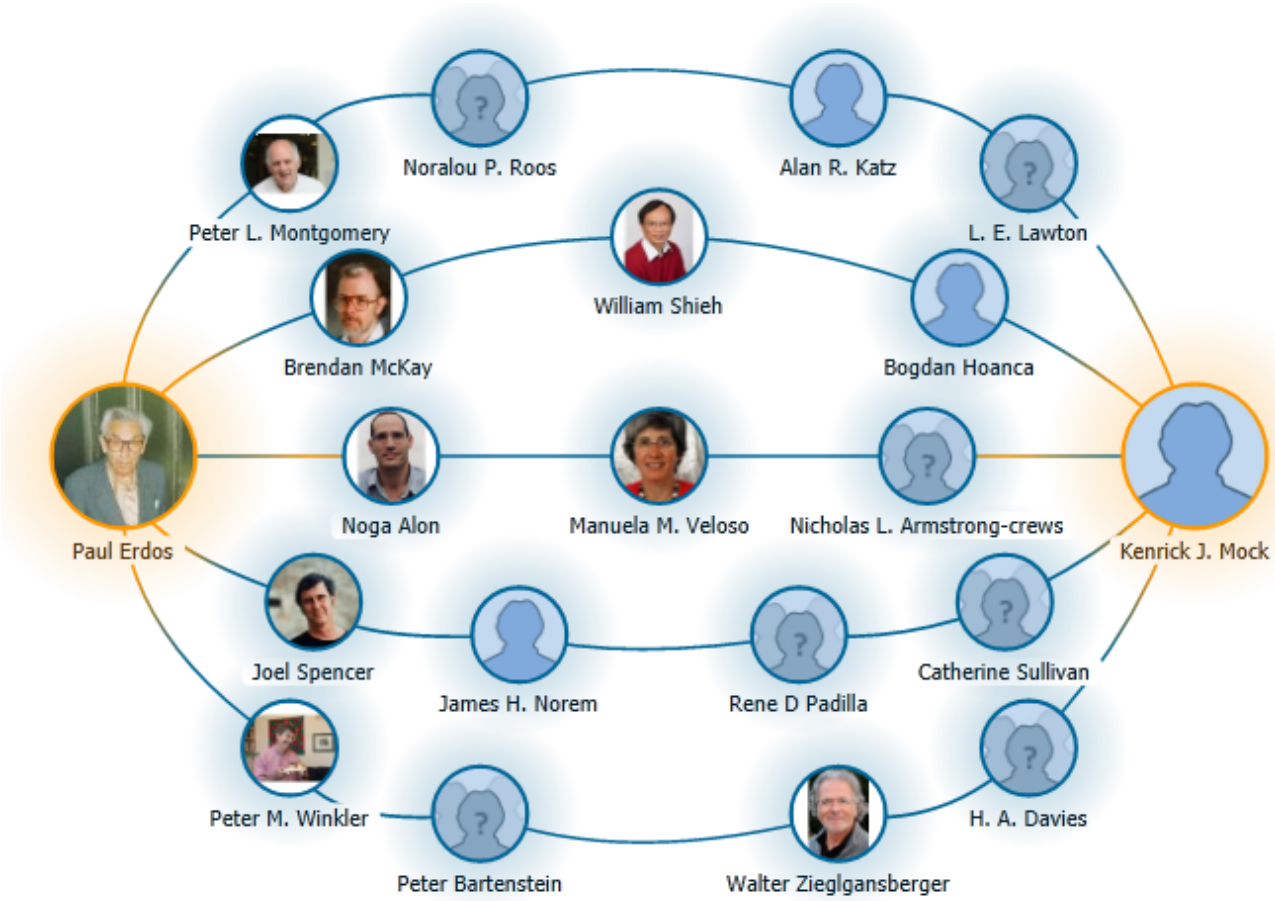
Social Networks

Collaboration Networks

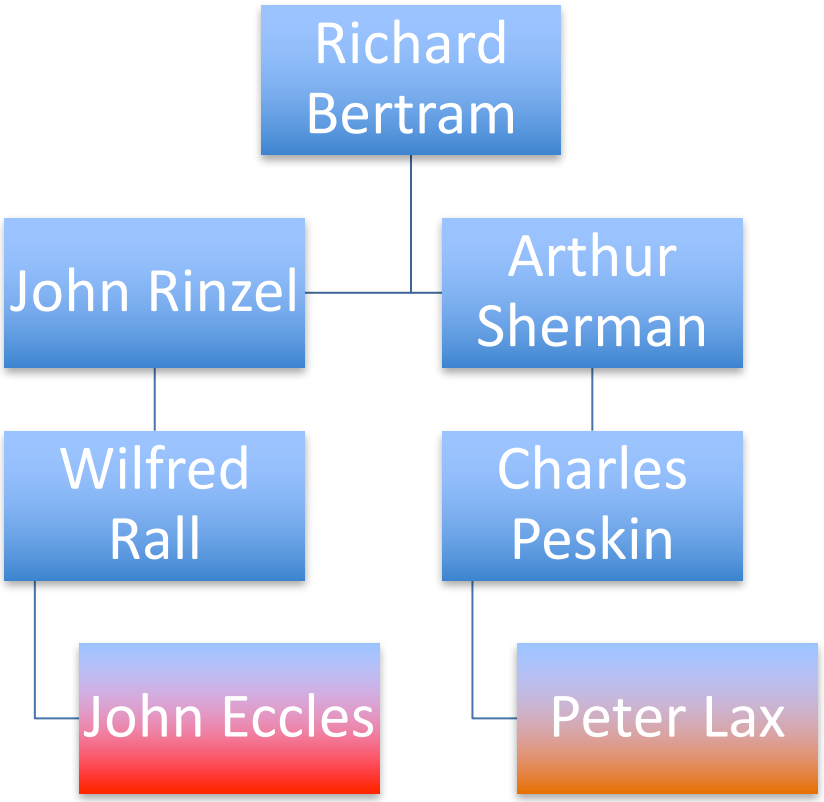
Paul Erdős was a Hungarian mathematician and one of the most prolific of the 20th century. He had more than 500 collaborators!



Erdős number = 1

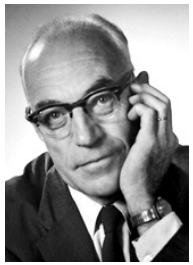
Erdős number = 4

Collaboration Networks



Nobel Prize (1963)

Abel Prize (2005)





Brief History of the Study of Social Networks

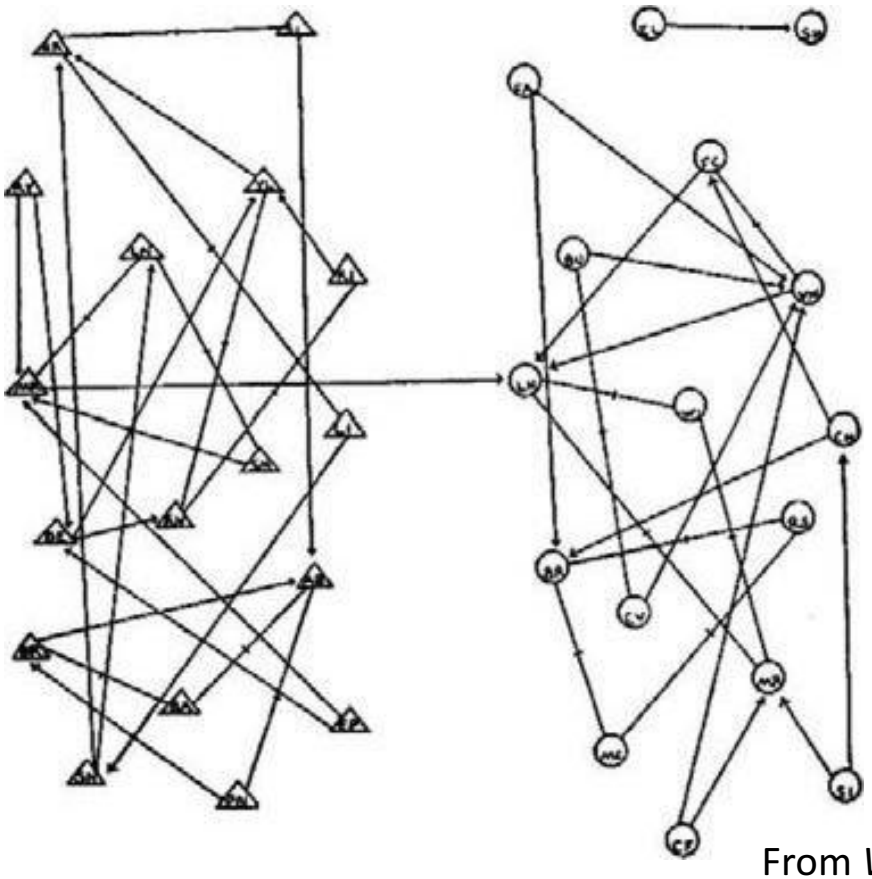


Jacob Moreno (1889-1974)

Romanian immigrant to the U.S. who studied group interactions. Published *Who Shall Survive?* in 1934, which was the first example published example of social network analysis.

He started the field of *sociometry*, now called social network analysis, which uses abstract networks and properties of these networks to study social interactions. He called the networks *sociograms*.

Brief History of the Study of Social Networks



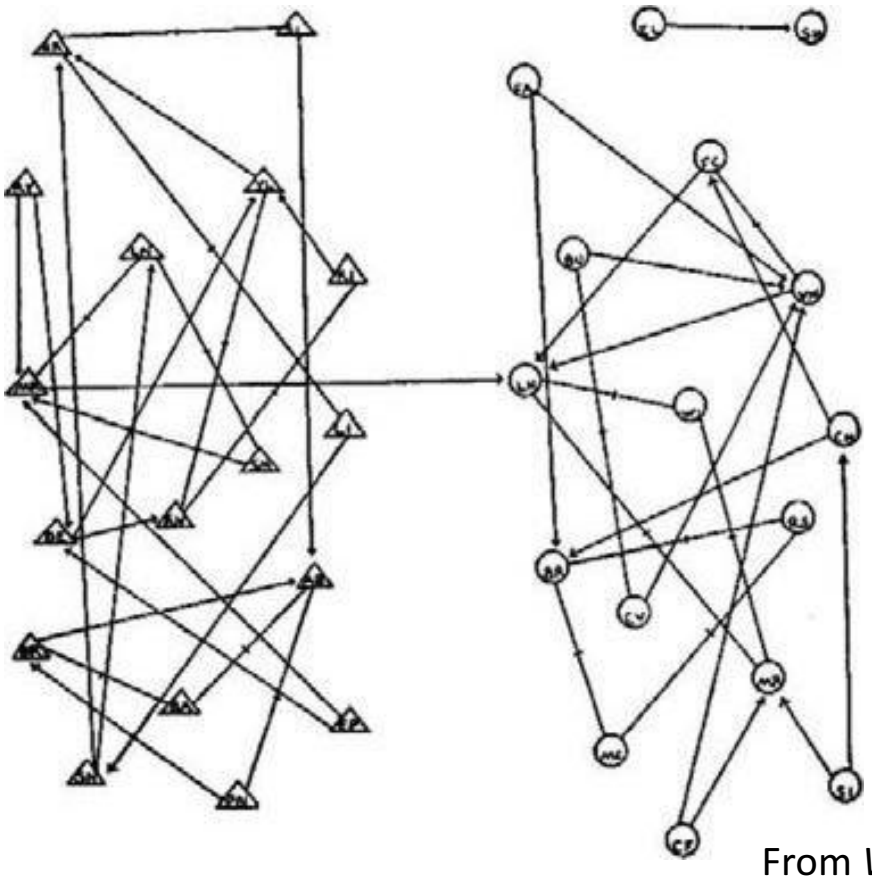
From *Who Shall Survive?*

Friendship network between a class of school children. Triangles=boys, Circles=girls.

Does this network diagram, or sociogram, lead to any insights?

Boys and Girls Live in Different Worlds

One component:
Can get from one
Vertex to any other



Another component

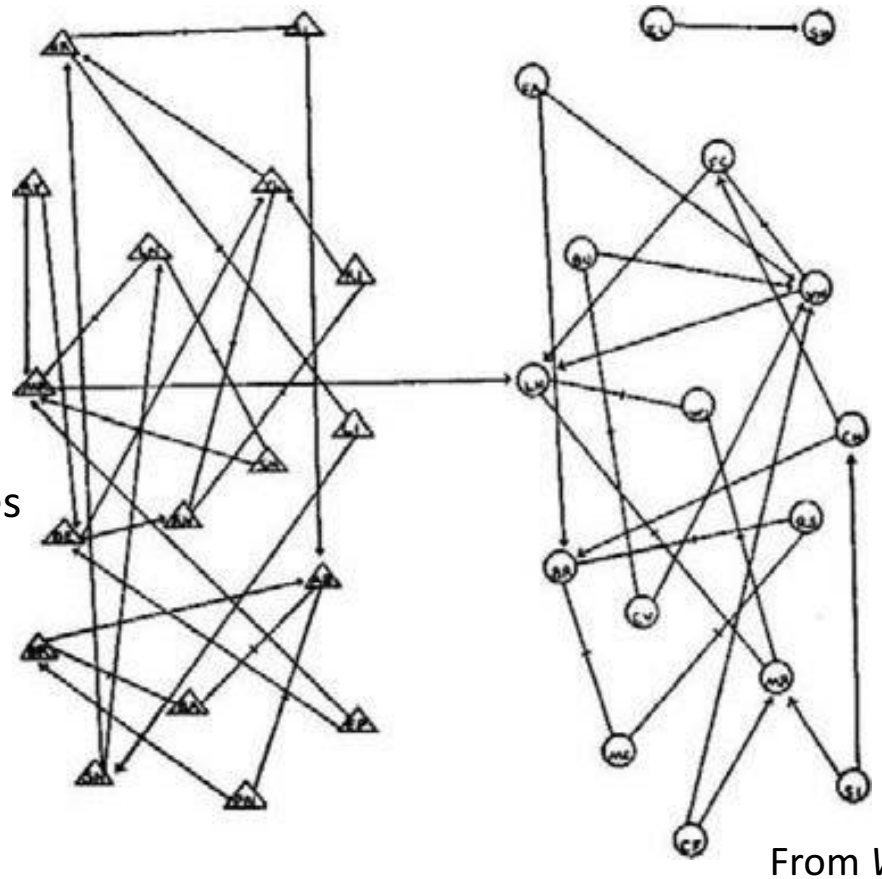
From *Who Shall Survive?*

Friendship network between a class of school children. Triangles=boys, Circles=girls.

Boys and Girls Live in Different Worlds

A 1-core

A 2-core:
Each vertex
connected to
at least 2 vertices
in the subset

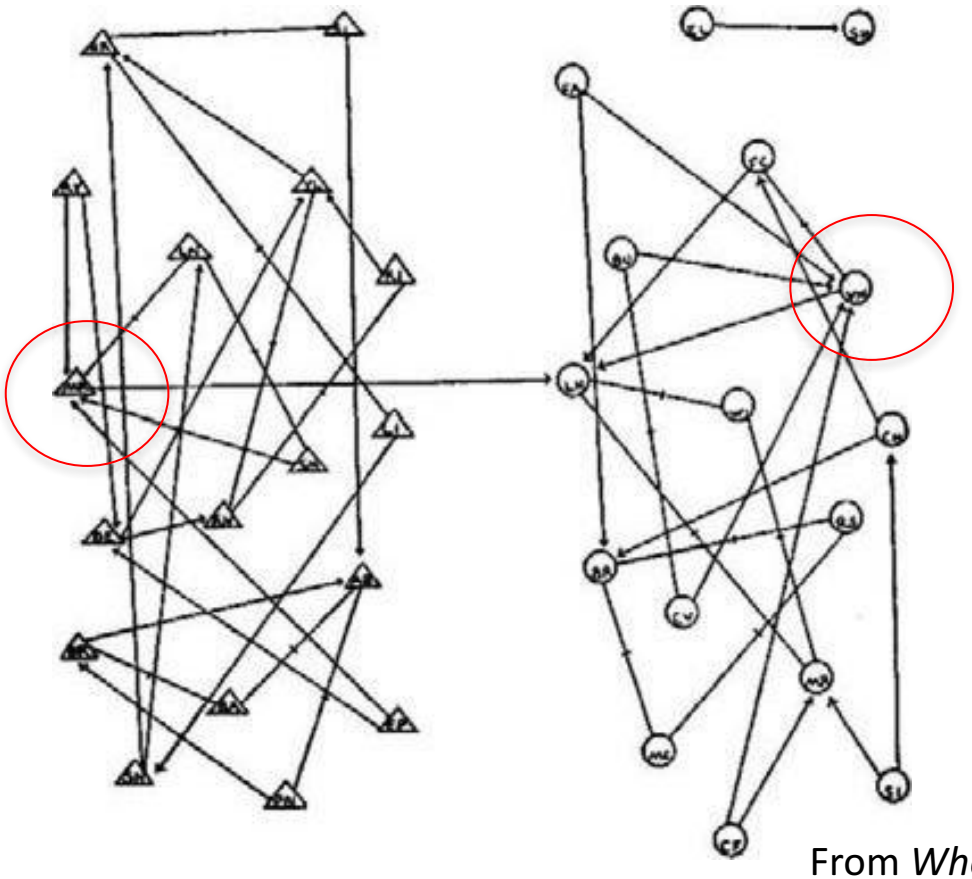


Another 2-core

From *Who Shall Survive?*

Friendship network between a class of school children. Triangles=boys, Circles=girls.

Some Kids Are Hubs

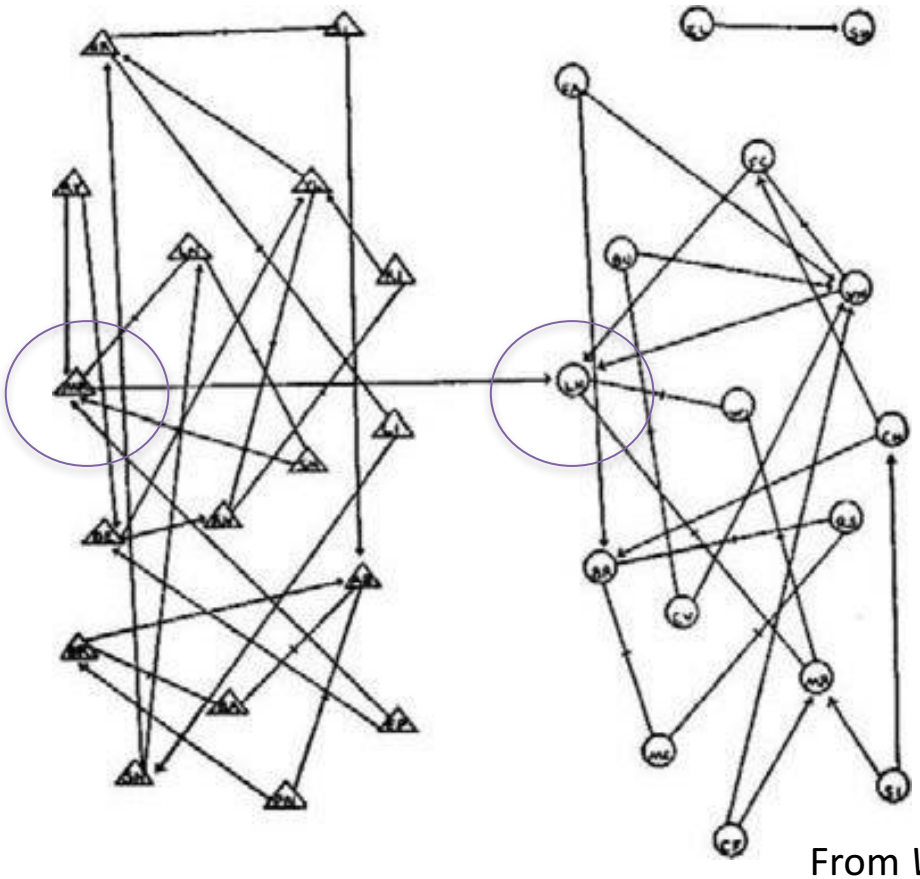


From *Who Shall Survive?*

Friendship network between a class of school children. Triangles=boys, Circles=girls.

Popular kids have high **degree centrality**

Some Kids Connect the Two Subpopulations

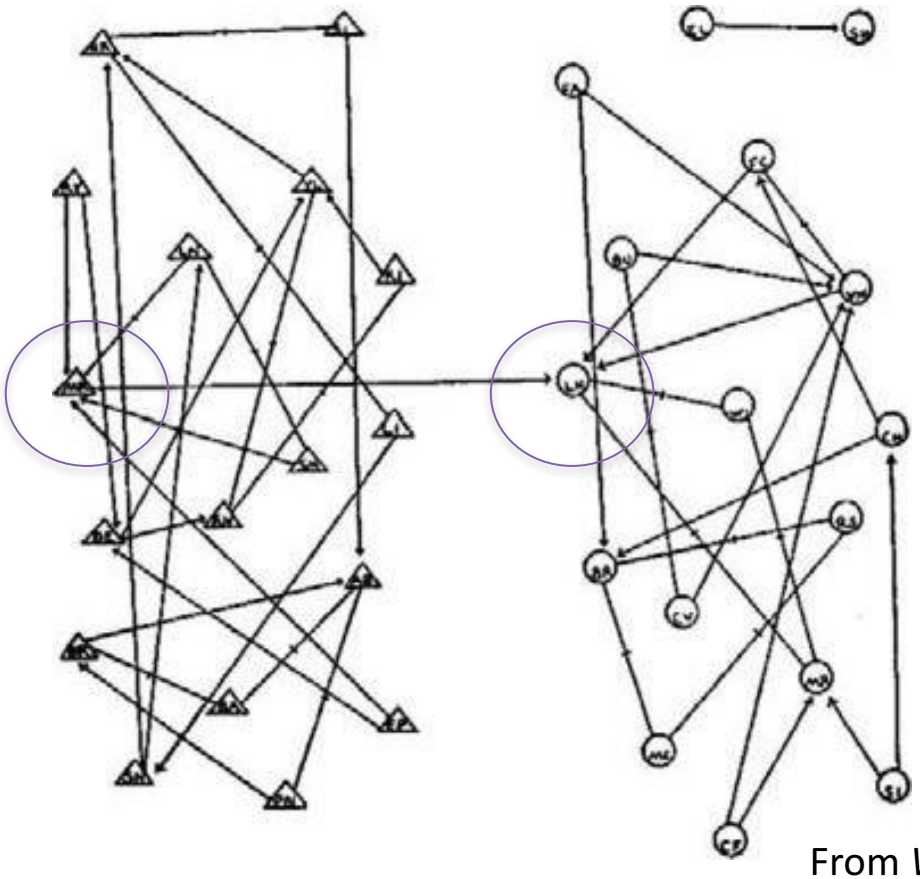


From *Who Shall Survive?*

Friendship network between a class of school children. Triangles=boys, Circles=girls.

These kids have high **betweenness centrality**

Shortest Paths Between Kids Varies, But is Usually Short

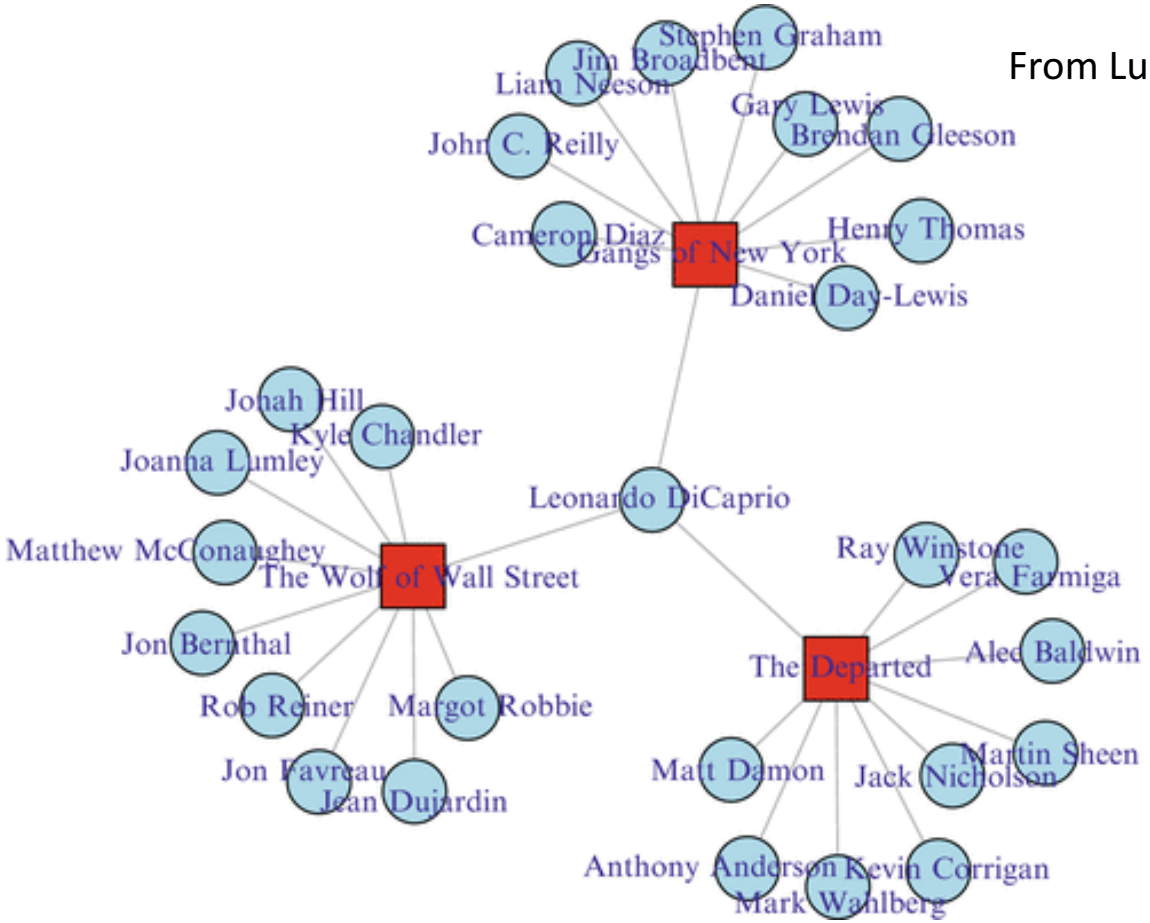


From *Who Shall Survive?*

Friendship network between a class of school children. Triangles=boys, Circles=girls.

This is an example of a small-world network

Affiliation Networks



From Luke (2015)

Example of a *bipartite network* in which there are two types of vertices: The "actors" connect to the "groups", but there are no actor-actor or group-group connections

How Does One Acquire the Information for a Social Network?

Interview people

"Who are your friends?" a *free choice* study

"Who are your friends at FSU?" restricted to geographic location

"Who are your 10 closest friends?" a *fixed choice* study

A study like this produces a directed network. Some directed edges between vertices may be bidirectional.

Limitations: time consuming
what does "friend" mean?
based on an individual's recall

How many acquaintances does an average person in U.S. have? 2000

How Does One Acquire the Information for a Social Network?

Direct Observation



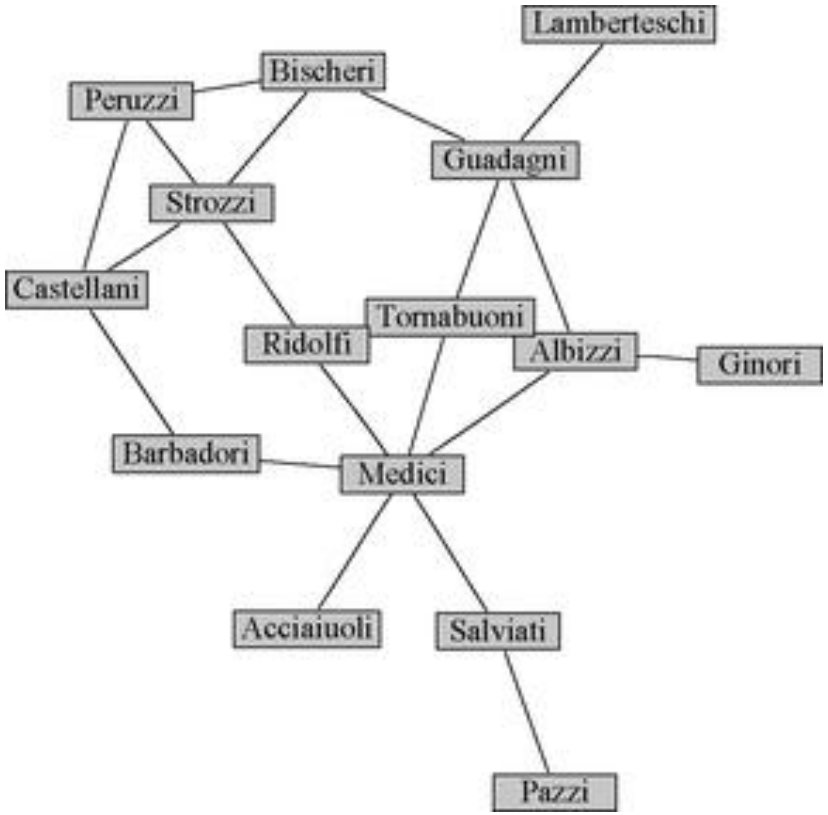
Dian Fossey studied gorilla social networks in Rwanda from 1966 until her death (probably murder) in 1985

Jane Goodall has studied chimpanzee social networks for 55 years in Tanzania. Started as a secretary for Louis Leakey



How Does One Acquire the Information for a Social Network?

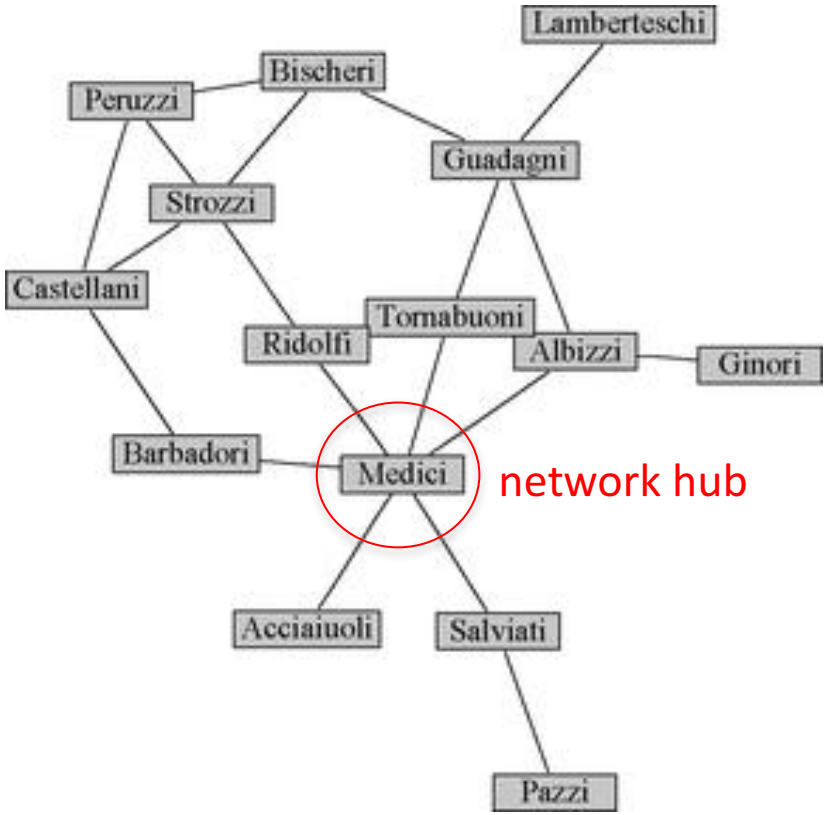
Archival Records



Intermarriage network of ruling families of Florence in 15th century

How Does One Acquire the Information for a Social Network?

Archival Records



Intermarriage network of ruling families of Florence in 15th century

Getting Network Information From Hidden Populations

The Direct Approach

Telephone interview: “How often do you use illegal drugs?”

Question proposed for 2020 census: “Are you a U.S. citizen or legal immigrant?”

A More Effective Approach

Snowball sampling: gain trust of one person in target population,
Then invite them to give names of contacts.
Next interview each of these, getting more contacts.
Repeat until exhausted. Each iteration is called a sampling wave.
The number of contacts grows exponentially with number of waves.

Getting Network Information From Hidden Populations

An Even Better Approach

Random-walk sampling: Like snowball sampling, but at each step randomly choose one new contact to interview, rather than all new contacts.

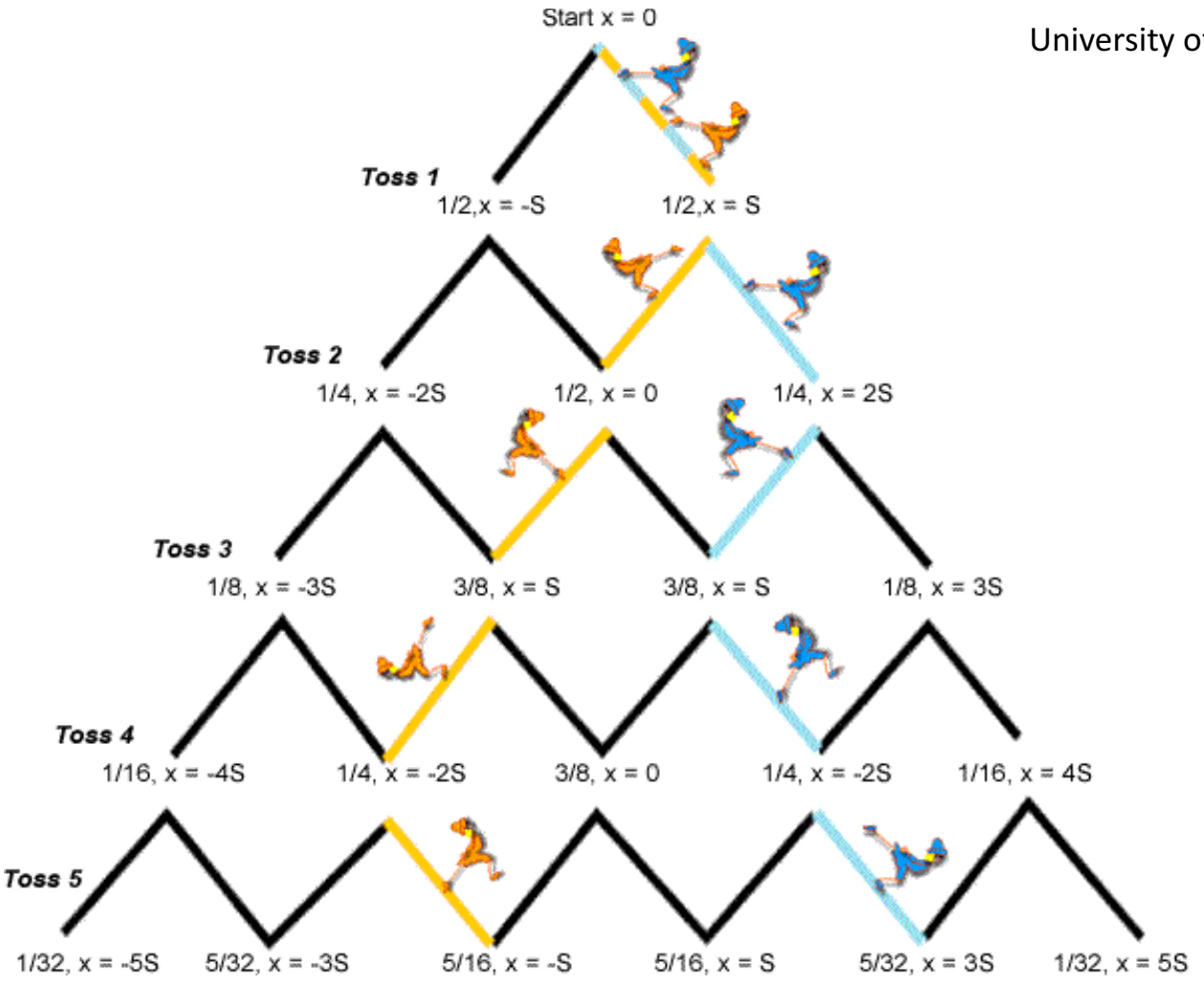
At equilibrium, the probability of being interviewed is proportional to the degree (number of edges) of the contact.

The higher the degree, the more likely that the contact is a hidden population.

Advantage of random-walk sampling: The sample size grows linearly with sampling waves, making convergence to equilibrium statistics much more rapid than for snowball sampling.

Random Walk?

University of Queensland



Random walk on a grid. Probabilities of being at each location given unbiased selection are given at each vertex.

Where Does Six Degrees of Separation Come From?



Social psychologist Stanley Milgram conducted a series of "small-world experiments" in the 1960s.

Randomly mail 96 packages, or "passports" to recipients in Omaha, Nebraska.

Ask each recipient to get the passport to a friend of Milgram's who lived in Boston. Provide name, location , and occupation.

But don't send it directly to him. Can only send the passport to a friend who you think has the best chance of getting it to the target.

The recipient provides his/her own name/location, and must then follow the same directions.

Only someone who knows the target can send the passport directly to the target.

Where Does Six Degrees of Separation Come From?

The path length from starting point to end point is equal to the number of names in the passport once it arrives to the target.

A total of 18 passports arrived to the target. What was the average path length? 5.9

Joe Schmo, Tuscan
Linda Light, New Orleans
Wendy Wing, Boston
Lou Blue, New York
Ray Day, Boston

Similar, and with greater sample size, experiments have been performed since then. All give values close to 6. Thus, average 6 degrees of separation from 2 randomly chosen individuals in the world.

Almost certainly less if restricted to one location like Tallahassee.
We live in a small (social) world.

Stanley Milgram is Most Famous for His Obedience Experiments at Harvard?

From an article in American Psychologist (1990):

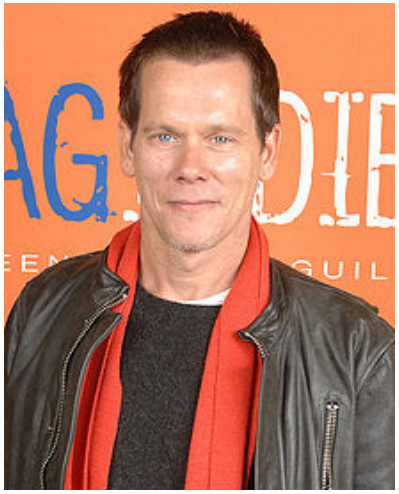
> In Milgram's basic paradigm, a subject walks into a laboratory believing that s/he is about to take part in a study of memory and learning. After being assigned the role of a teacher, the subject is asked to teach word associations to a fellow subject (who in reality is a collaborator of the experimenter). The teaching method, however, is unconventional—administering increasingly higher electric shocks to the learner. Once the presumed shock level reaches a certain point, the subject is thrown into a conflict. On the one hand, the strapped learner demands to be set free, he appears to suffer pain, and going all the way may pose a risk to his health. On the other hand, the experimenter, if asked, insists that the experiment is not as unhealthy as it appears to be, and that the teacher must go on. In sharp contrast to the expectations of professionals and laymen alike, some 65% of all subjects continue to administer shocks up to the very highest levels.

Kevin Bacon



Footloose (1984)

Mystic River (2003)



The River Wild (1994)



Apollo 13 (1995)

Flatliners (1990)

Patriots Day (2016)

Six Degrees of Kevin Bacon

Bacon in 1994 interview: “I have worked with everyone in Hollywood or someone who has worked with them”

Six Degrees of Kevin Bacon

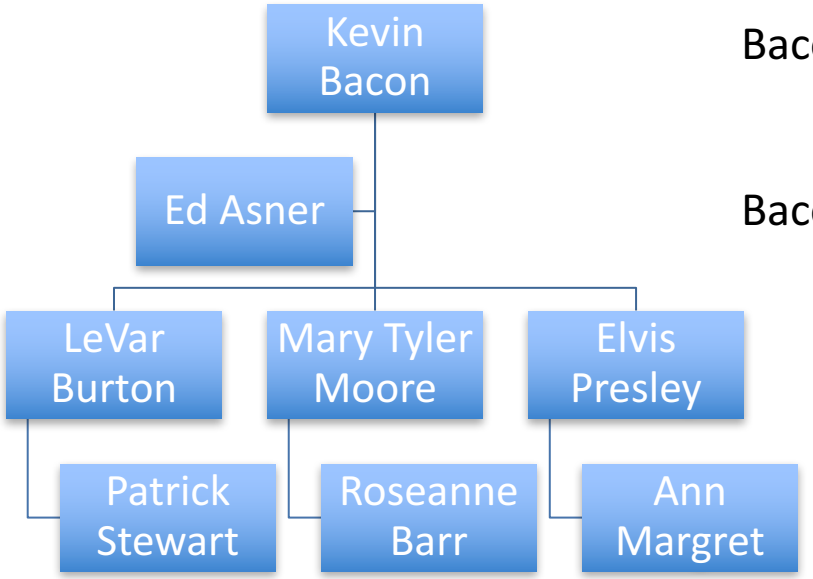
Bacon in 1994 interview: “I have worked with everyone in Hollywood or someone who has worked with them”

Motivated four college students at Albright College to create a network of those who have been in movies with Bacon, or those who have been in movies with them

Six Degrees of Kevin Bacon

Bacon in 1994 interview: “I have worked with everyone in Hollywood or someone who has worked with them”

Motivated four college students at Albright College to create a network of those who have been in movies with Bacon, or those who have been in movies with them



Hypothesis: All current major actors in Hollywood have Bacon number 6 or lower

What About Facebook and Other Social Media?

Lots of data, but few studies. Reason is that these data are proprietary.

But it is certain that the companies themselves employ people to analyze their social network data.

The End