Social network Analysis
Lecture 5–Strength of weak ties paradox

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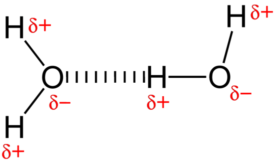
Outline

- We first look at how links can play different role in the network structure: a few edges spanning different groups while most are surrounded by dense patterns of connections.
- We then look at how nodes can play different role in the network structure.

Strength of weak ties: Mark Granovetter:

- **"It is the distant acquaintances who are actually to thank for crucial information leading to your new job, rather than your close friends!"**



- Mark Granovetter (born October 20, 1943): an American sociologist and professor at Stanford University.
- 1969: submitted his paper to the American Sociological Review—rejected!
- 1972, submitted a shortened version to the American Journal of Sociology—published in 1973 (Granovetter, 1973).
- According to Current Contents, by 1986, the Weak Ties paper had become a citation classic, being one of the most cited papers in sociology.

Strong vs weak ties

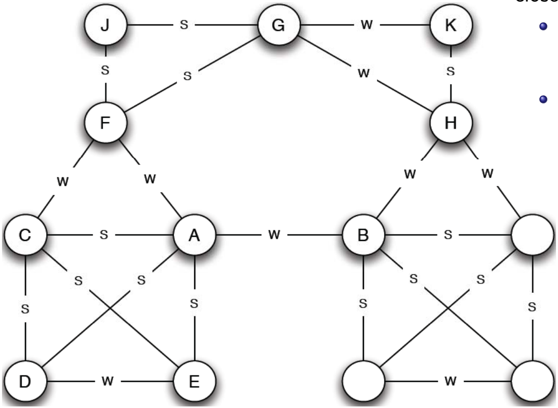
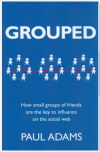
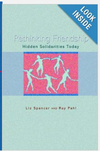


Figure: A network with strong triadic closure property

- Tie strength refers to a general sense of closeness with another person:
  - Strong ties: the stronger links, corresponding to friends, dependable sources of social or emotional support;
  - Weak ties: the weaker links, corresponding to acquaintances.
    - The most notable role of weak ties in social networks is their structural significance as connectivity-generating factors: they tend to be bridges that connect distant clusters within social structures.
    - Weak ties are less subject to the closure-producing transitivity pressures that operate on stronger ones, and hence less likely to be confined within local social environments.
    - Weak ties thereby facilitate the interpersonal dissemination of novel phenomena, be those useful information or harmful diseases.

Tie strength in social network





- According to [Rethinking Friendships: Hidden Solidarities Today (Princeton, 2006) by Liz Spencer and Ray Pahl], there are eight different types of relationships:
  - Associates: dont know each other well, and only share a common activity, such as a hobby or a sport.
  - Useful contacts: share information and advice, typically related to our work or career.
  - Fun friends: socialize together primarily for fun without a deep relationship to provide each other with emotional support.
  - Favor friends: help each other out in a functional manner but not in an emotional manner.
  - Helpmates: display characteristics of both favor friends and fun friends; socialize together for fun and also help each other out in a functional manner.
  - **Comforters: similar to helpmates but with a deeper level of emotional support.**
  - **Confidants: disclose personal information to each other, enjoy each others company, but aren't always in a position to offer practical help.**
  - **Soulmates: display all of these elements and are the people were closest to.**
- We have a much smaller number of strong ties than weak ties.

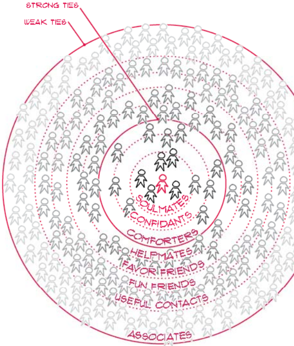
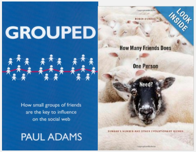


Figure: Credit: (Adams, 2011)

Tie strength: the 5-15-50-150-500 rule



- According to [How Many Friends Does One Person Need?: Dunbar's Number and Other Evolutionary Quirks, Robin Dunbar, Harvard University Press (November 1, 2010)]:
  - Most peoples social networks have a common pattern, unchanged for thousands of years.
  - There are clear boundaries based on the number of connections we have; it starts at five and goes up by a factor of three.
    - Inner circle: 5
    - sympathy group: 12-15
    - Semi-regular group: 50
    - stable social group: **150** (the Dunbar number)
    - friends of friends group (weak ties): 500

- Robin Ian MacDonald Dunbar (born 28 June 1947): a British anthropologist and evolutionary psychologist and a specialist in primate behavior at University of Oxford.
- Best known for his Dunbar's number: a measurement of the "cognitive limit to the number of individuals with whom any one person can maintain stable relationships".

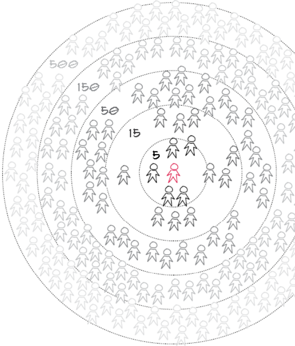
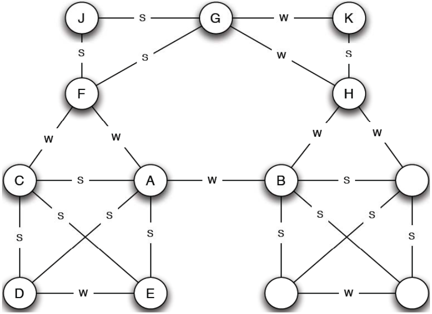


Figure: Credit: (Adams, 2011)

More discussions on tie strength

- Discrete or continuous?
  - Strong and weak ties: discrete
  - Later on, we define tie strength as a continuous quantity for empirical test.
- Positive vs negative? More later...

Quantify the strength of ties as a continuous quantity



- We extend the strong and weak ties to a continuum.
- The neighborhood overlap of an edge (x, y):

$$NO(x,y) = \frac{|\text{common neighbors of } x \text{ and } y|}{|\text{neighbors of at least one of } x \text{ or } y|} = \frac{|(N(x) \cap N(y)|}{|(N(x) - \{y\}) \cup (N(y) - \{x\})|}$$

- For example, $NO(A, B) = 0$, and $NO(A, F) = 1/6$ in the above example.
- local bridges are the edges of neighborhood overlap 0 -and hence we can think of edges with very small neighborhood overlap as being almost local bridges.
- Intuitively, edges with very small neighborhood overlap consist of nodes that travel in social circles having almost no one in common.

Why the paradox?

- There exists a micro-mechanism to explain this global-level paradox based on the concepts of
  - local bridge (global structure)
  - triadic closure (local mechanism)
- We will establish that local bridges tend to be weak ties in the world where (strong) triadic closure mechanism operates.
  - This is a recurring theme indicating the powerful roles that networks play in bridging the local and the global—to offer explanations for how simple processes at the level of individual nodes and links can have complex effects that ripple through a population as a whole.

Local bridge

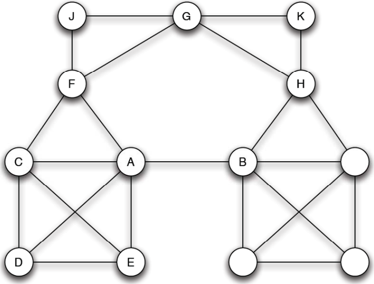


Figure 3.4: The A-B edge is a local bridge of span 4, since the removal of this edge would increase the distance between A and B to 4.

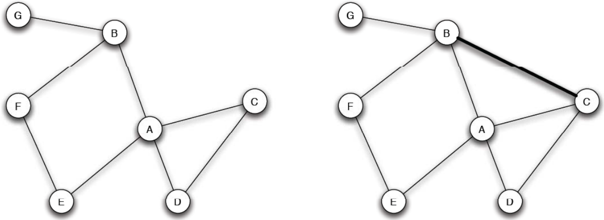
- The following are all equivalent definitions of local bridge
  - Any edge with zero neighbor overlap is called a local bridge.
  - Any edge whose endpoints have no friends in common.
  - Any edge whose deletion results in increasing the distance between the endpoints to a value strictly more than two.
  - Any edge that does not from the side of any triangle in the graph.
- For example, AB is the only local bridge in the above graph.

Triadic closure: Friend of a friend is also friend

- 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.
- This principle can explain the evolving of network over times in many situations.
- We can measure the strength of triadic closure via the *clustering coefficient* for any given node A and two randomly selected nodes B and C:

$$
\begin{aligned}
CC(A) &= \mathbb{P}(B \in N(C) | B, C \in N(A)) \\
&= \mathbb{P}(\text{two randomly selected friends of } A \text{ are friends}) \\
&= \mathbb{P}(\text{fraction of pairs of } A\text{'s friends that are linked to each other})
\end{aligned}
$$

- For example, in Figure 3.1(a) (next slide), $CC(A) = 1/C_4^2 = 1/6$.



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

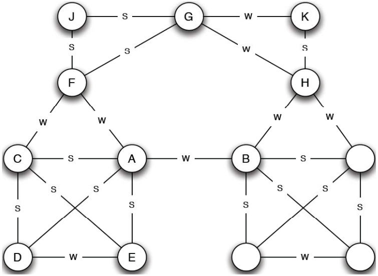
Figure 3.1: The formation of the edge between B and C illustrates the effects of triadic closure, since they have a common neighbor A.

Figure: Taken from (Easley and Kleinberg, 2010)

Reasons for Triadic Closure

- Opportunity: if A spends time with both B and C, then there is an increased chance that B and C will end up knowing each other and potentially becoming friends
- Trusting: the fact that each of B and C is friends with A (provided they are mutually aware of this) gives them a basis for trusting each other that an arbitrary pair of unconnected people might lack.
- Incentive: if A is friends with B and C, then it becomes a source of latent stress in these relationships if B and C are not friends with each other.

The Strong Triadic Closure Property



- **A node A violates the Strong Triadic Closure Property if it has strong ties to two non-linked nodes B and C.**
    - No node in the left figure violates the Strong Triadic Closure Property.
    - If we change AF and AB to strong ties, then it violates the Strong Triadic Closure Property due to the absence of link BF

Local Bridges and Weak Ties

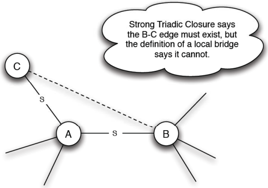


Figure 3.6: If a node satifies Strong Triadic Closure and is involved in at least two strong ties, then any local bridge it is involved in must be a weak tie. The figure illustrates the reason why: if the A-B edge is a strong tie, then there must also be an edge between B and C, meaning that the A-B edge cannot be a local bridge.

- **Claim: If a node A in a network 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.**
- In other words, assuming the Strong Triadic Closure Property and a sufficient number of strong ties, the local bridges in a network are necessarily weak ties.
- We now established a connection between local bridge (a global structural notation) and strong and weak ties (local notion)!
- Note that if A is only involved in one strong ties, then the above claim mayn't hold.
  - For example: consider a network with three nodes A, B, C and two ties, namely a strong tie (A, B) and weak tie (A, C). Then both ties are local bridges.

Structural Holes Theory: Ronald Stuart Burt

- Ronald Stuart Burt (born 1949): an American sociologist and the Hobart W. Williams Professor of Sociology and Strategy at the University of Chicago Booth School of Business.
- Most notable for his research on social networks and social capital, particularly the concept of structural holes in a social network.
  - Burt, Ronald (2004). "Structural Holes and Good Ideas". American Journal of Sociology.

Embeddedness

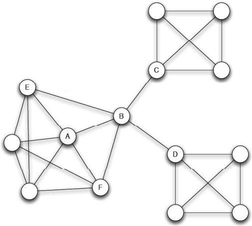


Figure 3.11: The contrast between densely-knit groups and boundary-spanning links is reflected in the different positions of nodes A and B in the underyling social network.

- The embeddedness of an edge in a network to be the number of common neighbors the two endpoints have (the numerator in the neighborhood overlap).
  - Local bridges are precisely the edges that have an embeddedness of zero.
- If two individuals are connected by an edge of high embedddedness:
  - This makes it easier for them to trust one another, and to have confidence in the integrity of the transactions (social, economic, or otherwise) that take place between them.
  - In the event of misbehavior, there is potential for social sanctions and reputation consequences from their mutual firends.
- If two individuals are connected by an edge of low embedddedness (such as local bridge):
  - No similar kind of deterring threat exists for edges, since there is no one who knows both people involved in the interaction.

Structural holes

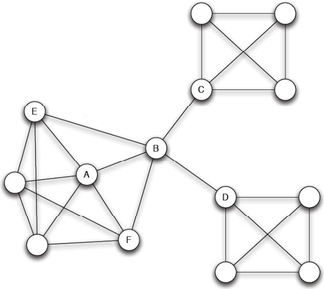


Figure 3.11: The contrast between densely-knit groups and boundary-spanning links is reflected in the different positions of nodes A and B in the underlying social network.

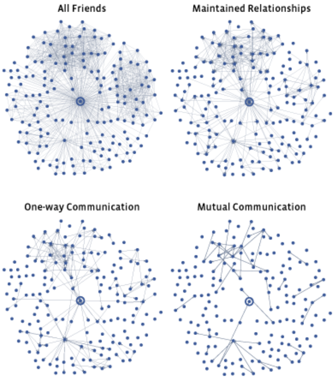
- Node B in Figure 3.11, with her multiple local bridges, spans a structural hole in the organization – the "empty space" in the network between two sets of nodes that do not otherwise interact closely.
- B's position offers advantages in several dimensions relative to A's:
  - Informational
  - Innovative
  - Gatekeeping

A or B?

- There are trade-offs in the relative positions of A and B.
  - Bs position at the interface between groups means that her interactions are less embedded within a single group, and less protected by the presence of mutual network neighbors.
  - On the other hand, this riskier position provides her with access to information residing in multiple groups, and

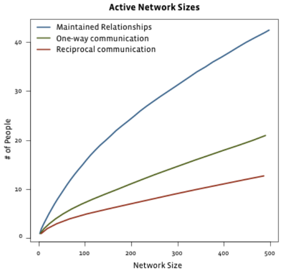
Case study: Tie Strength on Facebook

- Ref: [Cameron Marlow, Lee Byron, Tom Lento, and Itamar Rosenn. Maintained relationships on Facebook, 2009. http://overstated.net/2009/03/09/maintained-relationships-on-facebook]
- Questions to be answered by the study:
  - Is Facebook increasing the size of people's personal networks?
- Method:
  - Monitor the communications Random sample of users over the course of 30 days;
  - Defined 4 different networks
    - All Friends: the largest representation of a persons network is the set of all people they have verified as friends.
    - Reciprocal Communication: as a measure of a sort of core network, people with whom a person had had reciprocal communications, or an active exchange of information between two parties.
    - One-way Communication: people with whom a person has communicated.
    - Maintained Relationships: to measure engagement, people for whom a user had clicked on a News Feed story or visited their profile more than twice.



Case study: Tie Strength on Facebook: undirected network

- For each user, calculate the size of these four networks, respectively, and plot this as a function of the number of friends a user has.
- As a function of the people, a Facebook user passively (top line) engages with 2 and 2.5 times more people than actively (bottom two lines) communicates within the network.
- Online world is no different from the physical world: strong ties can still be relatively sparse even in on-line settings where weak ties abound.

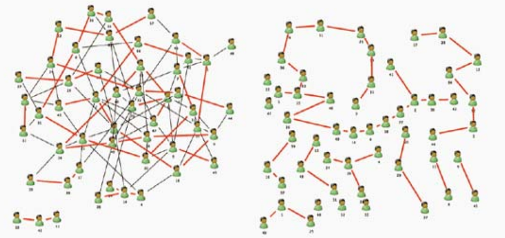


Case study: Tie Strength on Twitter: directed network

- Ref: [Bernardo A. Huberman, Daniel M. Romero, and Fang Wu. Social networks that matter: Twitter under the microscope. First Monday, 14(1), January 2009. http://firstmonday.org/article/view/2317/2063]
- Questions to be answered by the study:
    - Is Twitter increasing the size of people's personal networks?
- Findings:
    - The driver of usage is a sparse and hidden network of connections underlying the declared set of friends and followers.

Case study: Tie Strength on Twitter: directed network

- Most of the links declared within Twitter were meaningless from an interaction point of view.
- Thus the need to find the hidden social network; the one that matters when trying to rely on word of mouth to spread an idea, a belief, or a trend.



(a) All links are declared followees and the red links are actual friends.

(b) After removing the black links and reorganizing the network look simpler than before. This is the hidden network that matters the most.

Case study: files "twitter_streaming_API.r" and "twitter_streaming_API"

- There are two packages in R for retrieving tweets
  - twitteR by Jeff Gentry: `http://cran.r-project.org/web/packages/twitteR/index.html`
  - streamR by Pablo Barbera: `http://cran.r-project.org/web/packages/streamR/`
- Both need authentication via OAuth. The same oauth token can be used for both twitteR and streamR.
- Details will be shown in class...

Some discussion based on the empirical analysis

- The contrast between the ease of forming links and the relative scarcity of strong ties in environments like Facebook and Twitter.
- Understanding the effect that on-line media have on the maintenance and use of social networks is a complex problem for which the underlying research is only in its early stages.

References I

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