

## Strength of weak ties

Long-range links are often casual acquaintances,

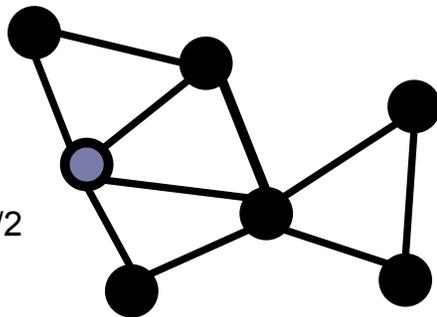
... but are very important for search  
and other network phenomena

## Explaining triadic closure

1. **Opportunity.** If you spend a lot of time with your best friend and your girlfriend, there is an increased chance they will meet.
2. **Incentive.** If your best friend hates your girlfriend, it stresses both relationships.
3. **Homophily.** If you have things in common with both your best friend and your girlfriend, they have things in common too.

**Definition:** The **clustering coefficient** of a node  $v$  is the fraction of pairs of  $v$ 's friends that are connected to each other by edges.

Clustering  
Coefficient =  $1/2$



The higher the clustering coefficient of a node, the more strongly triadic closure is acting on it

## factors influencing diffusion

- network structure (unweighted)
  - density
  - degree distribution
  - clustering
  - connected components
  - community structure
- strength of ties (weighted)
  - frequency of communication
  - strength of influence
- spreading agent
  - attractiveness and specificity of information

## how does strength of a tie influence diffusion?

- M. S. Granovetter: *The Strength of Weak Ties*, AJS, 1973:
- finding a job through a contact that one saw
  - frequently (2+ times/week) 16.7%
  - occasionally (more than once a year but < 2x week) 55.6%
  - rarely 27.8%
- but... length of path is short
  - contact directly works for/is the employer
  - or is connected directly to employer

## strength of tie: frequency of communication

- Kossinets, Watts, Kleinberg, KDD 2008:
  - which paths yield the most up to date info?
  - how many of the edges form the “backbone”?

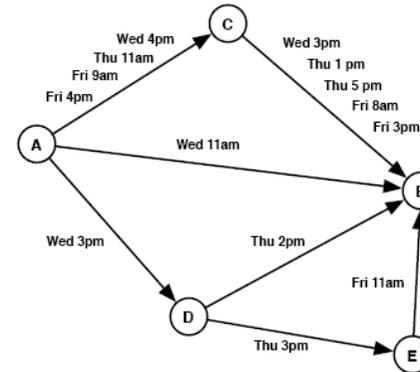
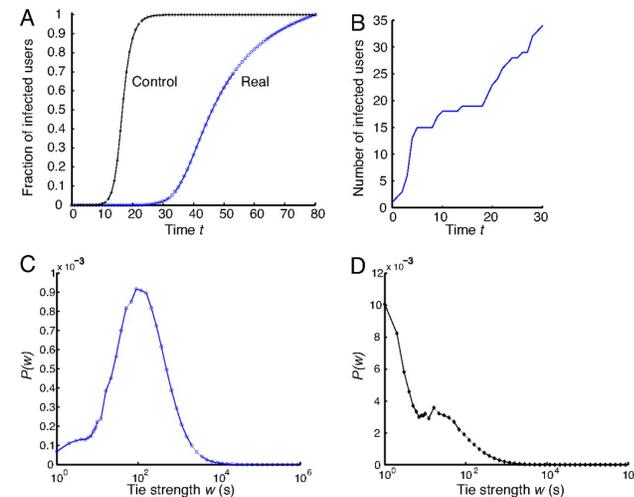


image source: Kossinets et al. “The structure of information pathways in a social communication network”, KDD 2008

## the strength of intermediate ties

- strong ties
  - frequent communication, but ties are redundant due to high clustering
- weak ties
  - reach far across network, but communication is infrequent...
- Onnela J. et.al. PNAS 2007;104:7332-7336
  - use nation-wide cellphone call records and simulate diffusion using actual call timing
    - in simulation, individuals are most likely to obtain novel information through ties of intermediate strength

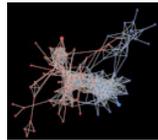
## Localized strong ties slow infection spread.



source: Onnela J. et.al. PNAS 2007;104:7332-7336

## how can information diffusion be different from simple contagion (e.g. a virus)?

- simple contagion:
  - infected individual infects neighbors with information at some rate
- threshold contagion:
  - individuals must hear information (or observe behavior) from a number or fraction of friends before adopting
- in lab: complex contagion (Centola & Macy, AJS, 2007)
  - how do you pick individuals to “infect” such that your opinion prevails
  - try it out in NetLogo:
    - <http://projects.si.umich.edu/netlearn/NetLogo4/DiffusionCompetition.html>



## diffusion of innovation

- surveys:
  - farmers adopting new varieties of hybrid corn by observing what their neighbors were planting (Ryan and Gross, 1943)
  - doctors prescribing new medication (Coleman et al. 1957) (see lab to play with data set)
  - Christakis and Fowler (spread of obesity & happiness in social networks) 2008
- online behavioral data:
  - Lerman (spread of Flickr photos & Digg stories) 2007
  - Backstrom et al. (joining LiveJournal groups & CS conferences) 2006
  - + others e.g. Anagnostopoulos et al. 2008

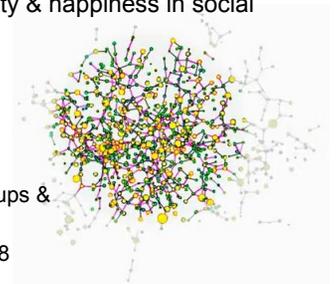
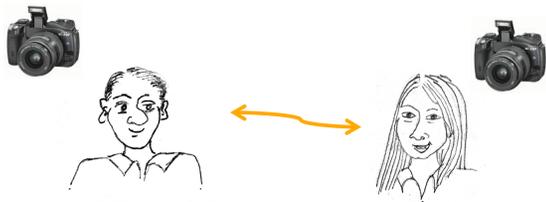


image source: Christakis & Fowler, 'The Spread of Obesity in a Large Social Network over 32 years', NEJM 357(4):370-379, 2007

## Open question: how do we tell influence from correlation?



- approaches:
  - time resolved data: if adoption time is shuffled, does it yield the same patterns?
  - if edges are directed: does reversing the edge direction yield less predictive power?

## Example from reading: adopting new practices

- Davis, corporate governance in the 1980s

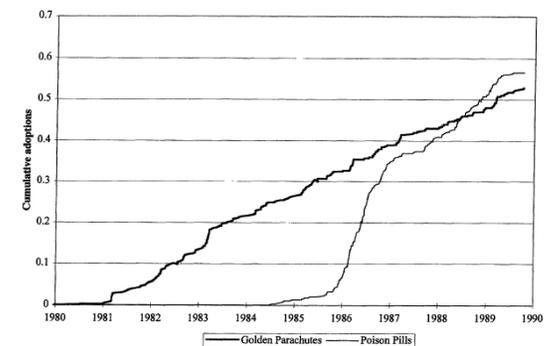


FIG. 1—Diffusion of poison pills and golden parachutes among 1986 Fortune 500 firms, 1980–89.

Source: Corporate Elite Networks and Governance Changes in the 1980s; Gerald F. Davis, Henrich R. AJS Volume 103 Number 1 ( July 1997): 1– 37.

## differences

- poison pills
  - diffused through interlocks
  - geography had little to do with it
  - more likely to be influenced by tie to firm doing something similar & having similar centrality
- golden parachutes
  - did not diffuse through interlocks
  - geography was a significant factor
  - more likely to follow “central” firms
- why did one diffuse through the “network” while the other did not?

## Burt: structural holes and good ideas

- Managers asked to come up with an idea to improve the supply chain
- Then asked:
  - whom did you discuss the idea with?
  - whom do you discuss supply-chain issues with in general
  - do those contacts discuss ideas with one another?
  
- 673 managers (455 (68%) completed the survey)
- ~ 4000 relationships (edges)