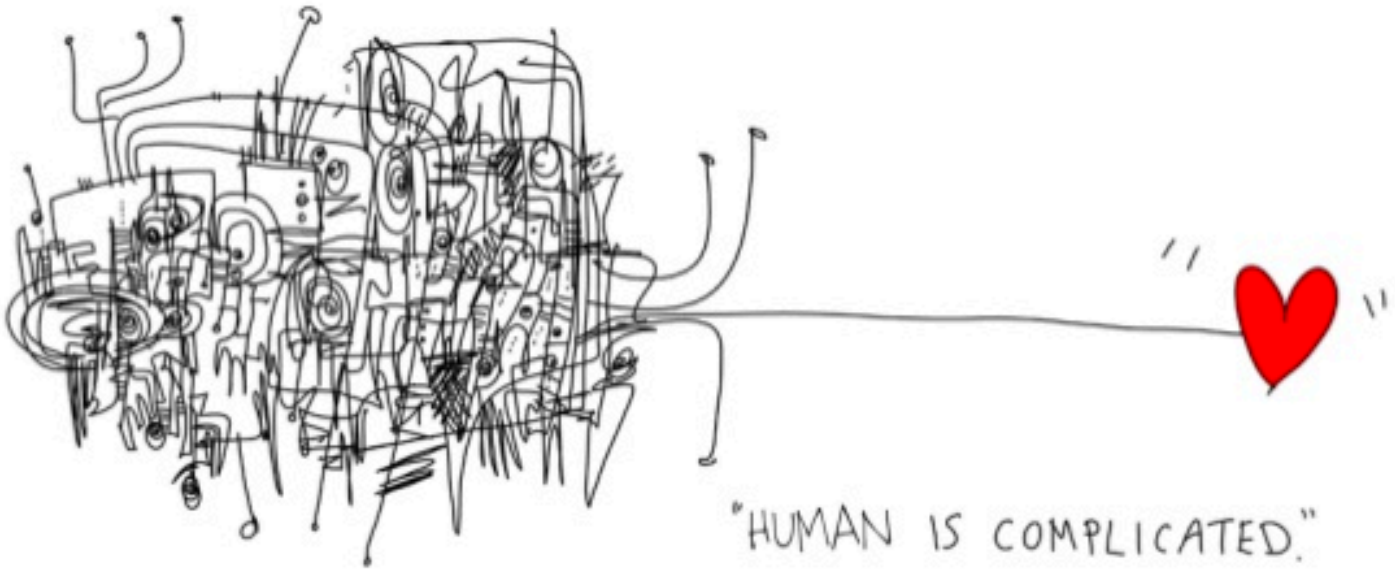
Social Networks

Some content from Ding-Zhu Du, Lada Adamic, and Eytan Adar

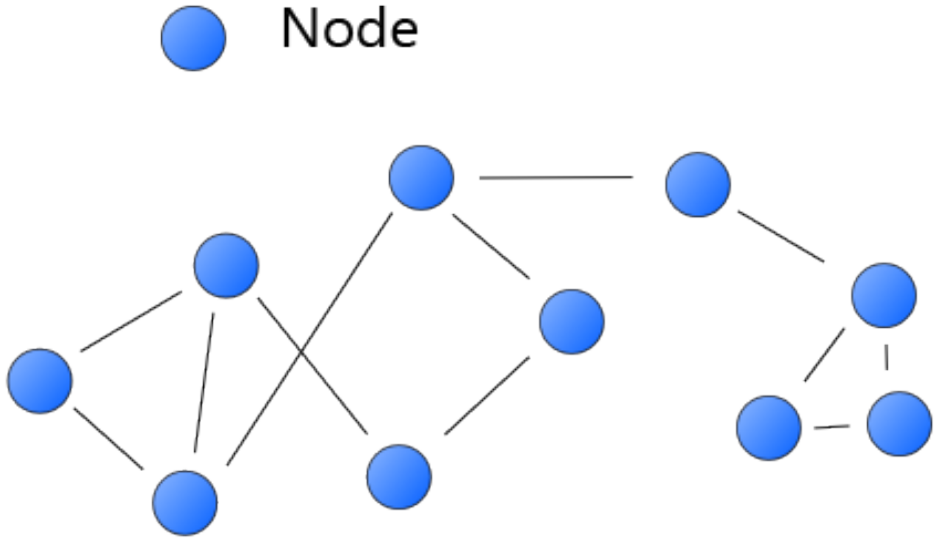
Thesis

- There is much to learn from the interaction between **computer science** and **social science**, to study **social networks** from the lens of computer science.



What is a Network?

A network consists of two or more nodes that are linked in pairs.



Social Network

- Nodes are people (called “actors” or “vertices”)
- Links (called “ties” or “edges”) are relationships

Example 1: Friendship Network

- Nodes: all persons in some community
- A link exists between two persons if they are friends.

Property of Friendship

- **Six Degrees of Separation**

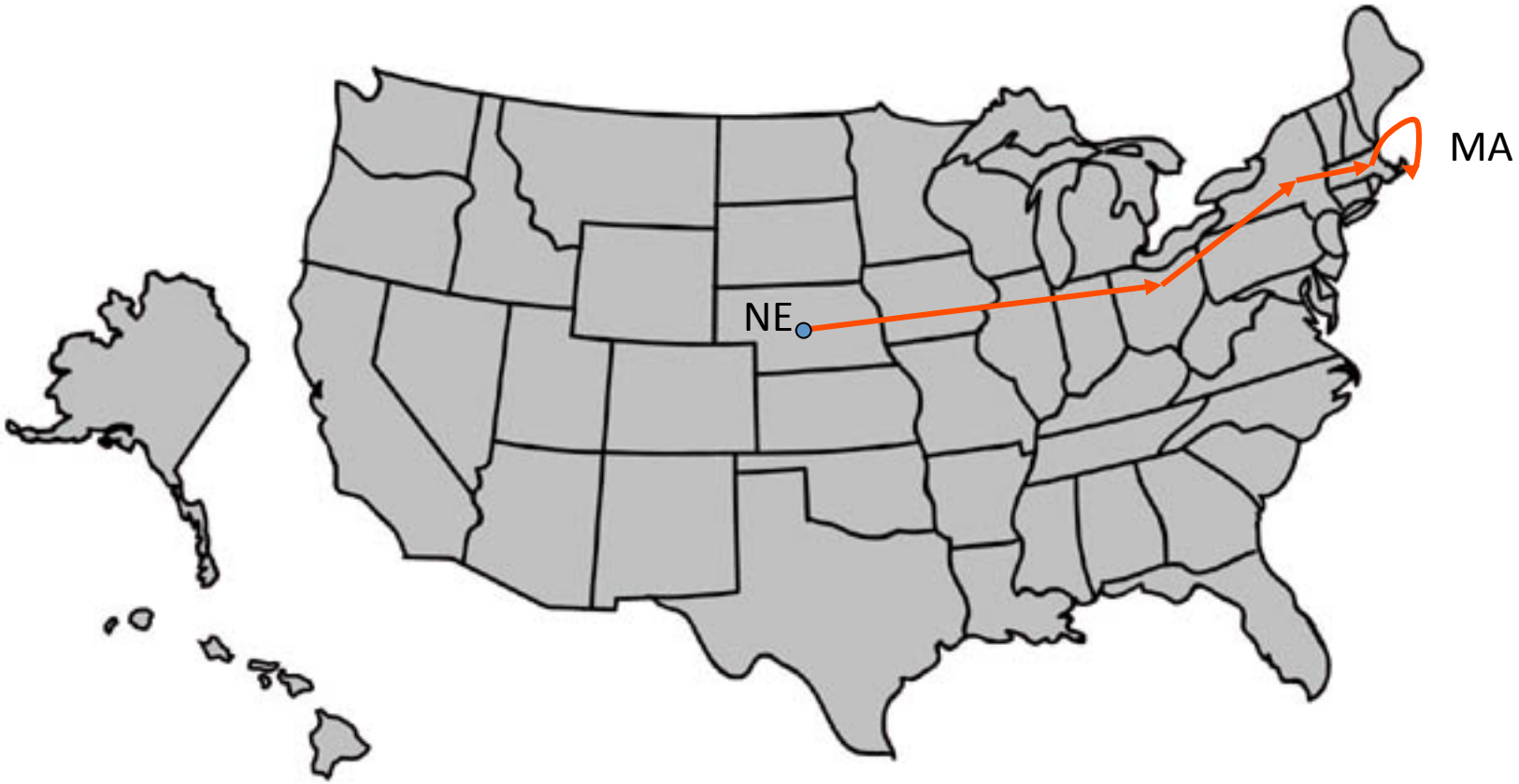
  Milgram (1967)

  The experiment:

  - Random people from Nebraska were to send a letter (via intermediaries) to a stock broker in Boston.
  - Could only send to someone with whom they know.

Stanley Milgram (1933-1984)

Small world experiment



Milgram's experiment (1960's):

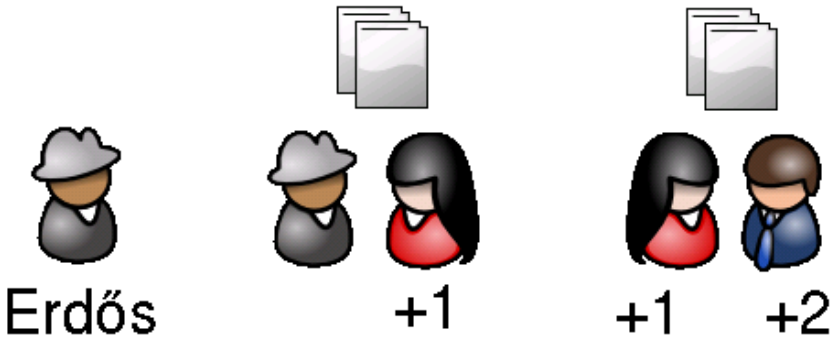
- Given a target individual and a particular property, pass the message to a person you correspond with who is "closest" to the target.
- "Six degrees of separation"

Small World Network

- "A **small world network** is a type of mathematical graph in which most nodes are not neighbors of one another, but most nodes can be reached from every other by a **small** number of hops or steps." - Wikipedia

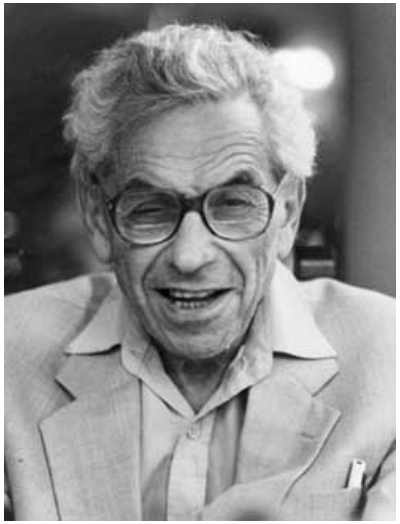
Example 2: Coauthorship Network

- Nodes: all publication authors
- A link exists between two authors if they are coauthors in a publication.



Coauthorship Network is a Small World Network

- **Erdős number:** is the collaboration distance with mathematician **Paul Erdős**.

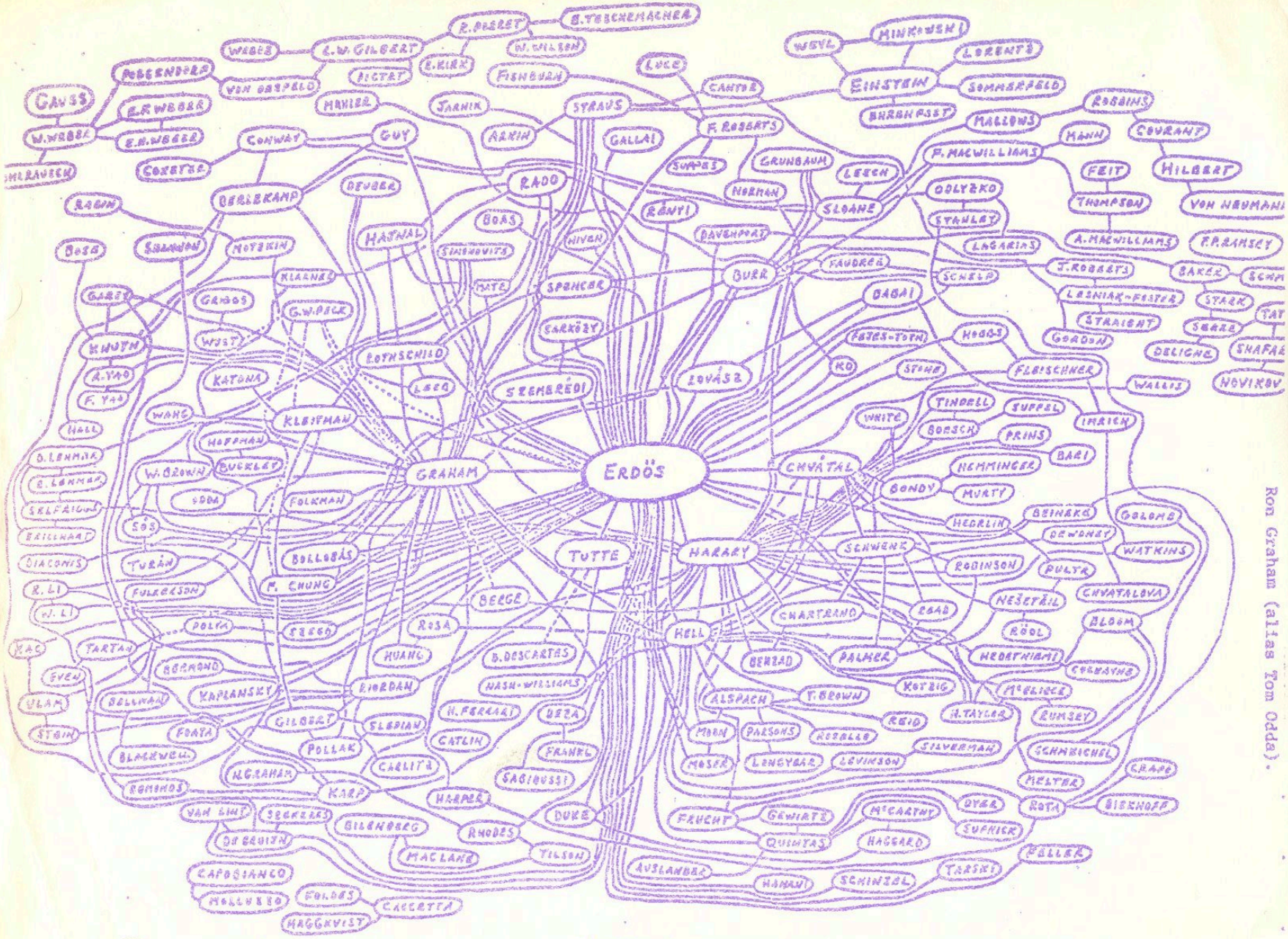


What is your Erdős number?

Distribution in Dec.2010

Erdös number 0	---	1 person
Erdös number 1	---	504 people
Erdös number 2	---	6593 people
Erdös number 3	---	33605 people
Erdös number 4	---	83642 people
Erdös number 5	---	87760 people
Erdös number 6	---	40014 people
Erdös number 7	---	11591 people
Erdös number 8	---	3146 people
Erdös number 9	---	819 people
Erdös number 10	---	244 people
Erdös number 11	---	68 people
Erdös number 12	---	23 people
Erdös number 13	---	5 people

* Two persons are linked if they are coauthors of an article.


ERDÖS
GRAHAM
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BERLEKAMP
GRAVER
WEST
KLARNER
SPENCER
BURR
FAUDREE
SCHELP
SLOANE
NORTON
LEECH
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GALLAI
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WEYL
LORENTZ
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SOMMERFELD
BRAUNFELD
MALLOWS
ROBBINS
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J. ROBERTS
BAKER
LAGARIAS-FOSTER
STARK
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SEGAL
GORDON
DELIGNE
SHAFAREVICH
NOVIKOV
WALLIS
FLEISCHNER
STONE
KO
FOZES-TOTH
HOGGS
TINDELL
SUPPEL
IMRICH
WHITE
BORSCH
PRINS
BARI
HEMMINGER
BONDY
MURTY
BEINEKE
GOLOMB
HEDRLIN
DE WONSKI
WATKINS
SCHWENK
ROBINSON
PULTR
CHVATALOVA
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RÖDL
BLOOM
CHARTRAND
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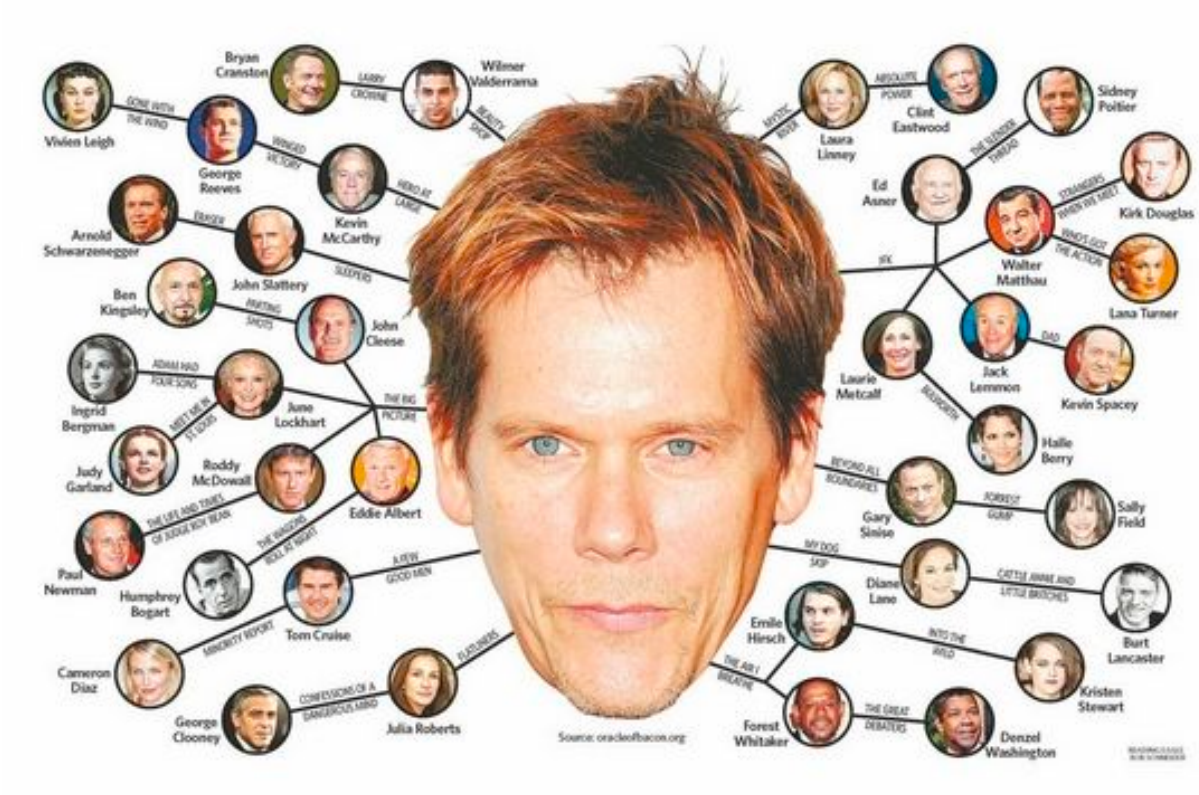
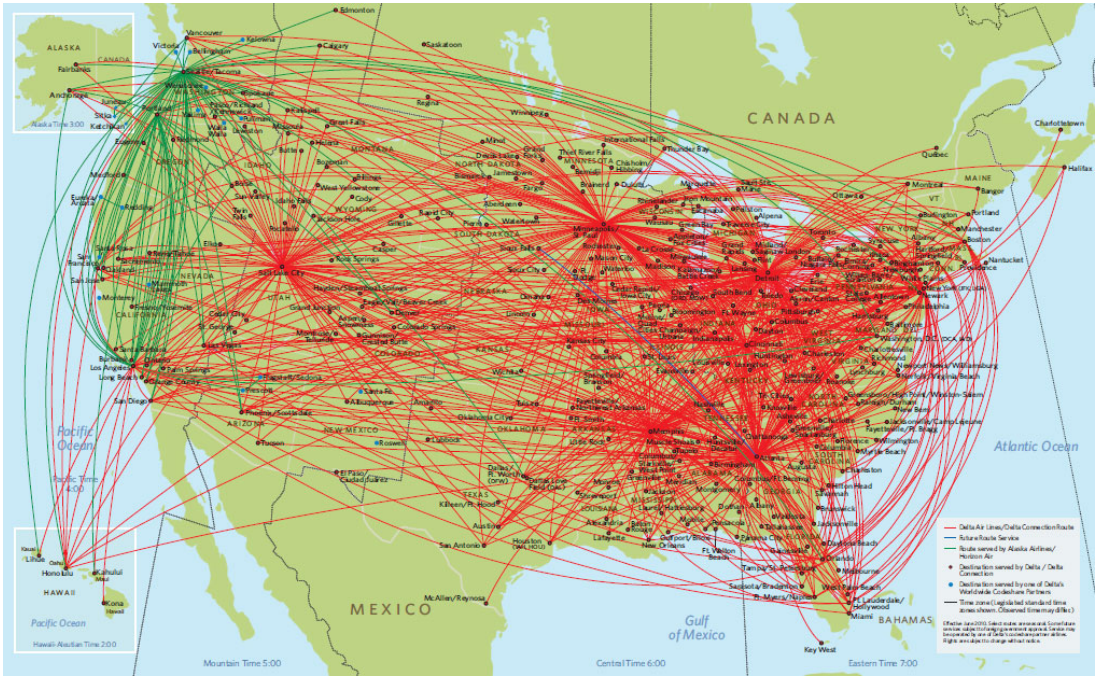
Bacon Numbers

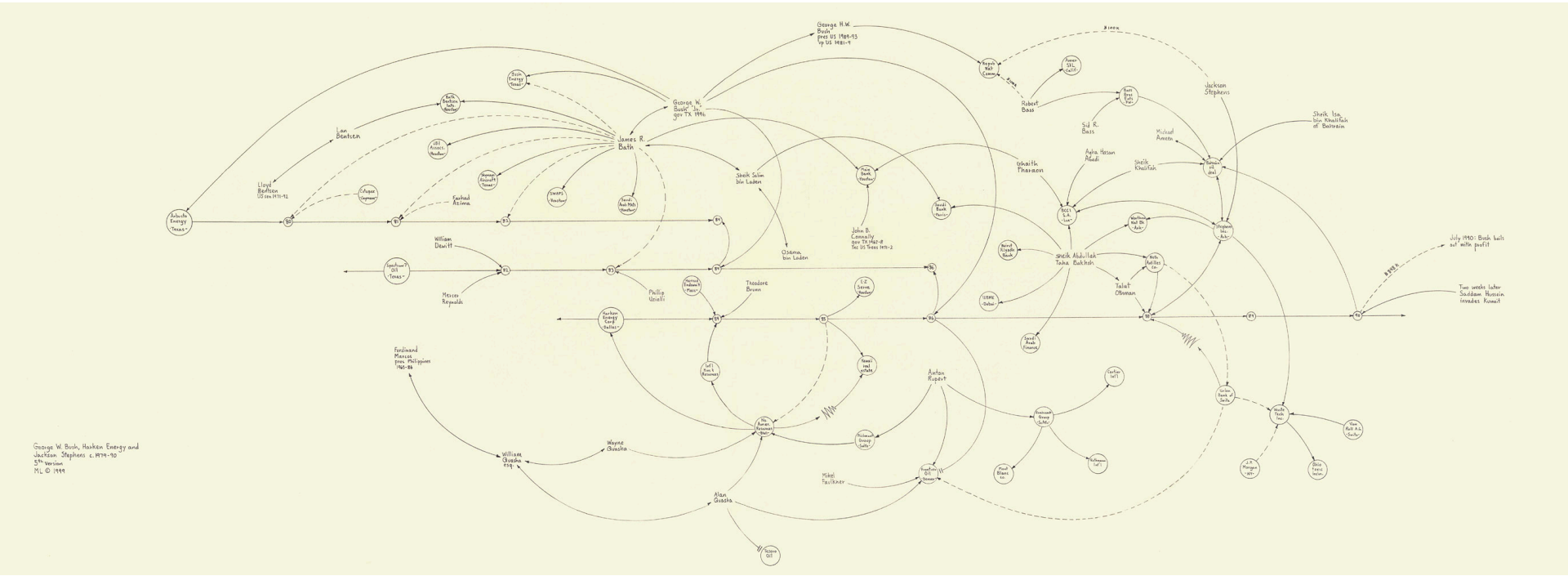


Example 3:
Flight Map Is a Small World Network

- Nodes: all cities with an airport.
- A link exists between two cities if there exists a direct flight between them.



Mark Lombardi Drew Conspiracy Networks



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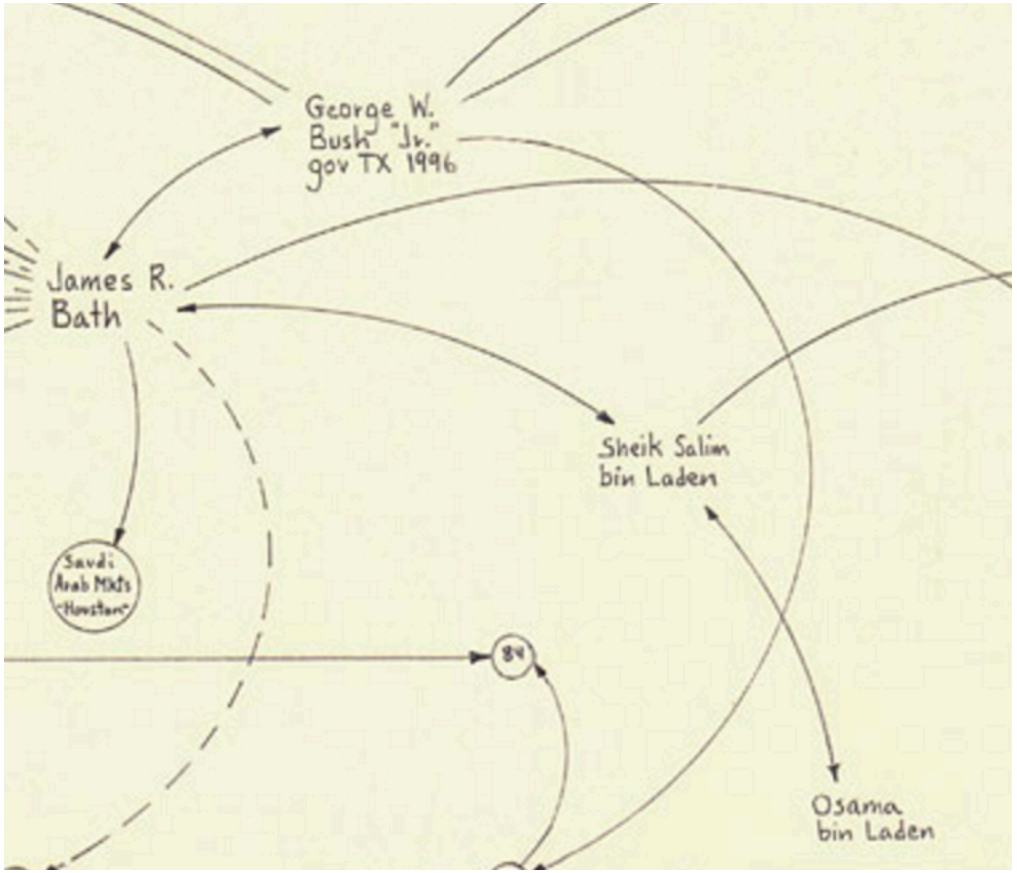
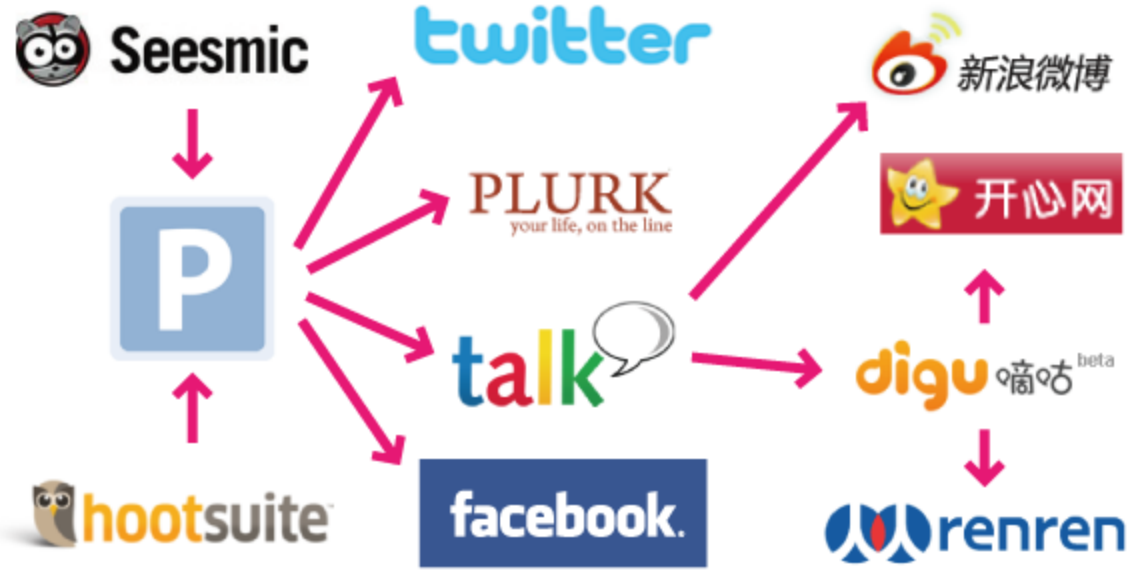


George W. Bush, Harken Energy and
Jackson Stephens c. 1979-90
5th version
ML © 1999

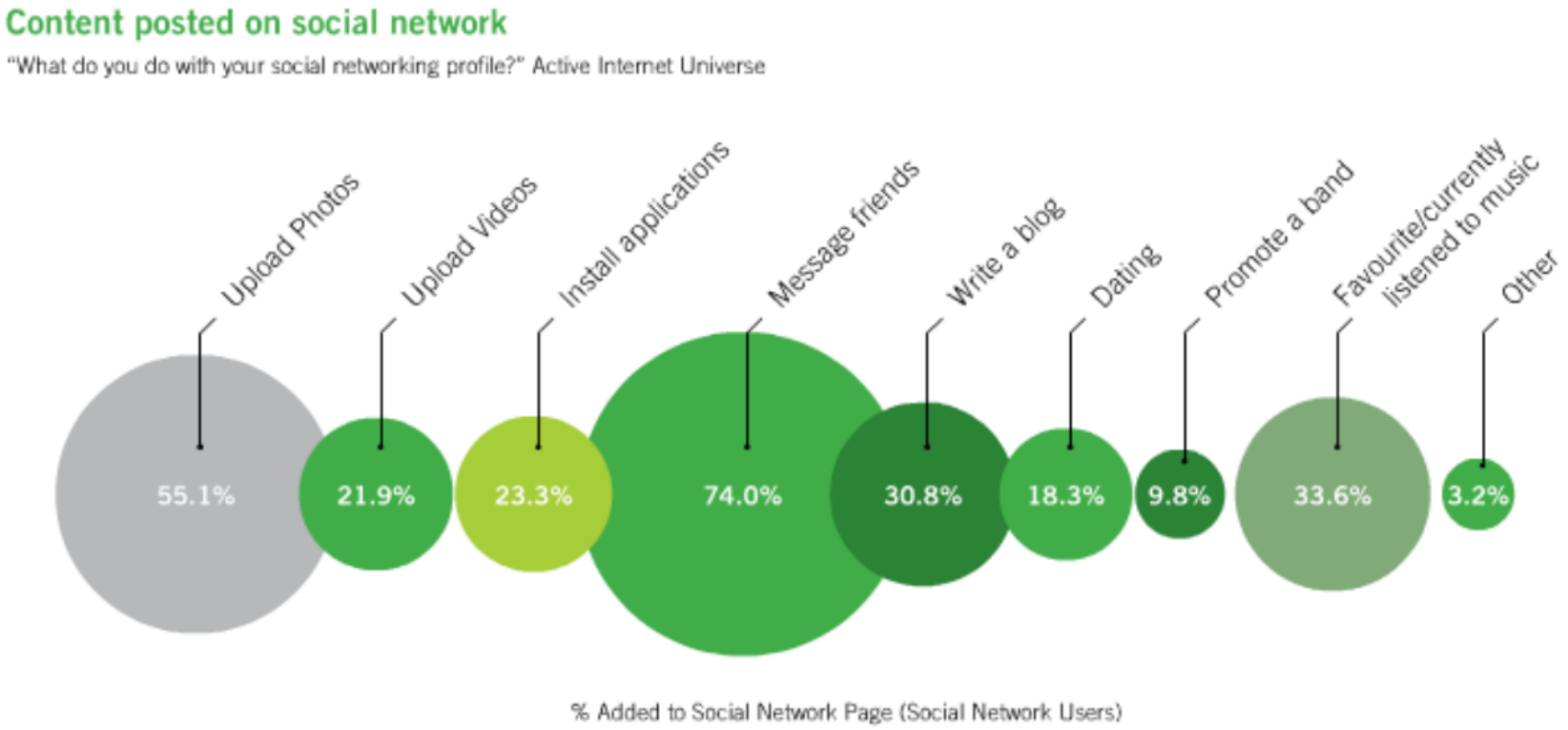
Social Influence

- Social influence occurs when one's emotions, opinions, or behaviors are **affected by others**.
- Although social influence is possible in the workplace, universities, communities, it is most popular **online**.



The Internet provides a platform to create and study social networks

What Are Online Social Networks Used For?

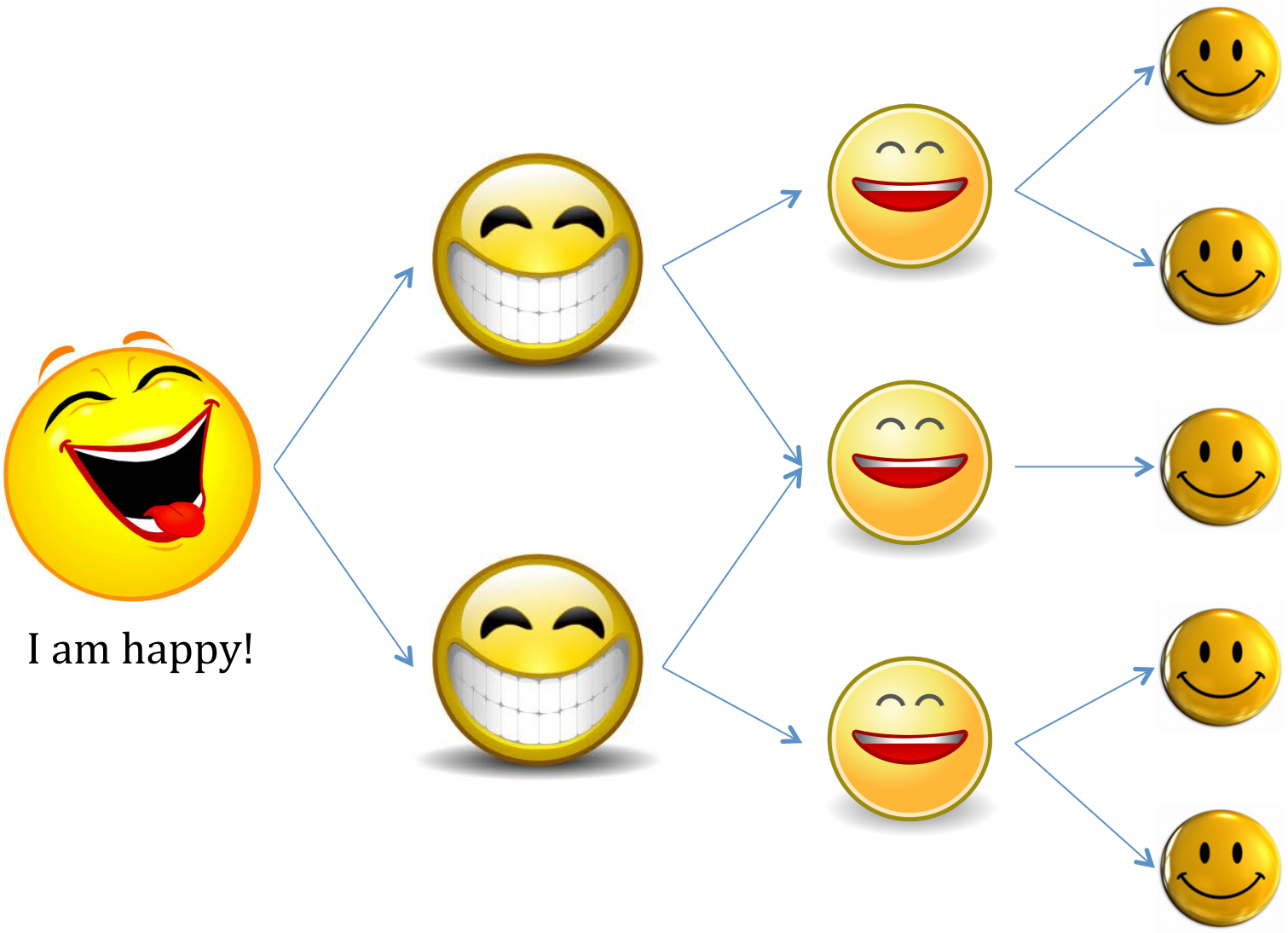


Question 1?

Does Six Degrees of Separation imply six degrees of influence?

Three Degrees of Influence

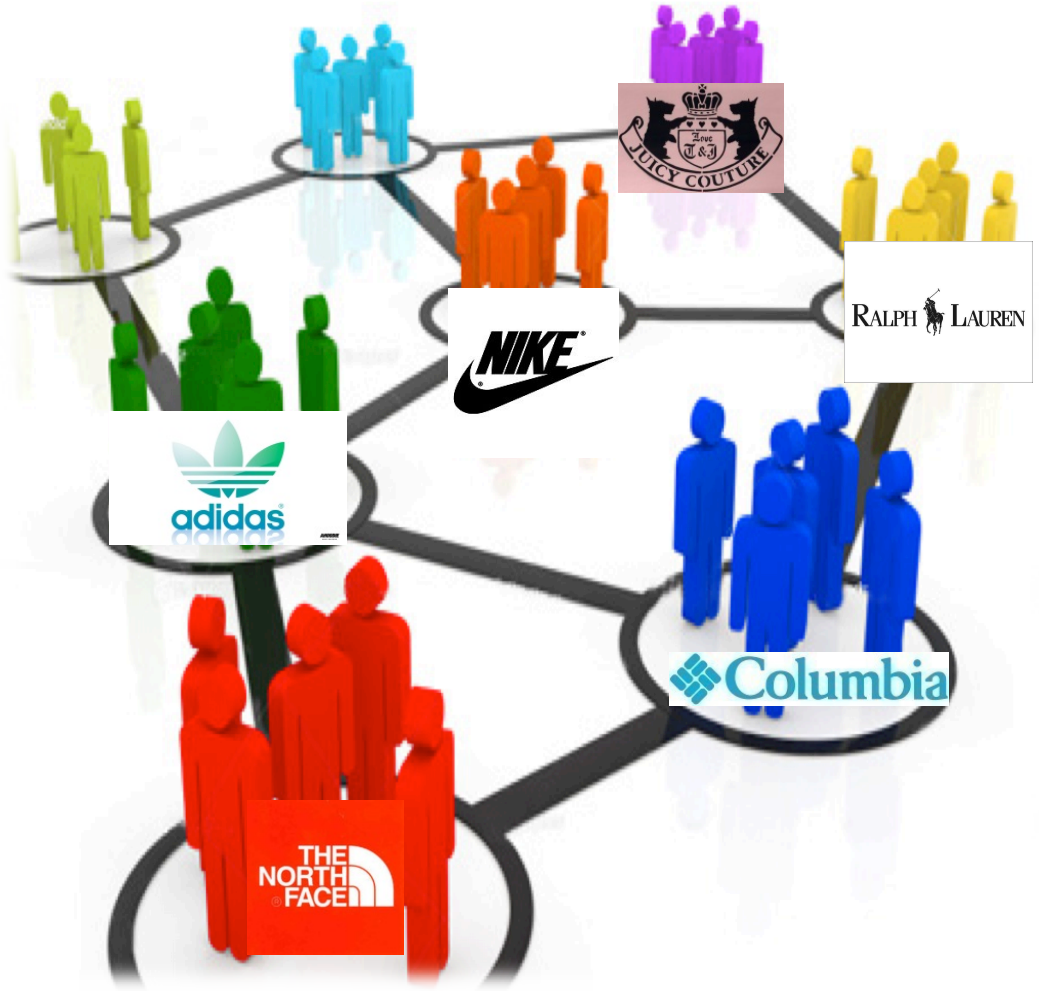
- The influence of actions ripples through networks 3 hops (to and from your friends' friends' friends).


I am happy!

Question 2?

How to explain Six Degrees of Separation and Three Degrees of Influence?

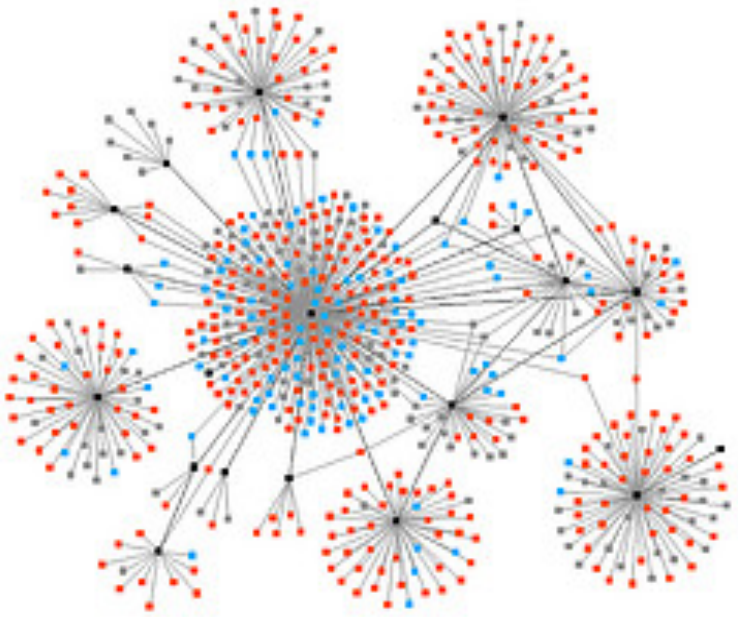
Community



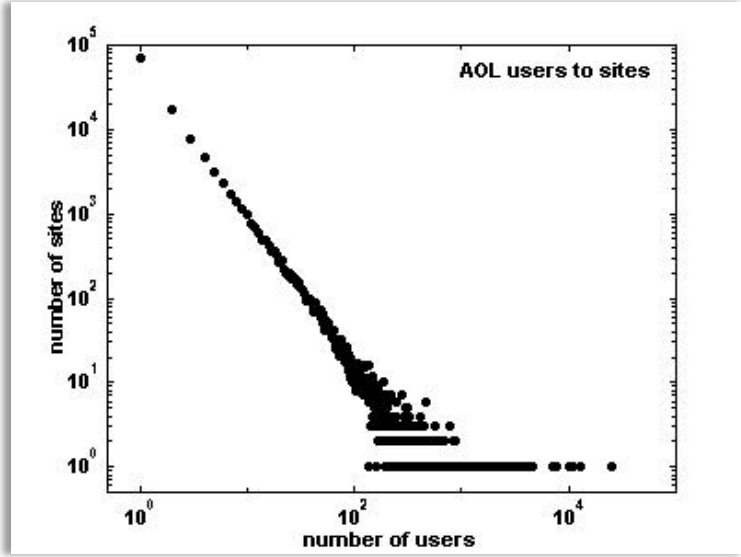
- People in a same community share common interests in
  - clothes, music, beliefs, movies, food, etc.
- Influence each other strongly.

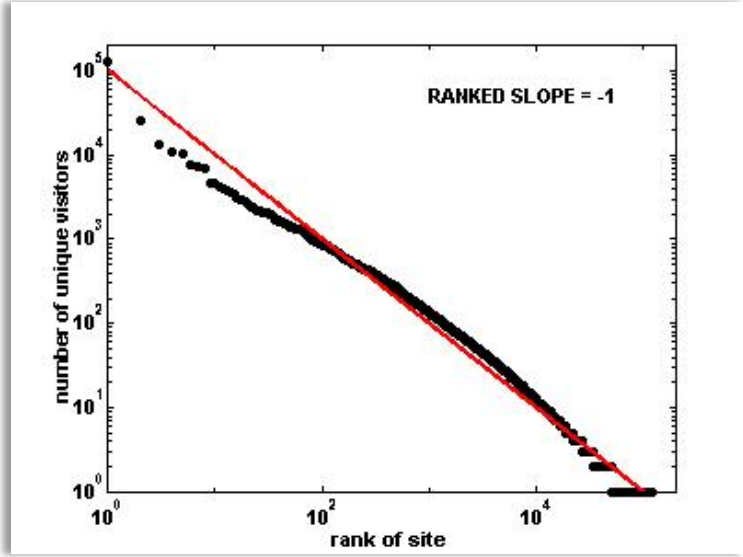
Power Laws

- Less nodes with higher degree and more nodes with lower degree.
- All peoples are surround leaders.



Examples of Power Laws





Power Laws (Scale-Free Networks)

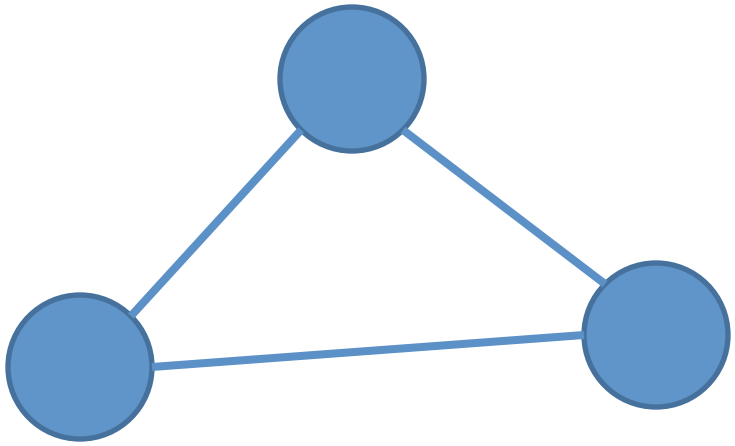
- Power-law
  - A scale-free network is a network whose degree distribution follows a power law, at least asymptotically.
  - That is, the fraction P(k) of nodes in the network having k connections to other nodes goes for large values of k as

    $$P(k) \sim x^{-k}$$

  - Typically k is in the range from 2 to 3.
  - Many networks have been reported to be scale-free.

Barabási & Albert (BA) Random Graph Model

- Very simple algorithm to implement
  - start with an initial set of m_0 fully connected nodes
    - e.g. $m_0 = 3$



  - now add new vertices one by one, each one with exactly m edges
  - each new edge connects to an existing vertex in proportion to the number of edges that vertex already has → ***preferential attachment***

Common Tasks

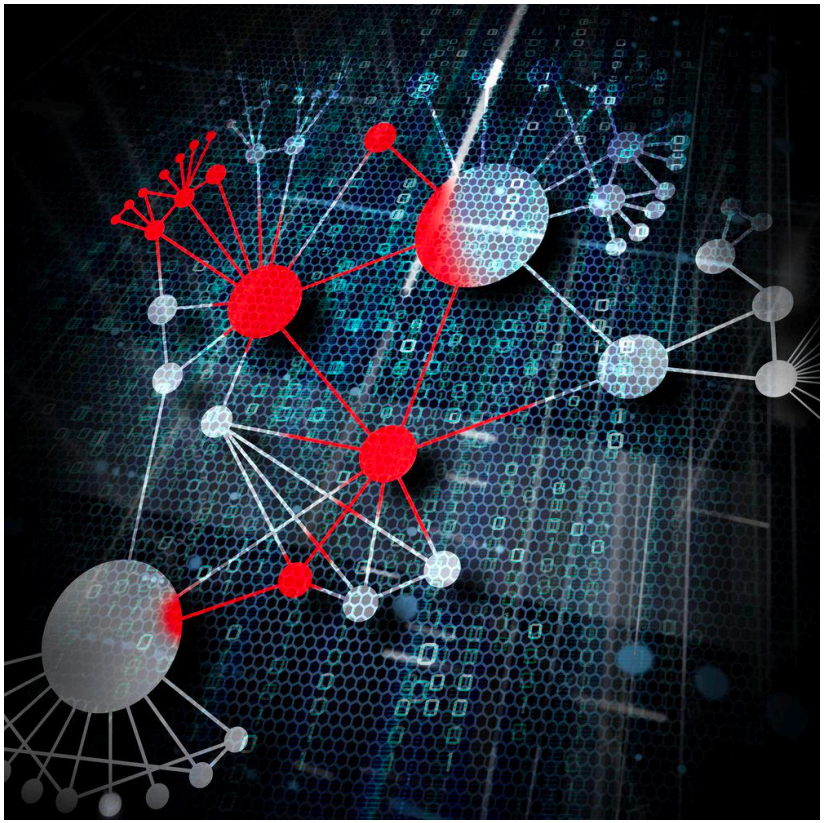
- Measuring “importance”
- Diffusion modeling
- Clustering
- Structure analysis
- Privacy

Centrality Measures

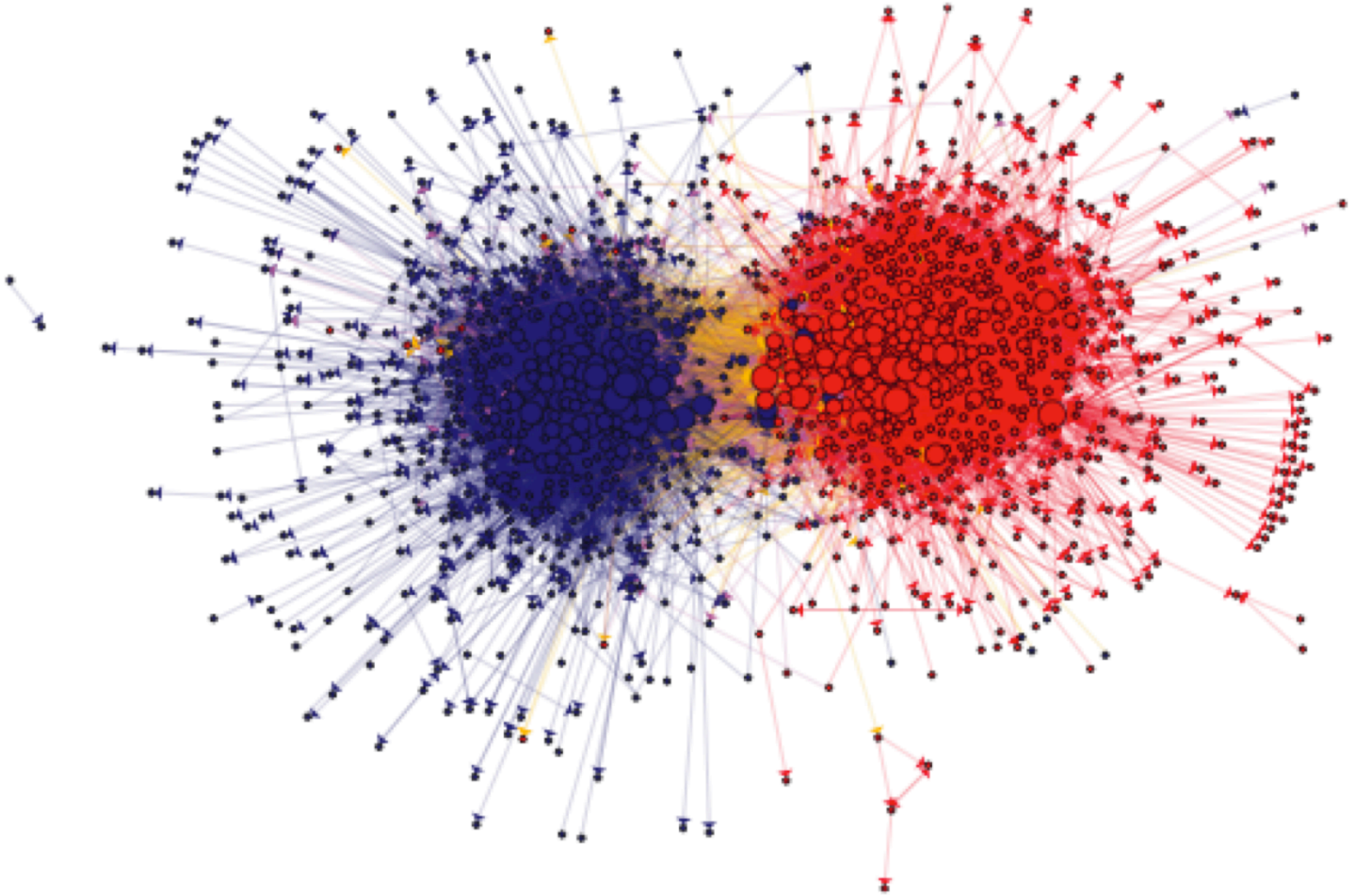
- Degree centrality
  - Edges per node (the more, the more important the node)
- Closeness centrality
  - How close the node is to every other node
- Betweenness centrality
  - How many shortest paths go through the edge node (communication metaphor)

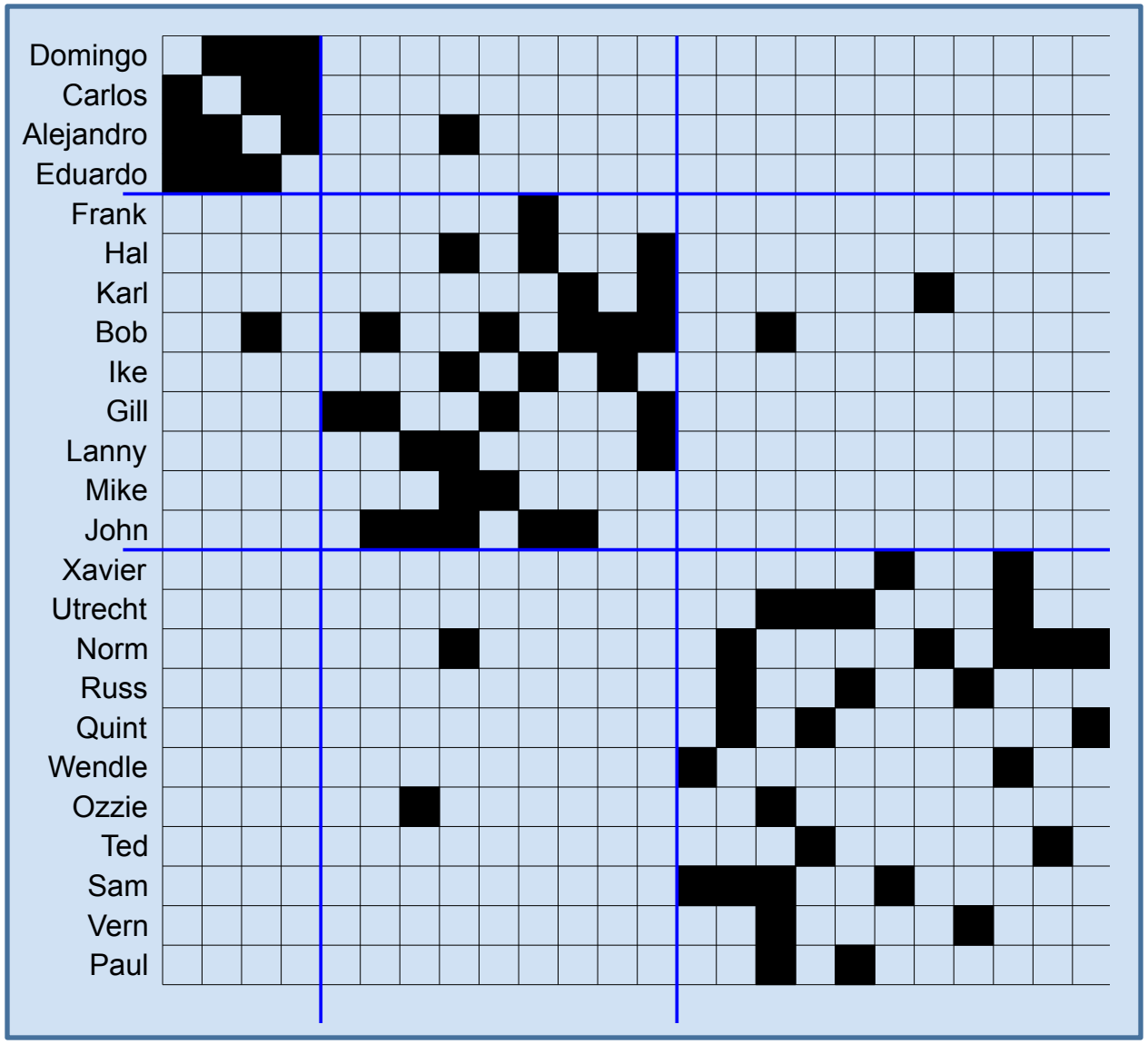
Virus/Disease Spread

- Diffusion through networks:
  - Biological viruses in friendship networks
  - STDs in sexual networks
  - Needle sharing in drug user networks
  - Computer viruses in computer networks

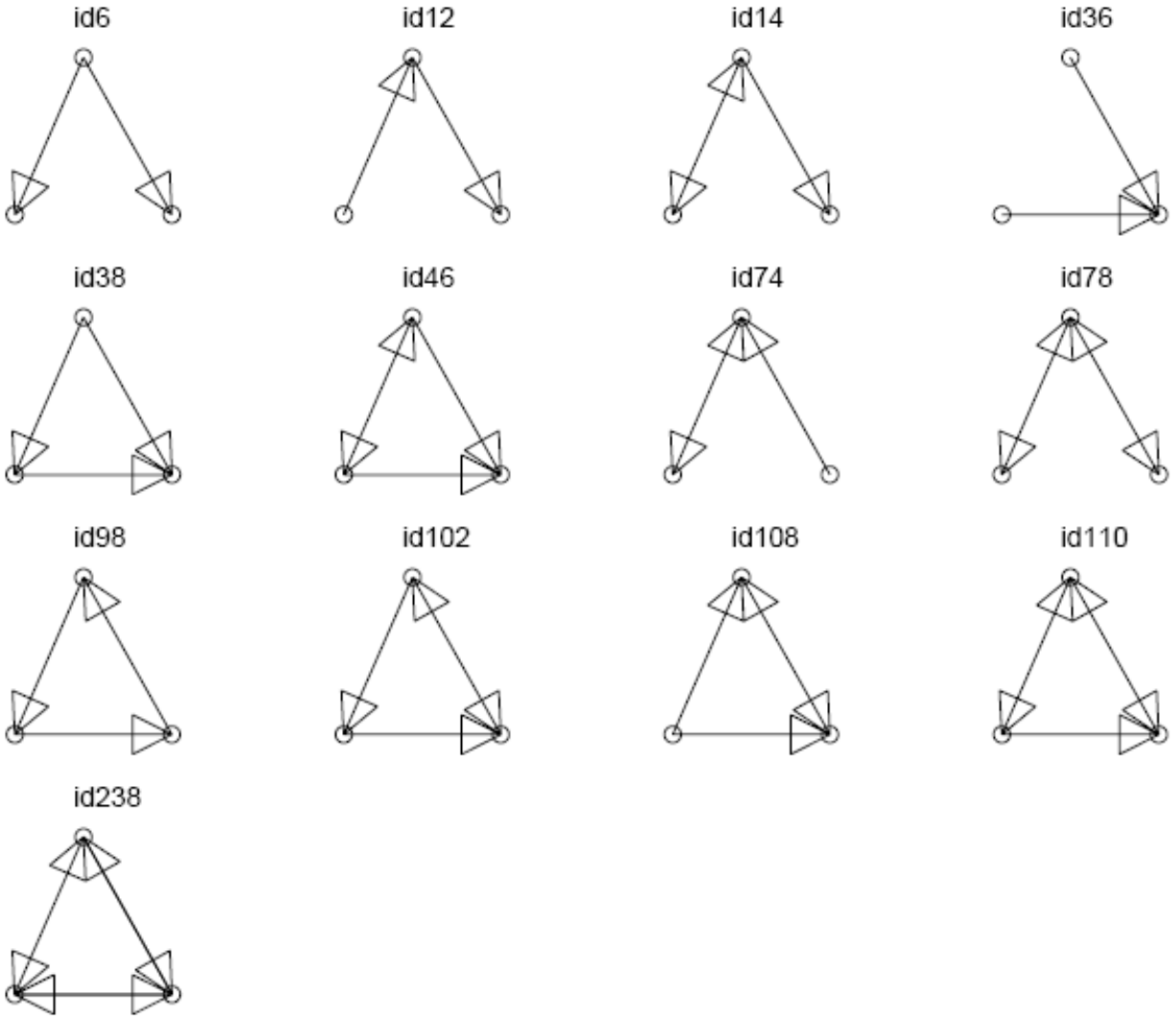


Clustering

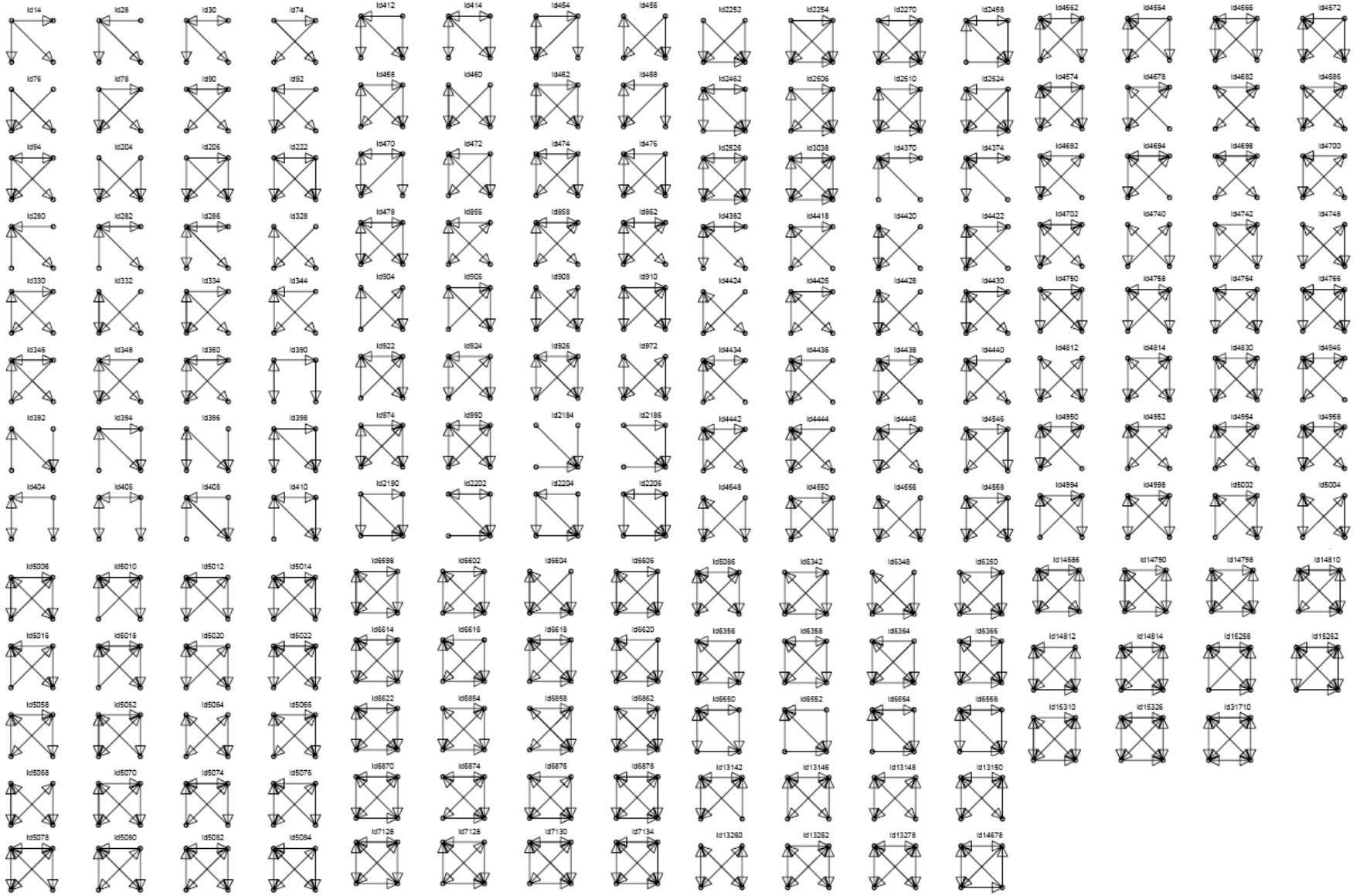


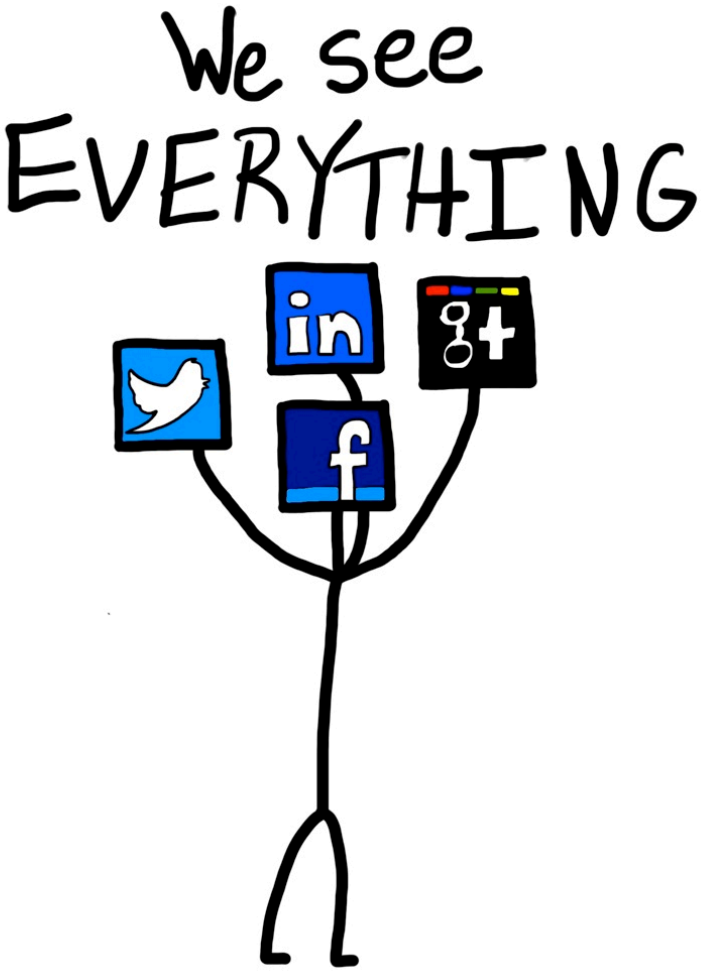

Domingo
Carlos
Alejandro
Eduardo
Frank
Hal
Karl
Bob
Ike
Gill
Lanny
Mike
John
Xavier
Utrecht
Norm
Russ
Quint
Wendle
Ozzie
Ted
Sam
Vern
Paul

Looking for Connection Patterns



Looking for Connection Patterns



(Lack of) Privacy

- Privacy in social networks is hard.
- You can be identified by your friends.
- Your data is being collected and stored everywhere you go.