Strong and Weak Ties

Ana Paula Couto

Computer Science Department

Universidade Federal de Minas Gerais

Based on http://www.cs.uoi.gr/~tsap/teaching/2013-cs-l14/references.html

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

Granovetter's Hypothesis

"It's not what you know but ***who*** you know"

Mark Gronvetter, late 1960s:

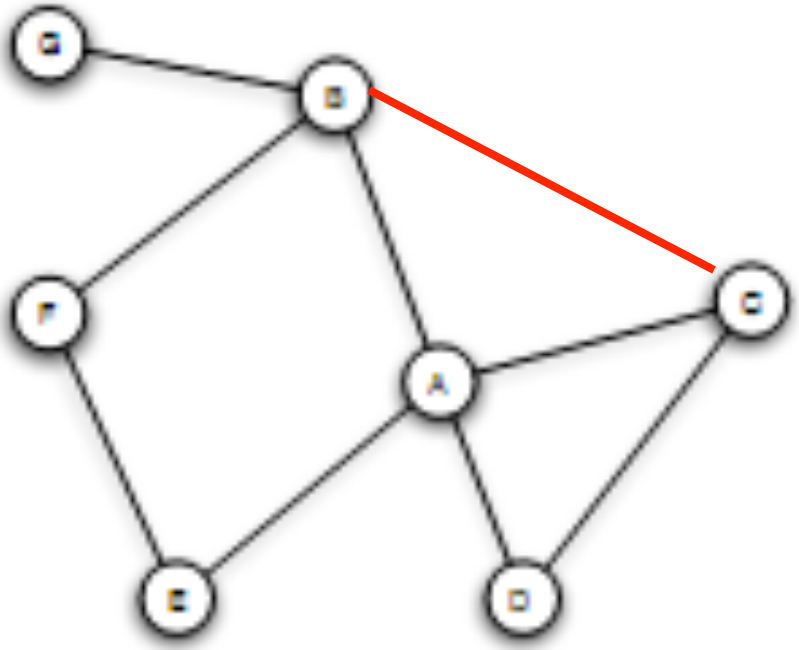
Many people learned information leading to their current job ***through personal contacts***, often described as ***acquaintances*** rather than closed friends

Two different perspectives on distant friendships

- Structural: Way friendships span different portions of the full network
- Local (interpersonal): Purely local consequences that follow from a friendship between two people being either strong or weak
- It offers a way of thinking about the architecture of social networks more generally

Triadic Closure

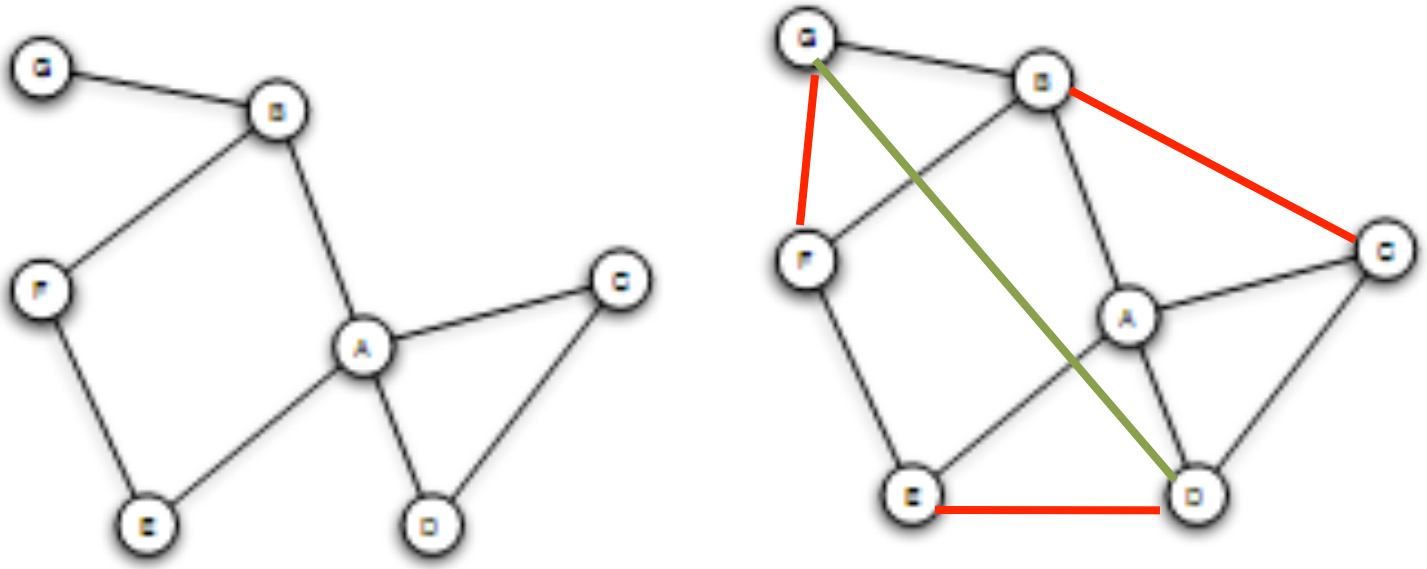
If two people in a social network have a friend in common, then there is an increased likelihood that they will become friends themselves at some point in the future



Triangle

Triadic Closure

Snapshots over time: How network evolves over time
What are the mechanisms by which nodes arrive and depart, and by which edges form and vanish?



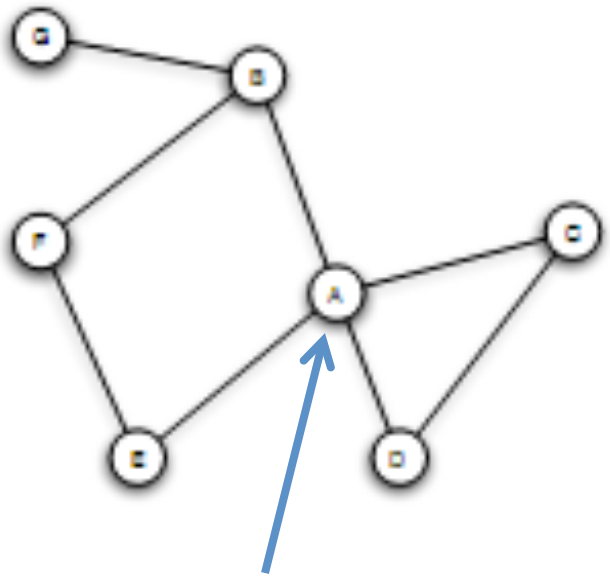
Clustering Coefficient

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

$$C_i = \frac{2\,|\{e_{jk}\}|}{k_i(k_i-1)} \qquad e_{jk} \in E, u_i, u_j \in Ni, k \text{ size of } \mathrm{N_i}, \mathrm{N_i} \text{ neigborhood of } u_i$$

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

Clustering Coefficient



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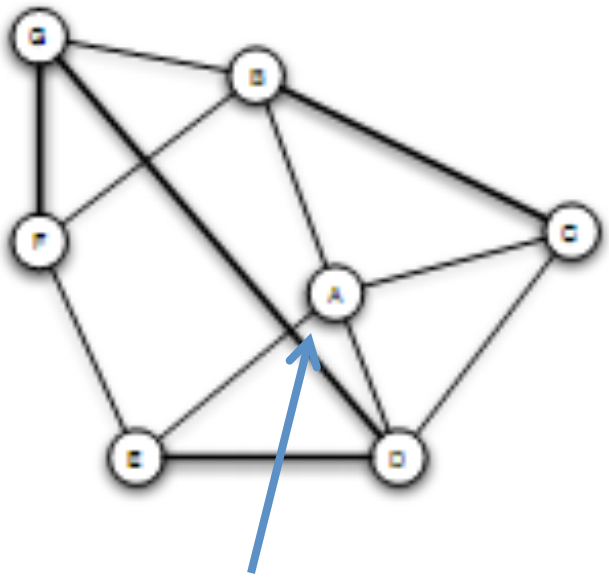

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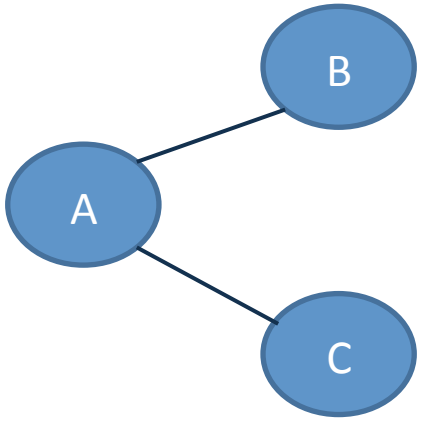
Ranges from 0 to 1

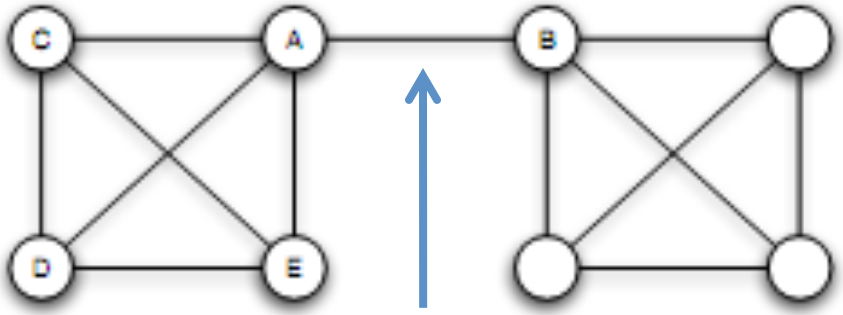
Triadic Closure

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



1. Opportunity: if A spends time with both B and C, then there is an increased chance that they will end up knowing each other
2. Trust
3. Incentive of A (latent stress for A, if B and C are not friends, dating back to social psychology. Teenage girls who have a low clustering coefficient: more likely to contemplate suicide)

Bridges and Local Bridges



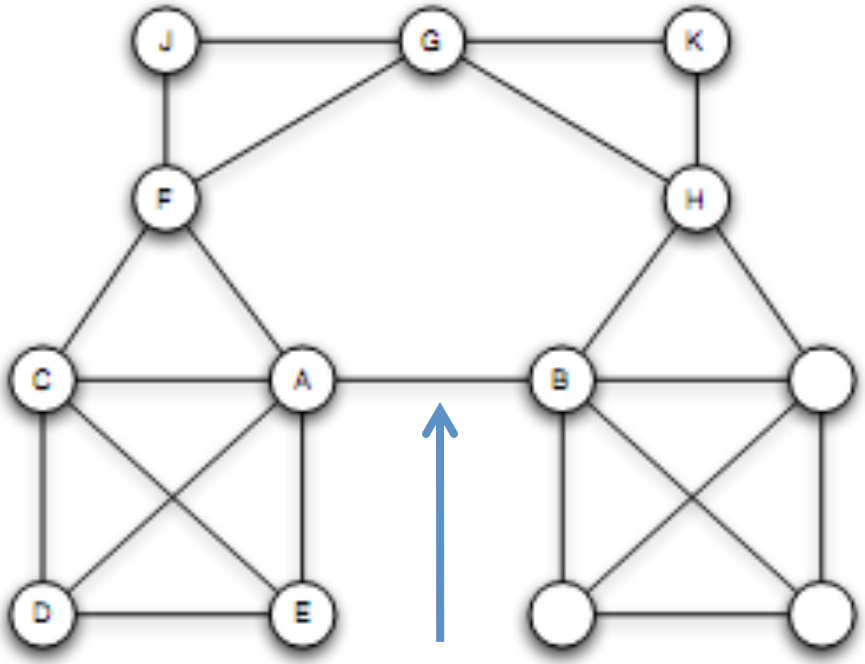
Bridge
(aka cut-edge)

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

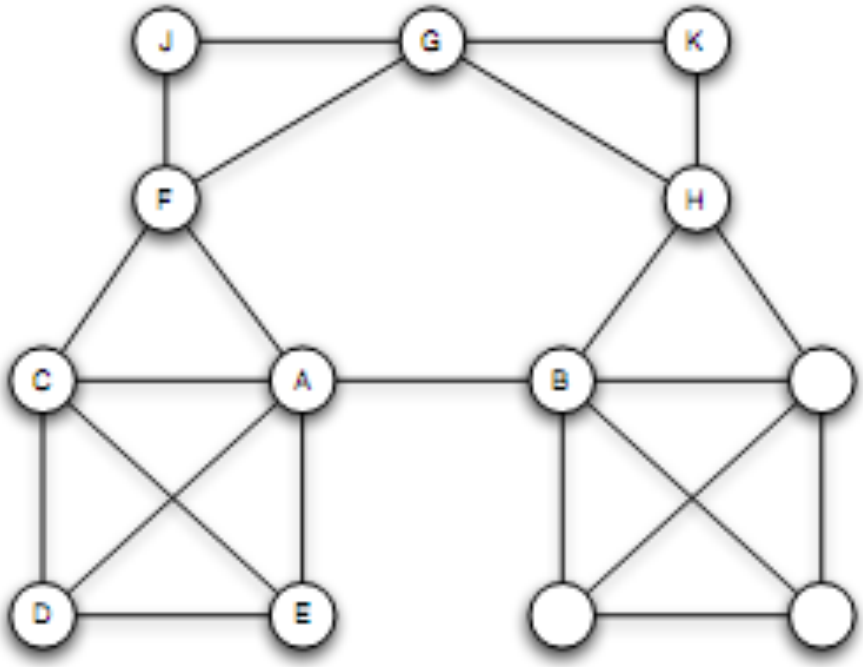


Local Bridge

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
(A-B edge is local with span 4)

Bridges and Local Bridges



An edge is a local bridge, if an only if, it is not part of any triangle in the graph: endpoints would still be at a distance 2

Back to job seeking:

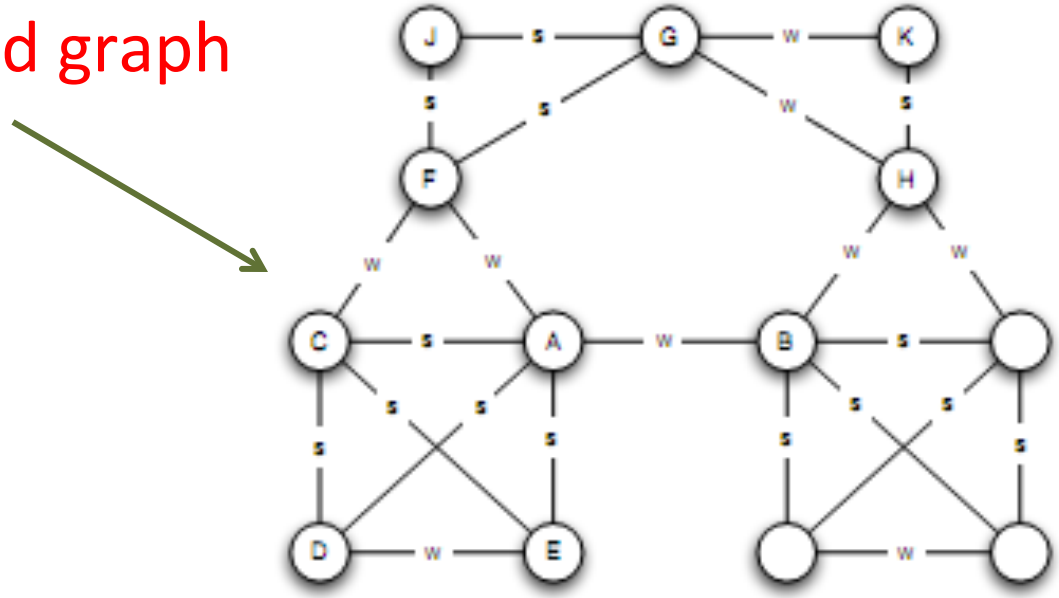
If you are going to get truly new information, it may come from a friend connected by a local bridge

But why distant acquaintances?

The Strong Triadic Closure Property

- Levels of strength of a link
  - Strong (friends) and weak ties (acquaintances)
  - Complexity: Vary across different times and situations

Annotated graph

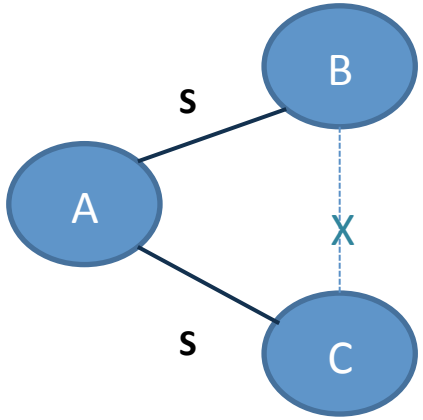


The Strong Triadic Closure Property

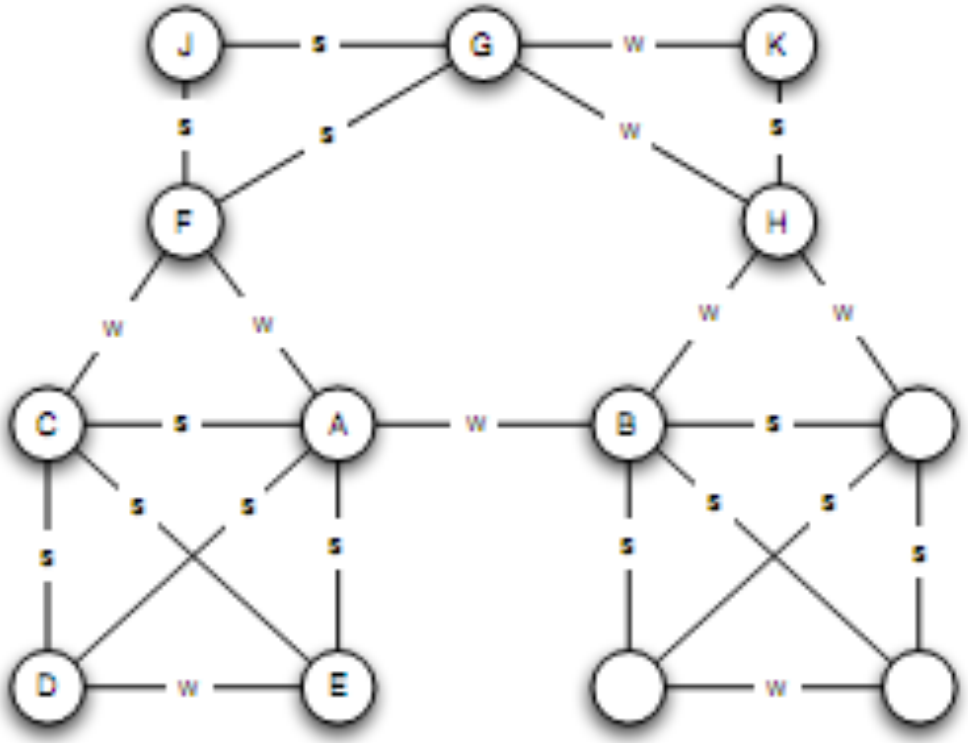
If a node A has edges to nodes B and C, then the B-C edge is especially likely to form if both A-B and A-C are strong ties

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

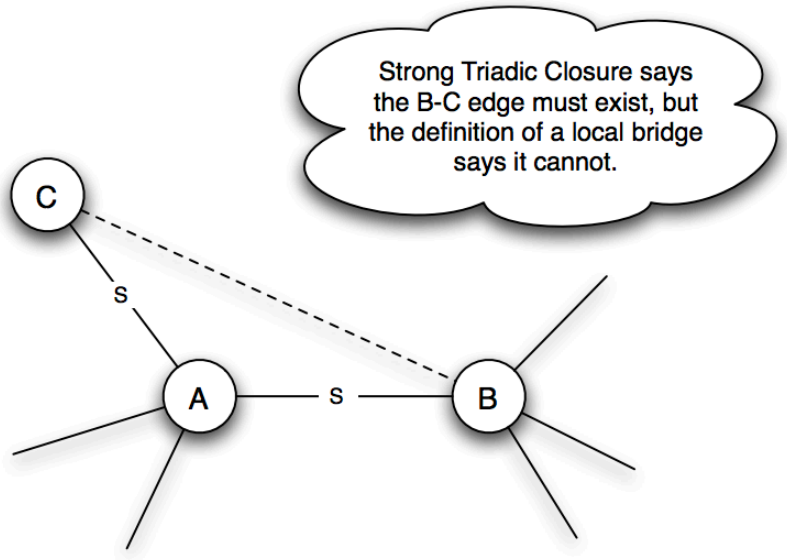
- ✓Local (interpersonal) distinction: weak and strong ties
- ✓Global structural distinction: local bridges or not

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

Local Bridges and Weak Ties

Proof: by contradiction



- Consider a node A that satisfies the Strong Triadic Closure property
- Suppose A is a local bridge with node B
- A is involved in at least two strong ties, A must have a strong tie to some other node: C
- Is there an edge connecting B and C?
  - Since A to B is a local bridge, A and B must have no friends in common (span !>2)

  And so B-C must not exist !Strong Triadic Closure contradiction: B and C must exist!
- Existence of a local bridge that is a strong tie cannot hold!!!!

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

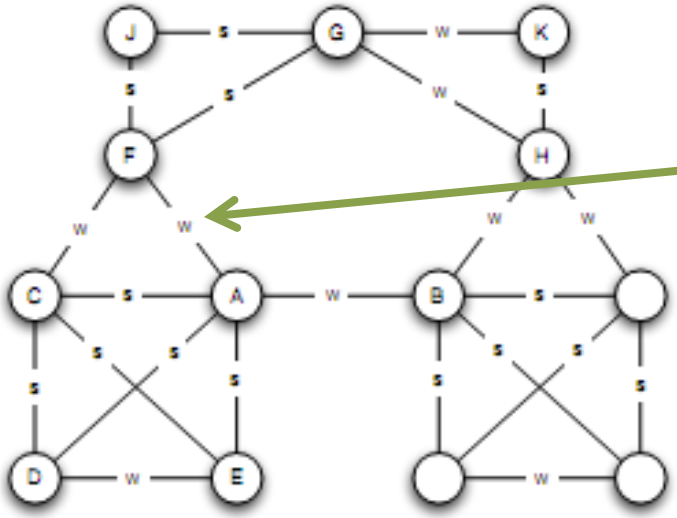
"almost" local bridges

Neighborhood overlap of an edge e_{ij}

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

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

Jaccard coefficient



A: B, E, D, C

F: C, J, G

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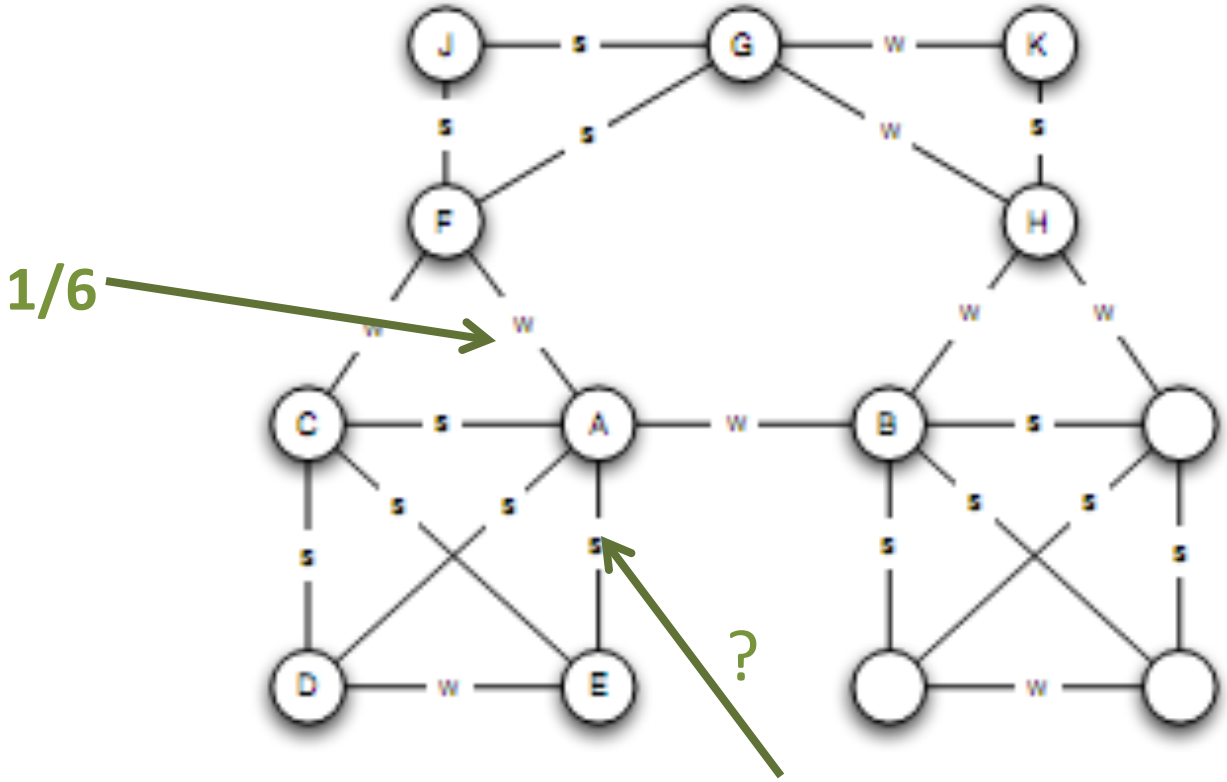
When is this value 0?

Generalizing Weak Ties and Local Bridges

Neighborhood overlap = 0 : edge is a local bridge

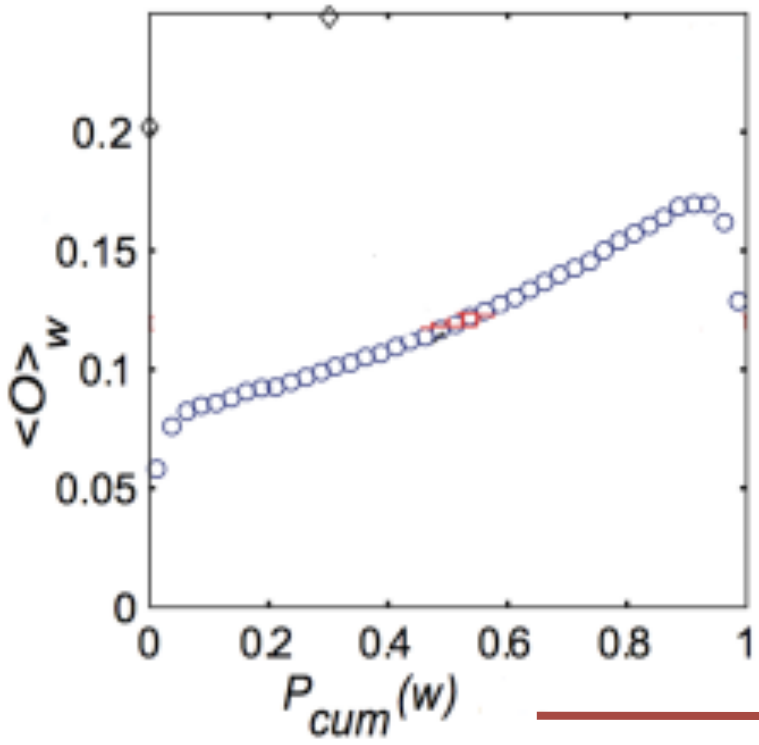
Small value: “almost” local bridges



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

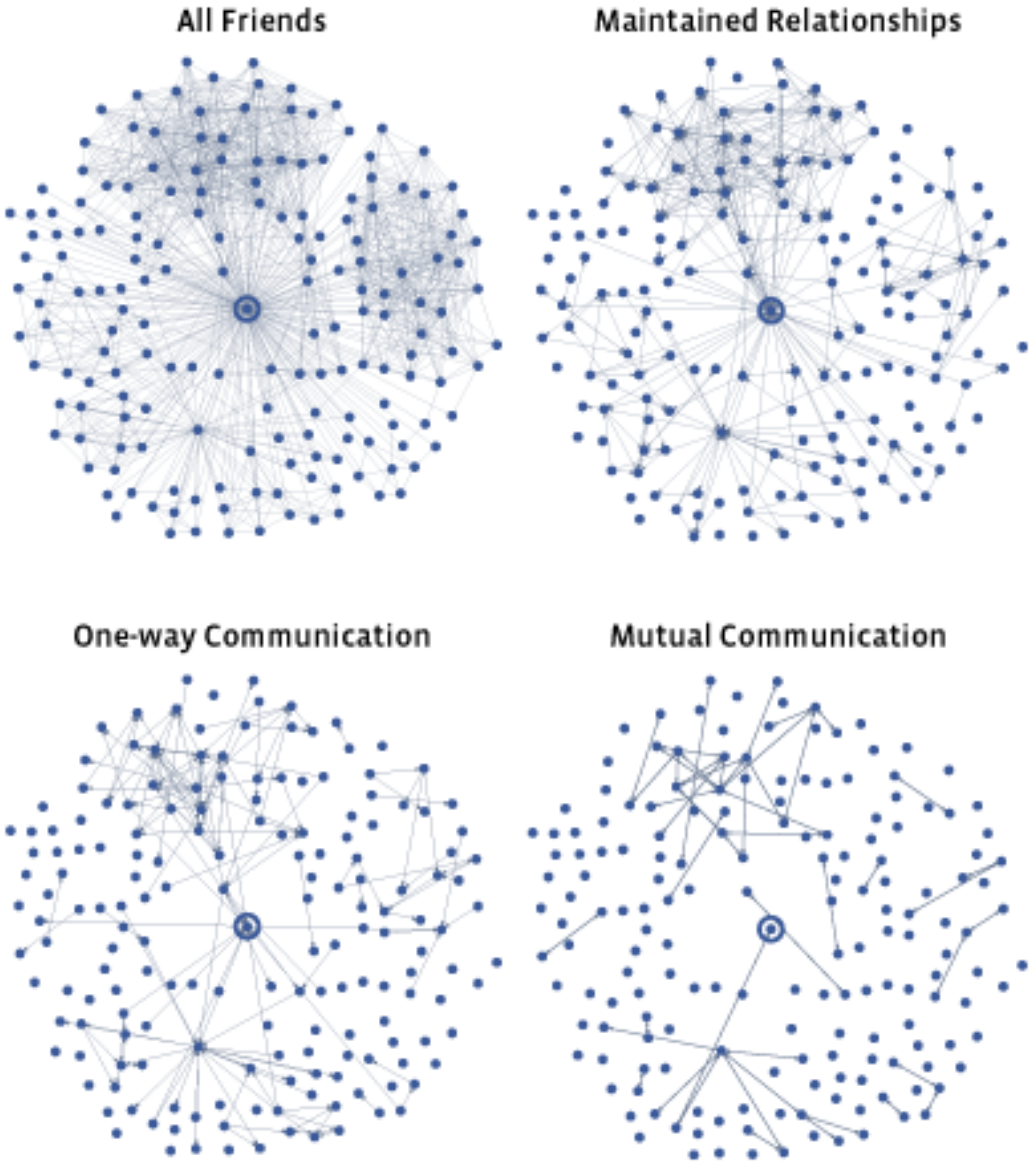
Test:
How online activity is distributed across links of different strengths

Tie Strength on Facebook

Cameron Marlow, et al, 2009
At what extent each link was used for social interactions

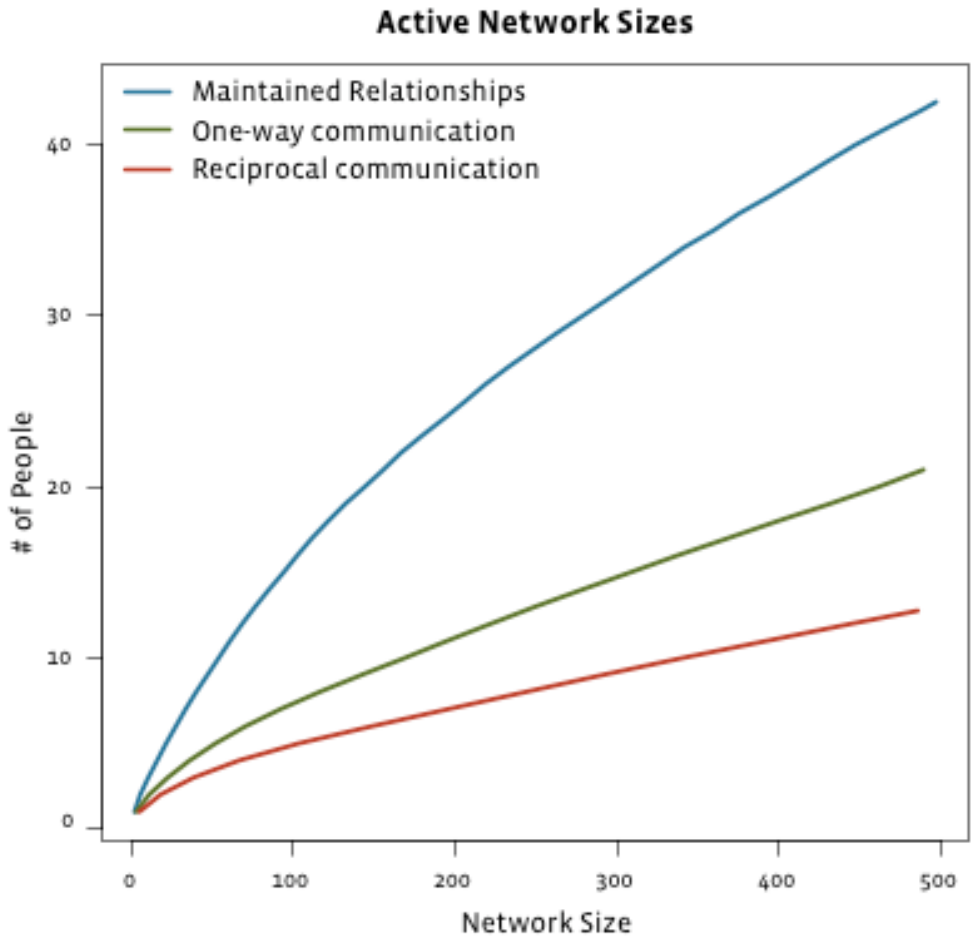
1. Reciprocal (mutual) communication: both send and received messages to friends at the other end of the link
2. One-way communication: the user send one or more message to the friend at the other end of the link
3. Maintained relationship: the user followed information about the friend at the other 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

Atividade (TP2):

1. Atividade a distância: Não haverá aula dia 20/04
2. Ler 3.5 – Closure, Structural Holes, and Social Capital
3. Selecionar um dos artigos citados e fazer um resumo (problema, motivação e principais resultados) e mapear os conceitos já estudados na disciplina
4. Entrega via Moodle: 24/04