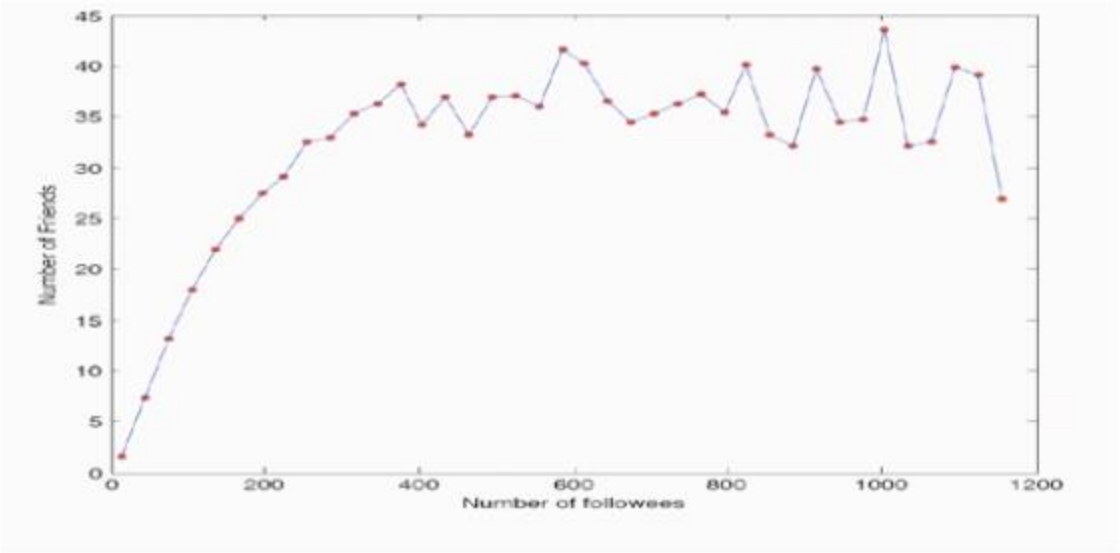
*Passive as a network middle ground*

# Tie Strength on Twitter

Huberman, Romero and Wu, 2009

Two kinds of links

- Follow
- Strong ties (friends): users to whom the user has *directed at least two messages* over the course if the observation period



# Social Media and Passive Engagement

- Strong ties require continuous investment of time and effort to maintain (as opposed to weak ties)

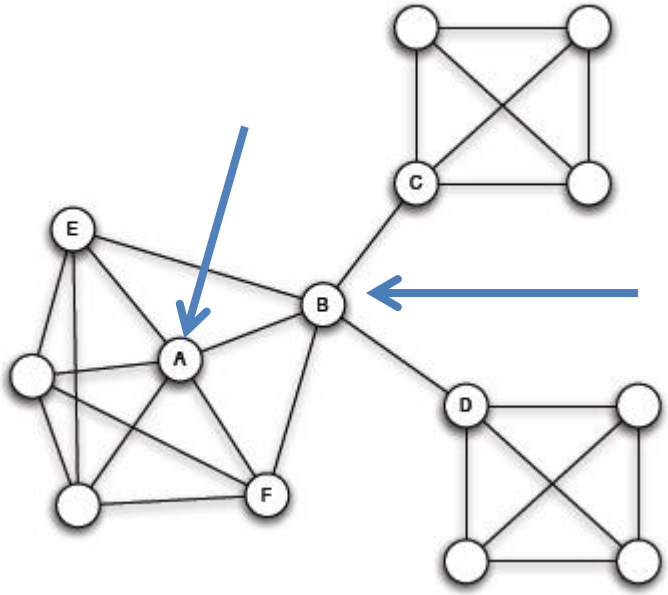
- Network of strong ties still remain sparse

- How different links are used to convey information

# Closure, Structural Holes and Social Capital

Different roles that **nodes** play in this structure

Access to edges that span different groups is not equally distributed across all nodes

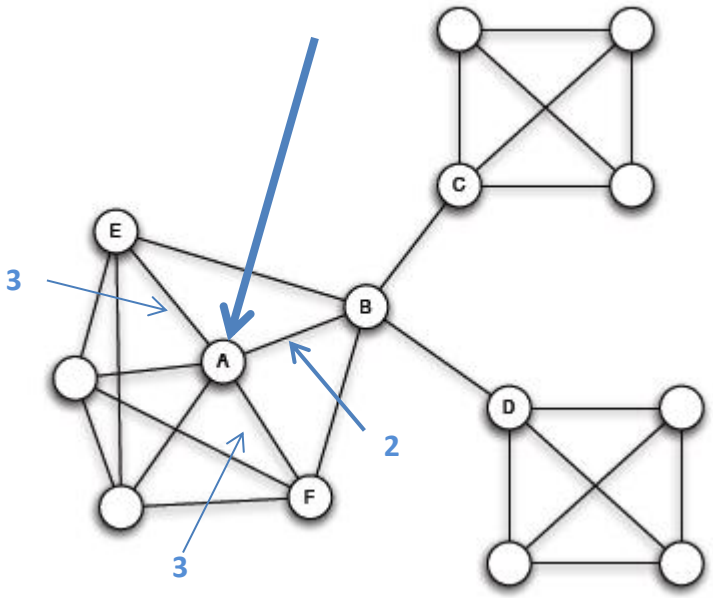


# Embeddedness

Large clustering coefficient

- Embeddedness of an edge: number of common neighbors of its endpoints (neighborhood overlap, local bridge if 0)

A all its edges have significant embeddedness




(sociology) if two individuals are connected by an embedded edge => trust

- "Put the interactions between two people on display"

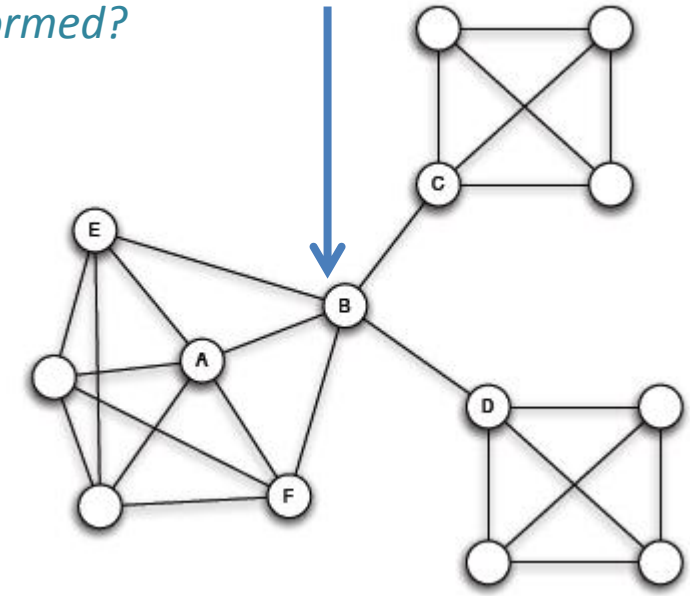
# Structural Holes

*(sociology) B-C, B-D much riskier, also, possible contradictory constraints*
*Success in a large cooperation correlated to access to local bridges*

B “spans a structural hole”

- B has access to information originating in multiple, non interacting parts of the network
- An amplifier for creativity
- Source of power as a social “gate-keeping”

*Will a triangle be formed?*



# Closure and Bridging as Forms of Social Capital

Social capital: benefits from membership in social networks and other social structures