Networks in Their Surrounding Contexts

Ana Paula Couto
Computer Science Department
Universidade Federal de Minas Gerais

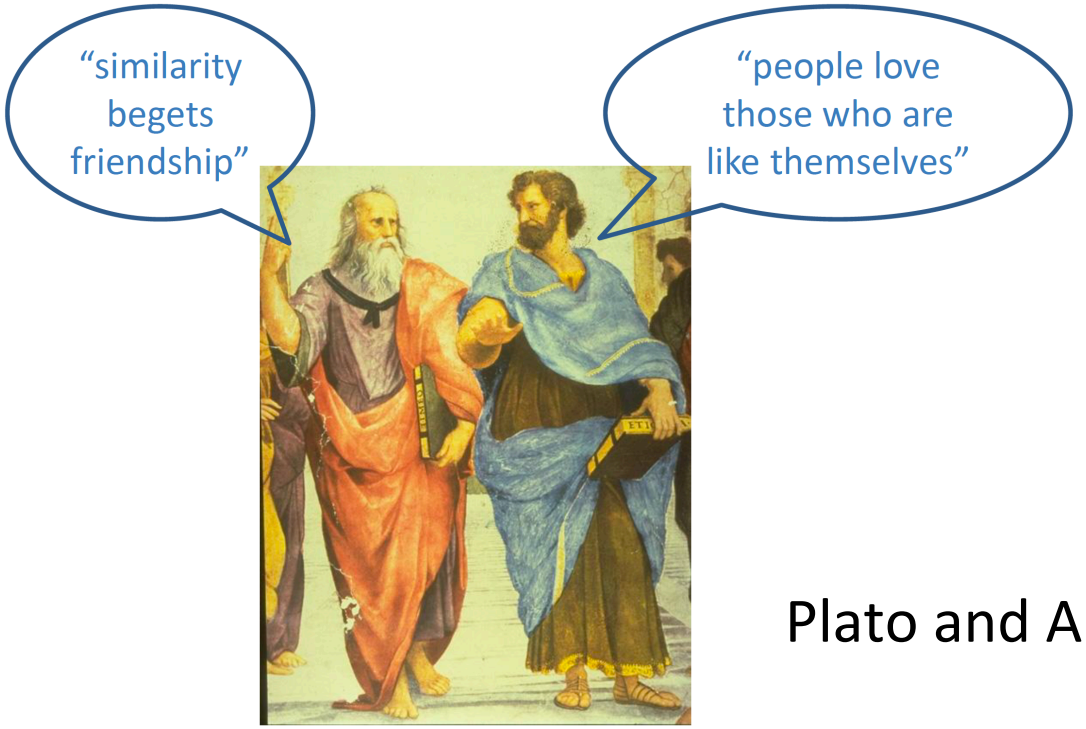
Based on http://www.cs.uoi.gr/~tsap/teaching/2013-cs-l14/references.html
https://www.ismll.uni-hildesheim.de/lehre/cmie-11w/script/lecture6.pdf

Objectives

- Examine additional processes (to triadic closure) that affect the formation of links in the network
- Surrounding context: factors other than node and edges that affect how the network structure evolves
- Represent the contexts together with the network in a common framework

Homophily

- Principle: We tend have similar characteristics with our friends
    - Friends don't look like a random sample of the underlying population



Plato and Aristotle

“birds of a feather flock together”

- People of similar character, background, or taste tend to congregate or associate with one another (like likes like)

Homophily

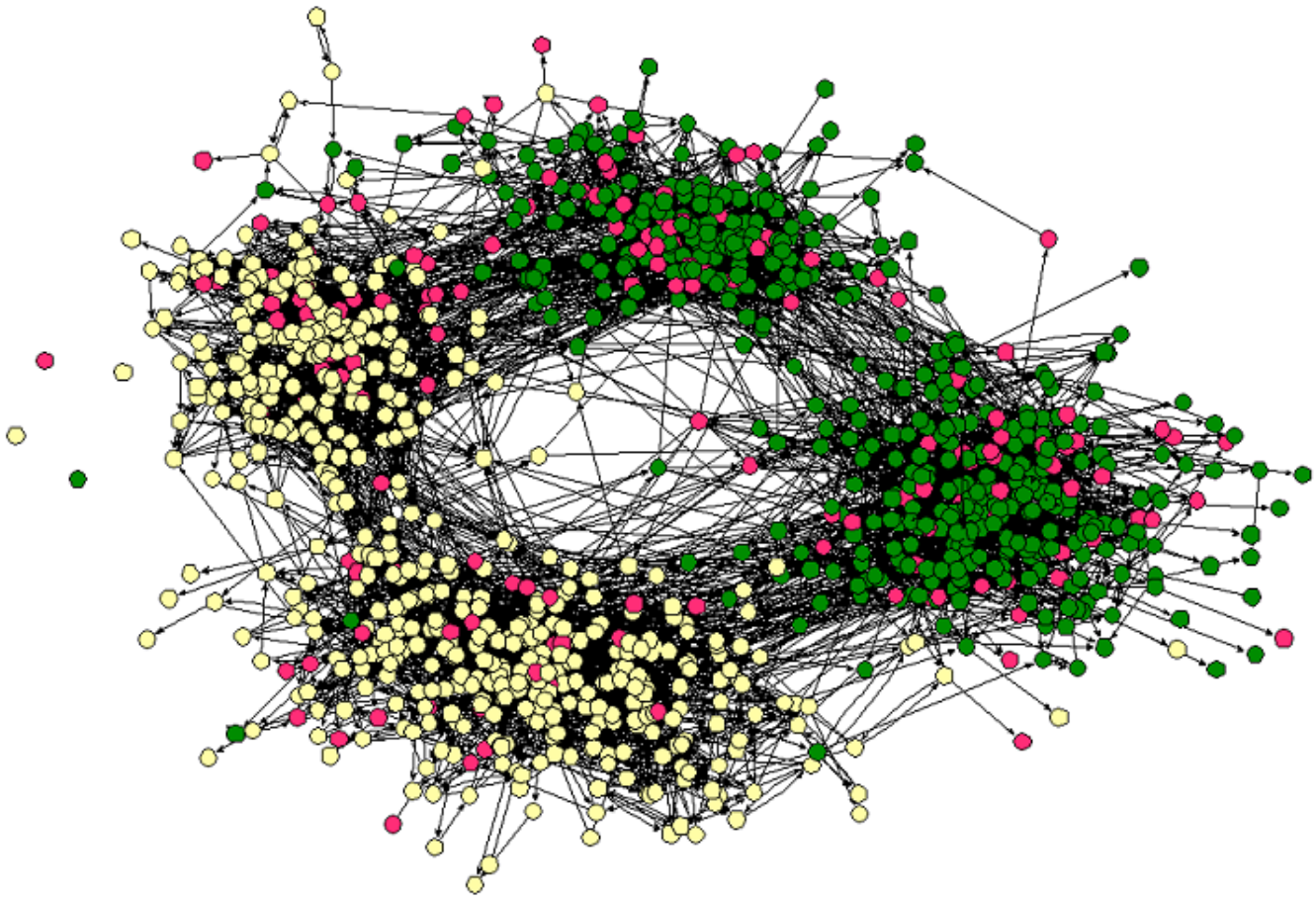
- Links in a social network tend to connect people who are similar to one another
  - basic notions governing the structure of social networks

- Its role in modern sociology by influential work in the 1950s (Lazarsfekd abd Merton)

Homophily vs. Triadic Closure for Link Formation

- With triadic closure:
  - a new link is added for reasons that are intrinsic to the network (need not look beyond the network)
  - Ex: a friendship that forms because two people are introduced through a common friend
- With homophily:
  - a new link is added for reasons that are beyond the network (at the contextual factors)
  - Ex: a friendship that forms because two people attend the same school or work for the same company

Example

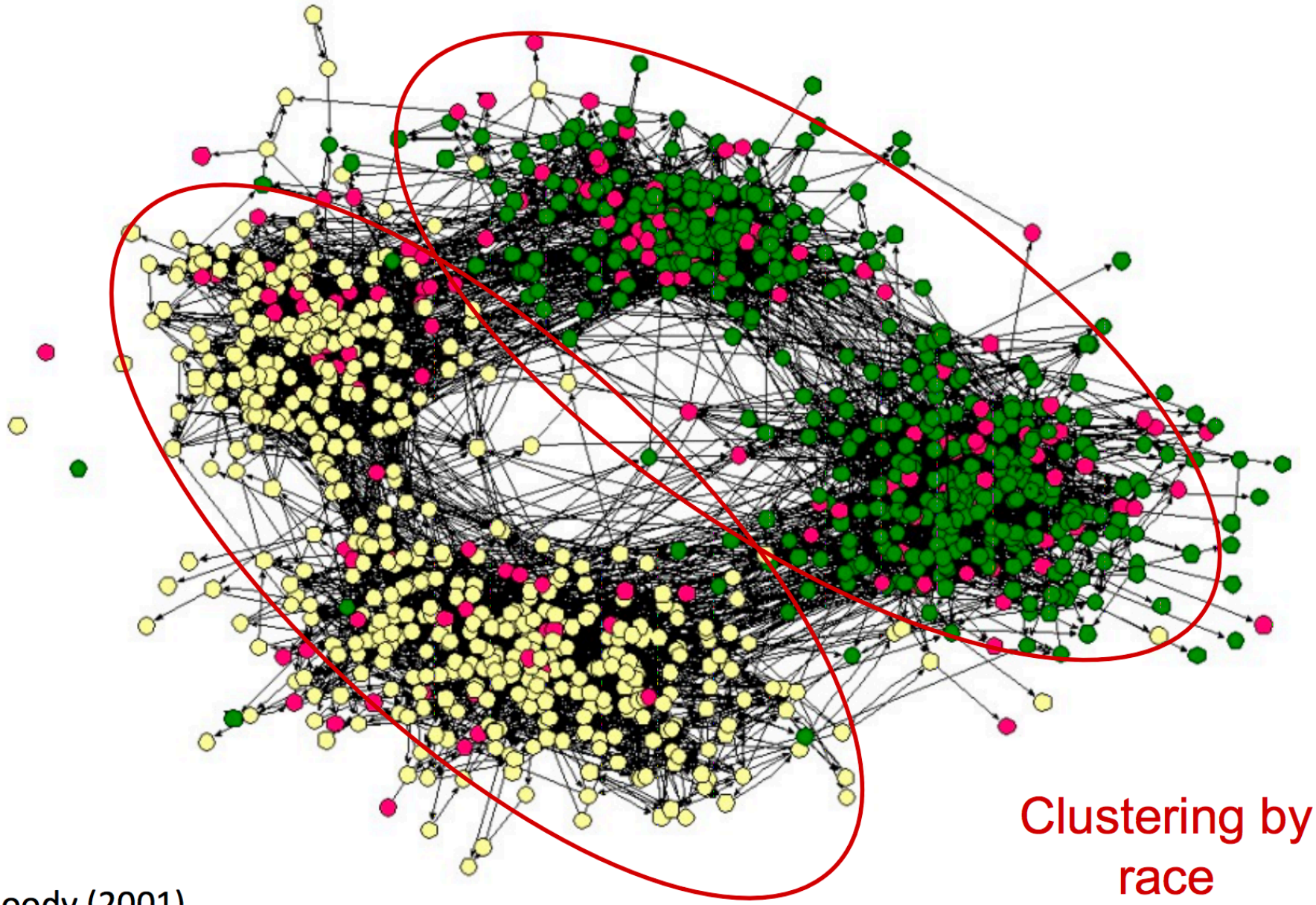


Social network from a town's middle school and high school (students of different races drawn as differently colored circles)

2 divisions:

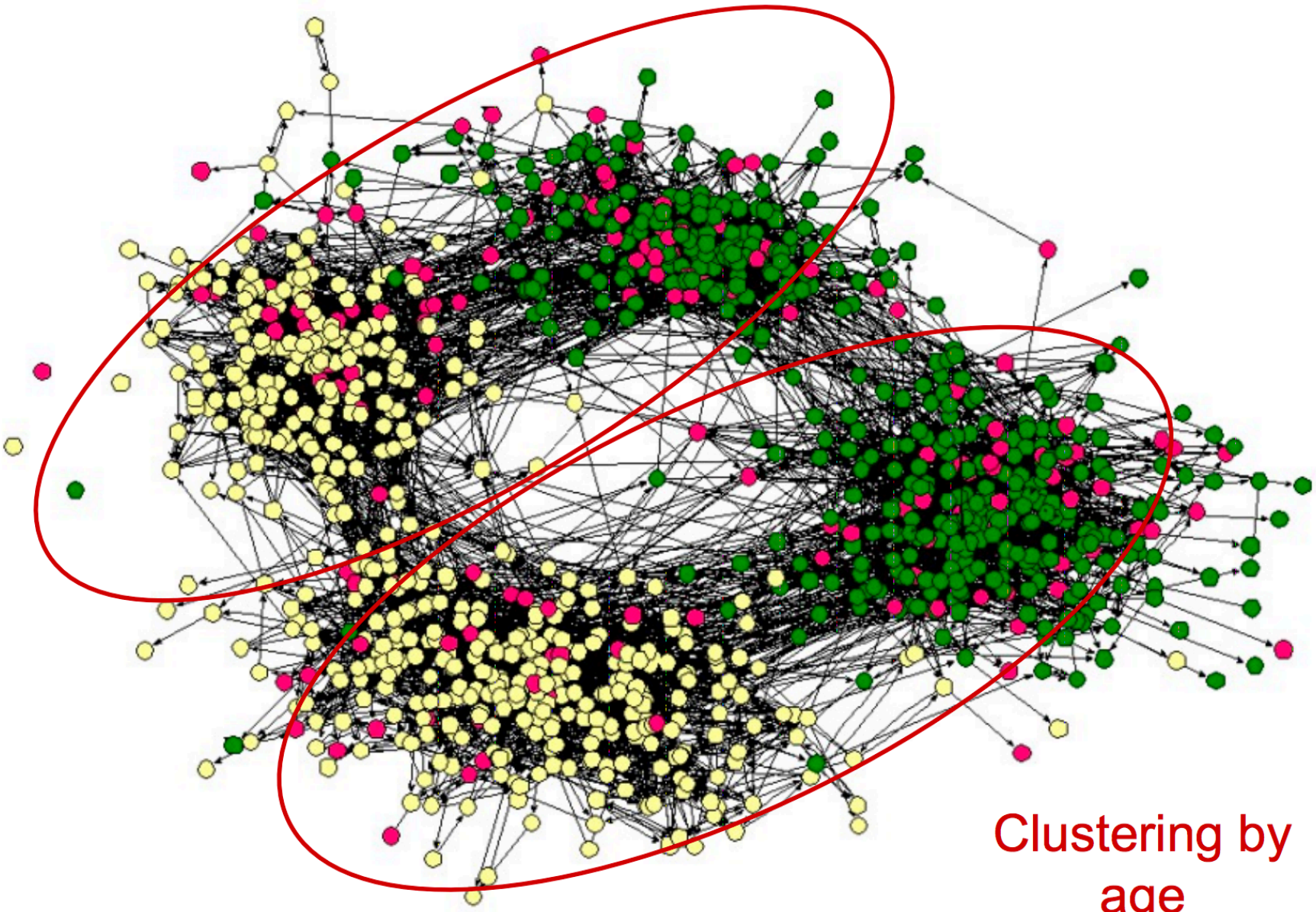
- one based on race and
- the other based on friendships in the middle and high schools

Example



Moody (2001)

Example



Moody (2001)

Homophily vs. Triadic Closure for Link Formation

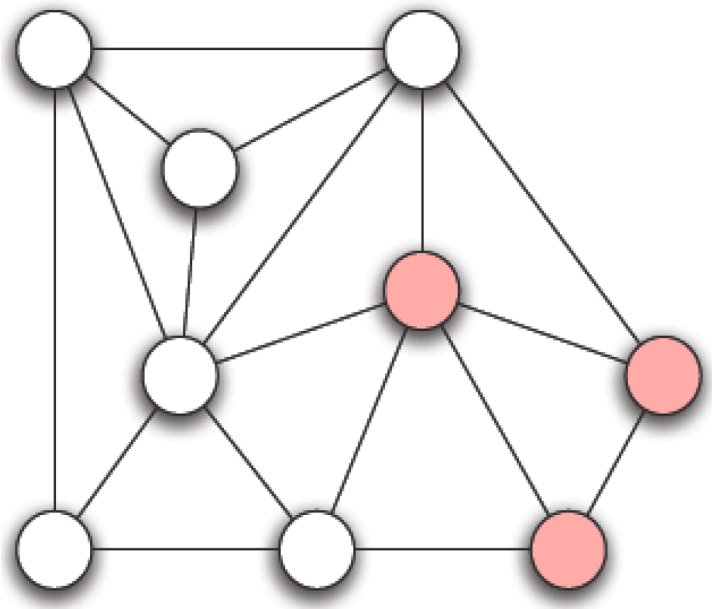
- Strong interactions between intrinsic and contextual effects
- Both operating concurrently

- Triadic closure (intrinsic mechanism):
  - B and C have a common friend A
  - B and C have increased opportunities to meet

- Homophily (contextual mechanism):
  - B and C are each likely to be similar to A in a number of dimensions
  - also possibly similar to each other as well
- Most links arise from a combination of several mechanisms
  - difficult to attribute any individual link to a single mechanism

Measuring Homophily

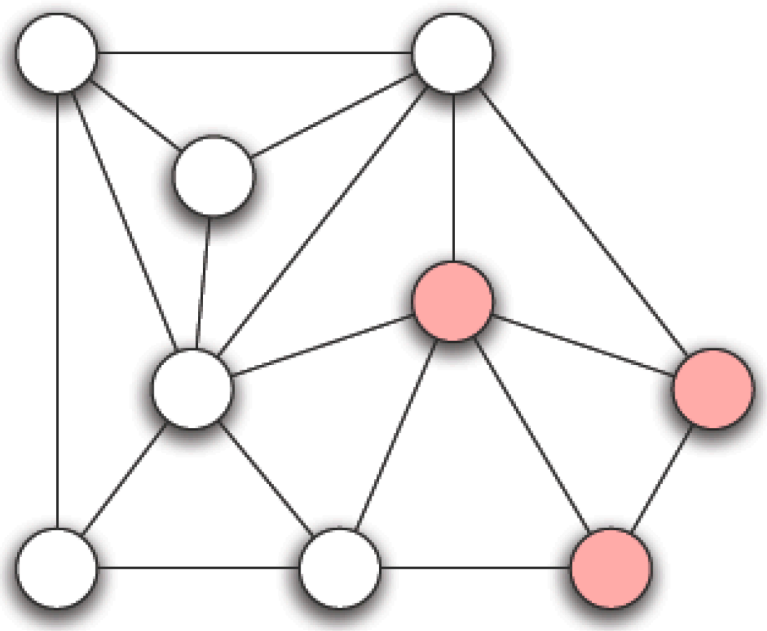
- Given a characteristic (like race, or age), how to test if a network exhibits homophily according to it?
- Ex friendship network:
  - Exhibits homophily by gender?
  - boys tend to be friends with boys, and girls tend to be friends with girls
  - cross-gender edges exist



friendship network of a (hypothetical) classroom: shaded nodes are girls and the six unshaded nodes are boys

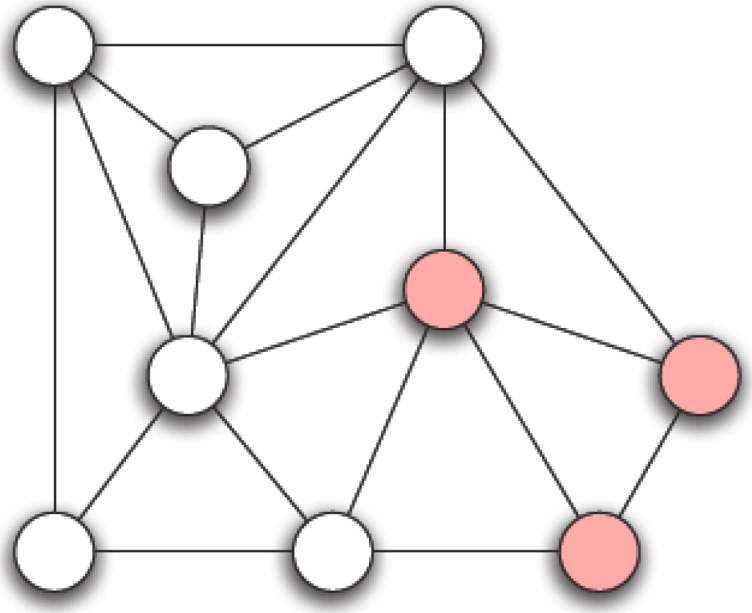
Measuring Homophily

- p the probability (fraction) of males
- q = 1-p the probability (fraction) of females
- For a given edge:
  - Homophily:
    - Prob(both ends male) = p*p
    - Prob(both ends female) = q*q
  - Cross gender:
    - Prob(ends male and female) = 2*p*q
- Homophily Test: If the fraction of cross-gender edges is **significantly** less than 2pq, then there is evidence for homophily



Measuring Homophily

- Ex:
  - p = 6/9 = 2/3
  - q = 1/3
  - 2pq = 4/9 = 8/18
  - 5/18 cross-gender edges
  - Test: 5/18 < 8/18 => some evidence of homophily
- Need definition of "significantly less than"
  - standard statistical significance
- What if cross-gender edges more than 2pq?
  - inverse homophily (Ex: network of romantic relationships)
- How to extend to characteristics with more than 2 states?



Mechanisms Underlying Homophily

- Homophily has 2 mechanisms for link creation
  - Selection: select friends with similar characteristics
    - individual characteristics drive the formation of links
    - involves immutable characteristics (determined at birth)
  - Social influence: modify behavior close to behaviors of friends
    - the reverse of selection
    - involves mutable characteristics (behaviors, activities, interests, beliefs, and opinions)

Mechanisms Underlying Homophily

- Q: When homophily is observed, is it a result of selection or social influence?
  - Have people adapted their behaviors to become more like their friends, or have they selected friends who were already like them?
- A: Track the network and monitor the results of the two mechanisms (more details later)

Mechanisms Underlying Homophily

- Most of the times, both mechanisms apply and interact with each other
- Studies show that teenage friends are similar to each other in their behaviors, and both selection and social influence apply:
  - teenagers seek social circles of people like them and peer pressure causes conform to behavioral patterns within these circles
- Q: how the two mechanisms interact and whether one is more strongly at work than the other? (more details later)

Longitudinal Studies

Difficult to tell if selection or social influence at play with a single snapshot of a network

Longitudinal studies tracking social connections and individual behaviors over time can help researchers uncover effect of social influence

Does behavior change after changes to the network, or does the network change after changes in behavior?

Social Influence of Obesity

- Christakis and Fowler tracked obesity status and social network of 12,000 people over 32 years
- Found homophily based on obesity status
- They wanted to know why

Christakis & Fowler (2007)
http://www.ted.com/talks/nicholas_christakis_the_hidden_influence_of_social_networks.html

Why Obesity Homophily?

1. Selection effects – people choose to befriend others of similar obesity status?
2. Confounding effects of homophily – other factors that correlate with obesity status?
3. Social influence – if friends changed their obesity status, did it influence person's future obesity status?

- Discovered significant evidence for hypothesis 3: Obesity is a type of "contagion" that can spread through social influence!