CHAPTER 4

Networks in their Surrounding Contexts

Homophily

- **Homophily** –we tend to be similar to our friends
- Friendship through common friend is ***intrinsic*** to network itself
- Friendship through common school is from the ***contextual*** factors outside of the network

- Triadic closure has both intrinsic and contextual effects
  - Intrinsic: when B and C have common friends A, more sources of trust and A can help their friendship
  - Contextual: since A-B and A-C friendships exist, *principle of homophily* suggests that B and C are likely similar to A, so likely similar to each other

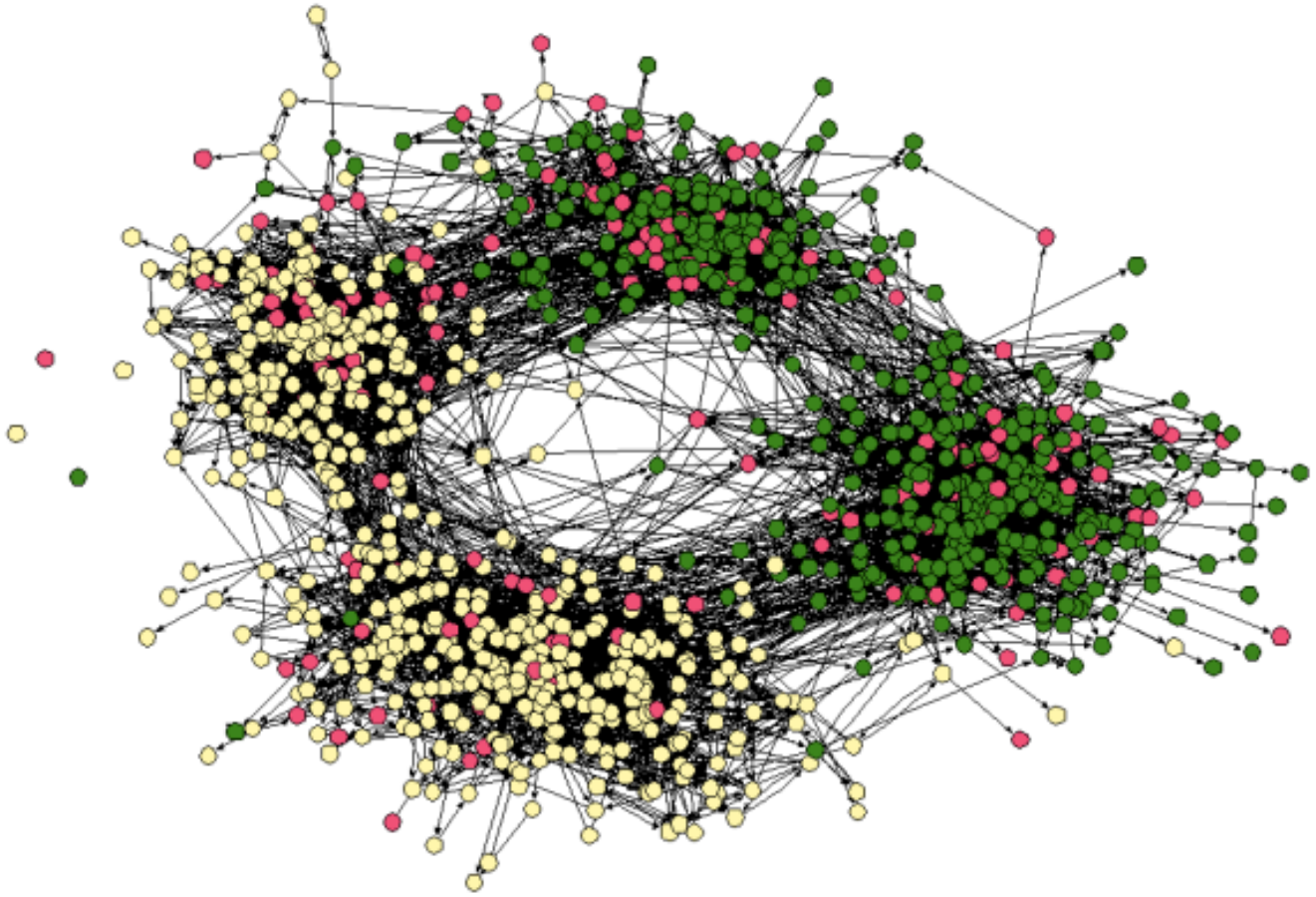
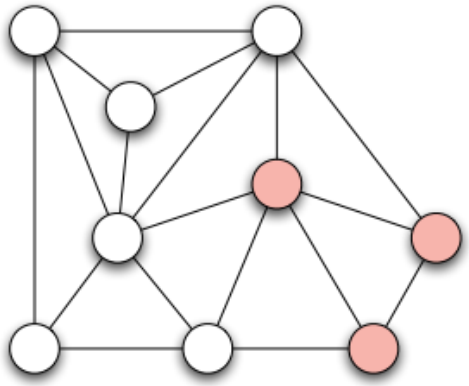


Figure 4.1: Homophily can produce a division of a social network into densely-connected, homogeneous parts that are weakly connected to each other. In this social network from a town's middle school and high school, two such divisions in the network are apparent: one based on race (with students of different races drawn as differently colored circles), and the other based on friendships in the middle and high schools respectively [304].

Measuring Homophily

- Shaded nodes are girls, unshaded nodes are boys
  - p fraction are male, q fraction are female
  - Probability of both ends of edge being male: p^2, female: q^2, male on one end and female on other: 2pq



- **Homophily test: If the fraction of cross-gender edges is significantly less than 2pq, then there is evidence for homophily**
- In this example, 5/18 edges are cross-gender.
- p=6/9=2/3 and q=3/9=1/3, so 2pq=4/9=8/18
- With no homophily, would see 8 cross-gender edges, but our example has 5. Evidence of homophily!

Mechanisms Underlying Homophily: Selection and Social Influence

- **Selection** – the tendency of people to form friendships with others who are like them (in the case of immutable characteristics such as race or ethnicity)
- **Social influence / socialization** – people modify their behaviors to bring them more closely into alignment with the behaviors of their friends
  - The reverse of selection
  - With selection, individual characteristics drive formation of links
  - With social influence, existing links shape people's mutable characteristics

Interplay of Selection and Social Influence

- Longitudinal studies – social connections and behaviors within group are both tracked over time
  - See behavioral changes after changes in an individual's network connections, as opposed to changes to network after an individual changes his or her behavior
  - Have people in network adapted behaviors to become more like friends, or have they sought out people who are already like them?
- Drug use intervention program across a social network
  - If drug use is almost entirely from selection effects, program might not reduce drug use beyond students it directly targets

Affiliation

- **Foci, or "focal points" of social interaction** – social, psychological, legal, or physical entities around which joint activities are organized (workplaces, hangouts, etc.)
- **Affiliation network** – affiliation of people (drawn on left) with foci (drawn on right)
  - Example of *bipartite graphs* (nodes can be divided into 2 sets such that every edge connects a node in 1 set to a node in the other set)
  - In other words, no edges join a pair of nodes that belong to same set; edges only between the 2 sets

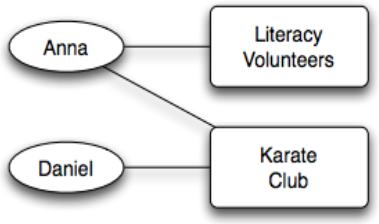


Figure 4.3: An affiliation network is a bipartite graph that shows which individuals are affiliated with which groups or activities. Here, Anna participates in both of the social foci on the right, while Daniel participates in only one.

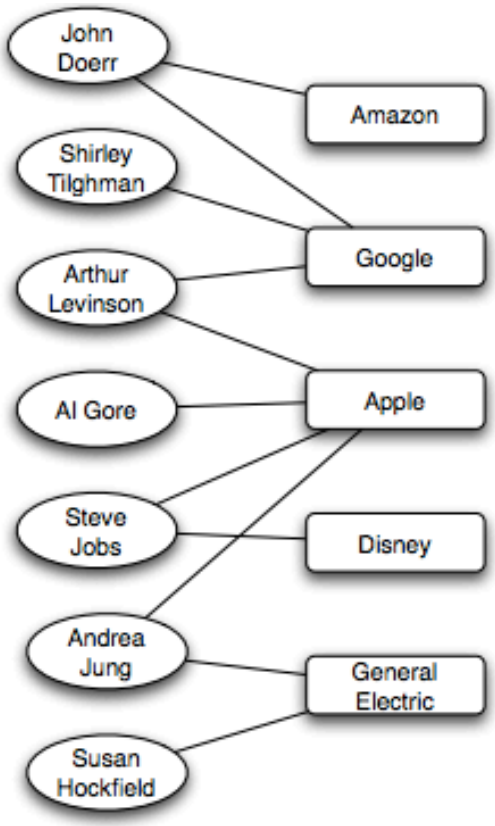


Figure 4.4: One type of affiliation network that has been widely studied is the memberships of people on corporate boards of directors [301]. A very small portion of this network (as of mid-2009) is shown here. The structural pattern of memberships can reveal subtleties in the interactions among both the board members and the companies.

Co-Evolution of Social and Affiliation Networks

- **Co-evolution** – interplay between selection and social influence
  - Both social networks and affiliation networks change over time
    - New friendship links
    - People become associated with new foci

- **Social-affiliation network** – social network on the people and affiliation network on the people and foci

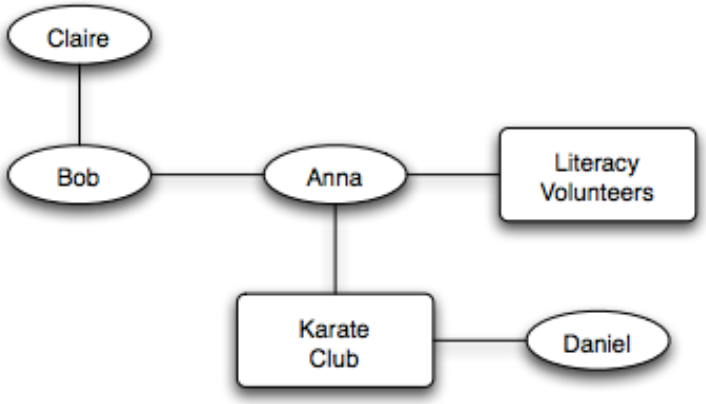
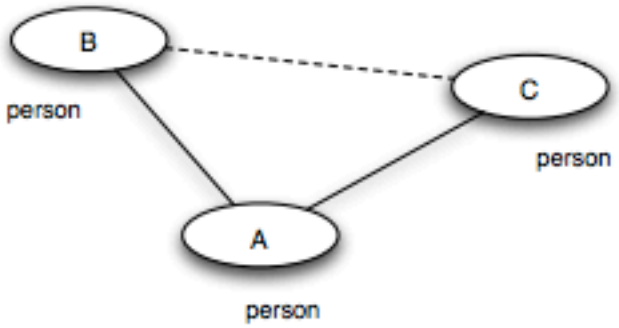


Figure 4.5: A social-affiliation network shows both the friendships between people and their affiliation with different social foci.

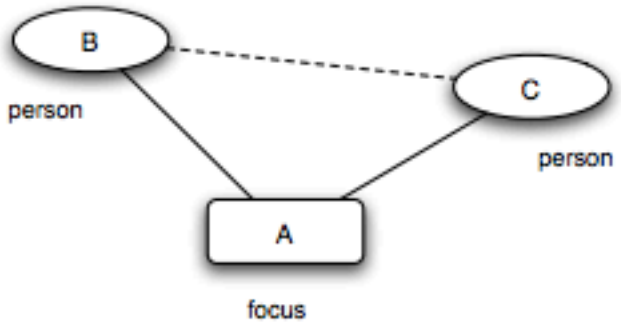
Social-Affiliation Networks

- Range of different mechanisms for link formation can all be viewed as types of *closure processes* (they involve "closing" the 3rd edge of a triangle in the network)

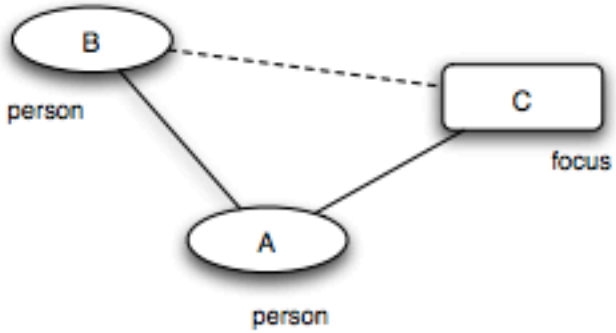
- Suppose B and C have common neighbor A, and then an edge forms between B and C
  - If A, B, and C each represent a person, formation of link is a triadic closure
  - If B and C each represent a person, but A represents a focus, then this is a principle of selection (forming links to others with shared characteristics). Focal closure.
  - If A and B are people, and C is a focus, then this is social influence (B takes part in focus that friend A already involved in). Membership closure.



(a) *Triadic closure*



(b) *Focal closure*



(c) *Membership closure*

Figure 4.6: Each of triadic closure, focal closure, and membership closure corresponds to the closing of a triangle in a social-affiliation network.

Tracking Link Formation in Online Data

- How much more likely is a link to form between 2 people in a social network if they have a friend in common? Multiple (k) friends in common?
- Answer empirically:
  - Snapshots of network at different times
  - For each k, find all pairs of nodes with exactly k friends in common in 1st snapshot, but not directly connected by edge
  - T(k) = fraction of these pairs that formed an edge by 2nd snapshot
  - Plot T(k) as function of k to show effect of common friends

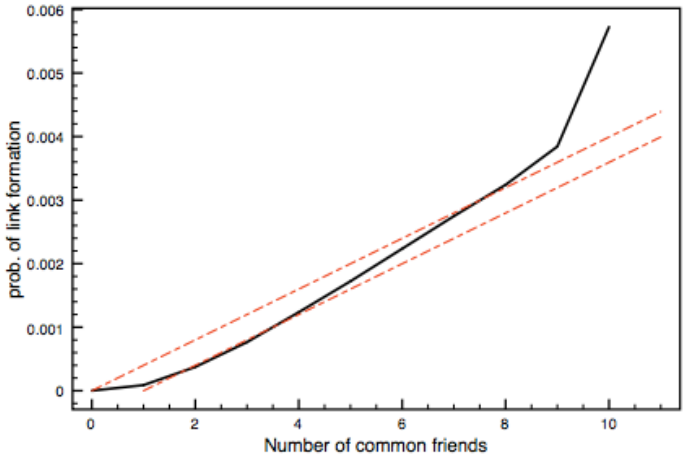


Figure 4.9: Quantifying the effects of triadic closure in an e-mail dataset [259]. The curve determined from the data is shown in the solid black line; the dotted curves show a comparison to probabilities computed according to two simple baseline models in which common friends provide independent probabilities of link formation.

Focal and Membership Closure

- Probability that link forms is $T(k) = 1-(1-p)^k$
  - (1-p) is probability that fails to form, over k trials. 1-probability(fail) = probability(succeed)
  - Compare this to actual plotted curve
- Focal and membership: similarly plotted to triadic closure
  - Focal closure: what is probability that 2 people form link as function of number of foci jointly affiliated with?
  - Membership closure: what is probability that person becomes involved with focus as function of number of friends who are already involved in it?
- **In triadic, focal, and membership closures, probabilities increase as the number k of common neighbors increases**

Quantifying the Interplay Between Selection and Social Influence

- Example: similarity between two editors based on their actions can be the ratio

$$\frac{\text{number of articles edited by } \textit{both } A \text{ and } B}{\text{number of articles edited by } \textit{at least one of } A \text{ or } B}$$

- The plot (on the next slide) shows that similarity increasing before and after first interaction, which shows both selection and social influence
- However, curve not symmetric at time 0. Fastest increase before 0, which particularly shows selection

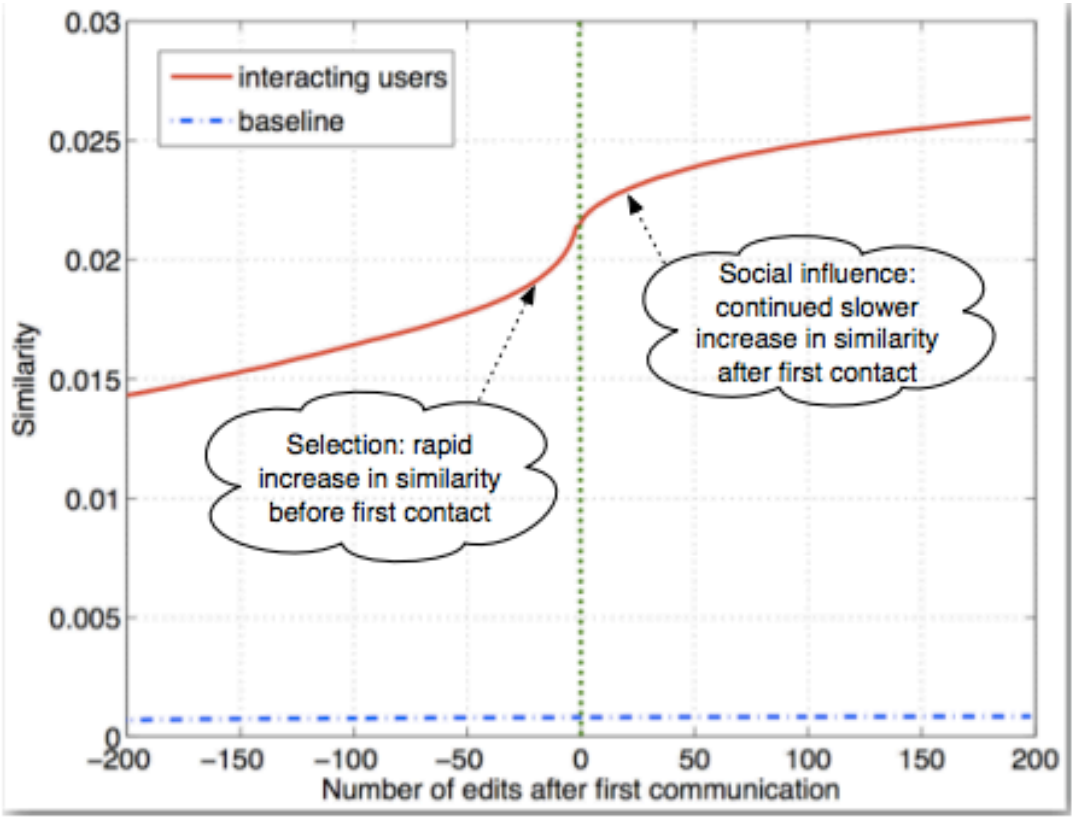


Figure 4.13: The average similarity of two editors on Wikipedia, relative to the time (0) at which they first communicated [122]. Time, on the x-axis, is measured in discrete units, where each unit corresponds to a single Wikipedia action taken by either of the two editors. The curve increases both before and after the first contact at time 0, indicating that both selection and social influence play a role; the increase in similarity is steepest just before time 0.