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!
Collaboration Networks

Richard Bertram

John Rinzel

Wilfred Rall

John Eccles

Nobel Prize (1963)

Arthur Sherman

Charles Peskin

Peter Lax

Abel Prize (2005)
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.*

Jacob Moreno (1889-1974)
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

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

From Who Shall Survive?
Boys and Girls Live in Different Worlds

From Who Shall Survive?

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

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

A 1-core

Another 2-core
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

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

These kids have high betweenness centrality

From *Who Shall Survive?*
Shortest Paths Between Kids Varies, But is Usually Short

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

This is an example of a small-world network
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

“How are your friends?” a free choice study

“How are your friends at FSU?” restricted to geographic location

“How 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
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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 on a grid. Probabilities of being at each location given unbiased selection are given at each vertex.
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**

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

The River Wild (1994)

Mystic River (2003)

Footloose (1984)

Flatliners (1990)

Apollo 13 (1995)

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

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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