

INTRODUCTION TO SOCIAL NETWORK ANALYSIS

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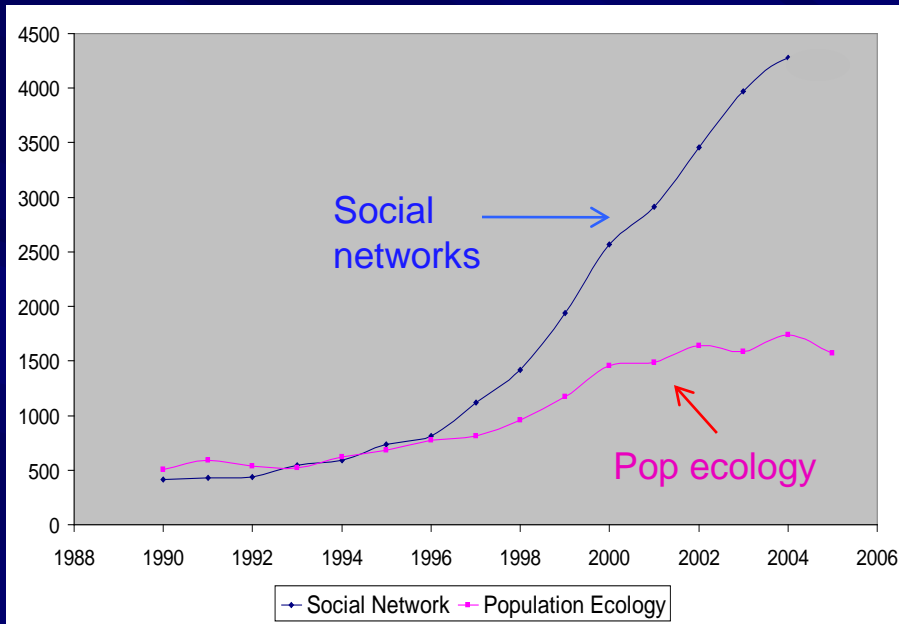
In this presentation ...

- SNA as a discipline
- What is distinct
- Overview of theoretical concepts
- A few methodological issues



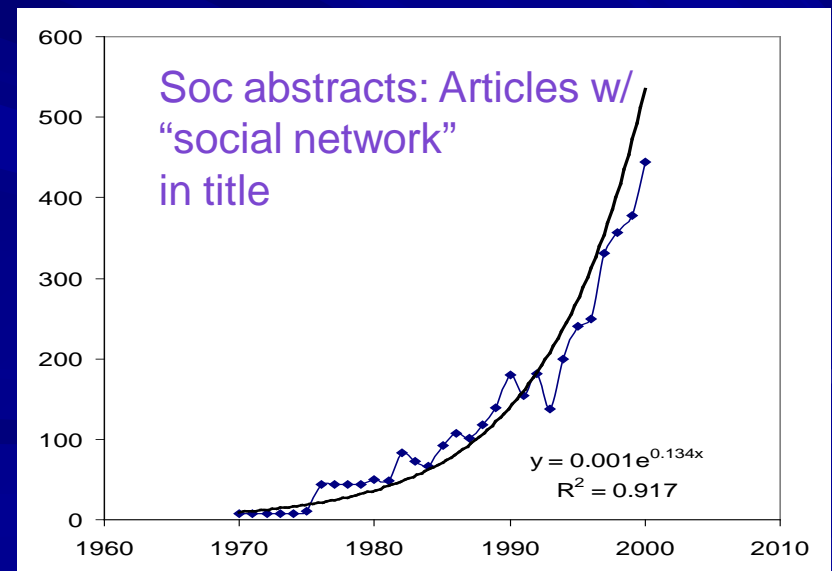
Painting by Idahlia Stanley

Explosive Growth



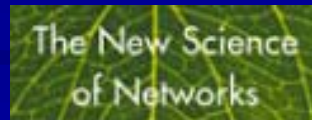
- Google page rank
- Social networking software
- Management consulting
- Network organizations
- Anti-terrorism
- Epidemiology

- Embeddedness, social capital, SRT, collab theory
- TCE, RD, Institutional theory, transactional knowledge, etc



Development of the Field

- 1900s
 - Durkheim
 - Simmel
- 1930s Sociometry
 - Moreno; Hawthorne studies
 - Erdos
- 1940s Psychologists
 - Clique formally defined
- 1950s Anthropologists
 - Barnes, Bott & Manchester school
- 1960s Anthros & graph theorists
 - Kinship algebras; Mitchell
 - Harary establishes graph theory w/ textbooks, journals, etc
- 1970s Rise of Sociologists
 - Modern field of SN is established (journal, conference, assoc, etc)
 - Milgram small-world (late '60s)
 - White; Granovetter weak ties
- 1980s Personal Computing
 - IBM PC & network programs
- 1990s Adaptive Radiation
 - UCINET IV released; Pajek
 - Wasserman & Faust text
 - Spread of networks & dyadic thinking; Rise of social capital,
- 2000s Physicists' "new science"
 - Scale-free
 - Small world



Formal Organization

■ Professional Assoc. (since '78)

- Int'l Network for Social Network Analysis -
www.insna.org

- Incorporated 1993

■ No dept. of Social Network Analysis

- But a few centers ...

■ Centers

- LINKS (U of Kentucky)
- Network Roundtable (U of Virginia)
- CASOS (Carnegie Mellon)
- Networked Governance (Harvard)
- Watson Research Center (IBM)
- NICO (Northwestern)
- ISNAE
- IMBS (UC-Irvine)
- Coalition Theory Network (European consortium)
- CCNR (Notre Dame, Physics)
- Nuffield Network Researchers (Oxford)
- Bader Lab (U of Toronto, Biology)
- CSSS (U of Washington, Statistics)

Conferences

- ION conference, U of KY
(by invitation only)
- Sunbelt annual
conference (since '79)
 - 2001: Budapest, HUNGARY
 - 2002: New Orleans, USA
 - 2003: Cancun, MEXICO
 - 2004: Portorôš, SLOVENIA
 - 2005: Los Angeles, USA
 - 2006: Vancouver, CANADA
 - 2007: Corfu, GREECE
 - 2008: St Pete, Florida, USA
 - 2009: San Diego, USA
 - 2010: Lake Garda, ITALY



June 29-Jul 04, 2010

Abstracts due today, Jan 15, 2010!

Drink the Kool-Aid!
Come to the conference!



Annual Workshops

- Sunbelt social networks conference
 - Multiple 1-day workshops at different levels
- Academy of Management
 - Several professional development workshops (PDWs)
- University of Essex, UK
 - 2-week in-depth courses at three levels of advancement
- CARMA
 - 2.5 day workshop
- ICPSR-Michigan
- University of Kentucky LINKS center
 - June 7-11, 2010. One week workshop with multiple tracks.

Resources

■ Specialized journals

- Social Networks, (since '79)
- CONNECTIONS, official bulletin of INSNA
- Journal of Social Structure (electronic)
- CMOT

■ Textbooks

- Kilduff & Tsai, 2004
- Scott, John. 1991/2000
- Degenne & Forsé. 1999
- Wasserman & Faust. 1994

■ Listservs & Groups

- SOCNET listserv (1993)
- REDES listserv
- UCINET user's group

■ Software

- UCINET 6/NETDRAW
- PAJEK
- SIENA
- ORA
- VISIONE
- STRUCTURE; GRADAP; KRACKPLOT

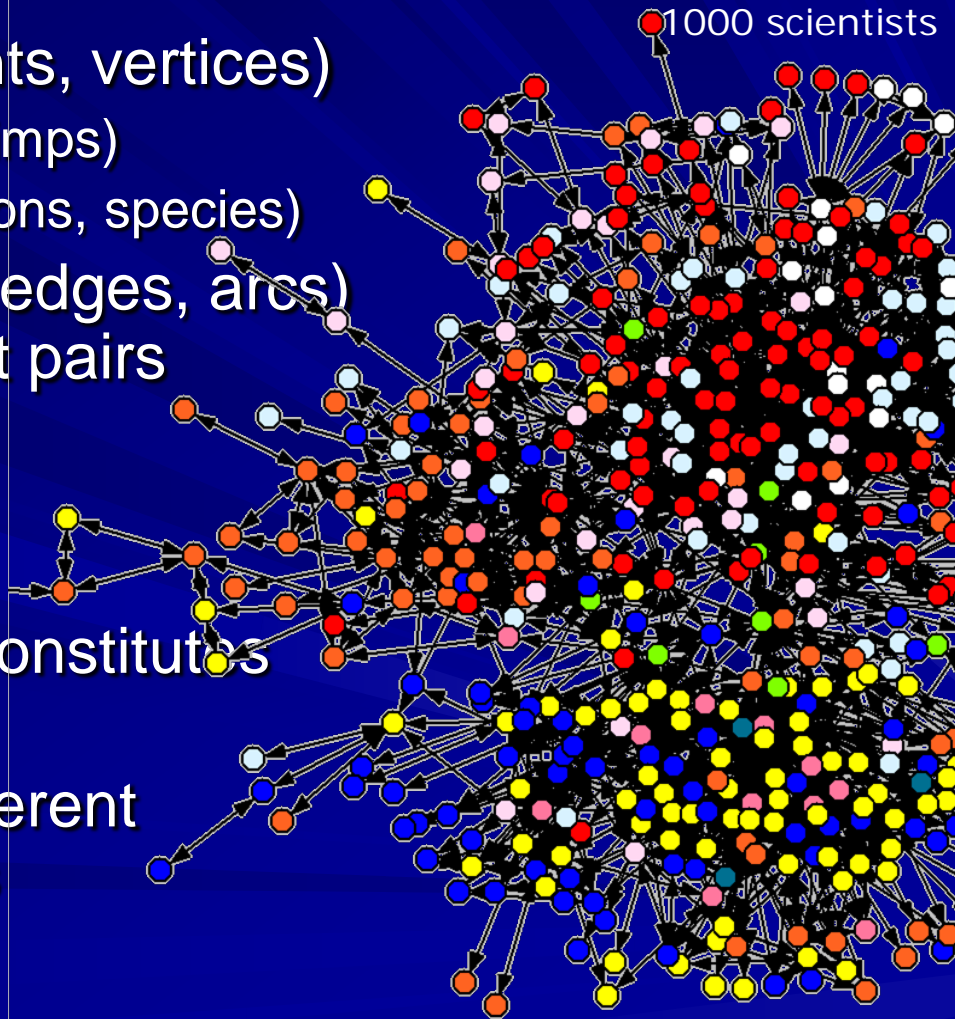
■ Online resources

- www.analytictech.com/mgt780
- <http://linkscenter.org>
- www.insna.org
- www.analytictech.com/networks

SOME BASICS

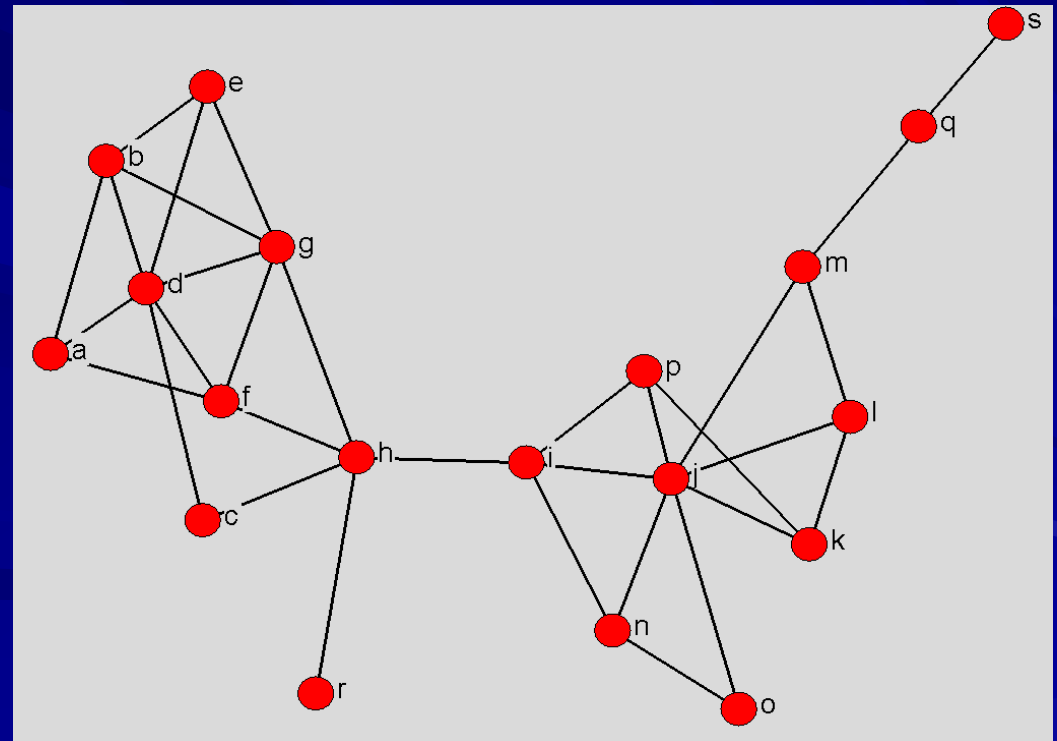
What is a Network?

- A set of actors (nodes, points, vertices)
 - Individuals (e.g., persons, chimps)
 - Collectivities (e.g., firms, nations, species)
- The set of ties (links, lines, edges, arcs) of a given type that connect pairs of actors in the actor-set
 - Directed or undirected
 - Valued or presence/absence
- Set of ties of a given type constitutes a social relation
- Different relations have different structures & consequences

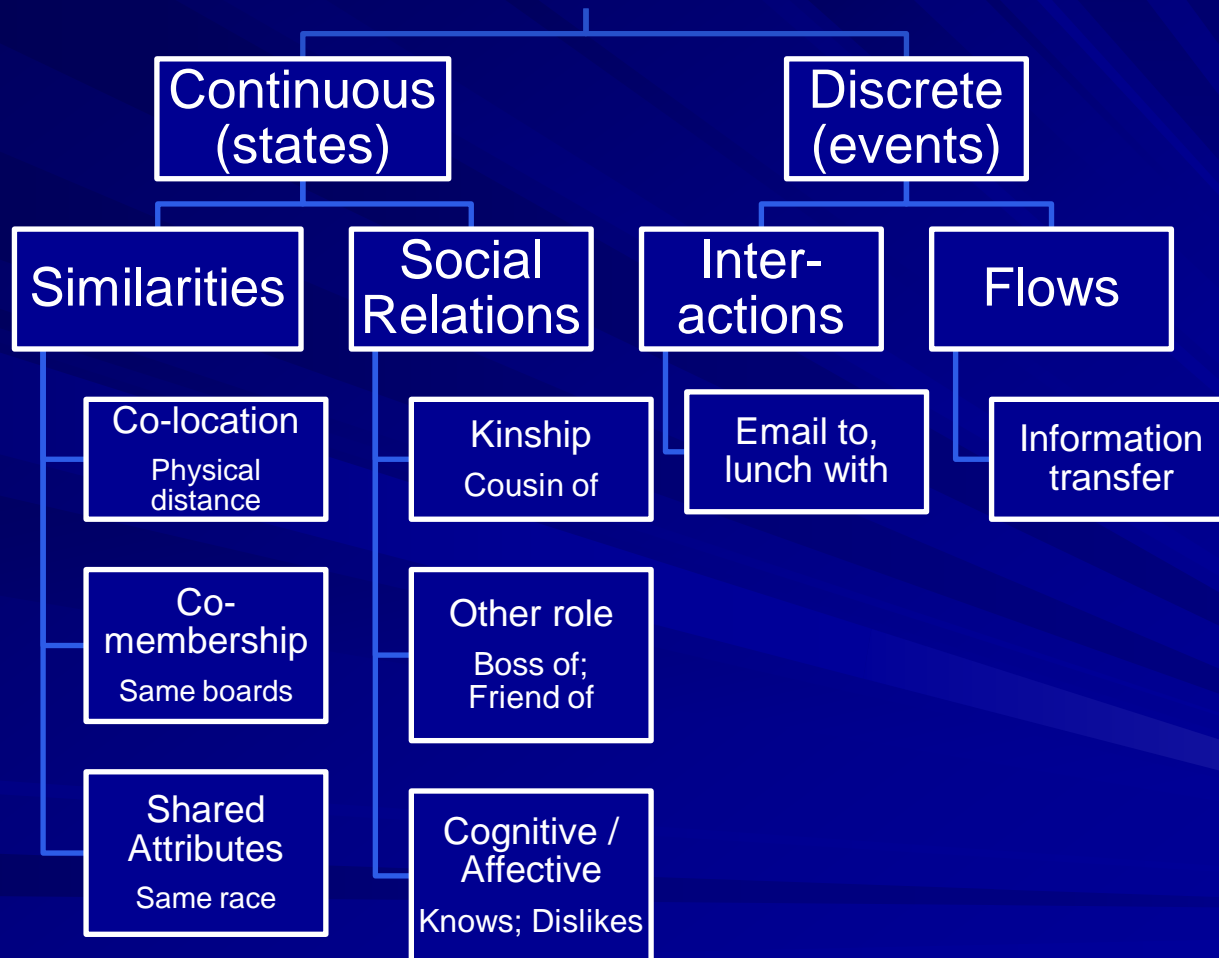


Notion of paths

- Because we look at all ties of a given type among a defined set of actors, the dyadic ties can link up to form chains of indirect connection
- Consequences of paths
 - Indirect influence
 - Flow to all connected parts
 - Searchability
 - Coordination of the whole

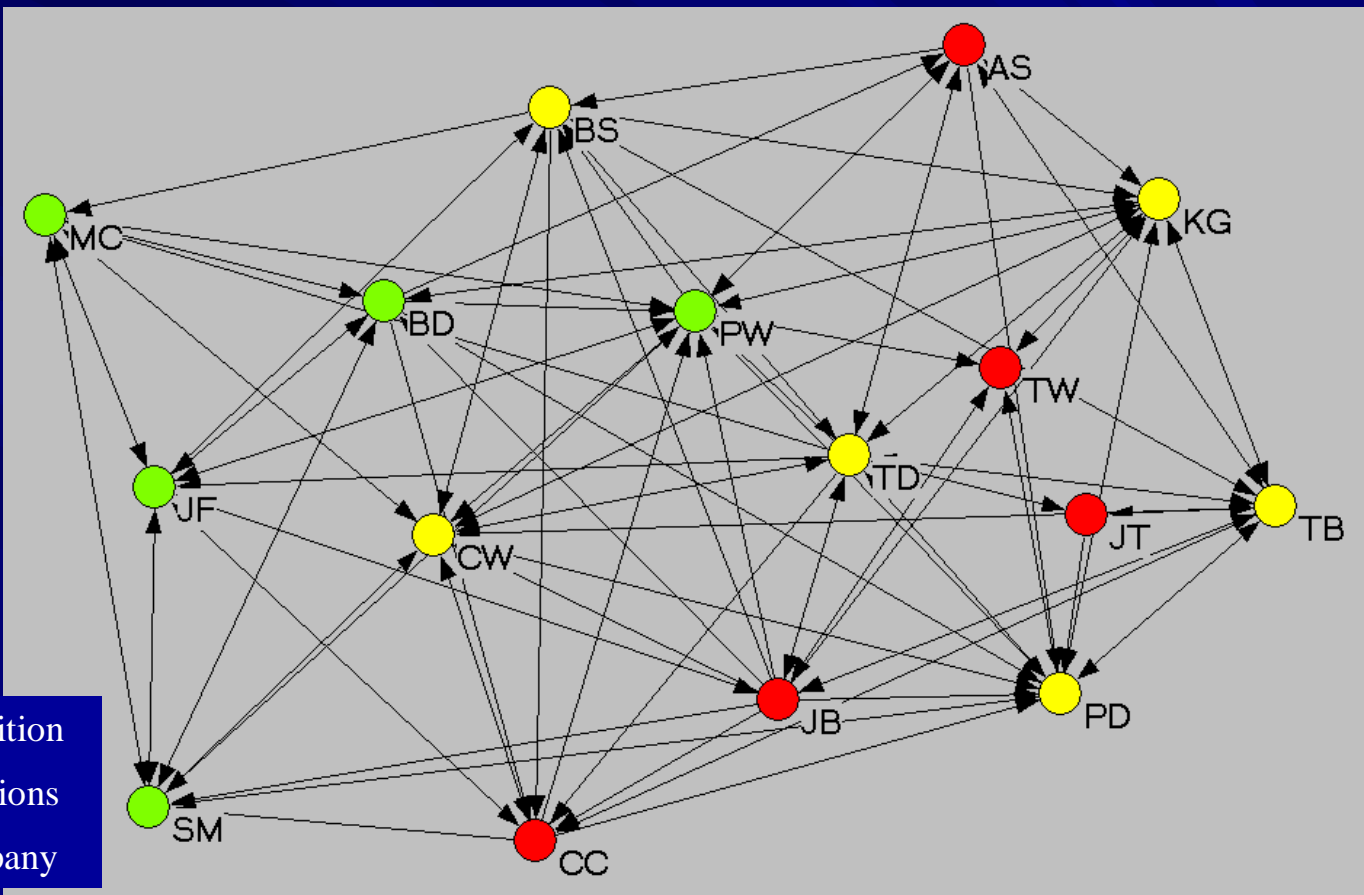


Types of Ties among Persons



Case Study: Simple Answers

Who you ask for answers to straightforward questions.

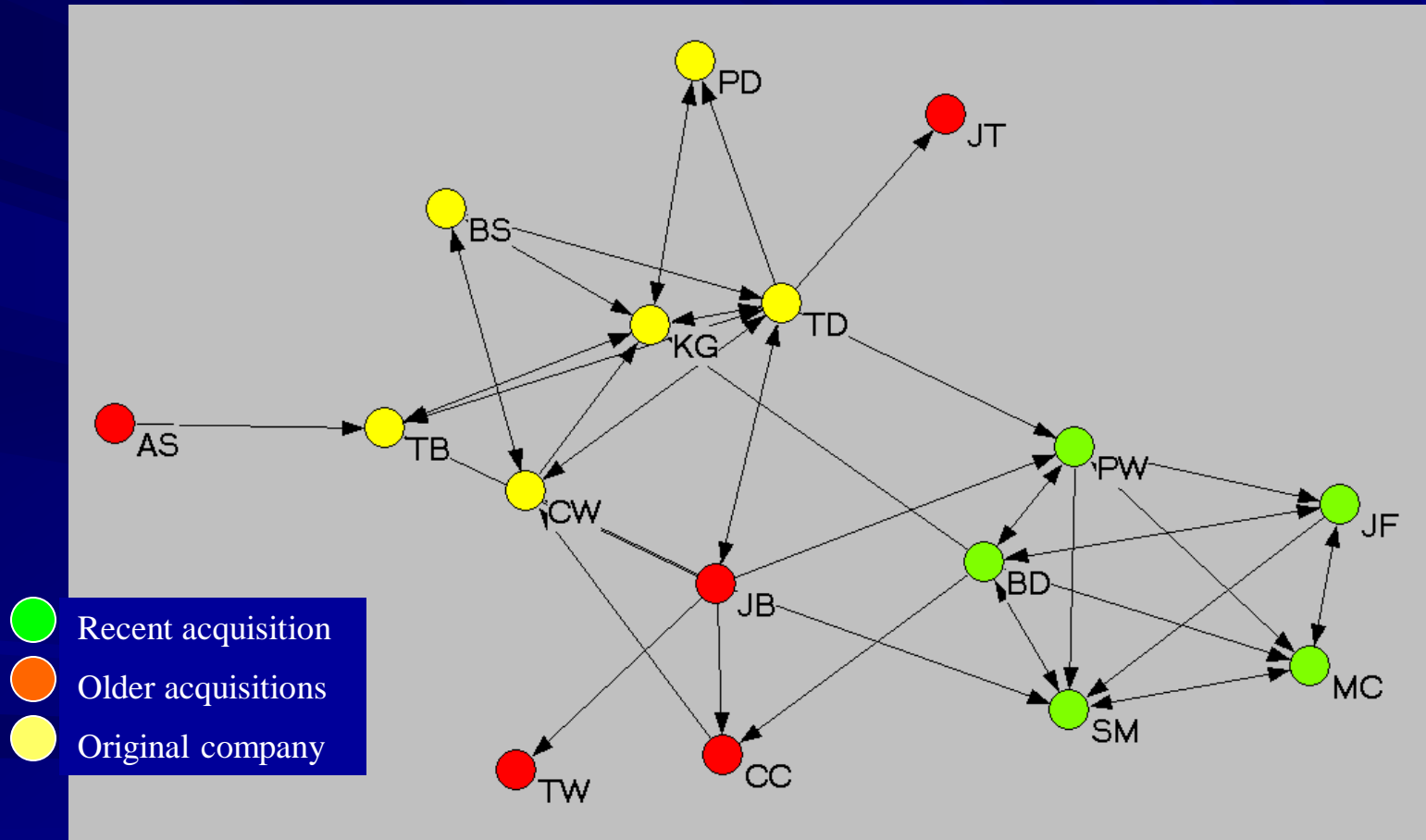


Cross, R., Borgatti, S.P., & Parker, A. 2001. Beyond Answers: Dimensions of the Advice

Network. *Social Networks* 23(3): 215-235

Problem Reformulation

Who you see to help you think through issues



Relations Among Organizations

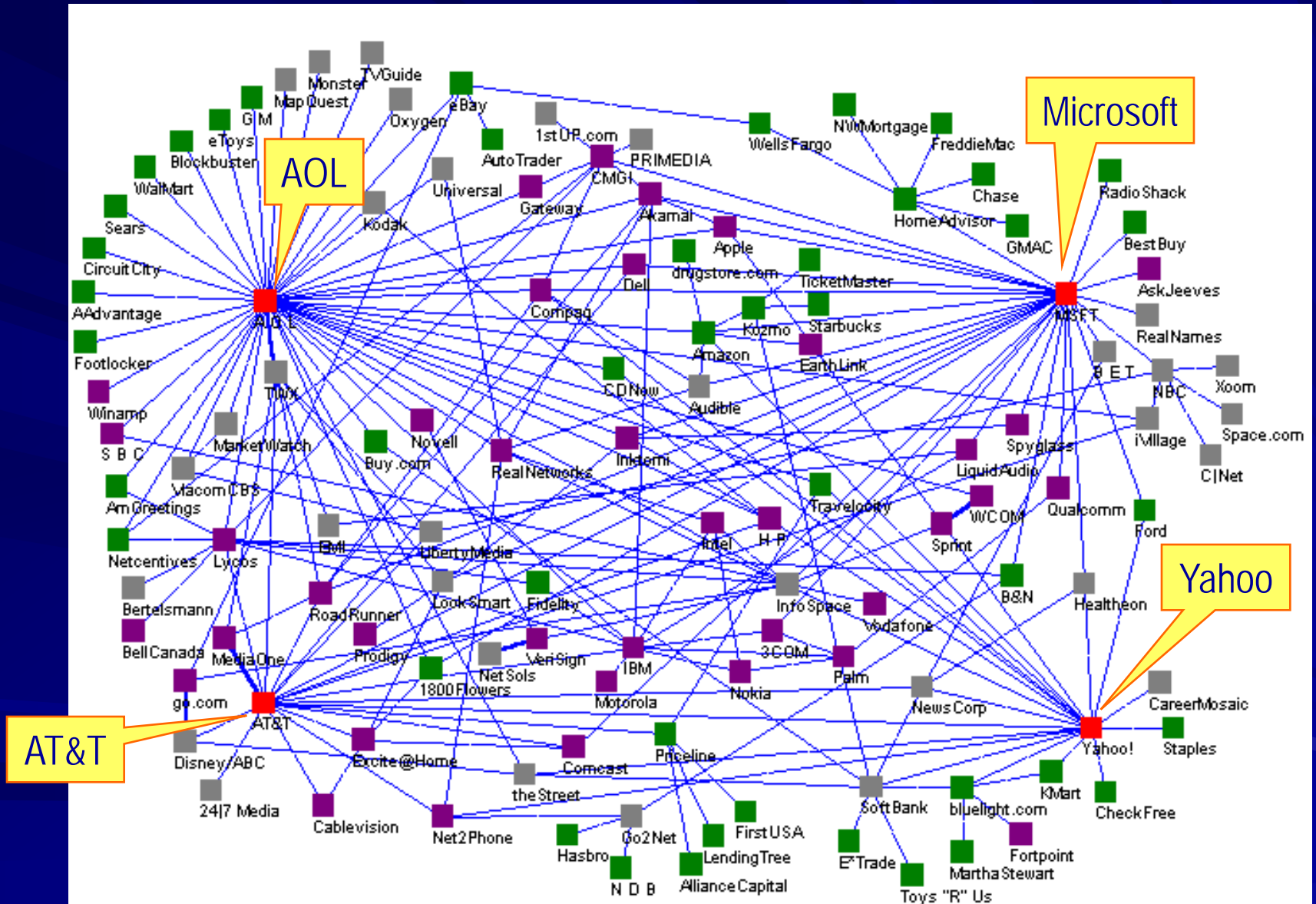
- As corporate entities
 - sells to, leases to, lends to, outsources to
 - joint ventures, alliances, invests in, subsidiary
 - regulates
- Through members
 - ex-member of (personnel flow)
 - interlocking directorates
 - all social relations

Types of Inter-Organizational Ties

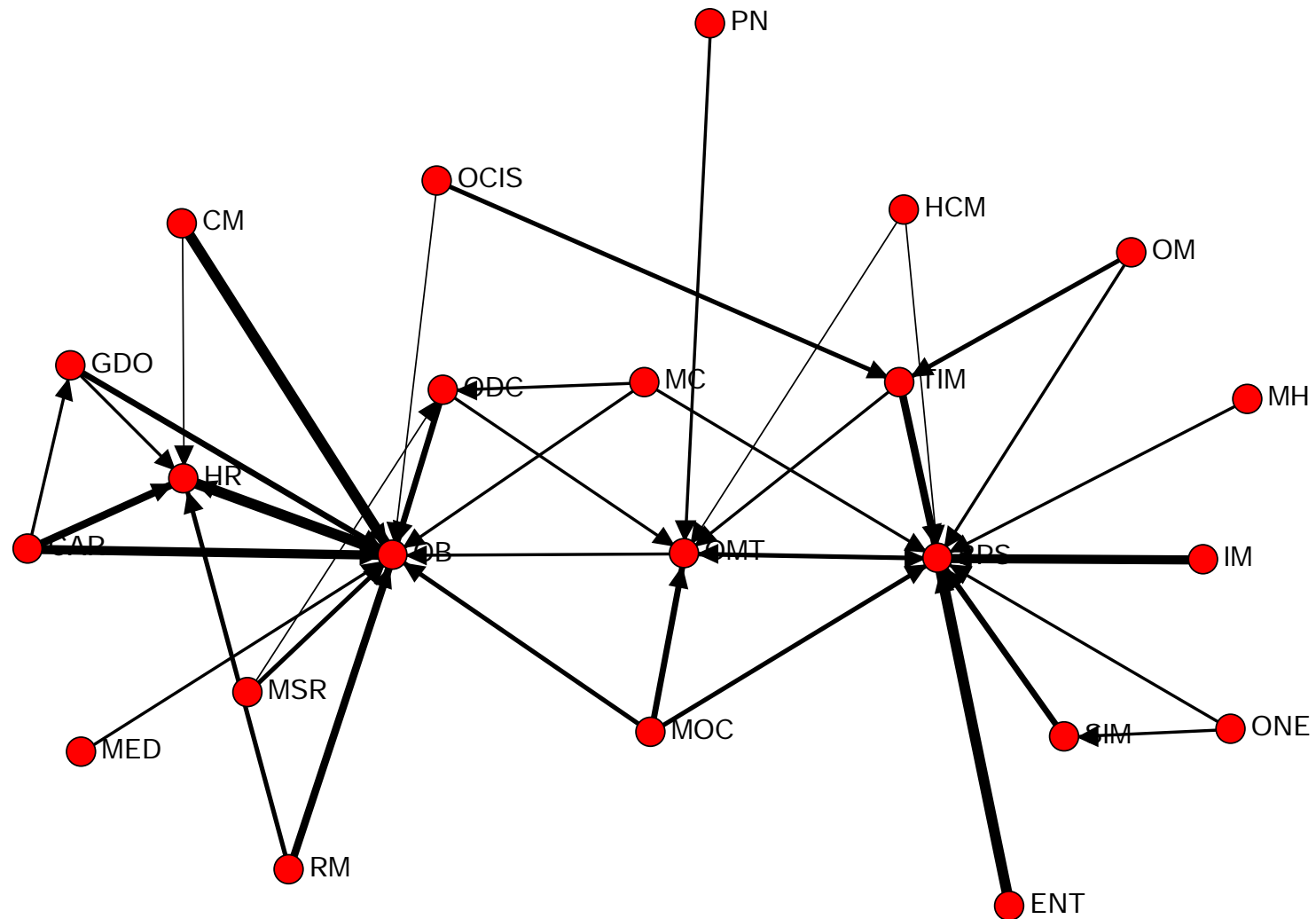
Cross-classified by type of tie and type of node

Type of Tie	Firms as Entities	Via Individuals
Similarities	Joint membership in trade association; Co-located in Silicon valley	Interlocking directorates; CEO of A is next-door neighbor of CEO of B
Relations	Joint ventures; Alliances; Distribution agreements; Own shares in; Regards as competitor	Chief Scientist of A is friends with Chief Scientist of B
Interactions	Sells product to; Makes competitive move in response to	Employees of A go bowling with employees of B
Flows	Technology transfers; Cash infusions such as stock offerings	Emp of A leaks information to emp of B

Internet Alliances



Academy of Management Division Co-Membership > 27%



Levels of analysis

- Dyad level
 - Cases are pairs of actors/nodes
 - Variables have a value for every pair of actors.
 - Vars are properties of relationships between pairs of actors
- Node level (note: nodes can be collective actors)
 - Cases are actors
 - Variables have a value for each actor
 - Vars are properties of the node's position in the network
- Group / Whole Network level
 - Cases are entire networks
 - Variables have a value for each group/network
 - Vars are properties of the network structure

Dyad Level

- Cases are pairs of actors/nodes
- Variables have a value for every pair of actors.
 - Vars are properties of relationships between pairs of actors
- Examples
 - Presence/absence of a given type between pairs of nodes
 - Who is friends with whom
 - Strength or duration of tie; frequency of interaction
 - Graph theoretic distance between pairs of nodes
 - No. of links in shortest path from A to B
 - Overlaps: Number of friends in common

Node level

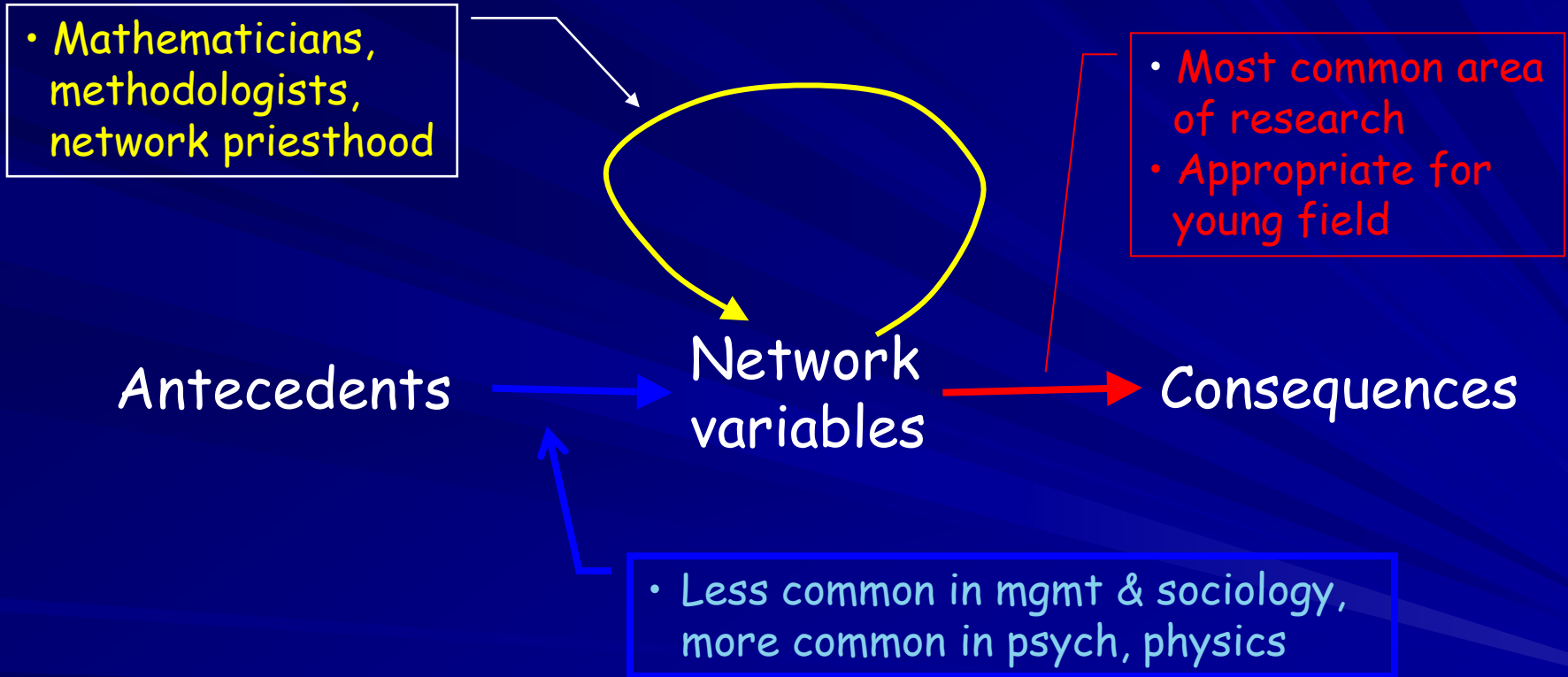
- Cases are actors/nodes
- Variables have a value for each actor
 - Vars are properties of the node's position in the network
- Examples
 - No. of ties of a given type each actor has
 - No. of friends
 - No. of strong ties; no. of simmelian ties; no. of reciprocated ties
 - Centrality
 - Network neighborhood composition
 - How many of node's friends are single
 - Structural holes

Group / Whole Network level

- Cases are entire networks
- Variables have a value for each group/network
 - Vars are properties of the network structure
- Examples
 - Network cohesion
 - Density: the proportion of pairs of nodes that have a tie of a given type
 - Average graph-theoretic distance among all pairs of nodes
 - Shape
 - Clumpiness: extent to which a network has clumps (small regions of network with many ties within, few to network as a whole)
 - Centralization: extent to which network revolves around one node



Causality and Network Research



Types of network theorizing

		Dependent Variable	
		Network Property	Non-Network Property
Independent Variable	Network Property	Network theory of networks	Network theory
	Non-Network Property	Theory of networks	Tired, old, mainstream attribute-based social science

Network Property = network–analytic property at any level of analysis, including dyad and node

Types of Network Theorizing by Level

	Type	Independent Variable	Dependent Variable	Example Hypotheses
Dyad Level	Net theory	Network tie	Attribute similarity	Friends → similar political attitudes
	Theory of net	Attribute similarity	Network tie	Smoking → friendship
	Net th. of nets	Network tie	Network tie	doing business w/ ea other → friendship
Node Level	Net theory	Node level network property	Actor attribute	Centrality → performance
	Theory of net	Actor attribute	Node level network property	Good looks → centrality
	Net th. of nets	Node level network property	Node level network property	Degree → betweenness
Group Level	Net theory	Group level network property	Other group attribute	Density → team performance
	Theory of net	Other group attribute	Group level network property	Prop women → density of trust ties
	Net th. of nets	Group level network property	Group level network property	Density → Avg path length

Antecedents

THEORY OF NETWORK

Theory of Network by Levels of analysis

■ Dyadic

- How ties are formed/dissolved
- Antecedents of dyadic properties, such as number of friends in common, or the length of shortest path between two nodes

■ Node

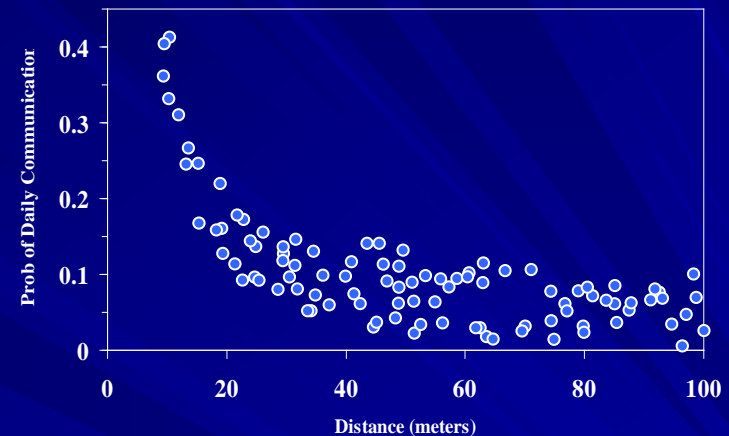
- How nodes come to occupy the positions they do
- How nodes acquire the network neighborhoods that they do
- E.g., antecedents of centrality, or of structural holes

■ Network / group

- How networks come to have the shape they do
- Antecedents of network density
 - Why is this group's trust network so much denser than that one's?

Antecedents of Ties

- Homophily: people who are similar on socially significant attributes more likely to form ties, interact, exchange flows, etc with each other
 - Same location → prob of interaction
- Preferential attachment
- Balance theory / cognitive dissonance / norms
 - Force toward transitivity and reciprocity
- Other ties (force toward multiplexity)
 - Interaction → relations; Interaction → flows; Relations → interaction → flows
 - Coercion → helping
 - Friendship leading to business partnership



	Male	Female
Male	1245	748
Female	970	1515

Homophily

- Tendency to interact with or have positive relations with people who are similar to oneself along socially significant lines

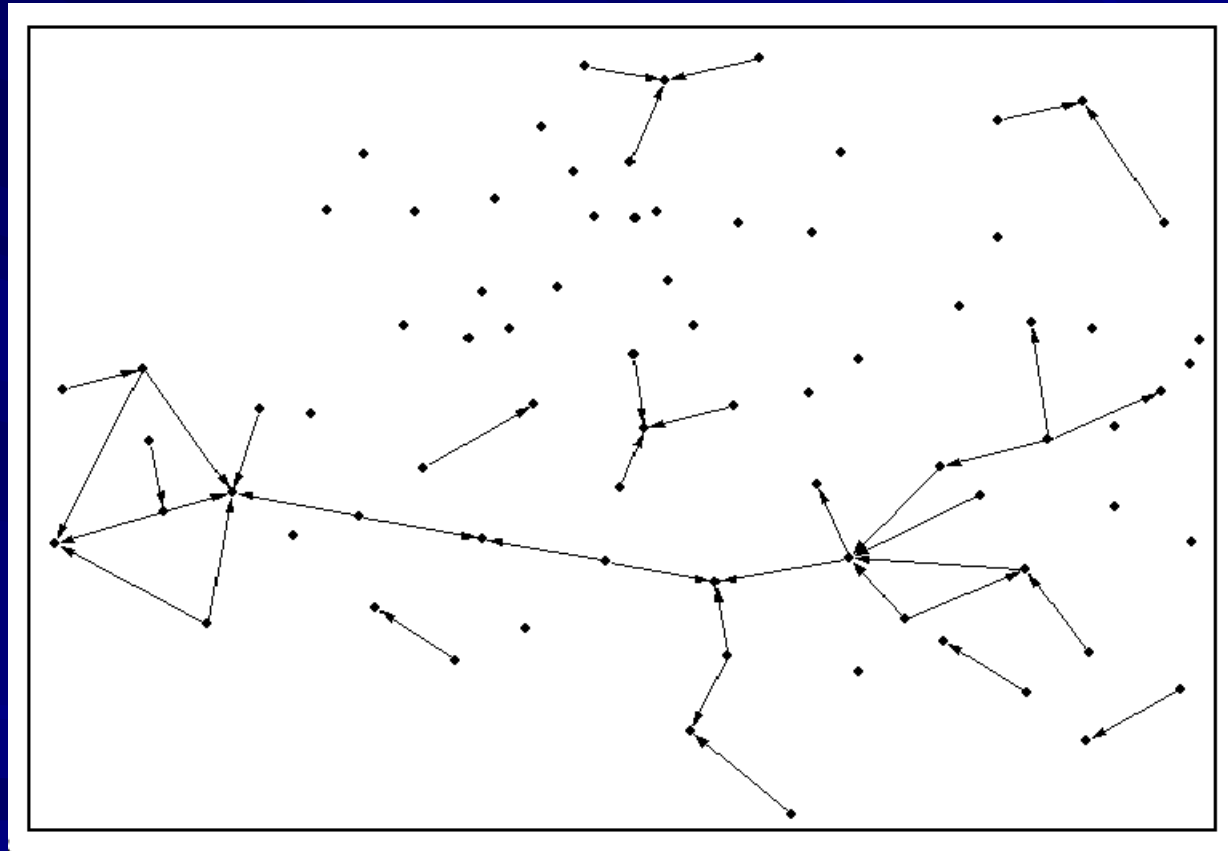
Gender	Male	Female	Race	White	Black
Male	1245	748	White	3806	29
Female	970	1515	Black	40	283

Age	< 30	30 - 39	40 - 49	50 - 59	60 +
< 30	567	186	183	155	56
30 - 39	191	501	171	128	106
40 - 49	88	170	246	84	70
50 - 59	84	100	121	210	108
60 +	34	127	138	212	387

Antecedents of Centrality

- Personality characteristics
 - Self-monitoring → centrality
- Skills
- Status/prestige/resources
 - Having things others want
- Centrality on other relations
 - Centrality in advice translating into centrality in friendship

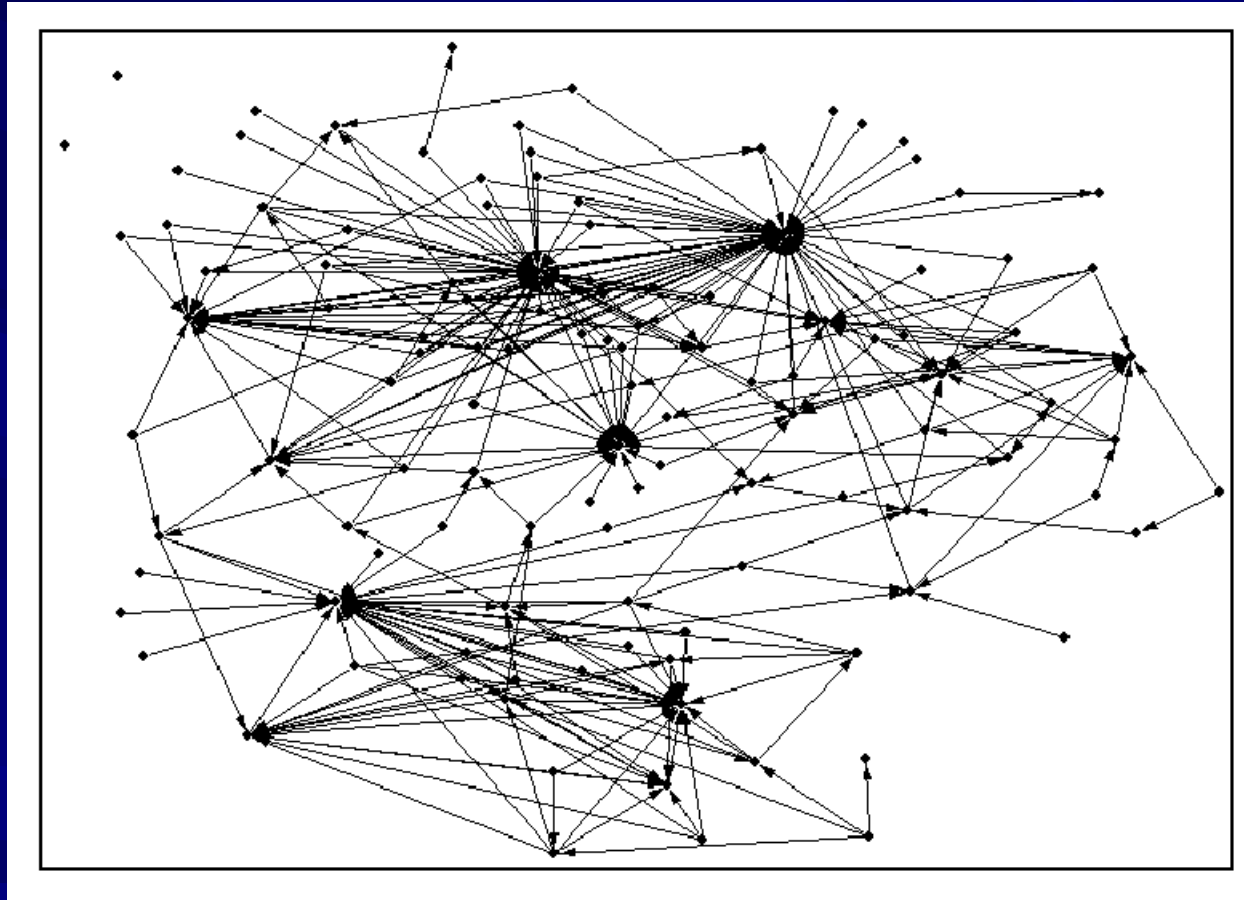
Case Study: Entwistle et al study of help with the rice harvest



Village 1

Data from Entwistle et al

Help with the rice harvest



Village 2

A note on network change

- US gov't wants to know whether they can predict when and where networks will emerge
- But from modeling point of view
 - networks always are
 - once you define a set of nodes and a type of ties there is a network, even if it is so sparse as to be empty
 - What actually changes over time are ties. As they change
 - the structure of the network changes
 - The positions of nodes changes
- Folk view of “network” is more like “group”
 - People talk of membership in multiple networks

Consequences of net-theoretic mechanisms

NETWORK THEORY

Mainstream Social Science

- Individual outcomes as a function of individual attributes
 - Predict career success as a function of a person's training, experience, skills, looks, etc .
- Analysis consists of correlating columns
 - Typically identify one column as the thing to be explained
 - We explain one attribute as a function of the others

Variables
(attributes)

	Age	Sex	Education	Income
1001				
1002				
1003				
1004				
1005				
...				

Cases
(entities)

Attributes to Relations

- Shift from *attributes of the individual* as sole explanation to their *relationships and interactions with others* as also explanatory

Environment

■ Shift ...

- away from intrinsic, dispositional characteristics of the individual unit as sole cause of individual outcomes
- to adding situational, environmental factors

• Weberian bureaucracy
• Taylorism / Sci Mgmt
• Early contingency theory



• Resource dependence
• Institutional theory
• Late contingency theory

Open systems

Environments in network analysis

- Very rich concept of environment
- Types of nodes connected to
- Structure of one's contacts are related to each other

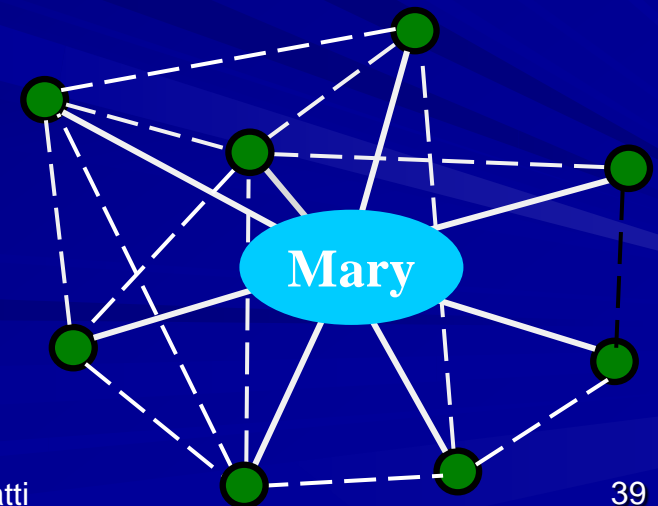
What's entailed in this shift?

■ Theory

- Looking to the person's environment for explanation
 - Seeing that environment as individuals
 - Focusing on the nature of the ties with those individuals
- Interpersonal processes as influence, contagion

■ Methodology

- Collecting data on relationships as well as individuals
- New unit of observation: the dyad



What else is entailed?

- Structure matters!
- Position matters!

Generic goals of network theory

- Explaining performance/rewards as a function of network properties
 - Benefits of ties/position/structure
 - position → opportunities and constraints
 - Status attainment; achievement as results of position in network or characteristics of network neighborhood
 - Social capital stream
- Explaining homogeneity of actor characteristics as a function of network properties
 - Why do certain people have the same attitudes? Influence process
 - Adoption of Innovation / Diffusion stream

Social Capital stream

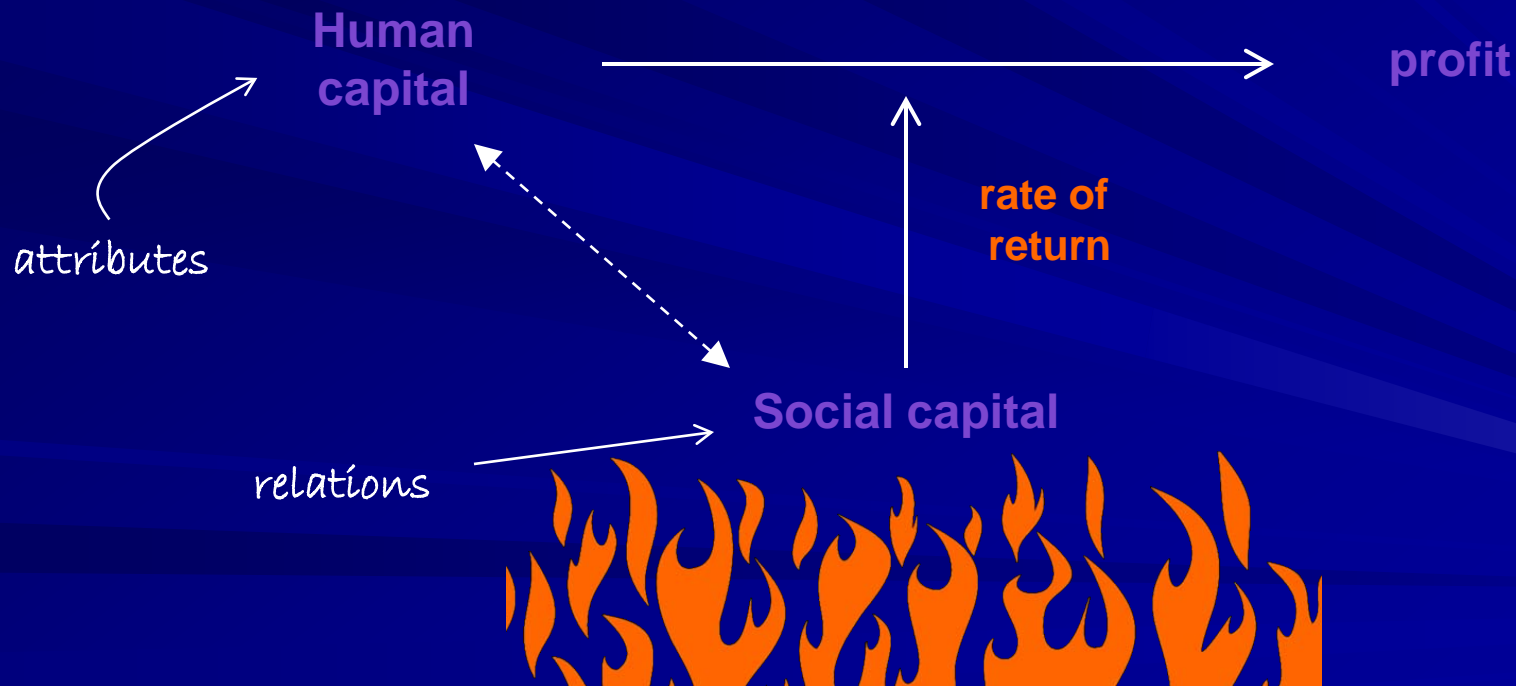
- Explaining performance/rewards as a function of network properties
 - Benefits of ties/position/structure
- Dyad level
 - quality of negotiated results between parties as a function of whether the parties are friends or not
- Node level:
 - Power in organization as a function of centrality
 - Speed of promotion as a function of structural holes
 - Resistance to colds as a function of number of friends
- Network level
 - Team's ability to solve problems as a function of centralization of communication network within the team

The case of entrepreneurial success

- Success a function of entrepreneur's talents and resources
- But the person themselves don't have to have all of these talents themselves,
 - they do need to know someone who does
- It's who you know, and what qualities those people have
- And it's about the nature of your relationship – can you draw on their resources?
 - Social resource theory (Nan Lin)

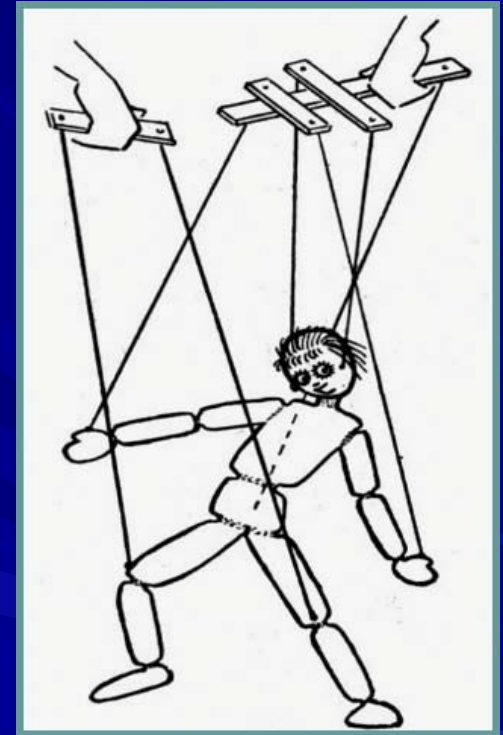
Rate of return on human capital

- Burt (1992): A person's connections determine the rate of return on human capital

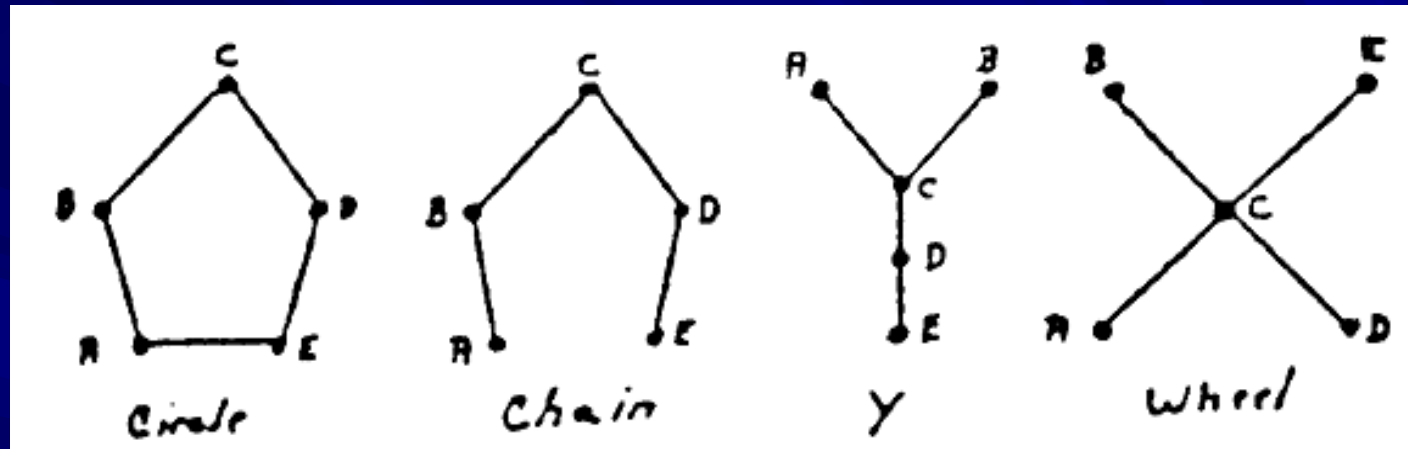


Other perspectives on social capital

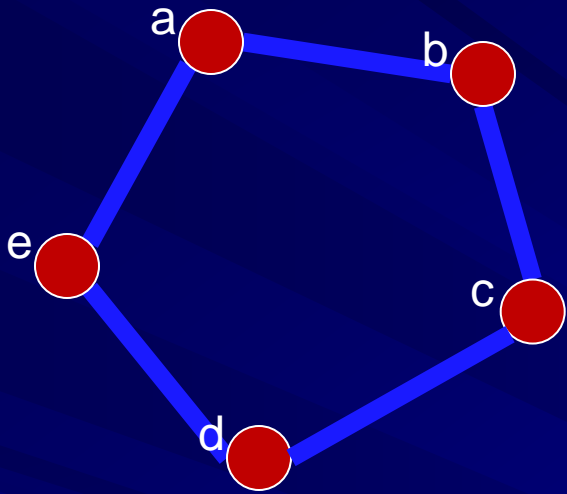
- Coleman
 - Social capital → human capital → achievement
- Diamond in the rough
 - Human capital → achievement → social capital
- Virtual human capital
 - Remote control of resources via social ties



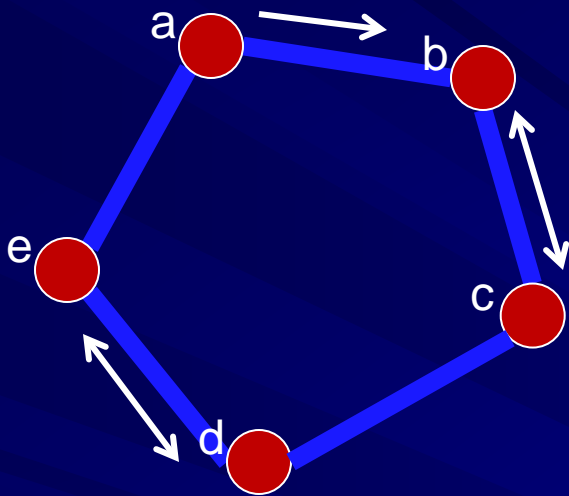
Bavelas-Leavitt experiments



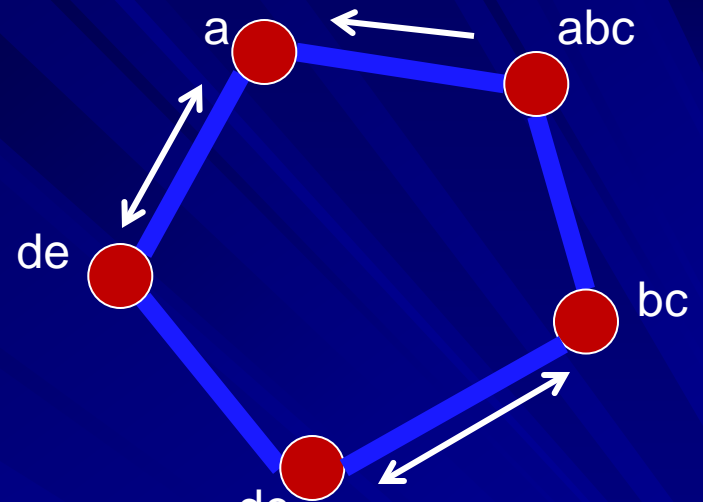
FPT	3	5	4	5
Time	50.4	53.2	35.4	32
No. of errors	7.6	2.8	0	0.6
No. of msgs	high	low	low	low



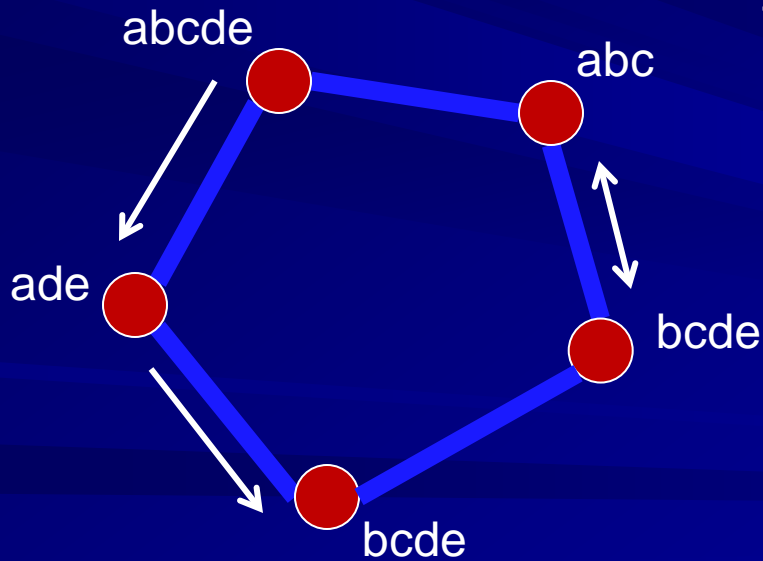
T0



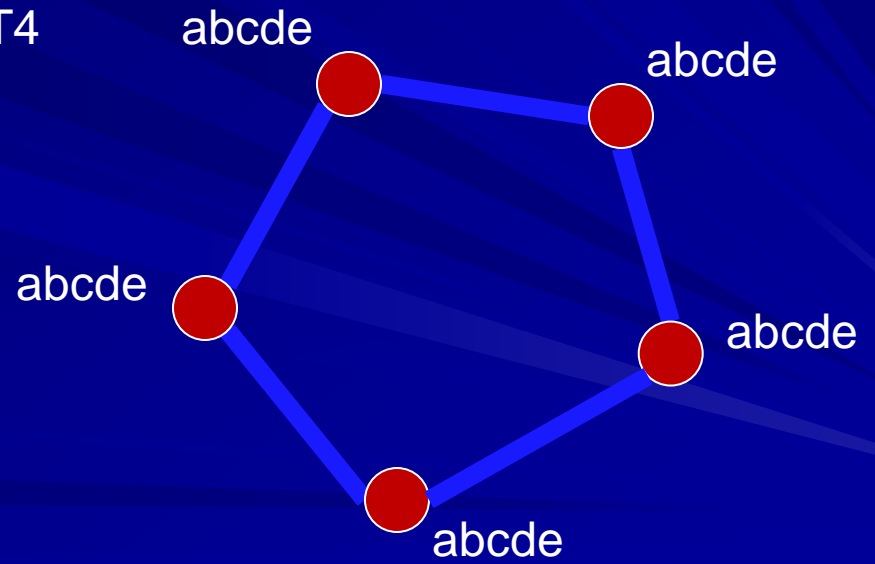
T1



T2



T3



T4

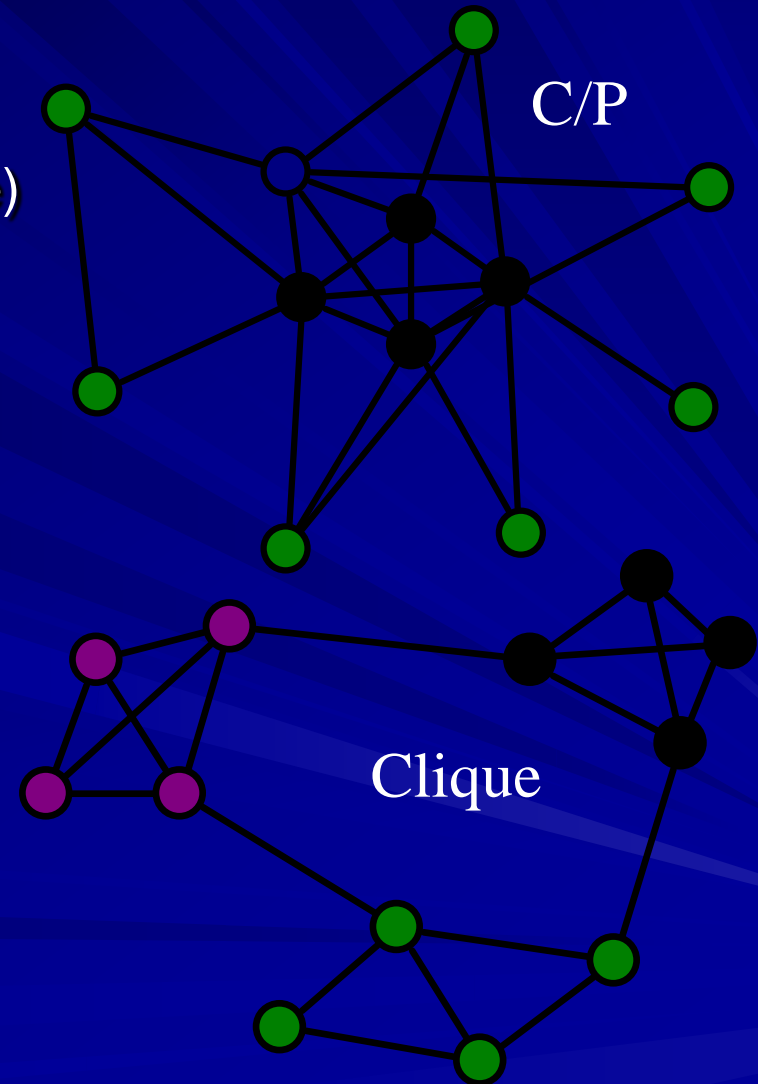
Core/Periphery Structures

■ Core/Periphery

- Network consists of single group (a core) together with hangers-on (a periphery),
 - Core connects to all
 - Periphery connects only to the core
- Short distances, good for transmitting information, practices
- Identification with group as whole
- E.g., structure of physics

■ Clique structure

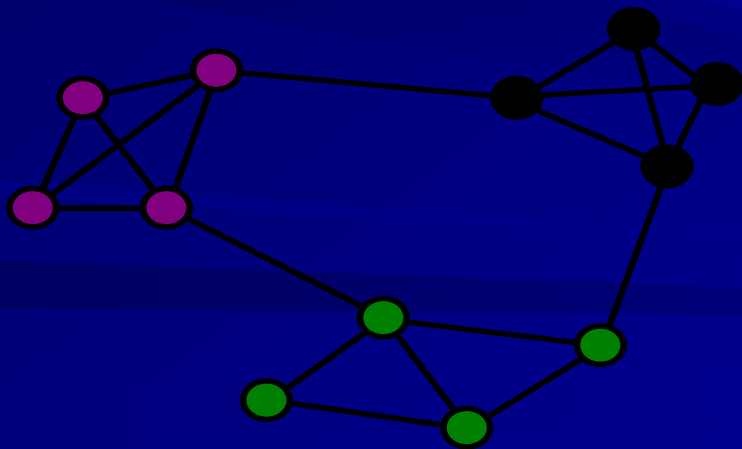
- Multiple subgroups or factions
- Identity with subgroup
- Diversity of norms, belief
- E.g., structure of social science



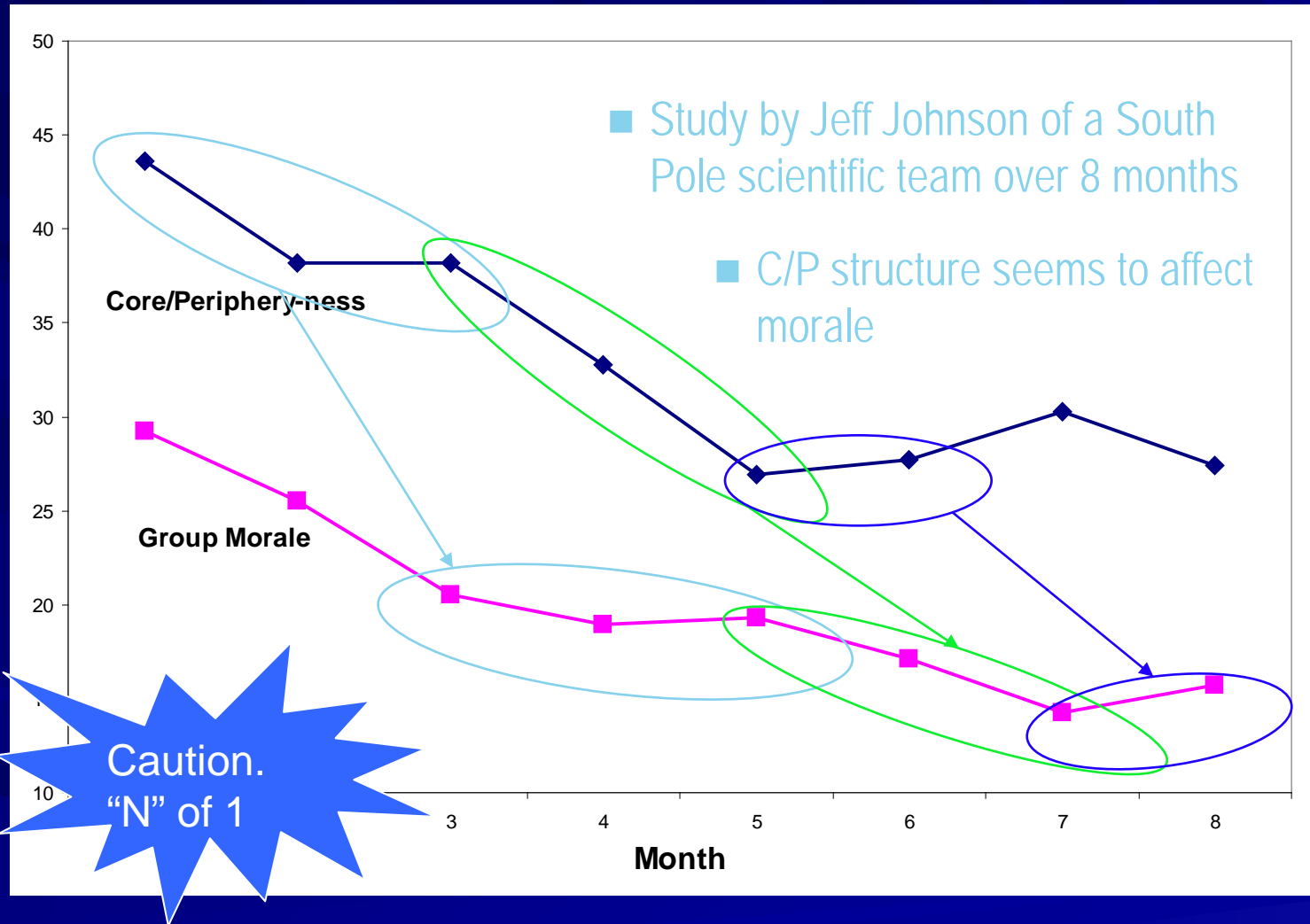
On Innovation and Network Structure

"I would never have conceived my theory, let alone have made a great effort to verify it, if I had been more familiar with major developments in physics that were taking place. Moreover, my initial ignorance of the powerful, false objections that were raised against my ideas protected those ideas from being nipped in the bud."

- Michael Polanyi (1963), on a major contribution to physics

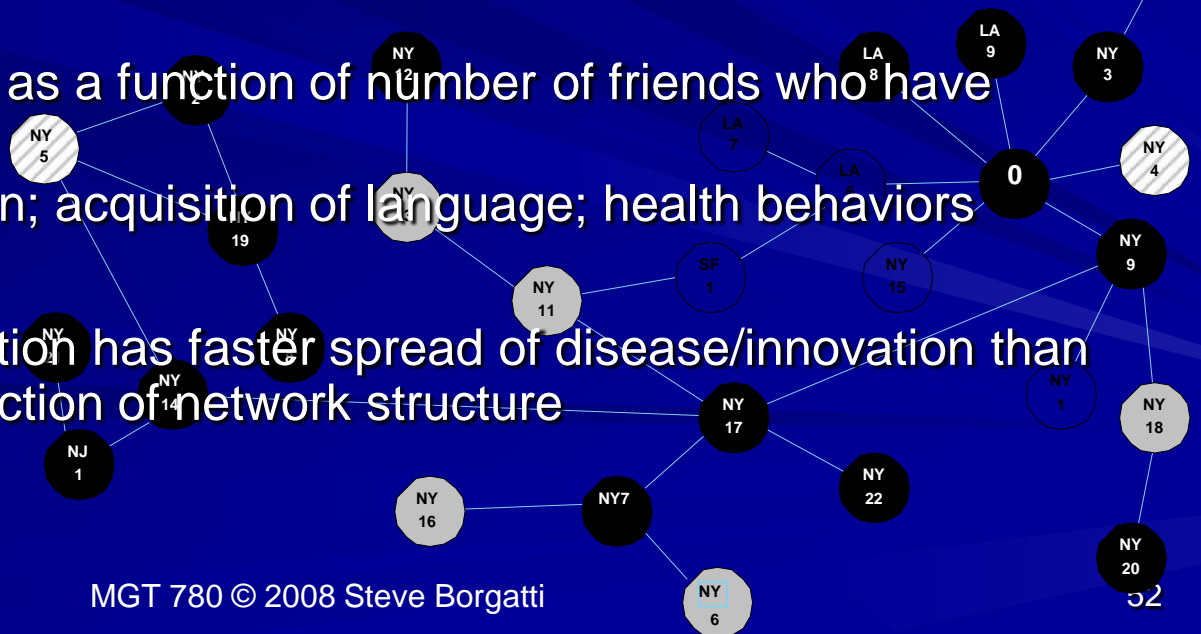


Case Study: Johnson's study of morale at the South Pole



Diffusion/Influence stream

- Explaining homogeneity of actor characteristics as a function of network properties
- Dyad level
 - Catching a cold from contact with infected other
 - Adoption of innovation due to interaction with others
 - Attitude formation; influence processes
- Node level:
 - Risk of adoption as a function of number of friends who have adopted
 - Attitude formation; acquisition of language; health behaviors
- Network level
 - Why one population has faster spread of disease/innovation than another as a function of network structure



How network theorizing works

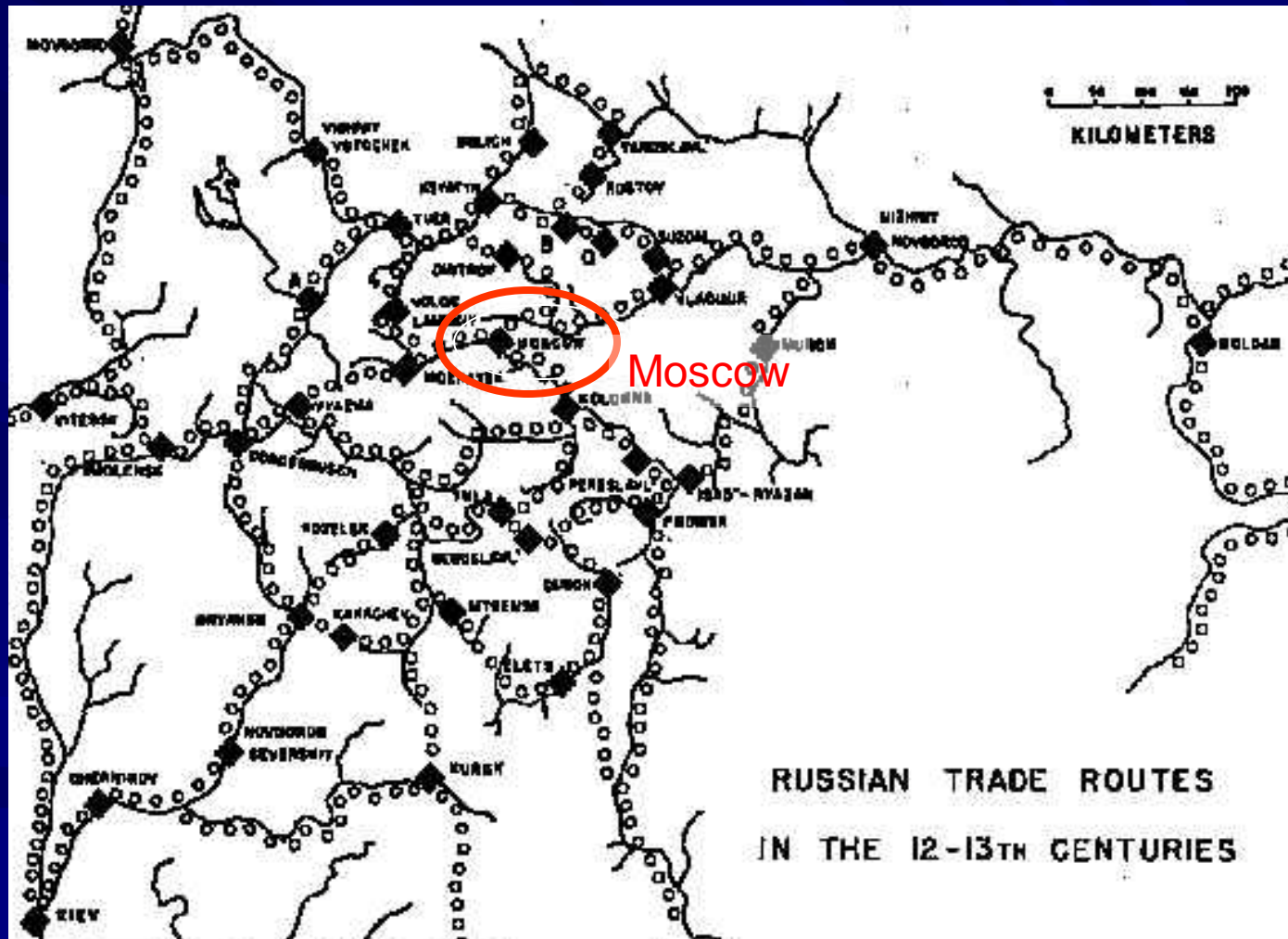
■ Model level

- The network: nodes connected by chains of interlinked ties
- Properties of the structure
- Properties of different positions in the structure
- A process or function defined on the network
 - Flows of resources
 - Coordination
- Model outcomes
 - Time until arrival of that-which-flows
 - Frequency/probability of arrival

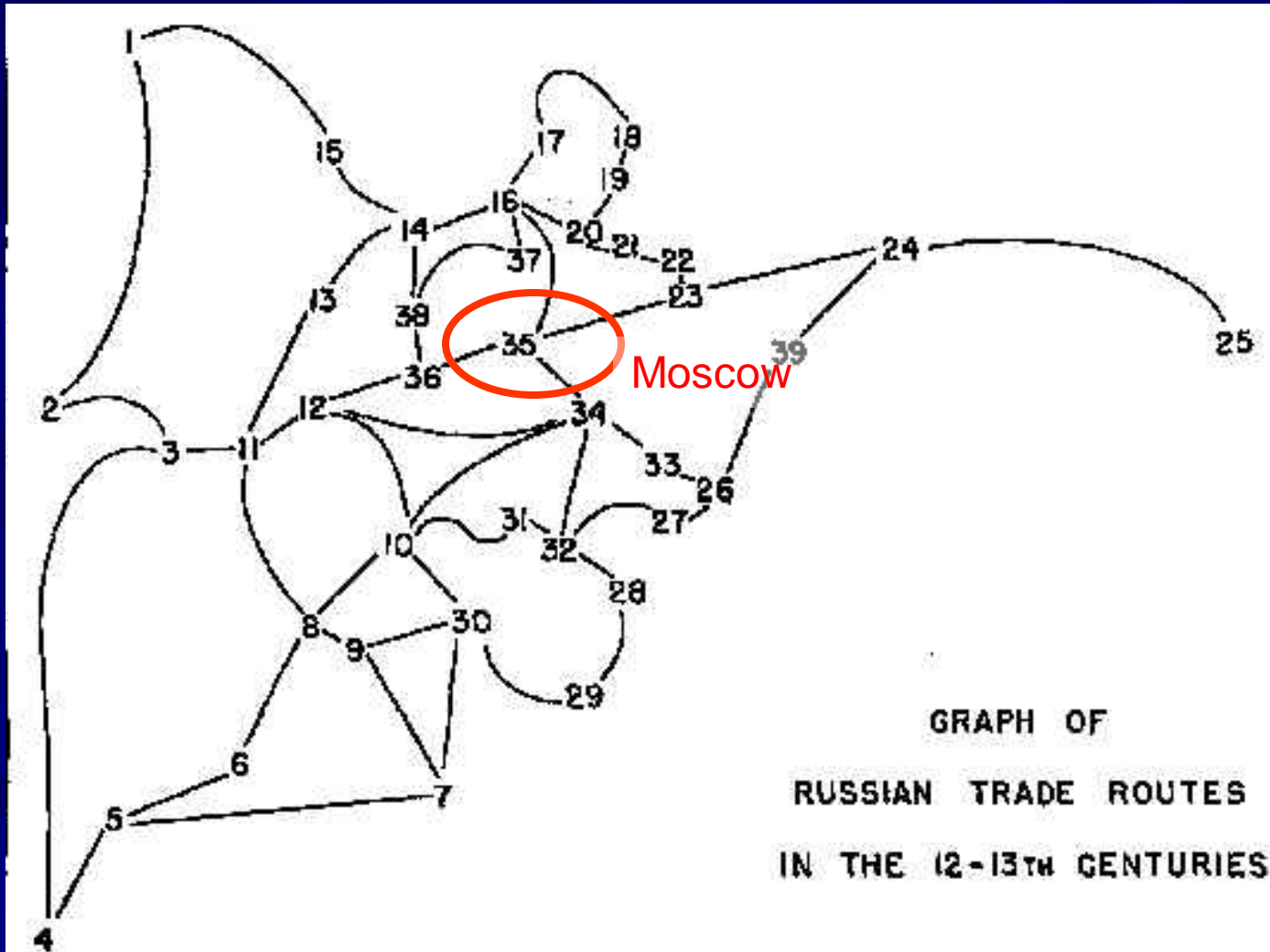
■ Interface level

- How outcomes such as innovativeness map to model outcomes such as obtaining non-redundant information

Case Study: Pitts' analysis of Moscow's emergence to pre-eminence



Position in the River Network

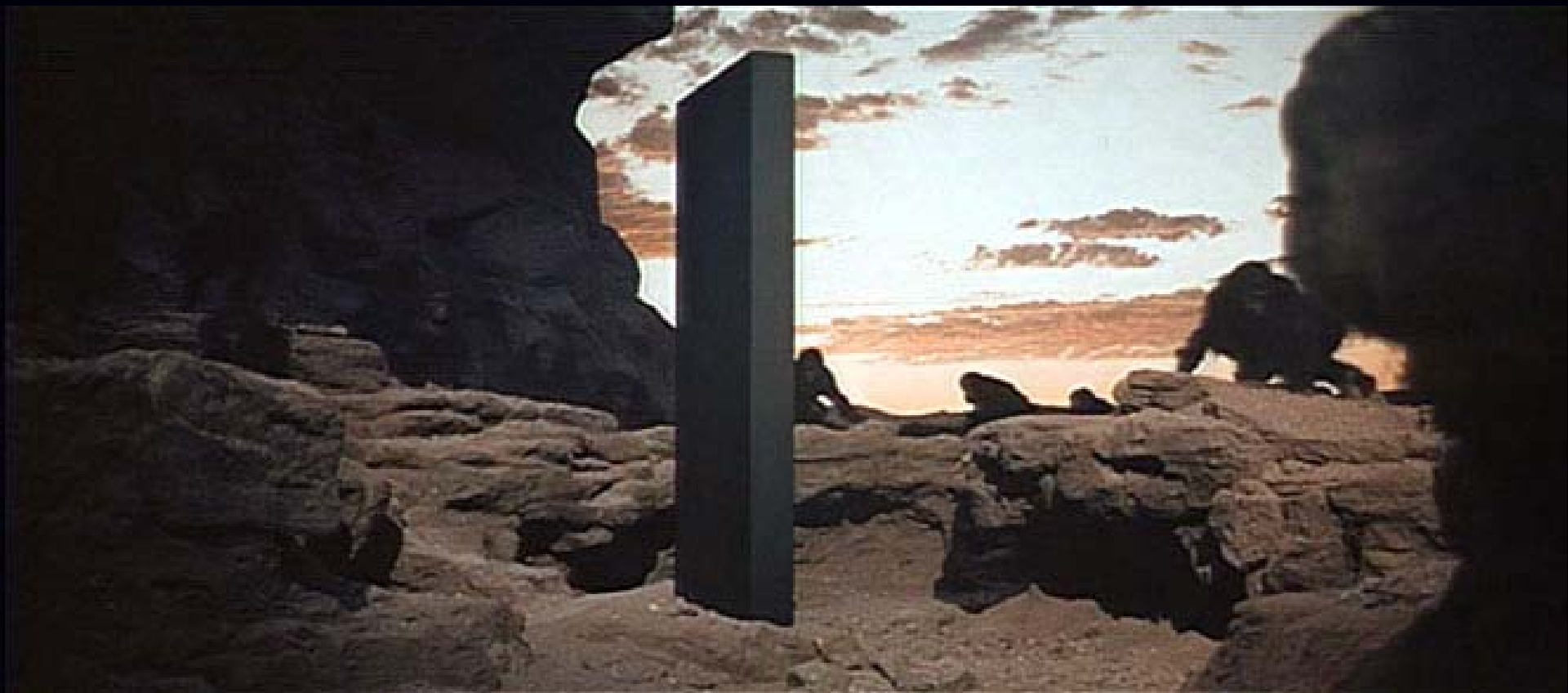


Summary of network theorizing

- Abstract model of network or “graph” that includes some kind of process, such as flow
- Relating structure/position in structure to flow outcomes
 - This part often amenable to mathematical treatment
- Relating model flow outcomes to more general outcomes, such as promotion speed or creativity

A note on methodology and theory

- In most fields, clear separation between theory and method
 - Although, any sociologist of science can show how theory is implicit in method
- In learning network field, many people think they are learning methods when they are actually learning theory
 - Mathematically expressed
 - Methodology is flashy and daunting
- But betweenness centrality is not a measure, it is a model of the number of times something flowing will pass by a given point, given that it flows along shortest paths only



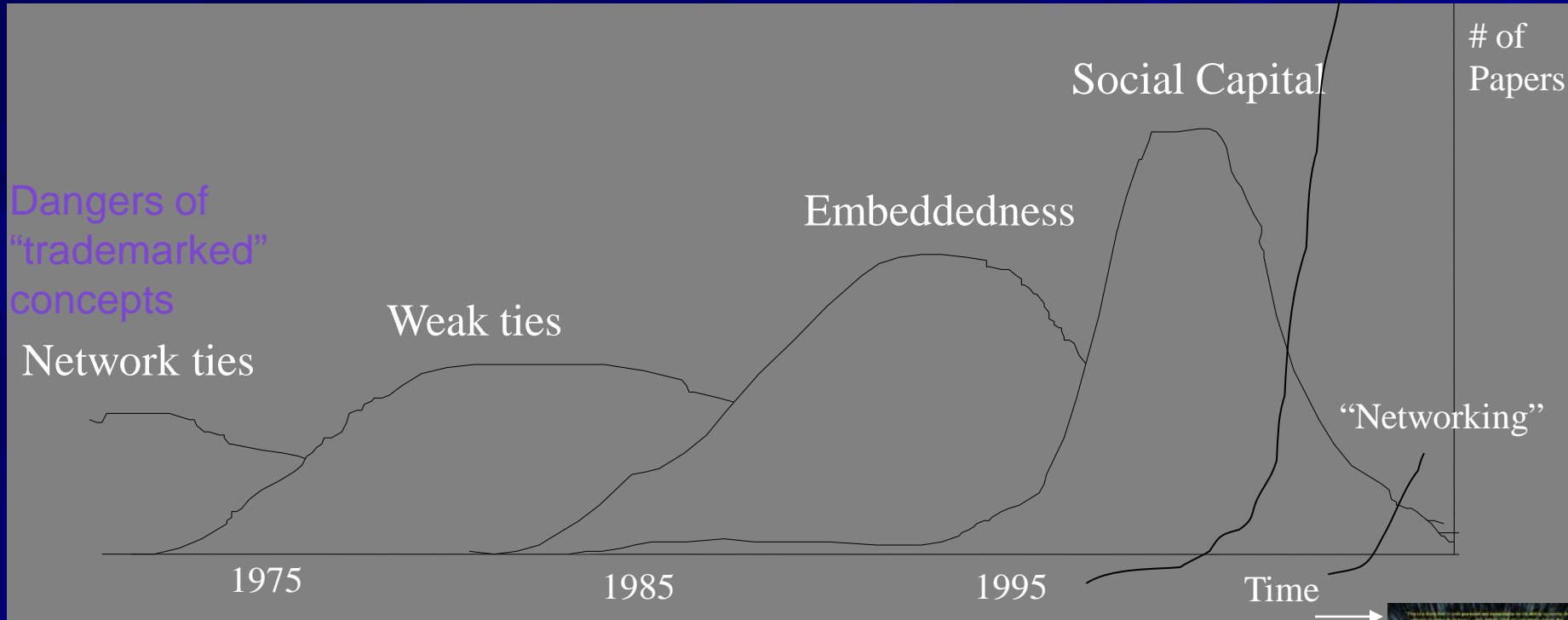
Where the energy is

- Stochastic methods – ERGM, SIENA
- Analyzing transactions & interactions
- Network evolution
- Simulation, what-if analysis, optimization
- Automated data collection & imputation
 - Taking advantage of the google era
- Large networks

Trends & Buzzwords

Is the field getting too popular too fast?

Small worlds
Scale-free
Communities?



WARNING: Totally made-up data! Do not take seriously!

Do fads sweep out equal areas under the graph?

