Basics

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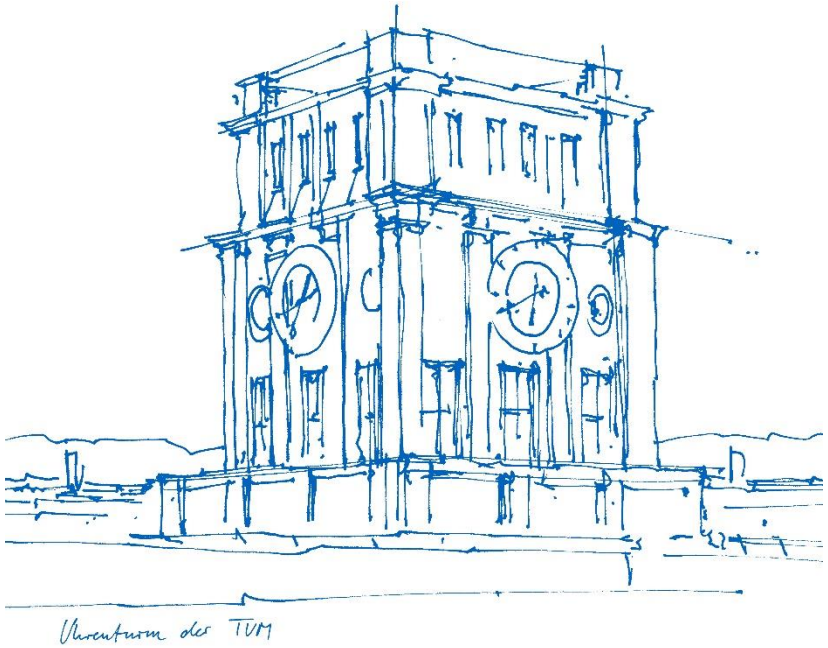


The Word “Complex”

Complex = composed of parts, French ~1650

Not easy to analyze, ~1715

Complicated ≠ complex

Complex vs. Complicated

A lot of people buying different products

Statistics can help to aggregate

Makes it less complicated, system description is stable

Complicated systems are reducible

Complex systems are not reducible

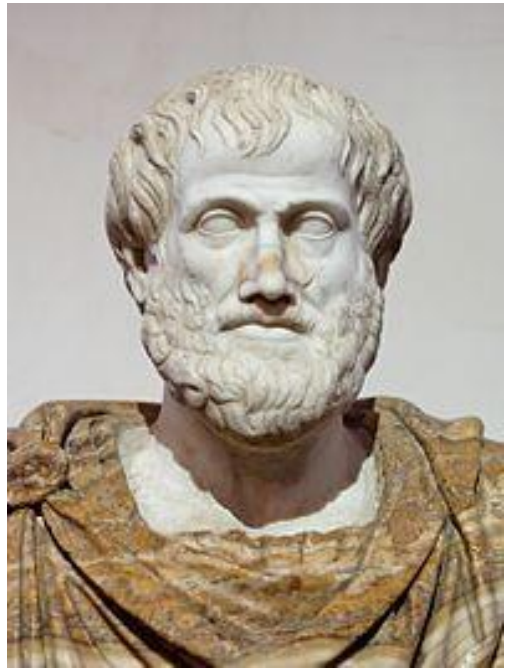
Reduction changes the system behavior

→ Connectivity creates complexity

The Whole and the Parts

Aristotle (384 BC – 322 BC) Metaphysics:

“... the totality is not, as it were, a mere heap, but the whole is something besides the parts.”



Adaptive Social Systems

What makes a systems social?

Elements (agents) of the system are thoughtful (not brilliant)

Agents can be human, animals, or even robots

Agents analyze their environment

Agents can change (adapt) their behavior to perform better

→ **Complex adaptive social systems**

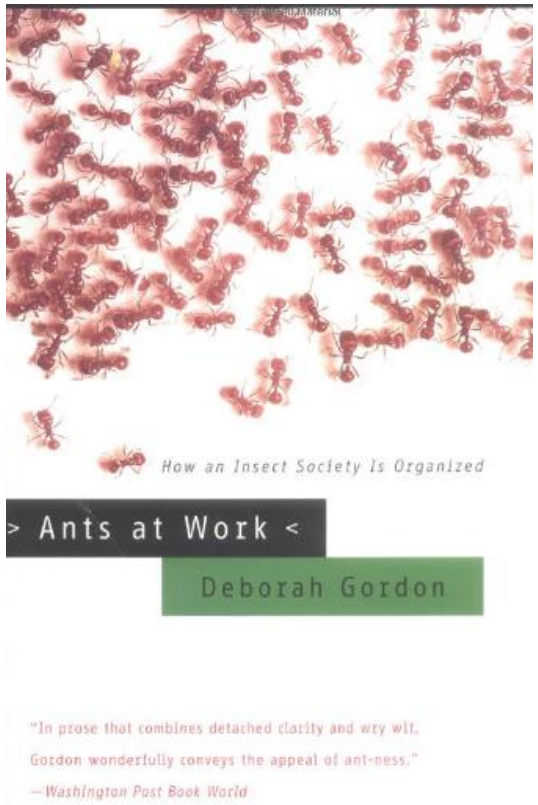
Emergence

Macro behavior and patterns arise out of micro actions

Relatively simple interactions

“Think local, act local”

The Myth of the Ant Queen,
Deborah Gordan, 2000



Model of Photocopier

“Xerographic copiers are among the most complex devices in use today”, Shrager et al. 1987

A lot of physical phenomena (light-sensitiveness, electronic fields) made it hard to observe and describe

The model helped them to teach their students

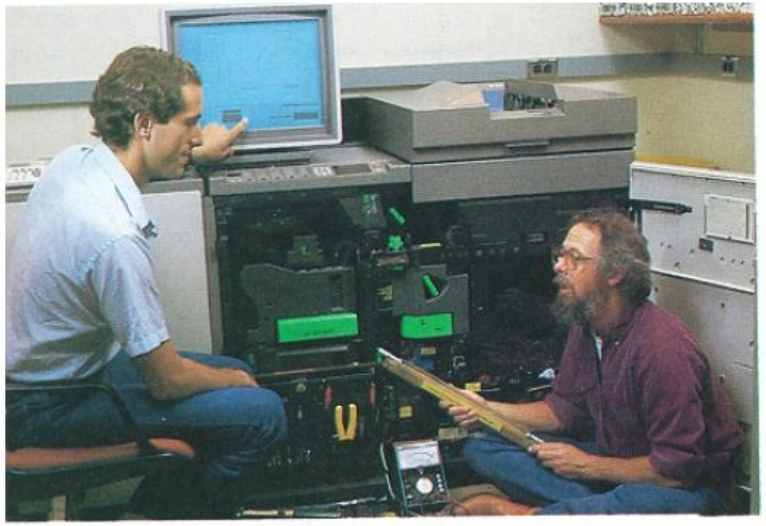


FIGURE 2. Anthropologist Julian Orr (right) Helps Psychologist Jeff Shrager (left) Compare the Predictions of the ARIA Computer Model with the Finer Details of Real Copier Dynamics, at the Xerox Palo Alto Research Center

Complex Systems

Nature

Society

Economy

Logistic

Technic

Why Analyzing?

Better understanding of the system

Theory building

Prediction

Simulation of interventions, what-if?

Levels of Complexity

Low complexity

Systems consisting of just a few elements with less and simple interactions.

E.g. the stopping distance S_B of a car is a function of the velocity v (in meter per seconds) and the braking rate a and can be described with the function

$$S_B = \frac{v^2}{2a}.$$

Levels of Complexity

Medium complexity

Systems consisting of some elements and more complex interactions or dependencies.

Transportation and logistical problems.

Business informatics: Algorithms: Linear programs, simplex algorithm, matching, max-flow problem.

Statistics: Multivariate methods.

$$\min \sum_{\vec{ij} \in A} c_{ij} \cdot x_{ij} \quad \text{with auxiliary conditions} \quad Ax = s$$

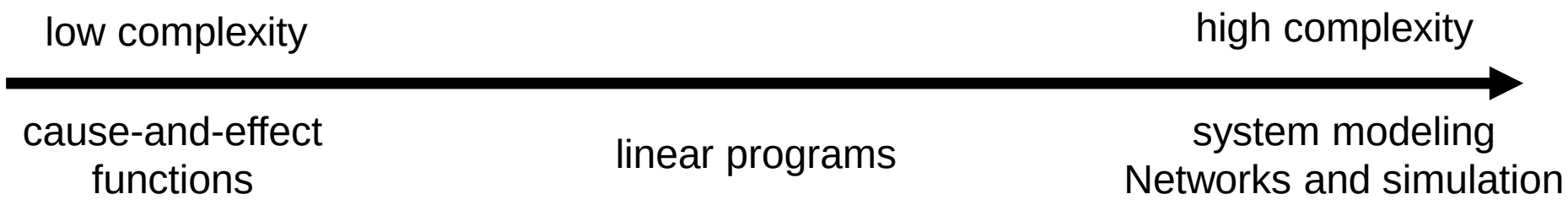
Levels of Complexity

High complexity:

Systems consist of a lot of elements

Interactions in many different ways

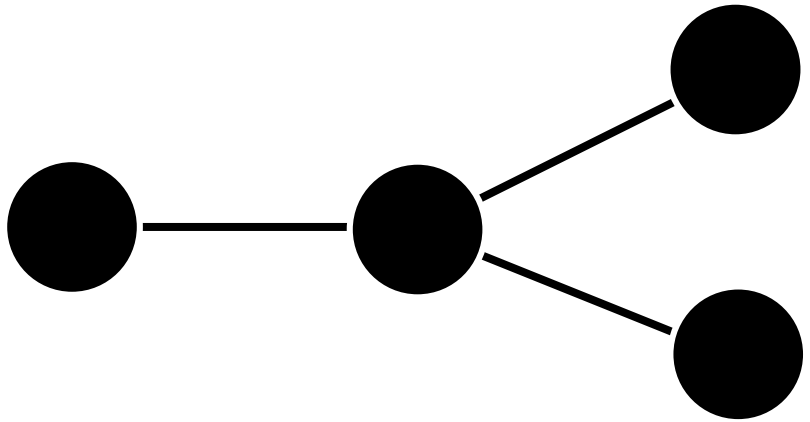
Linear models fall short in describing these systems



Graphs And Networks

A graph $G = (V, E)$ consists of

- a set of nodes and
- a set of edges



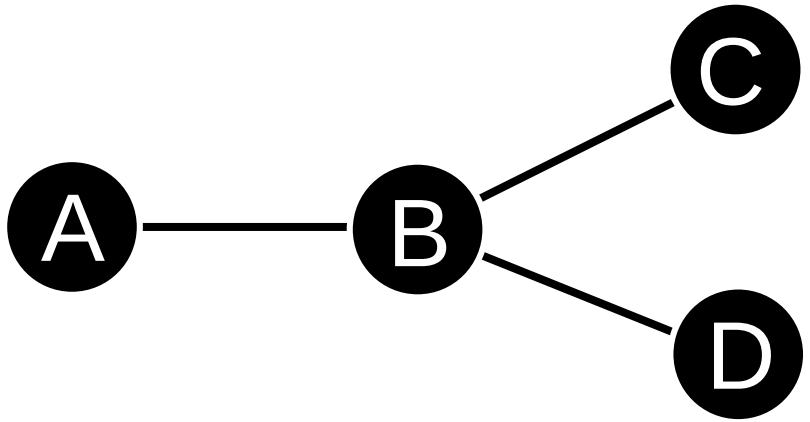
Graphs And Networks

A graph $G = (V, E)$ consists of

- a set of nodes and
- a set of edges

A network is a graph with “meaning” (labels)

e.g. co-occurrence of topics in news articles



Social Network Analysis

Analytical Challenges:

Network elite

Groups and clustering

Network structure

Network comparison

Visual reasoning

Algorithmic Puzzles:

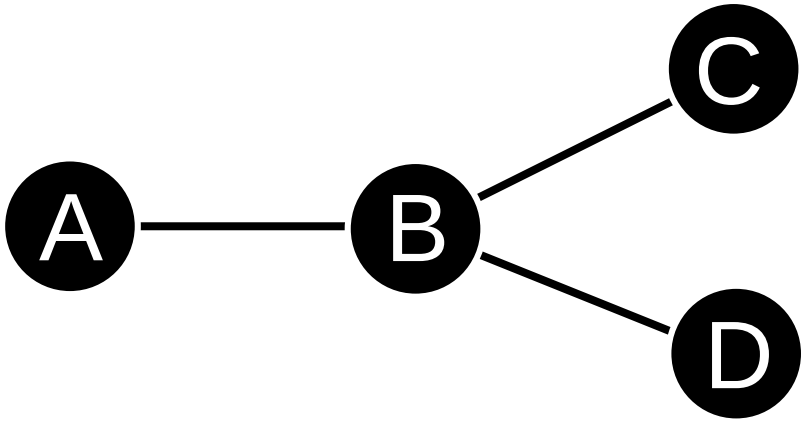
Centrality measures

Clustering algorithms

Structure measures

Network regression

Network visualization



Connections and Paths

Neighbors - directly connected

Path = node-link-node-link…

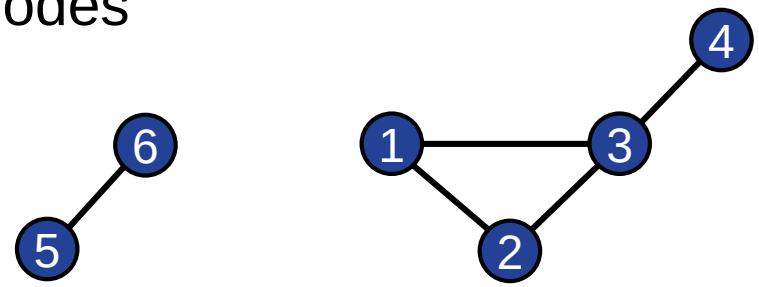
Indirectly connected - reachable, unreachable

Shortest paths

Diameter = longest shortest path (geodesic distance)

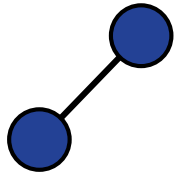
Characteristic path length = average shortest path

Component = set of reachable nodes

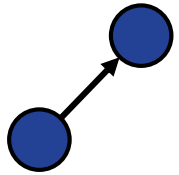


Different Links

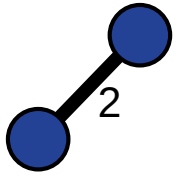
Undirected/symmetric



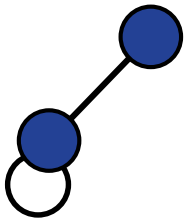
Directed links/asymmetric



Unweighted/weighted links



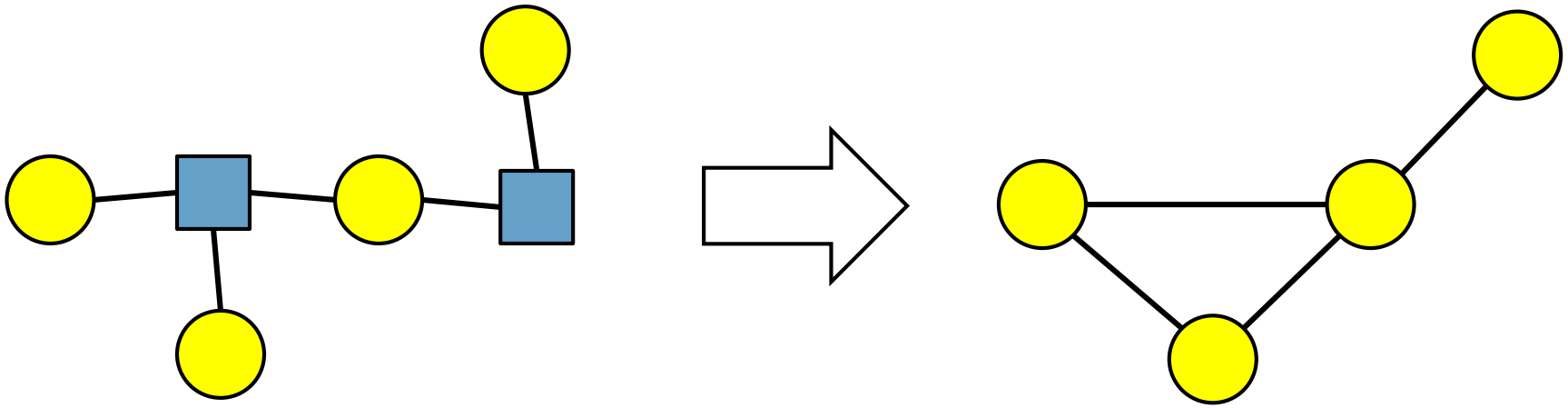
Self-loops



2-Mode to 1-Mode

Transforming 2-mode data to 1-mode data

Transform = Fold

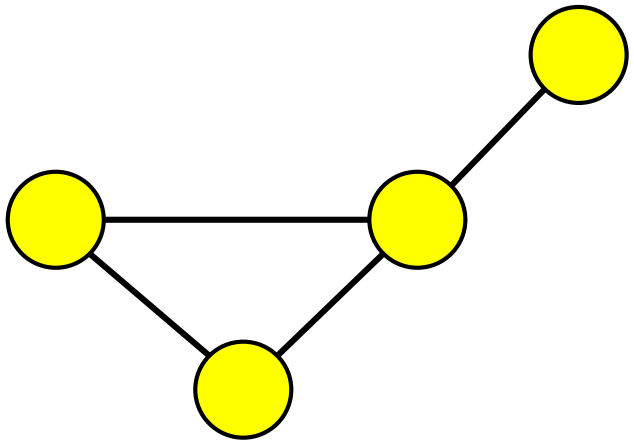


1-Mode vs. 2-Mode

1-Mode Networks

Network of people…

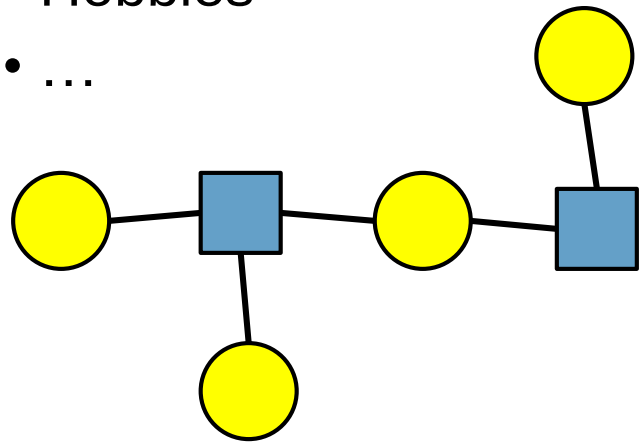
- Communication
- Friendship
- …



2-Mode Networks

People and …

- Events
- Organizations
- Publications
- Hobbies
- …



Data Questions

What are the nodes?

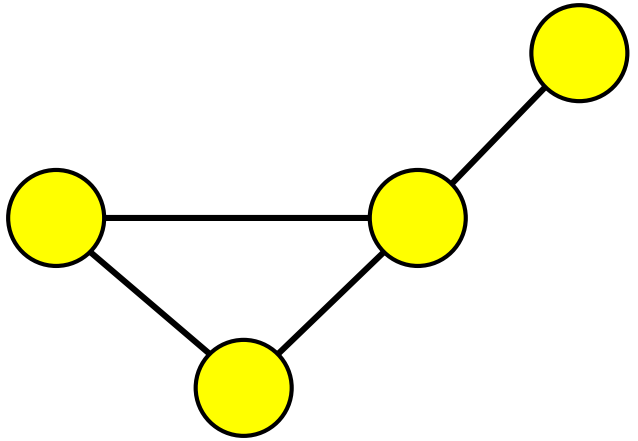
- Boundary specification

What are the links?

- Different types?

Is it relational data?

- N : M



Quality Issues of Network Data

Incomplete Data

- Inaccessibility, non-response, drop-out (in longitudinal studies), data loss, etc.

Inaccurate Data

- Measurement error, informant lack of recall, intentional lying, etc.

Inconsistent Data

- variables supposed to represent the same information have different values

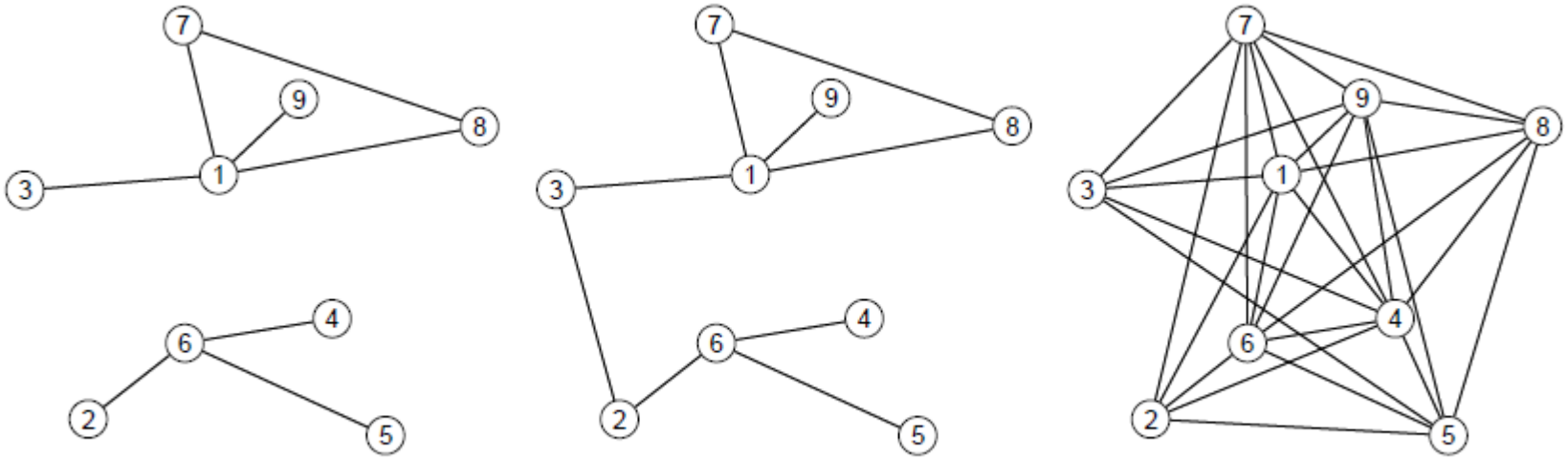
Data Collection/Aggregation?

Every single interaction represents a link in the network

Every single link can change a network

Different network can result in totally different measure results

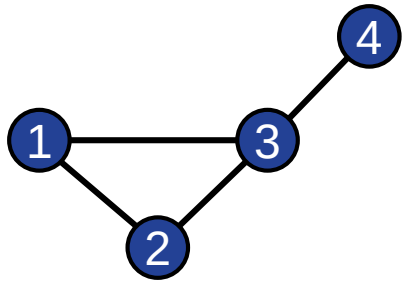
Big difference to statistical analysis (!)



(a) aggregation by hour (b) aggregation by day (c) aggregation by week

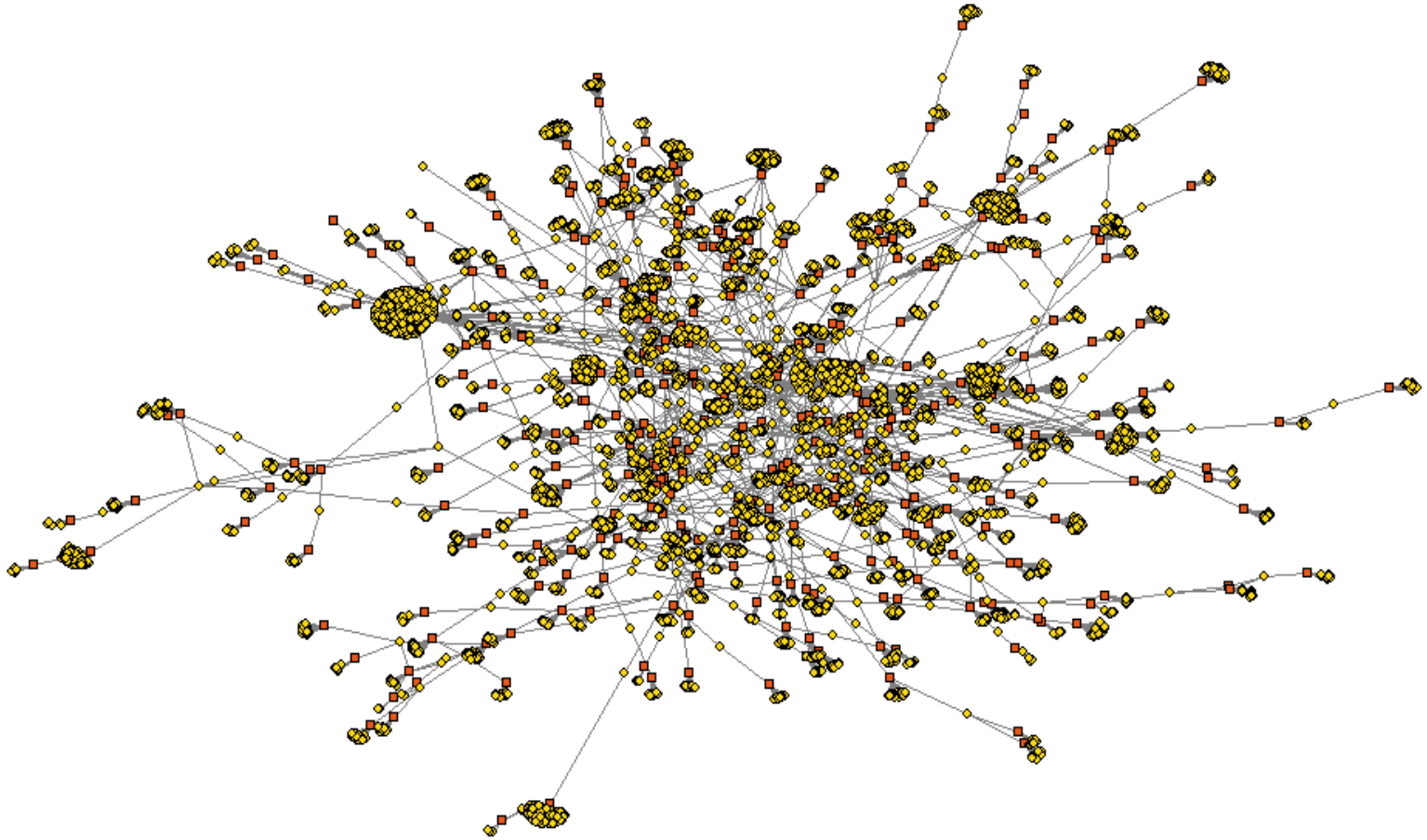
Matrix vs. Edgelist

	node 1	node 2	node 3	node 4
node 1		X	X	
node 2	X		X	
node 3	X	X		X
node 4			X	



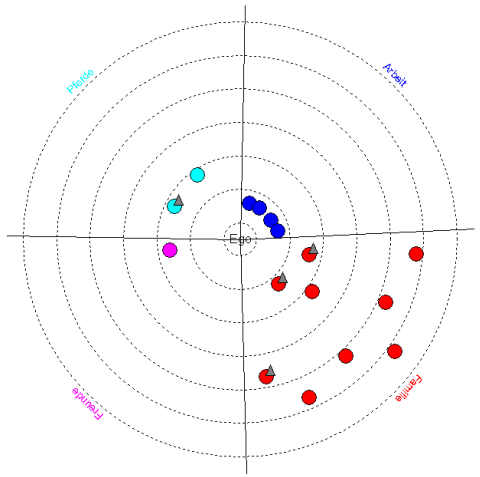
1	2
1	3
2	3
3	4

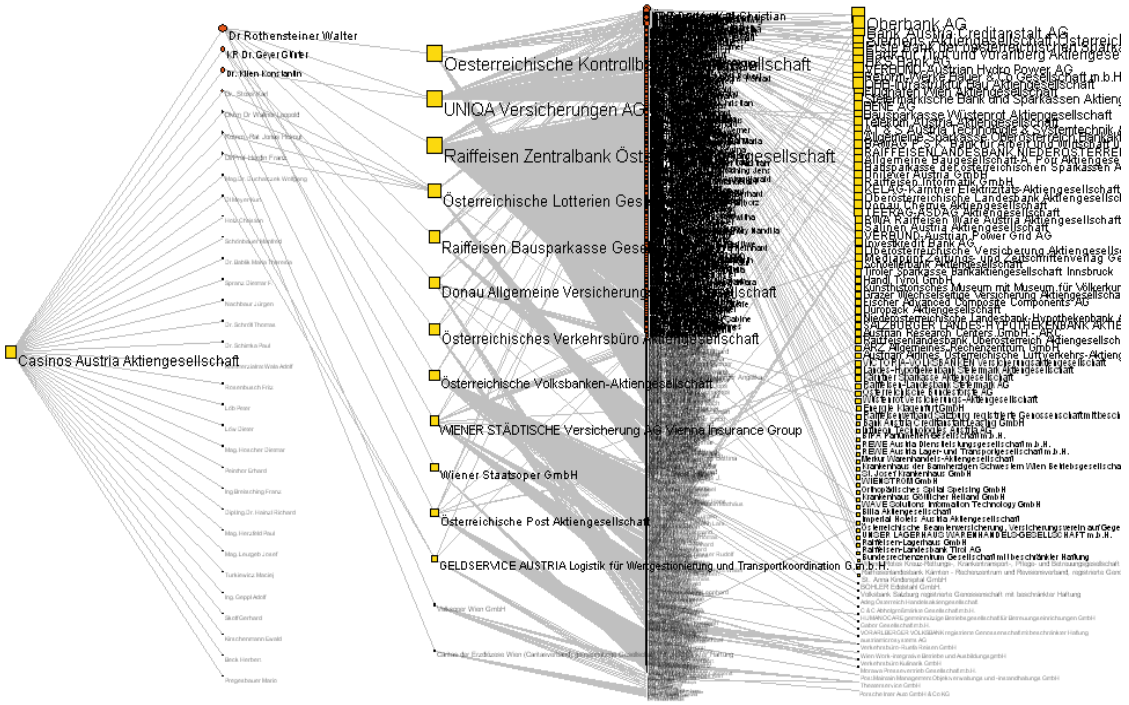
Whole Network



Ego Network, k-Step

Focal node with its neighbors





Types of Network Analysis

Networks as Dependent Variable

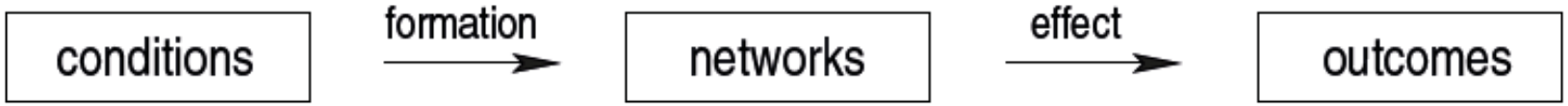
Why and how do network actors interact with each other in the observed way?

- Human capital on the creation of social capital

Networks as Independent Variable

What are the consequences of the observed network structure, such as performance, extent of resource sharing, etc.?

- How does the position of an organizational unit affect its performance?



Dependent vs. Independent Variable

Explain how gang membership and deviant behavior among youths are related:

1. Deviant behavior explains the kind of people with whom an individual hangs out.
2. The people with whom an individual hangs out explains whether or not they are likely to break the law.

Different Explanations

Attribute-based Explanations

- Are similar entities connected?

Rule-based Explanations

- E.g. mutuality?

Explanations Based on Network Position

- Do people with many connections get even more (Merton 1968)?

Explanations Based on Patterns of Relation

- E.g. is it a small-world network?

Combined Explanations

Longitudinal Network Studies

Multiple networks over time

What has changed?

Why did something change?