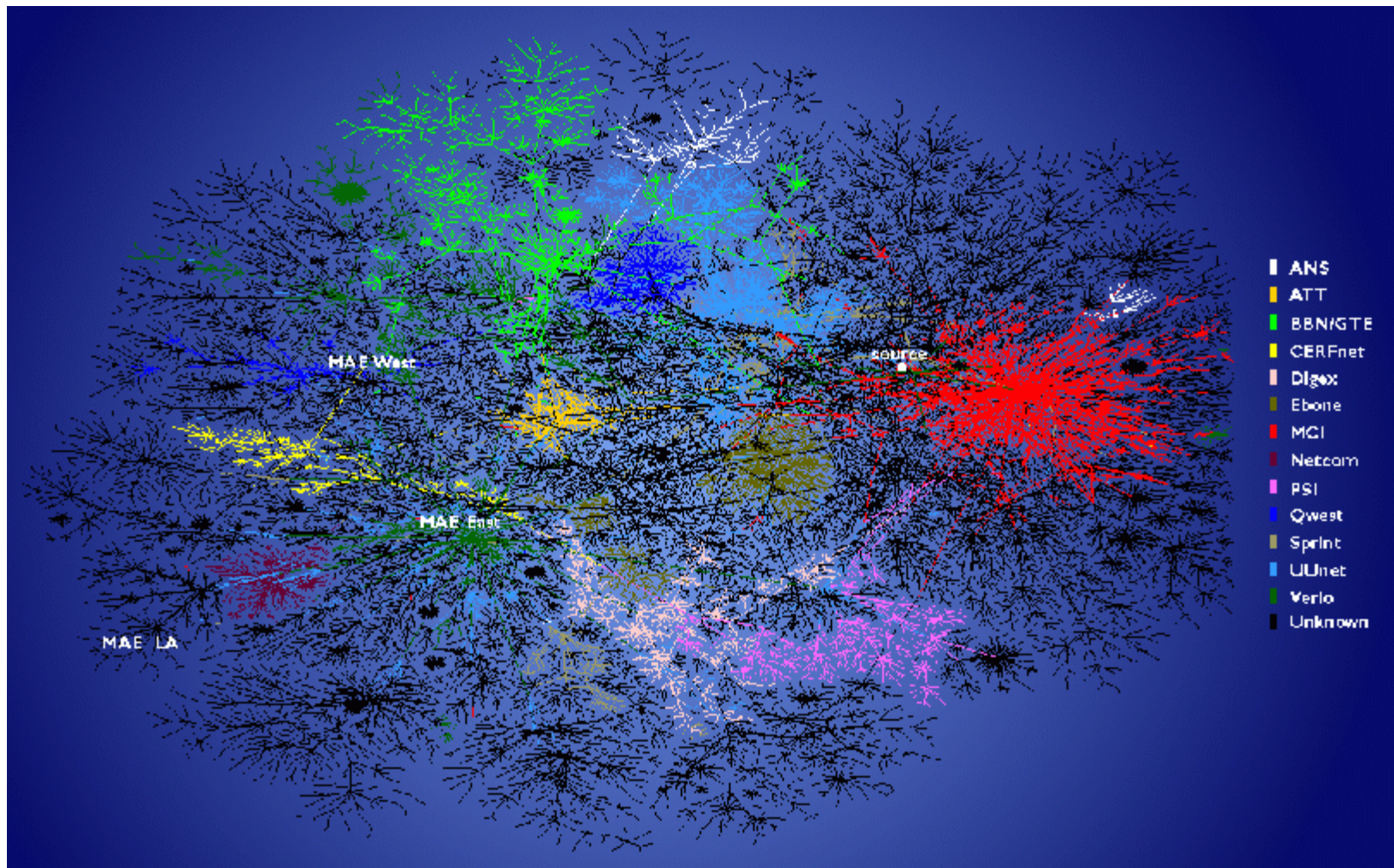# Social Network Research

Network science

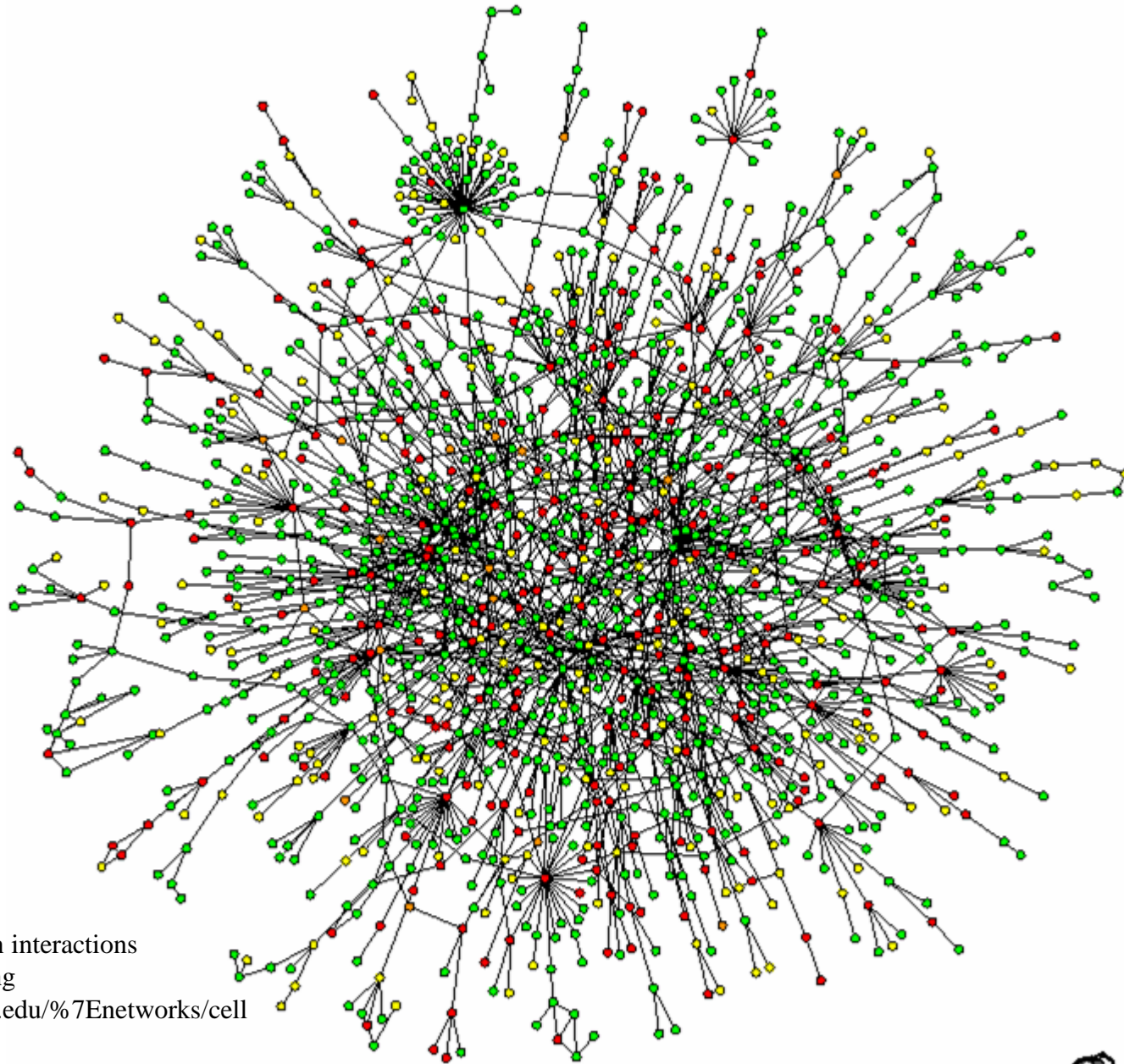A commitment to **relational** data structures

Areas include:
physics; biology, epidemiology, transport, economics, sociology, psychology, bibliometrics, anthropology, internet and computer studies, complex systems, communications theory, organisational research, history, politics, ecology ….

The legend reads:
- ANS
- ATT
- BBN/GTE
- CERFnet
- Digex
- Ebone
- MCI
- Netcom
- PSI
- Qwest
- Sprint
- UUnet
- Verio
- Unknown

The internet
C.P.Klaffy
http://www.caida.org/Papers/Nae/

Protein-protein interactions
Hawoong Jeong
http://www.nd.edu/%7Enetworks/cell

Zurich transportation system
Greater Zurich Transport System

BUT...

We are interested in Social Networks

Not all networks are the same

Social networks have some distinctive characteristics, and some very distinctive interpretations.

What is a Social Network?

The patterns of interaction and exchange among people (or other social entities), arising through human social processes.

We can represent a social network as a graph
- with *nodes* as the social entities (e.g. people), sometimes called *actors*.
- with lines (*edges*) or arrows (*arcs*) as the social connections between them.

Social connections can be manifold:

communication; acquaintance; collaboration; economic exchange; support; friendship; trust; hatred; competition; knowledge transfer; influence; violence ….
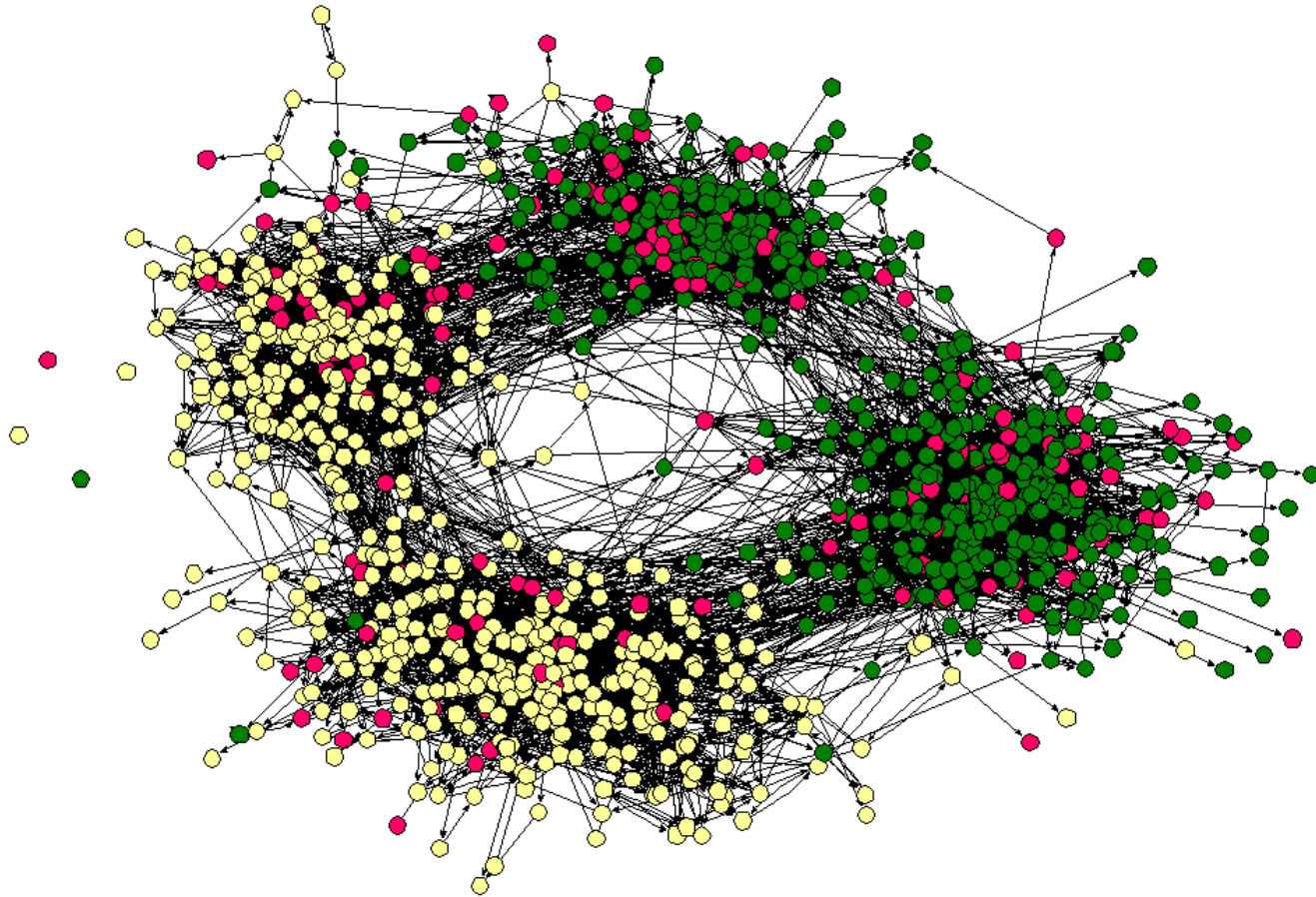
High School friendship
Moody, 2001

Jacob Moreno

A psychiatrist (now best remembered, it seems, as the Father of Psychodrama) is often credited with the development of *sociometry* (he proposed measuring social relationships for the entire city of New York in 1933, but didn't get funded)
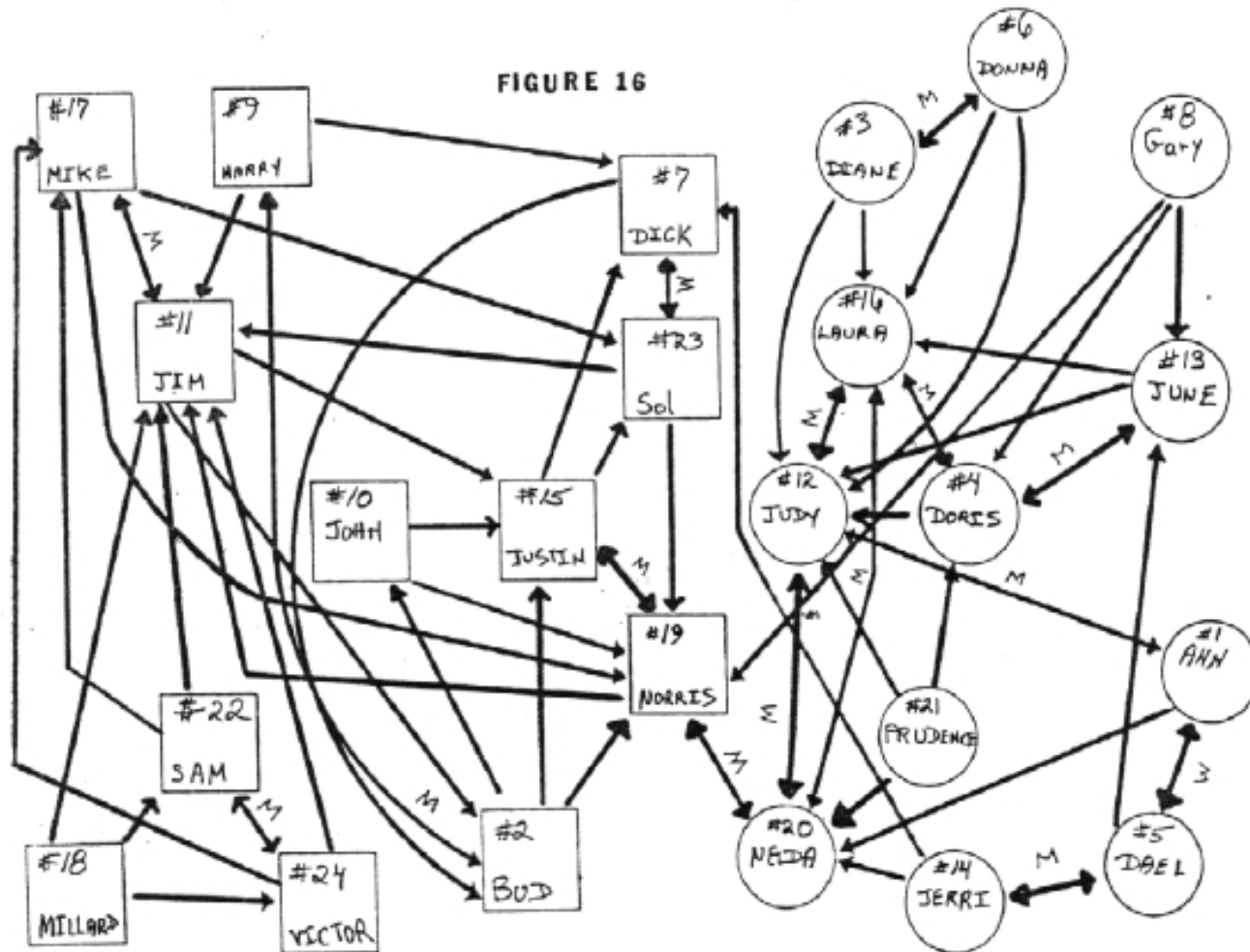
Moreno's sociomatrix …

NOMINEE'S ID NUMBERS

SEX	ID#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
F	1	■				+				-	-		+								+	-			
M	2	-	■							+						+				+			-	-	
F	3			■			+	-			-		+				+						-		
F	4				■						-		+	+			+			-	-				
F	5	+				■					-			+	+					-	-				
F	6	-		+			■						+			-	+						-		
M	7		+					■		-	+									-		-		+	
F	8				+		-		■				+					-		+					-
M	9		+					+		■		+	-			-									-
M	10		+					-			■	-				+				+		-			
M	11		+								-	■				+		+		-	-				
F	12	+						-			-		■			-	+				+				
F	13				+								+	■			+			-	-	-			
F	14					+	-	+		-					■						+		-		
M	15							+		-					-	■				+				+	-
F	16				+					-			+				■			+			-	-	
M	17				-							+						■		+	-	-		+	
M	18											+							■	-		-	+		+
M	19		-									+	-			+				■	+	-			
F	20						-			-			+		-			+		+	■				
F	21	-	-		+								+							-	+	■			
M	22						-			-			+					-	+				■		+
M	23	-						+					+						-		+	-		■	
M	24												+						+	-	-		+	-	■
TOTAL +		2	4	1	5	2	1	4	0	1	0	8	8	3	1	4	6	3	0	7	6	0	2	3	2
TOTAL −		4	2	0	1	0	4	4	0	4	9	1	1	1	2	3	1	2	0	7	6	10	4	3	3

NOMINATOR'S ID NUMBER

... displayed as a sociogram

FIGURE 16

What structure is evident in the arrangement of squares and circles?

Anthropologists

In 1950s, social anthropologists at Manchester University extended sociometric techniques to studies of families, kinship, and friendship networks in urban settings of both advanced and developing societies

► Elizabeth Bott, Max Gluckman, J. Clyde Mitchell, S.F. Nadel

John Barnes credited with applying analytic rigor to concept of "social network".

He saw "the whole of social life" as "a set of points some of which are joined by lines" to form a "total network" of relations. The informal sphere of interpersonal relations was a "partial network" within this total network (Barnes 1954:43).

Sociologists

In 1970s, sociologists at Harvard, Chicago, Toronto & elsewhere applied finite mathematical, graph theoretic, clustering, and spatial modeling methods to uncover small group structures and community networks

► Conflict among novice monks in a monastery (White et al 1976)

► Cleavages in urban political networks (Laumann & Pappi 1976)

► Community lost, preserved, or extended? (Wellman 1979)

By 1990s, network analysis had proliferated to business management, public administration, law, and related fields

► Strategic alliance networks (Gulati 1995)

► Self-managed work teams (Barker 1999)

Social Network Analysis

An interdisciplinary perspective emphasizing structural relationships as key explanatory concepts and principles:

- Structural properties of social formations are contexts that shape the perceptions, beliefs, attitudes, and actions of individuals and collectivities

- Social influence and collective action may be facilitated and/or constrained by direct and indirect exchanges (transactions) among social actors possessing differential resources (e.g., information, money, power, grace)

- Embeddedness (location of actors within actual situational contexts) must be analyzed as dynamic processes

Contrast structural-relational approaches to substantialist explanations premised on "thing-concepts" as basic unit of analysis: actor essence, self-action, normative conformity, rational choice, variable-centric, social identity approaches (Emirbayer 1997)

Theories and Methods

Network research involves continual interplay of theoretical and methodological tools to investigate substantive questions

THEORY: Analytic concepts, principles, interrelated propositions that explain empirical observations

- ► Relational vs substantive perspectives (Emirbayer 1997)

- ► Social capital theories (Coleman 1990; Lin 2001)

- ► Structural holes (Burt 1997)

- ► Organizational field-nets (Kenis & Knoke 2002)

METHODS: Measures, data, computer techniques to test theoretical propositions

- ► Matrix algebraic methods (Wasserman & Faust 1994)

- ► Visualization programs (Freeman 2000)

Multilevel and Interdisciplinary

Network applications appear in diverse substantive fields of most social sciences – anthropology, management, public health, sociology, economics (but political science?)

Studies span micro- meso- & macro-levels of analysis:

- personal social & health support systems

- children's play groups, high school cliques

- neighboring behavior, community participation

- work teams, voluntary associations, social movements

- military combat platoons, terrorist cells

- corporate strategic alliances, board interlocks

- international relations: trade, aid, war & peace

Multiple social processes

Tie

Reciprocity

Activity

Popularity

Triads

Brokerage
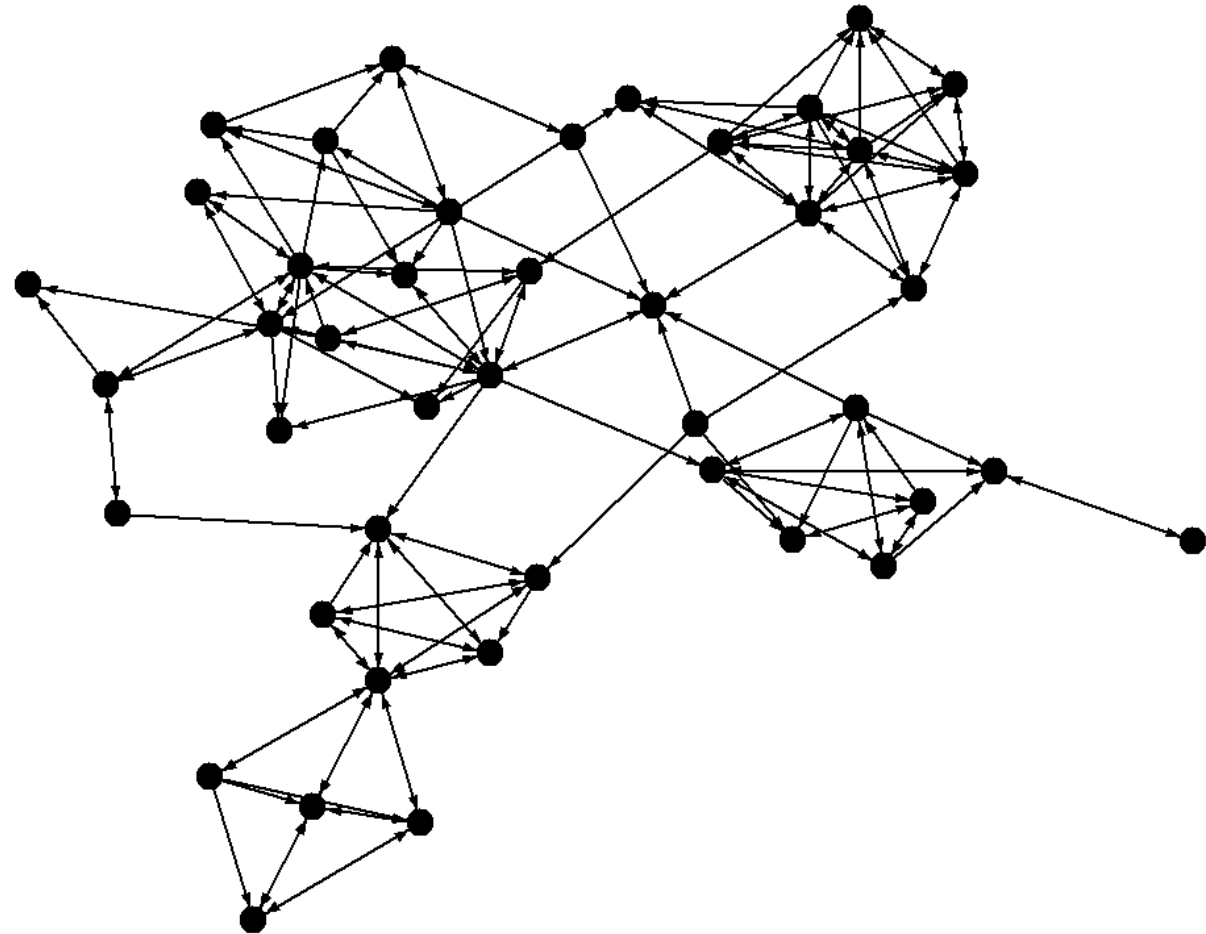
Basic questions

- Where do networks come from?

- Why do networks matter?

- What do networks mean?

- What do networks do?

Where do networks come from?

- (Social) networks come from attempts to control and reduce uncertainty

- (Social) networks are the visible trails left by our control attempts as we search for information

- (Social) networks are the social infrastructure of knowledge transfer and exchange

Why do networks matter?

- Connected action
  - Good ideas
  - Economic development
  - Coordination of production
  - Management of teams
  - Social relations
  - Diffusion of information, behaviors, attitudes, attributes

What do networks mean?

Phenomenology of networks:

Making sense of your world by thinking about how you are connected to others that are themselves connected.

What do networks mean?

Collaboration network among 36 lawyers in a New England law firm (Lazega, 2001)

Boston office:

Hartford office:

Providence off.:

least senior:

most senior:
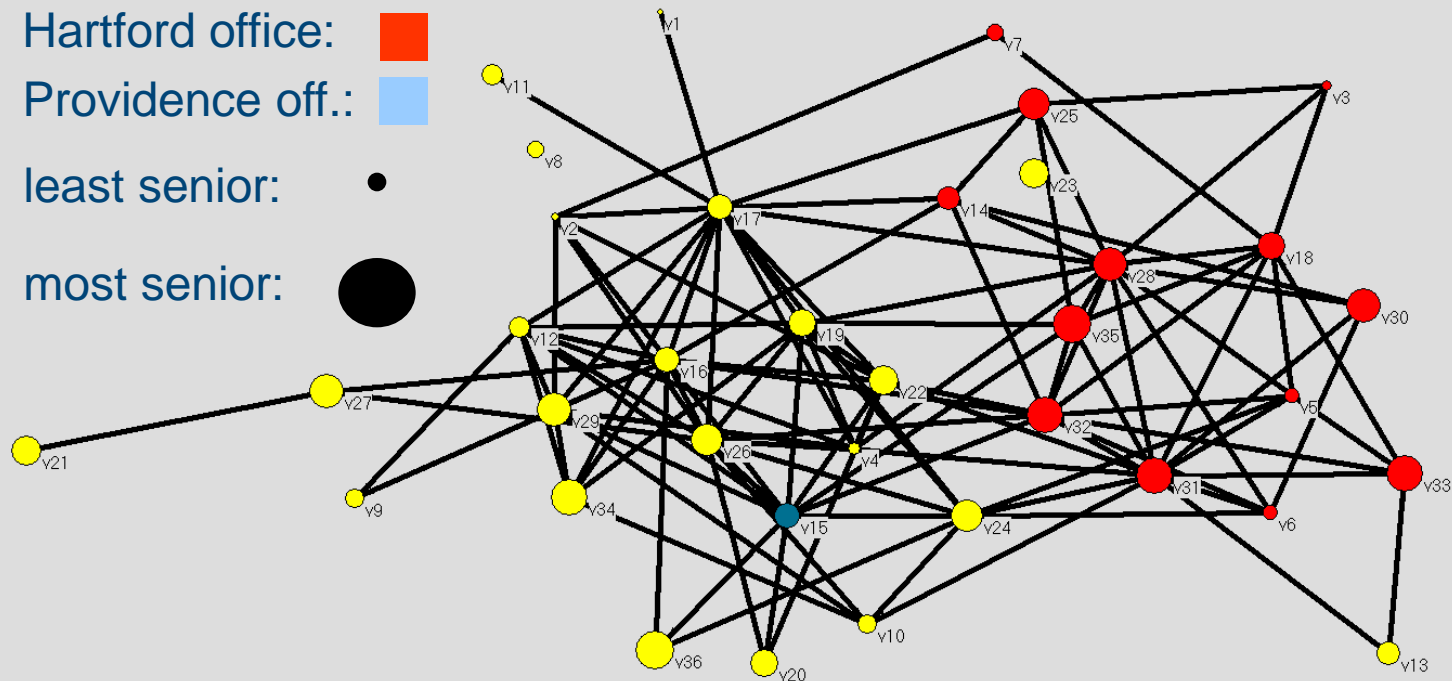
Collaboration among academics
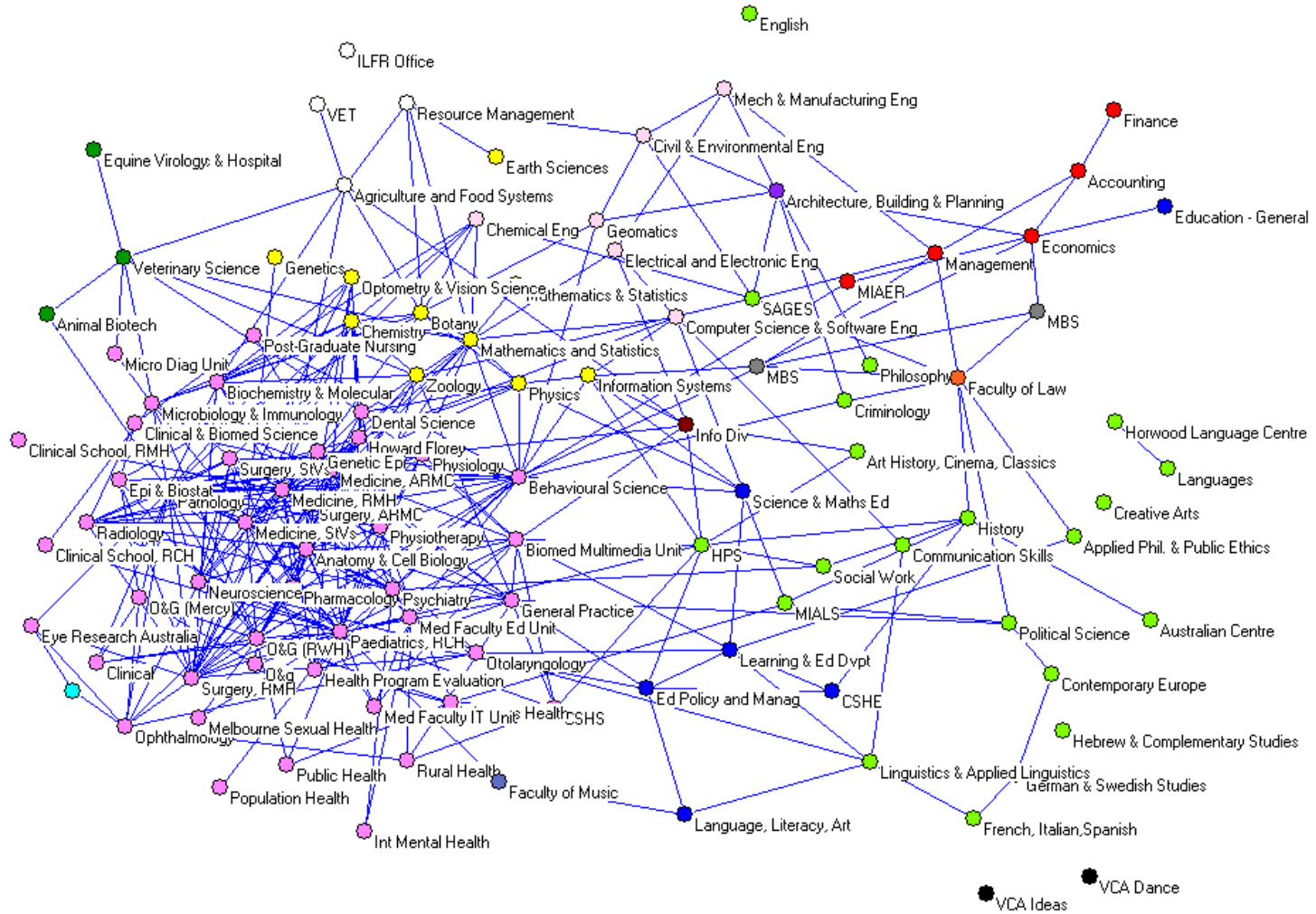
Sources of advice for farmers
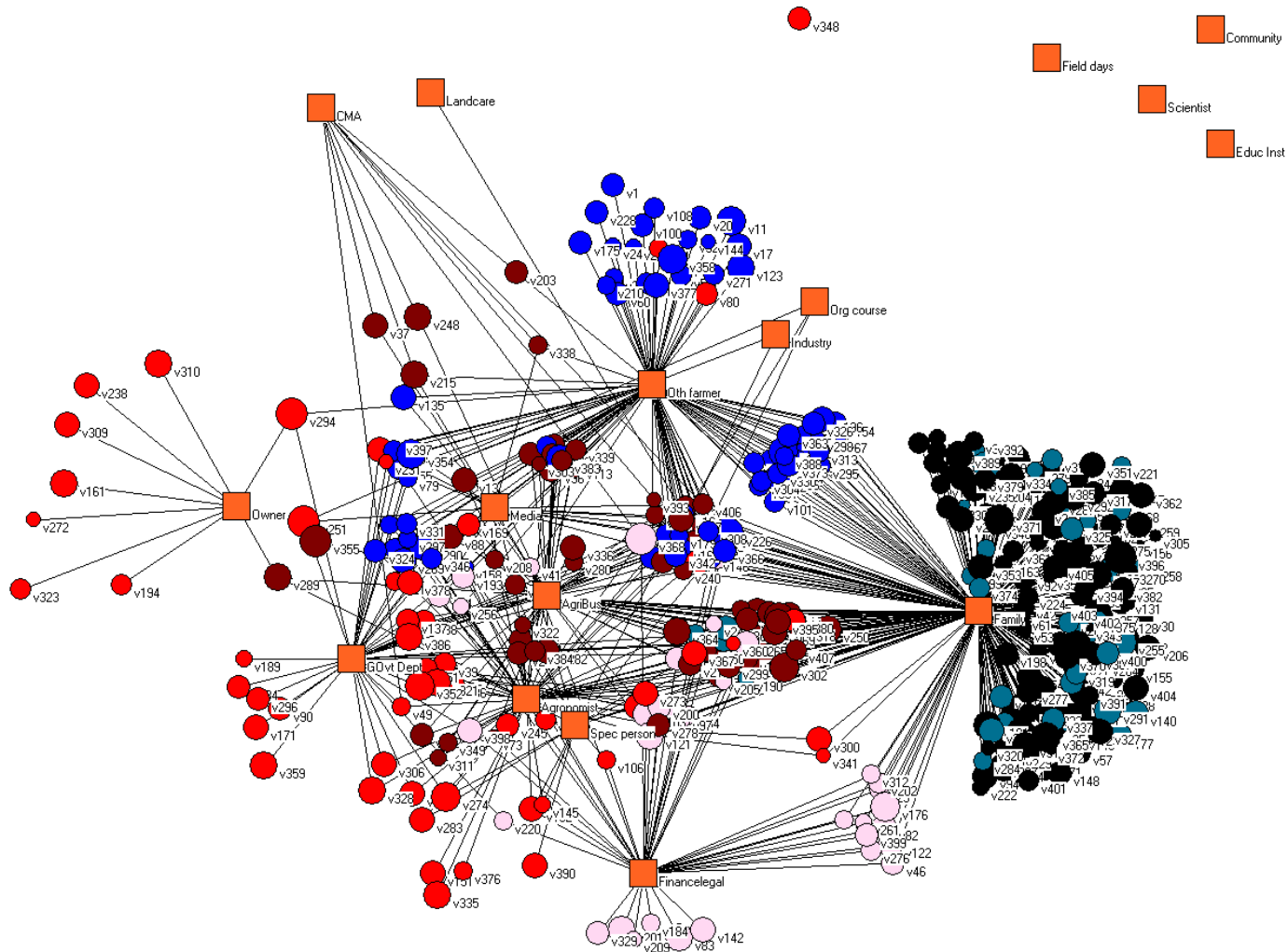
What do networks do?

- Coordination, identity, learning

- Access to opportunities

- Power and control

Weak and strong ties

- Interpersonal social networks are composed of strong ties (close friends) and weak ties (acquaintances)

- Strong ties and weak ties play different roles for community formation and information diffusion

- Strength of Weak Ties (*Granovetter, 1973*)
  - Occasional encounters with distant acquaintances can provide important bridges for information about new opportunities for job search

The strength of weak ties

- Bridges connecting two different communities are weak ties

- An edge is a *bridge* if its removal results in disconnection of its terminal nodes
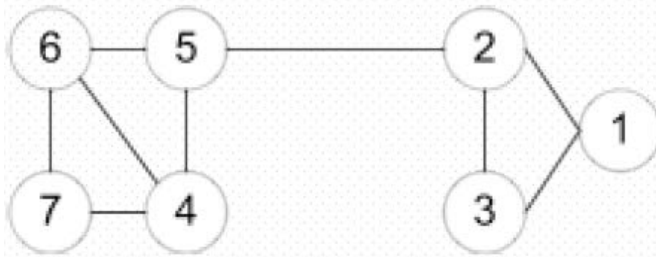
e(2,5) is a bridge
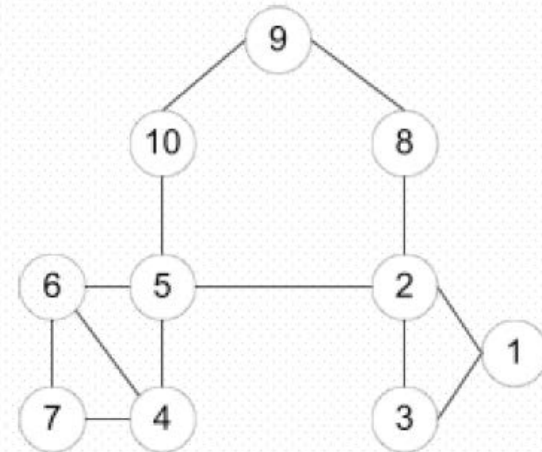
e(2,5) is NOT a bridge

Emergent properties of networks: The small network (Milgram, 1967)

- Basis of the SMW in the phenomenology of everyday life

- How many steps ("handshakes") –on average – does it take to link any two randomly selected individuals in a given population?

Milgram's experiment (I)

- Select group of target persons and a group of starter persons.

- Starters have to send a document to a target in a different city by choosing an appropriate intermediary.

- Try to generate an acquaintance chain from starters to targets. Measure the length of the chain.

- Target have to select acquaintance they know well and who might help them to reach the targets.

- Chain ends when the document (a letter) reaches the target or someone decides not to participate.

Milgram's experiment (II)

Starters (n = 296)

– Random sample of Boston Residents (n=100) control for proximity
– Random sample from all Nebraska (n = 96)
– A Sample of share owners from Nebraska (n=100)To control for business interests

- Target: A stockbroker living in Boston
- Target: A stockbroker living in Boston
- *"If you know the target person on a personal basis, mail this folder directly to him. Do this only if you have previously met the target person and you know each other on a first name basis. If you do not know the target person…..mail this folder to personal acquaintance who is more likely than you to know the target person….. It must be someone you know personally."*
- A roster was attached to the folder with the signature of each sender. This prevented looping back and forth
- Of the 296 subjects 217 moved their documents
- The target received 64
- The other were incomplete chains (with the probability of forwarding the document increasing with the number of intermediaries)

Milgram's experiment (III)
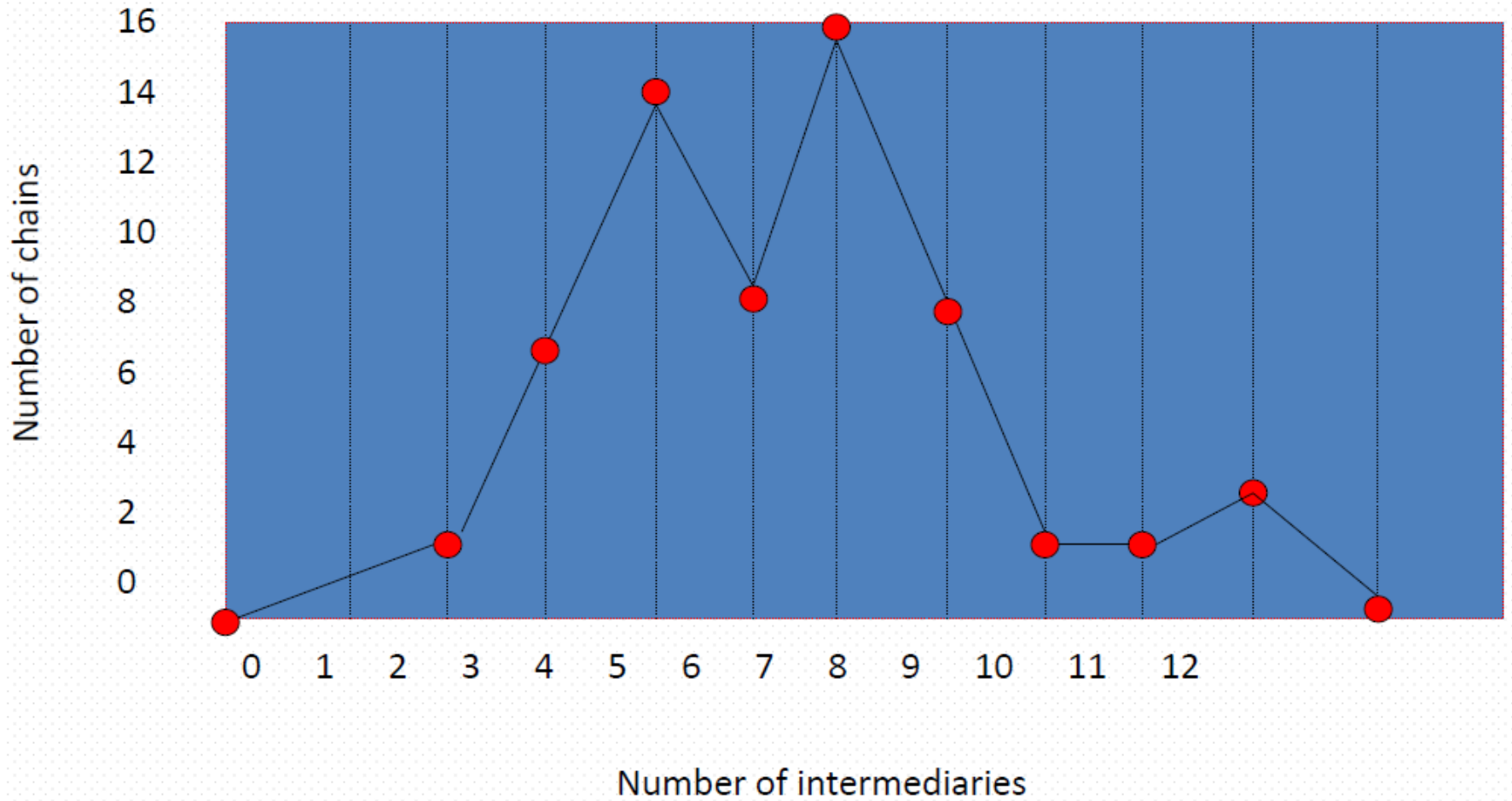
Milgram's experiment (IV): Six degrees of separation

- This result is the source of the so called "six degrees of separation" that seems to characterize a variety of different social, economic and biological networks

- By "small world networks" we mean networks with low average degree (sparse) but short path lengths

- The small world property has been documented in very diverse networks

What we do in standard empirical social science research?

We collect data from a sample of individuals

No structure on the domain!

Simple structure on the domain!

μ
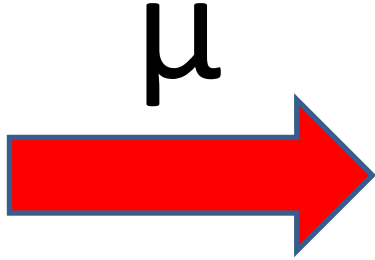
35

27

18

43

51

22

36

The range of the function μ is structured by the type of measurement scale used.

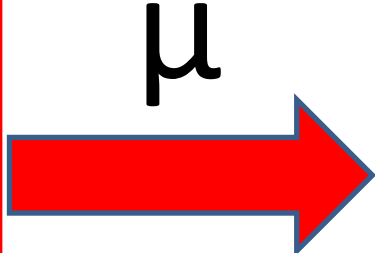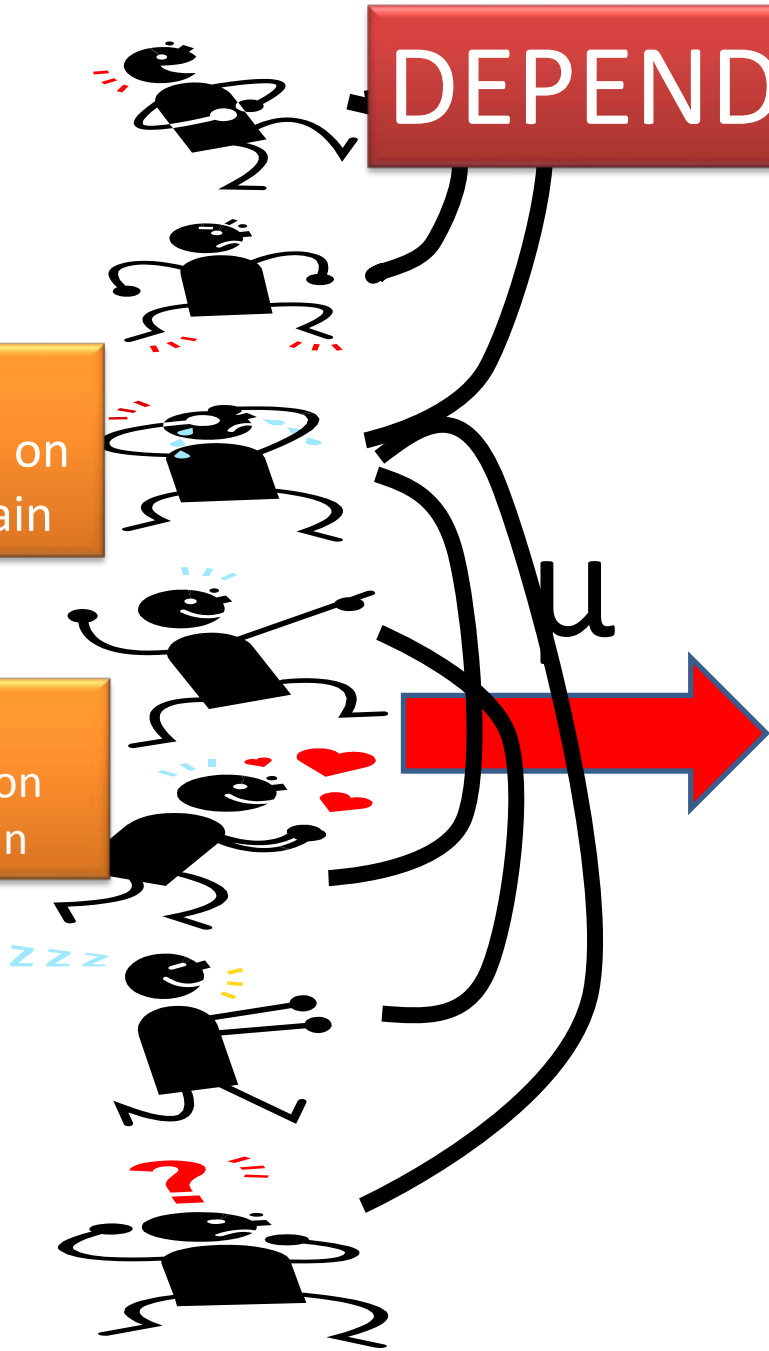Analysis by GLM:
$f(Y) = \alpha + \beta X + \varepsilon$

Hierarchical linear model extensions of GLM

DEPENDENCE!!

Simple structure on the domain

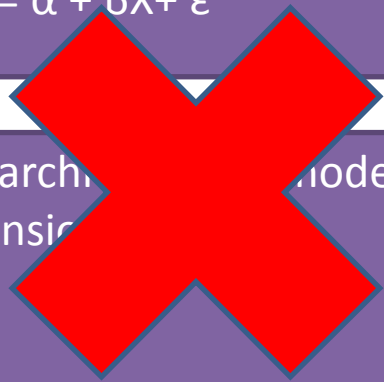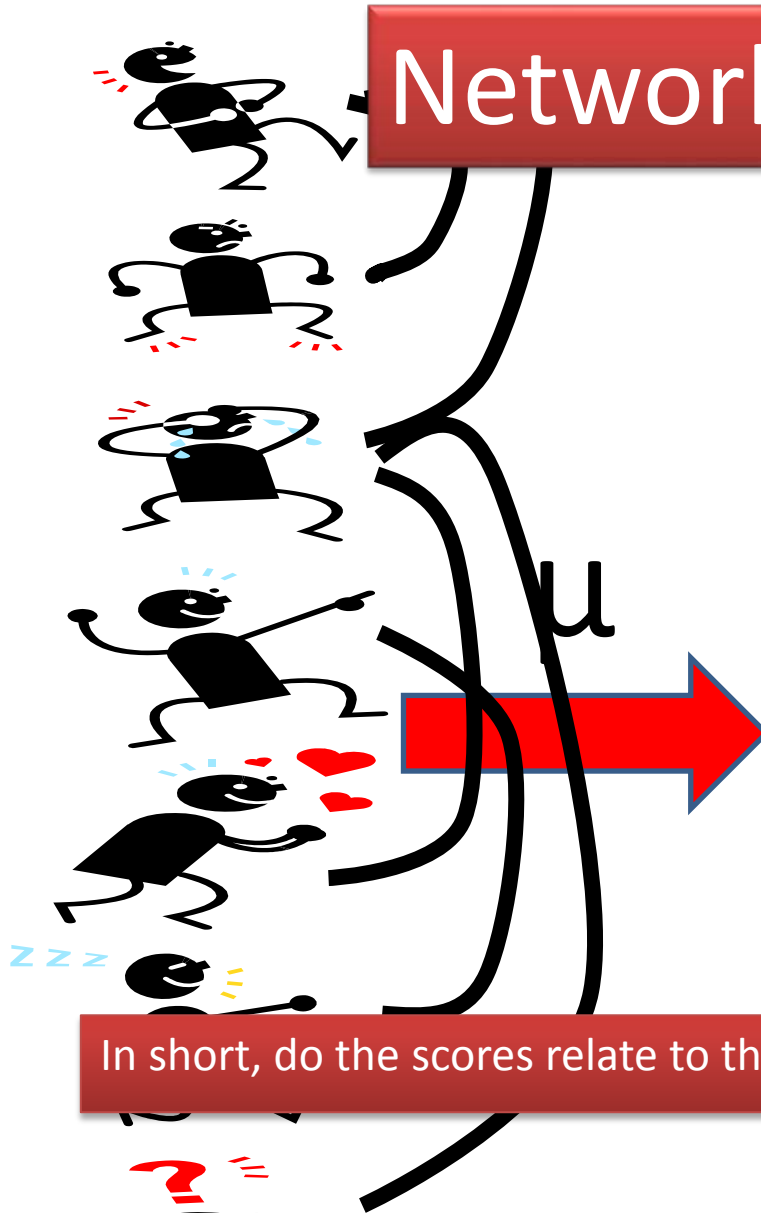Complex structure on the domain

µ

27

18

43

51

22

36

Analysis by GLM:
$f(Y) = \alpha + \beta X + \varepsilon$

Hierarchi... ...odel extensi...

Network Analysis

27

18

μ

43

51

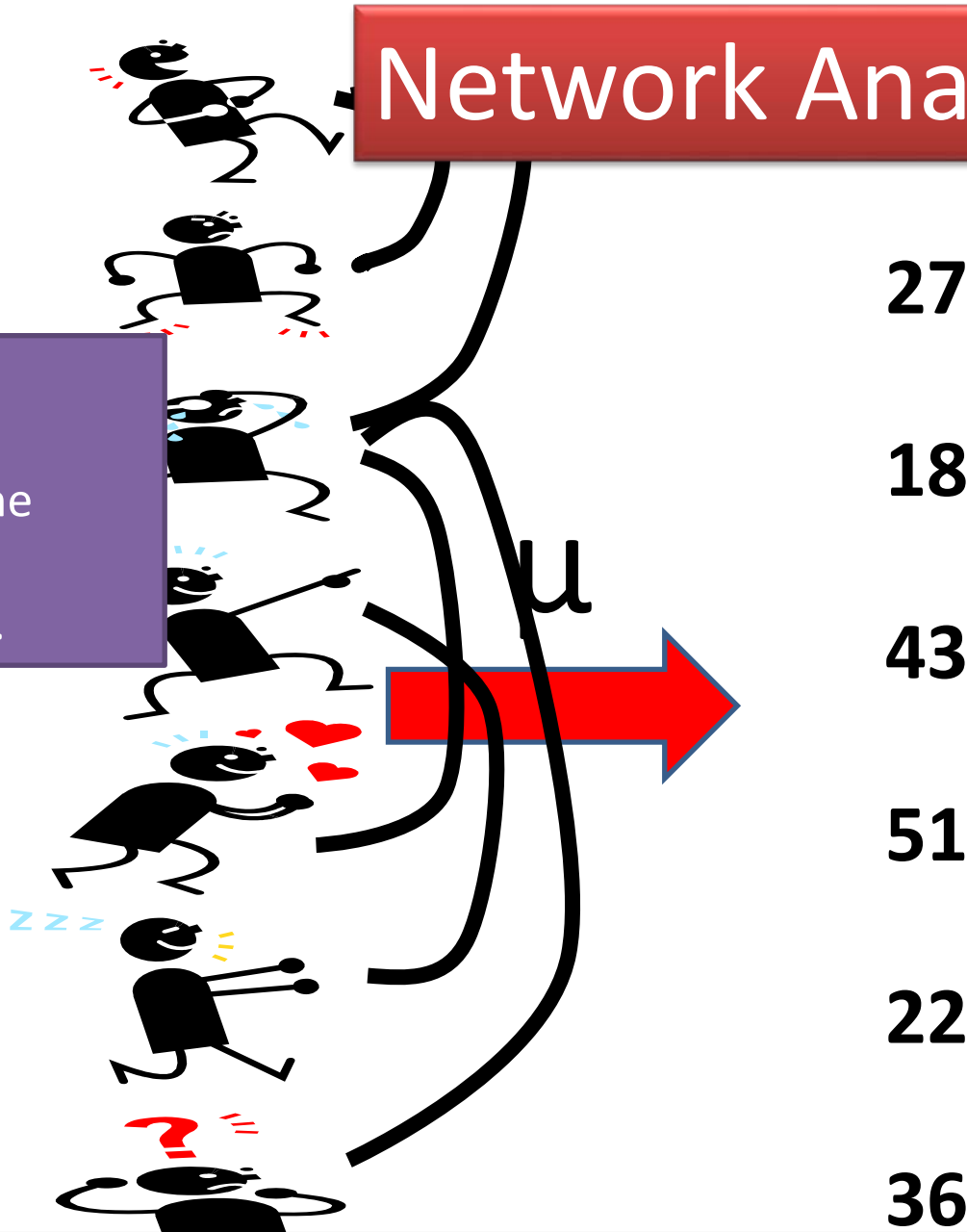**Research question:** Explain the scores from measurement μ, GIVEN the network structure on the domain of μ.

In short, do the scores relate to the structure?

Social influence, diffusion, contagion

Network Analysis

Research question: Explain the network structure.

μ'

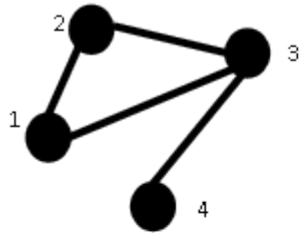| 0 | 1 | 1 | 0 | 0 | 0 | 0 |
1	0	0	0	0	0	0
1	0	0	0	1	0	1
0	0	0	0	0	1	0
0	0	1	0	0	0	0
0	0	0	1	0	0	0
0	0	1	0	0	0	0

Some basic terms

- *Actor*

  (Graph theory: Node, Vertex)

- *Relational tie*

  (Graph theory: Edge, Arc)

- *Directed vs Undirected networks*

(a)

	1	2	3	4
1	0	1	1	0
2	1	0	1	0
3	1	1	0	1
4	0	0	1	0

(b)

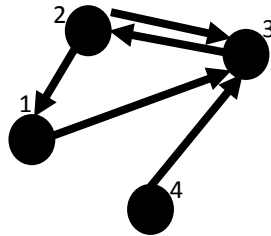| 0	1	1	0
1	0	1	0
1	1	0	1
0	0	1	0

(c)

1 2
1 3
2 3
3 4

(d)

(a)   Graph
(b)   Adjacency matrix with row and column headings
(c)   Adjacency matrix
(d)   Edge list

(a)

	1	2	3	4
1	0	0	1	0
2	1	0	1	0
3	0	1	0	0
4	0	0	1	0

(b)

0	0	1	0
1	0	1	0
0	1	0	0
0	0	1	0

(c)

1 3
2 1
2 3
3 2
4 3

(d)

(a)   Graph
(b)   Adjacency matrix with row and column headings
(c)   Adjacency matrix
(d)   Edge list

35

X$_{ij}$ ... network variables

27

Network structure creates dependence within individual attribute variables

0	1	1	0	0	0	0
1	0	0	0	0	0	0
1	0	0	0	1	0	1
0	0	0	1	0		
1	0	0	0	0		
0	1	0	0	0		
1	0	0	0	0		

18

43

51

Y$_i$ ... attribute variables

22

36

$$\begin{matrix} 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \end{matrix}$$

Network structure creates dependence within individual attribute variables

Dependence among network variables creates network patterns – *network self organization*
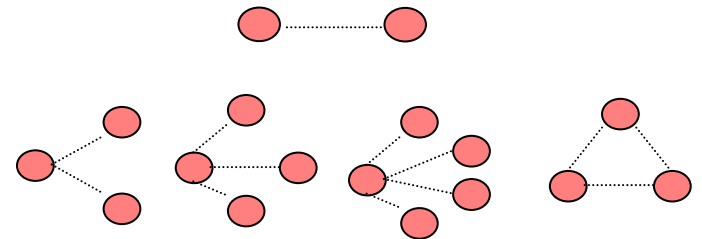
Why should one study social networks?

- Does the social environment affect individual outcomes? Does some property "flow" across the social system from individual to individual?

- Do individuals in certain social positions have different outcomes?

- How do individuals affect social structure? Why do individuals choose their social partners?

- What social processes underpin and sustain the social system?

Why should one study social networks?

- How are individual outcomes and the social system intertwined? What causal processes might be present: are individual or social factors (or both) the best explanation of the issue you are studying?

- What are the global outcomes of the social system? Is the system effective? Is it possible to intervene to improve outcomes?