

**GENEVA
GRADUATE
INSTITUTE**

INSTITUT DE HAUTES
ÉTUDES INTERNATIONALES
ET DU DÉVELOPPEMENT

GRADUATE INSTITUTE
OF INTERNATIONAL AND
DEVELOPMENT STUDIES

Networks

Social Networks Theories and Methods

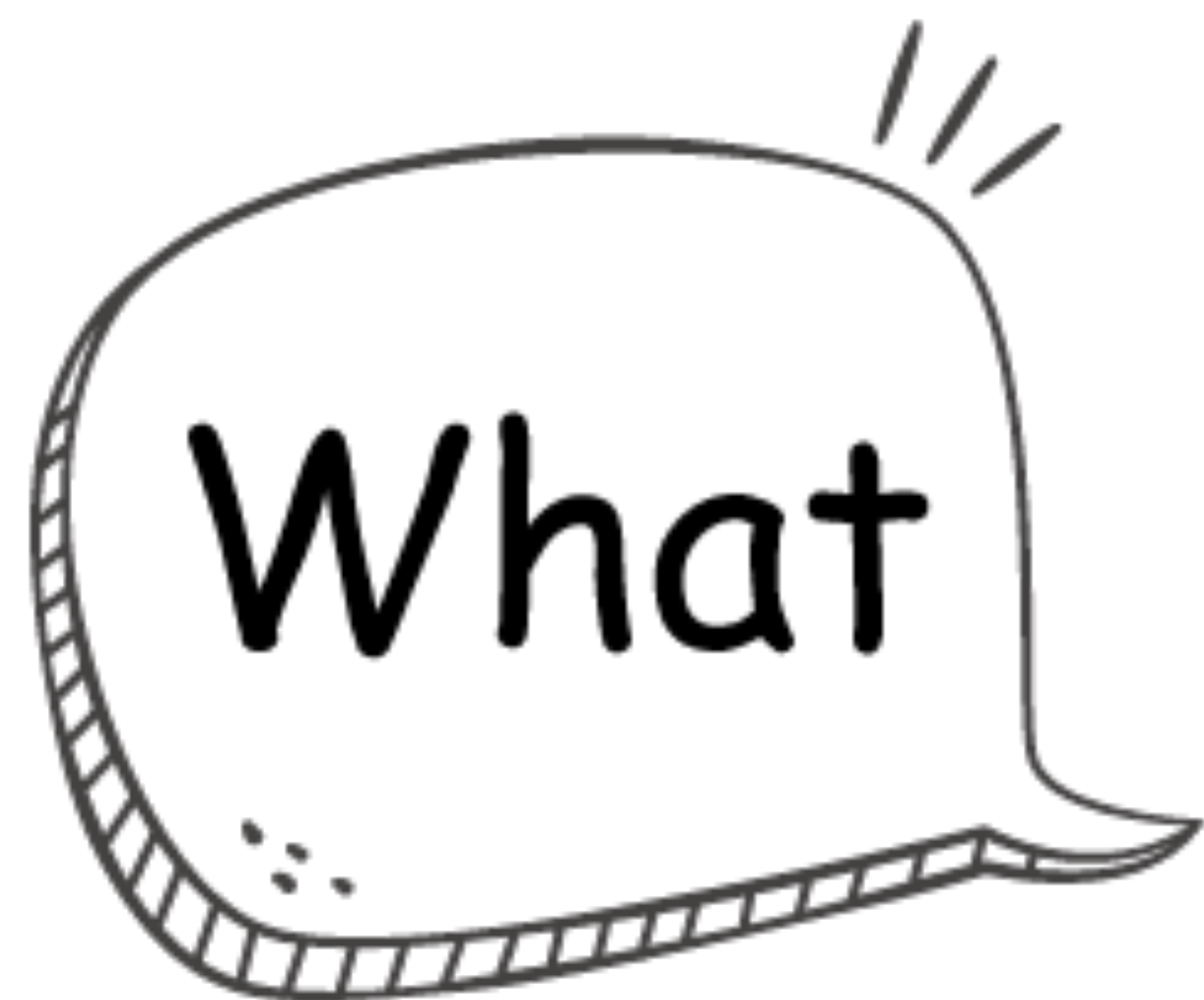
James Hollway

Course guides and sessions



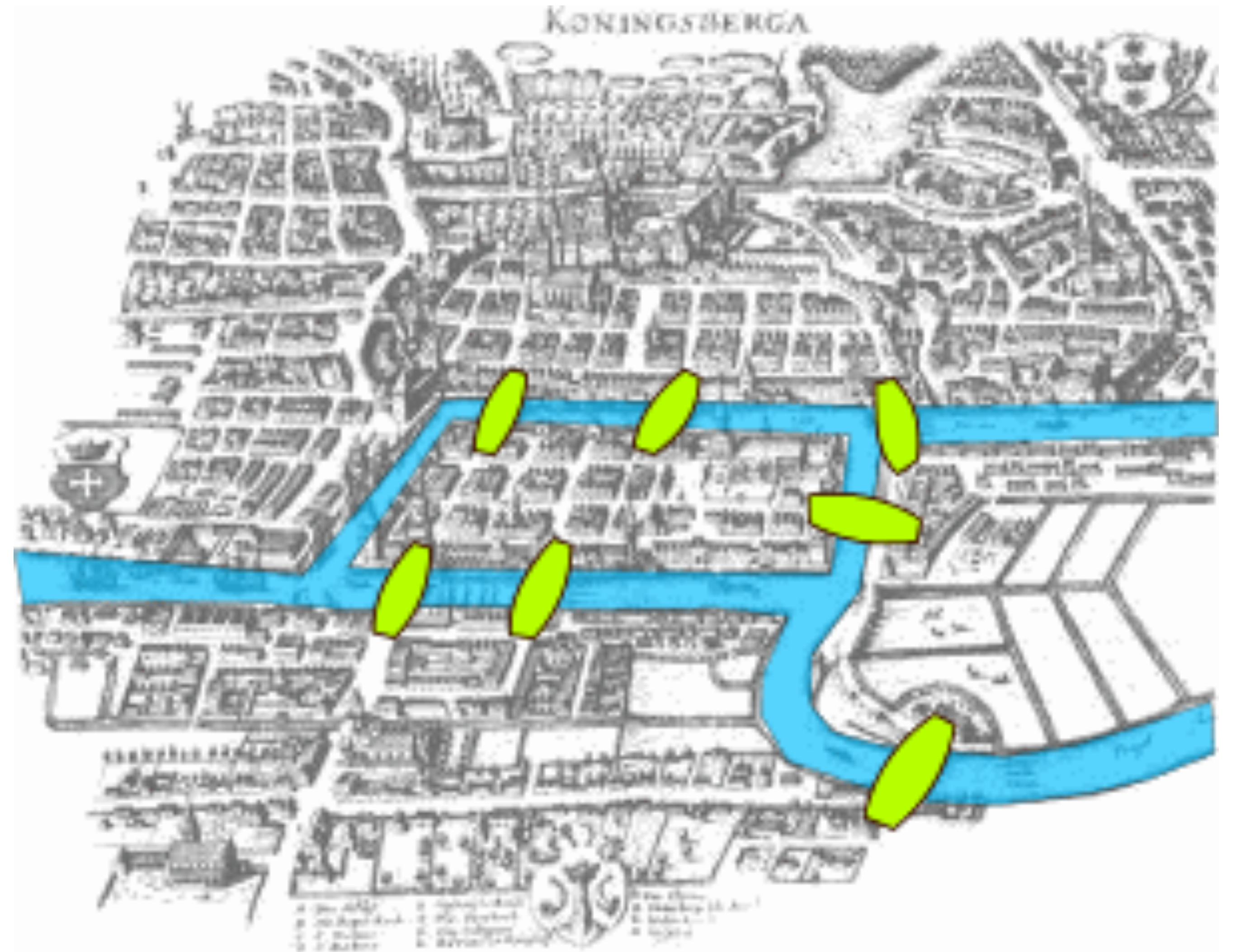
- Professor: James Hollway
- james.hollway@graduateinstitute.ch
- Lectures: Wednesdays, 2-4pm (S8)
 - Mix of conceptual and practical, complementary to readings
- Office hours: Tuesdays, 2-4pm (sometimes Zoom)
- TA: Idil Yildiz
 - idil.yildiz@graduateinstitute.ch
 - Office hours/overflow sessions: tbc...
 - Deepening comprehension, DIY experience





Seven Bridges of Königsberg

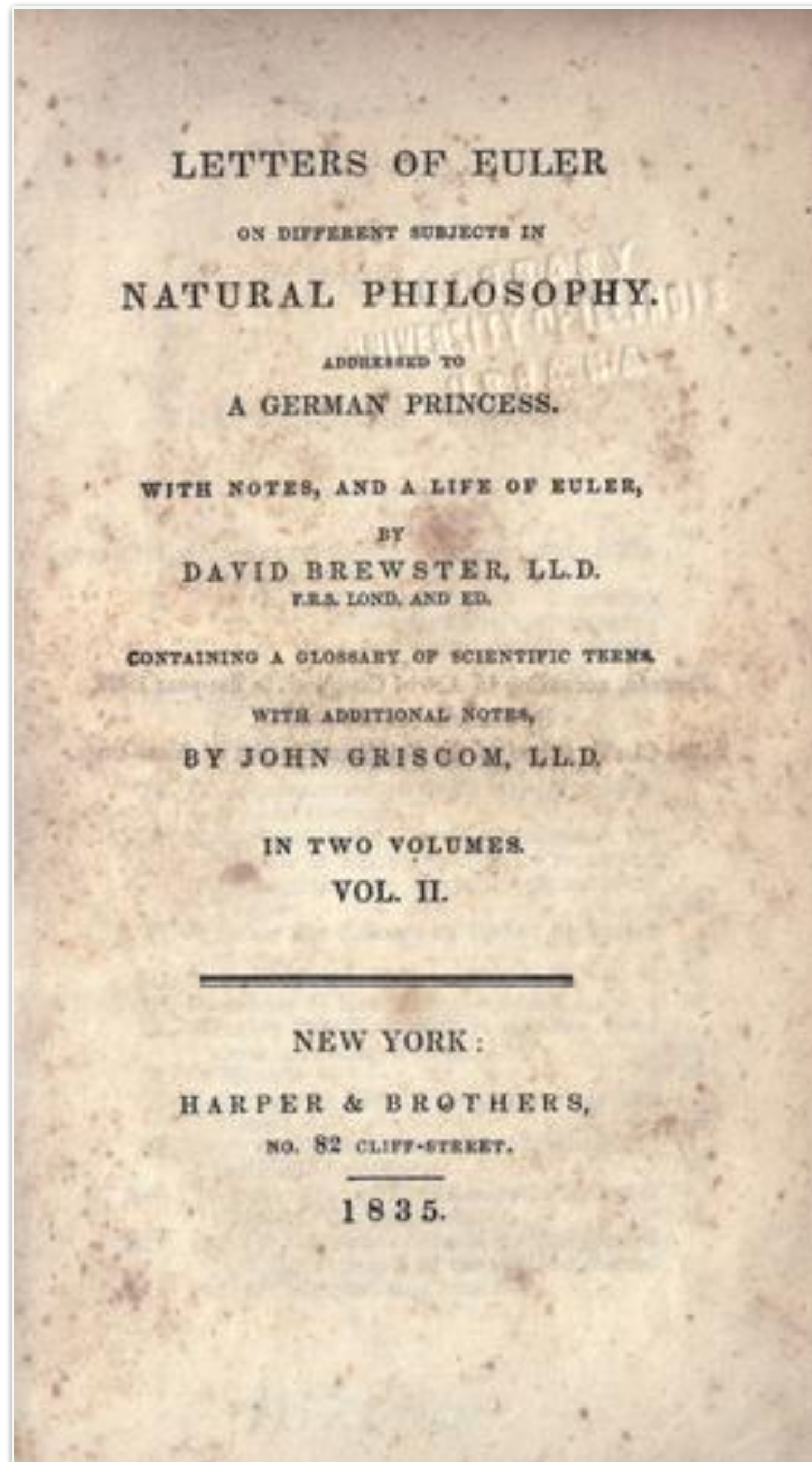
- Königsberg founded in 1255 by Teutonic Order around two islands on the Pregel River
- Became a wealthy port, and citizens spent Sunday afternoons walking the seven bridges connecting the city
- They came up with a puzzle: how can we cross all seven bridges only once in a single walk?



Lisez Euler...

- Luckily, Königsberg not too far from St Petersburg, where the Swiss polygraph Leonard **Euler** lived...
- Euler educated in Basel by one of famous **Bernoulli** family, Johann
- After failing to get a position in Basel, he followed Johann's sons, Niklaus and Daniel, to St Petersburg
- Niklaus died (1726) and Daniel returned to Basel (1733), and Euler inherited their positions
- Laplace: "Lisez Euler, lisez Euler, c'est notre maître à tous"

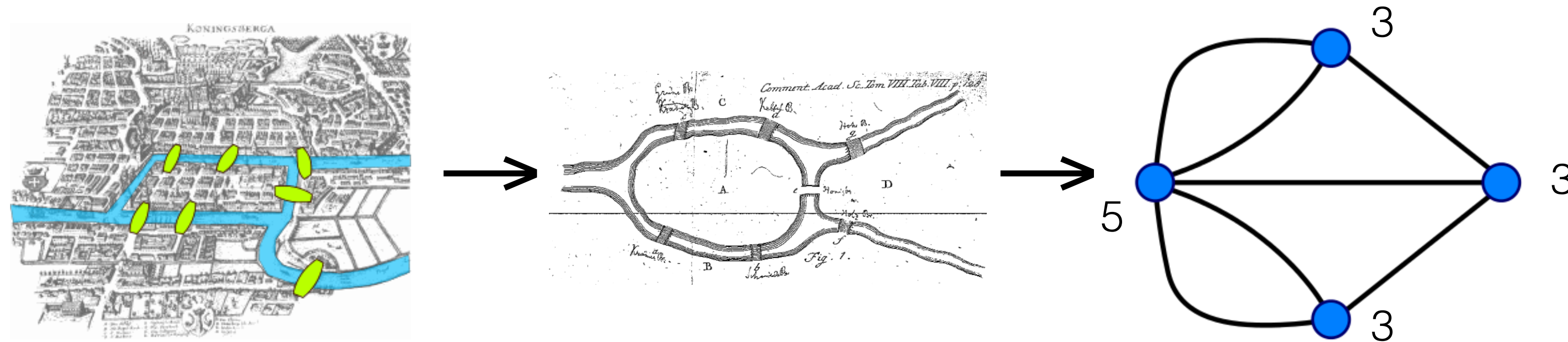




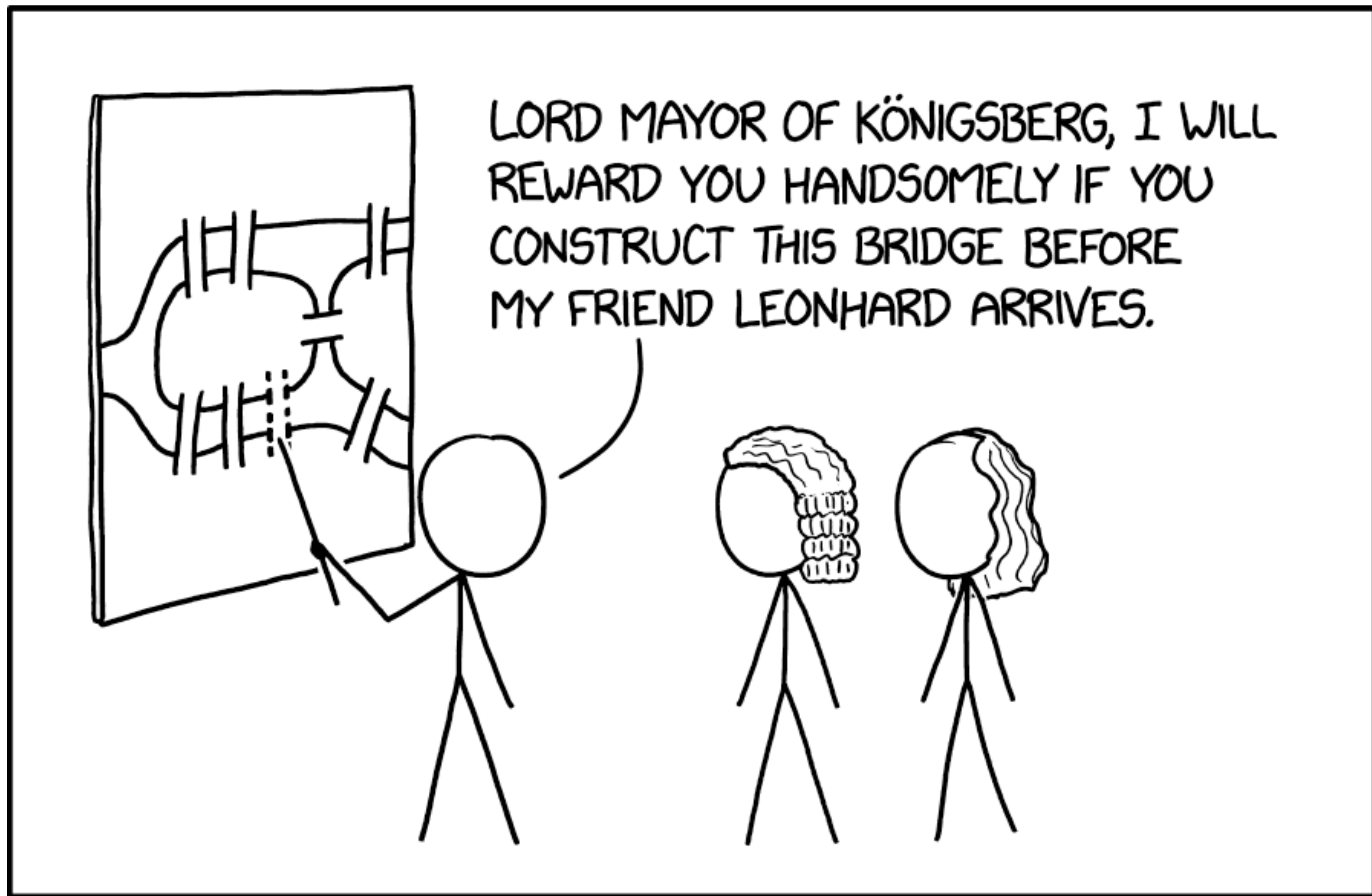
Why should he (or you) care?

- When the lord mayor of Danzig, Carl Gottlieb Ehler, wrote him for a solution to the Seven Bridges problem, he replied:
 - “. . . I do not understand why you expect a mathematician to produce [a solution], for the solution is based on reason alone, and its discovery **does not depend on any mathematical principle.**”
- Yet, later that year he admitted to an Italian colleague:
 - “This question is so banal, but seemed to me worthy of attention in that **[neither] geometry, nor algebra, nor even the art of counting was sufficient** to solve it.”
 - He saw the problem related to what Leibniz called **geometria situs**, or the geometry of position...

Bad for Königsberg, Great for graph theory

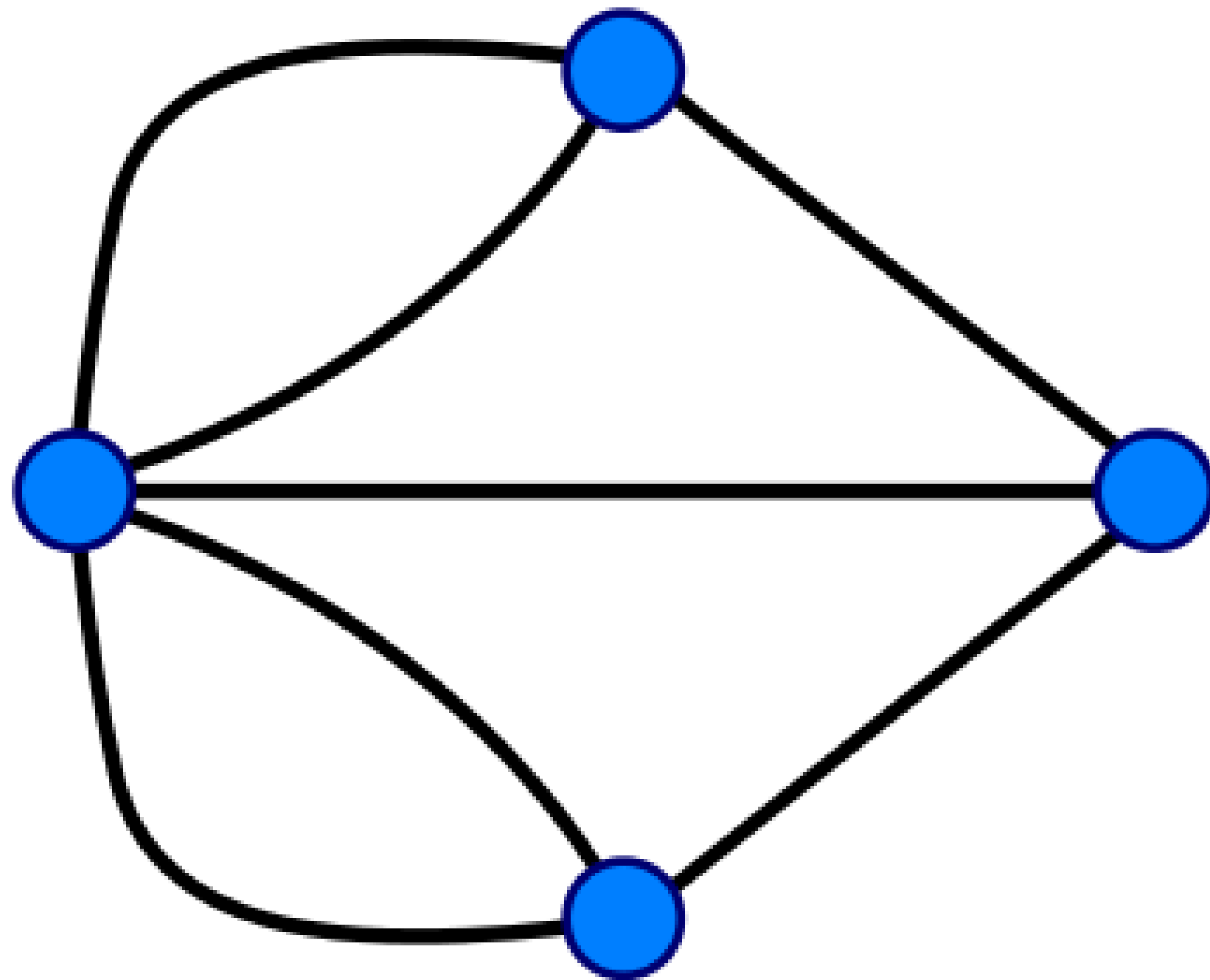


- In 1735, Euler founded **graph theory** by proving there was *no* solution to the problem
- Proof consisted of two steps:
 - First, route inside each land mass irrelevant, only the connections, meaning he could **abstract** to a *graph* of *vertices* (nodes) connected by *edges* (ties)
 - Second, for a unique path to exist, no more than 2 nodes should have an odd *degree* (# ties) – if enter, also need to leave, so all intermediate nodes must be even
- Because all nodes had odd degrees → no way of solving the problem

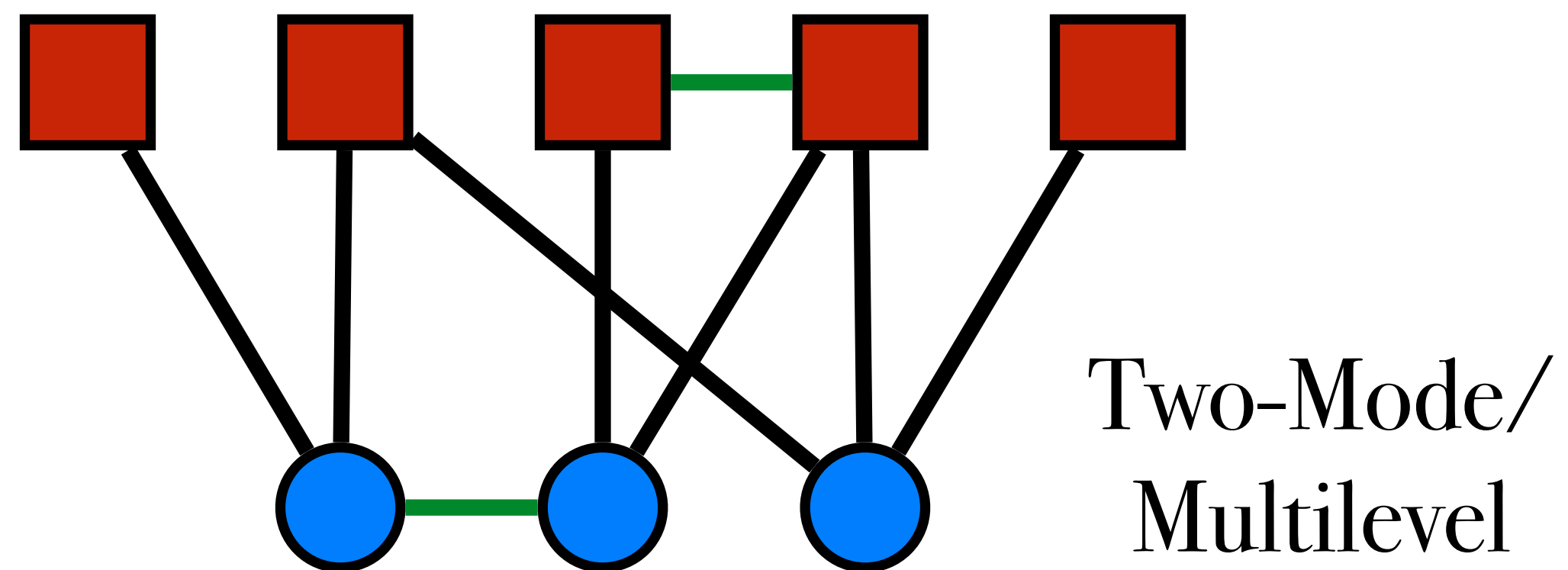
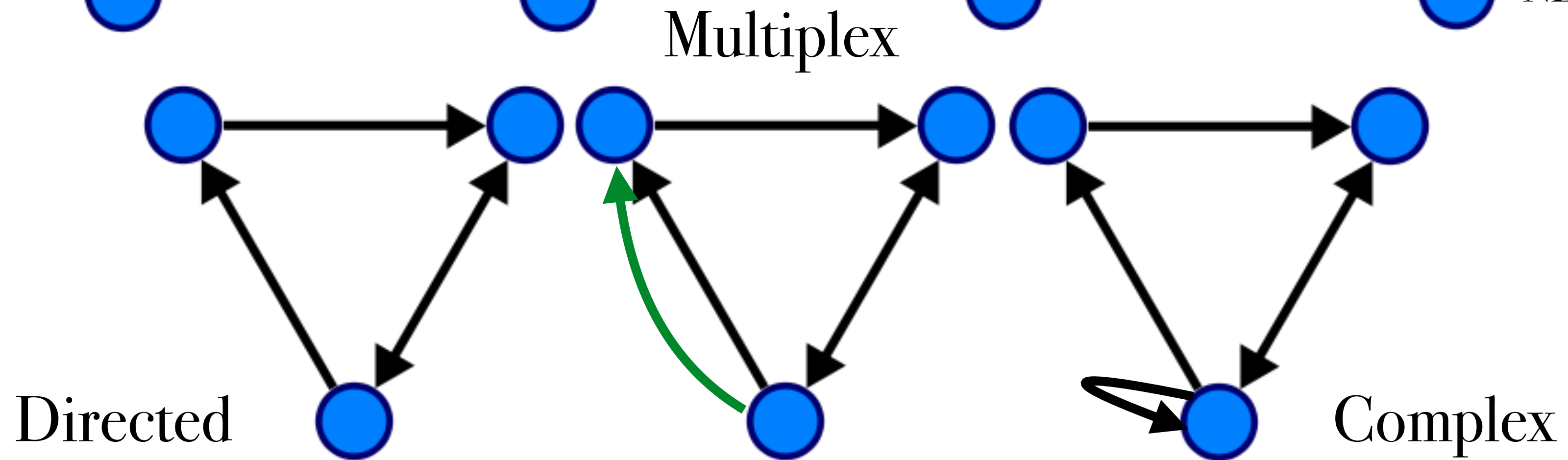
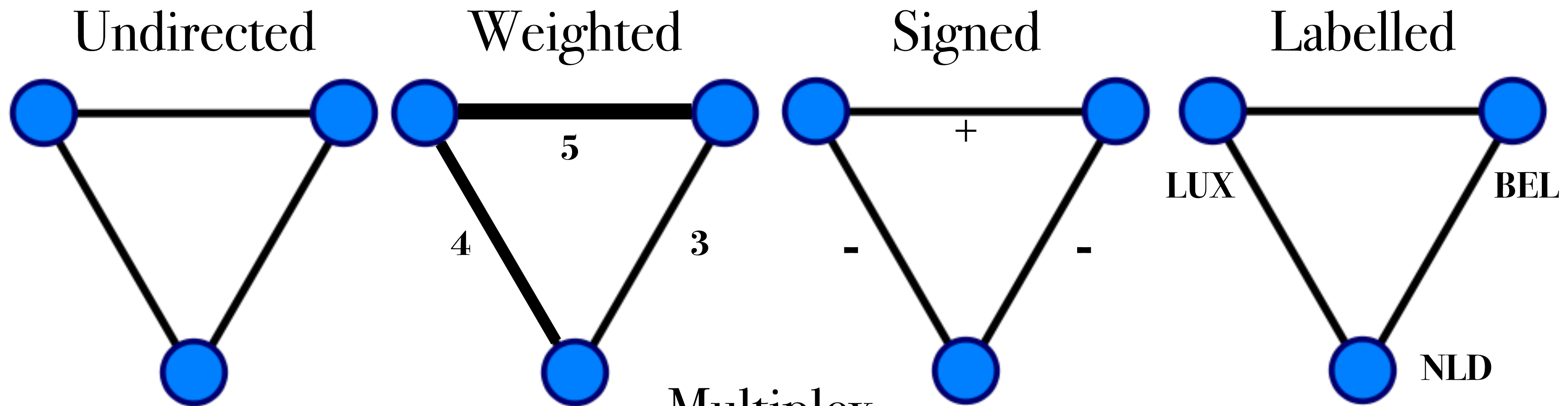


I TRIED TO USE A TIME MACHINE TO CHEAT ON MY ALGORITHMS FINAL BY PREVENTING GRAPH THEORY FROM BEING INVENTED.

Terminology

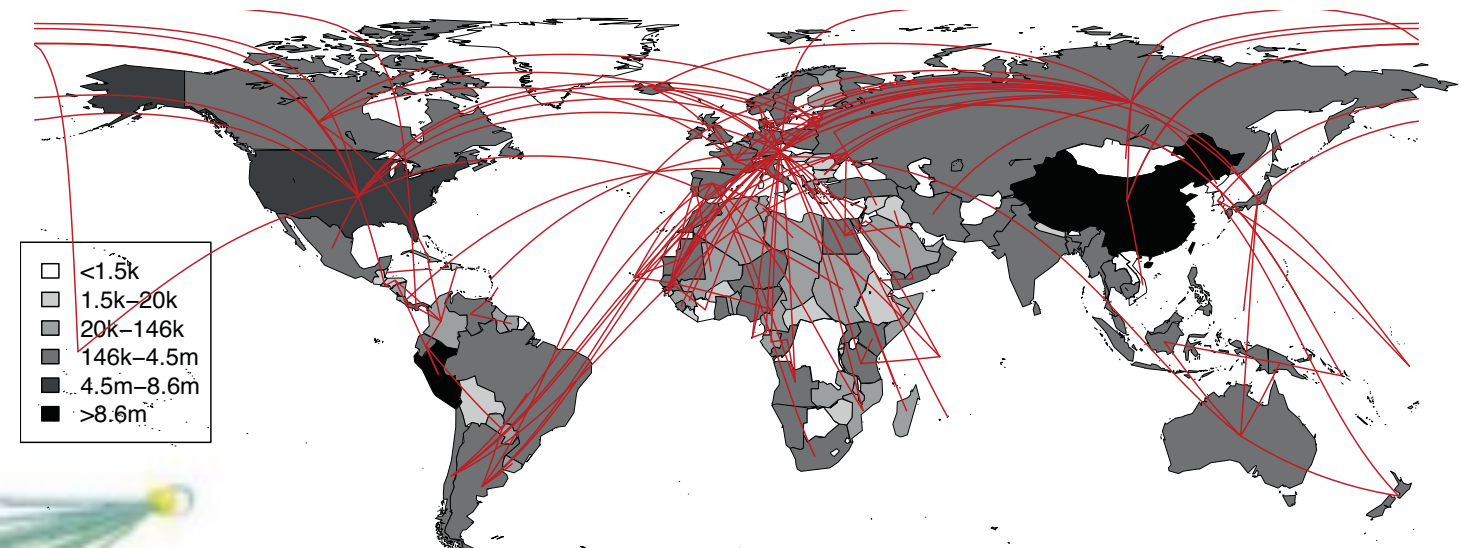
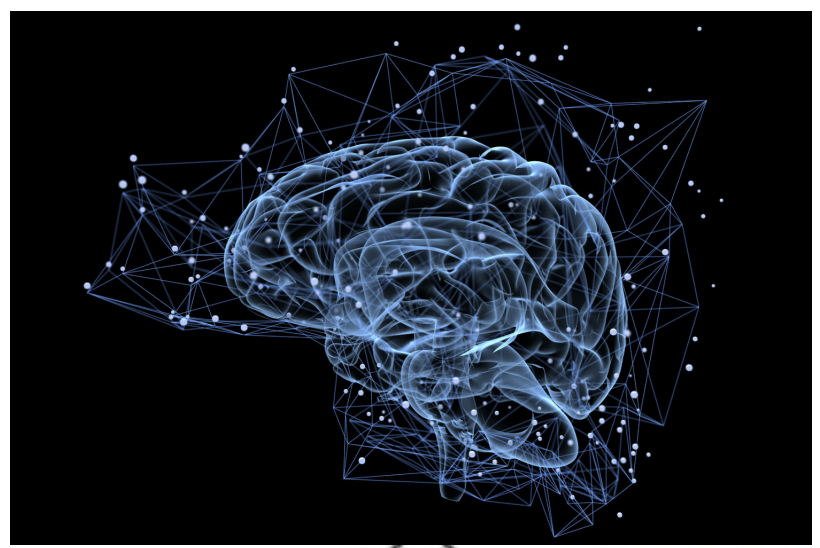
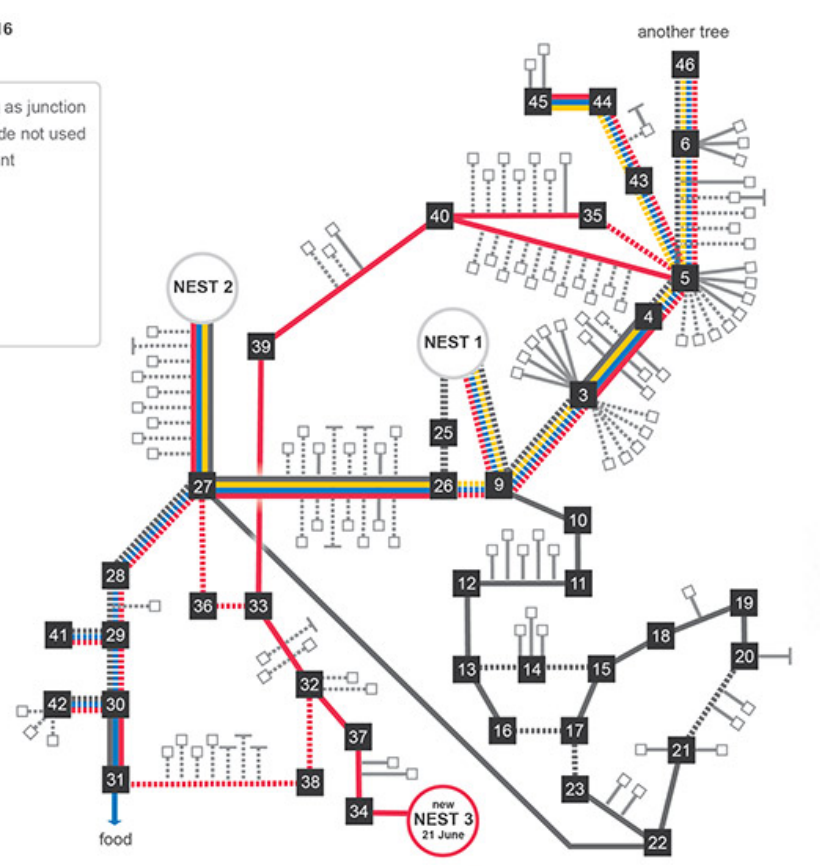
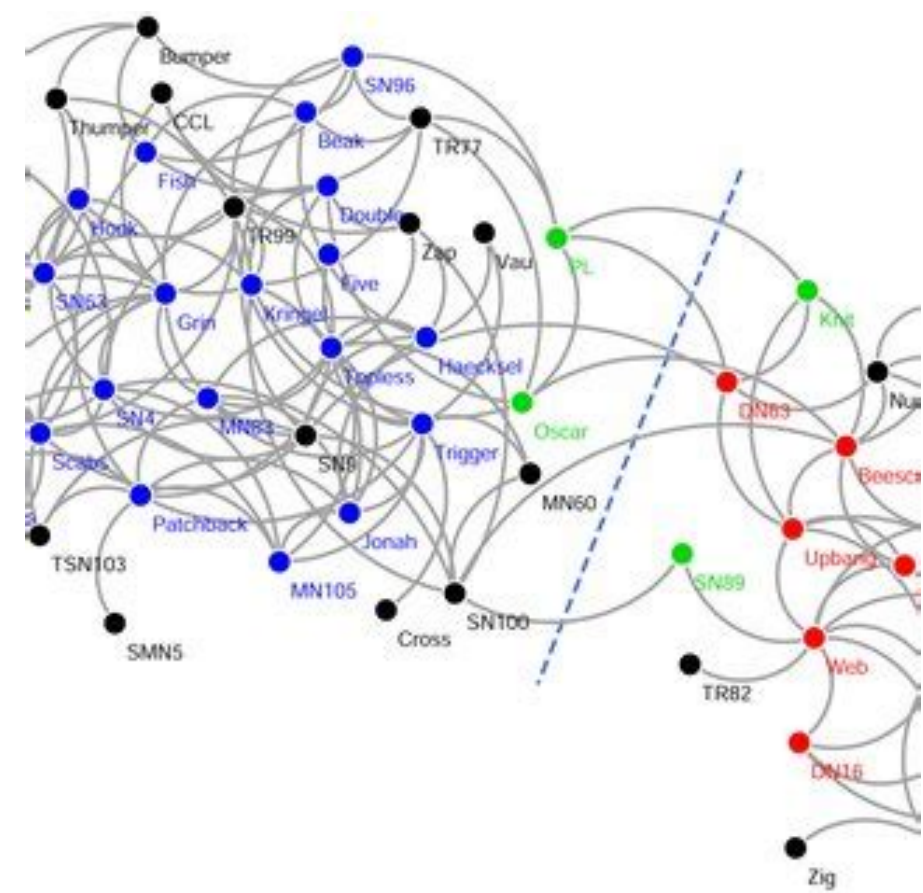


- Graph, network
- $G = (V, E)$
- Vertices, nodes, points
- Node set, mode
- $V = \{a, b, c, \dots\}$
- Edges, ties, links, lines, connections, arcs
- $E = \{\{a, b\}, \{b, c\}, \dots\}$

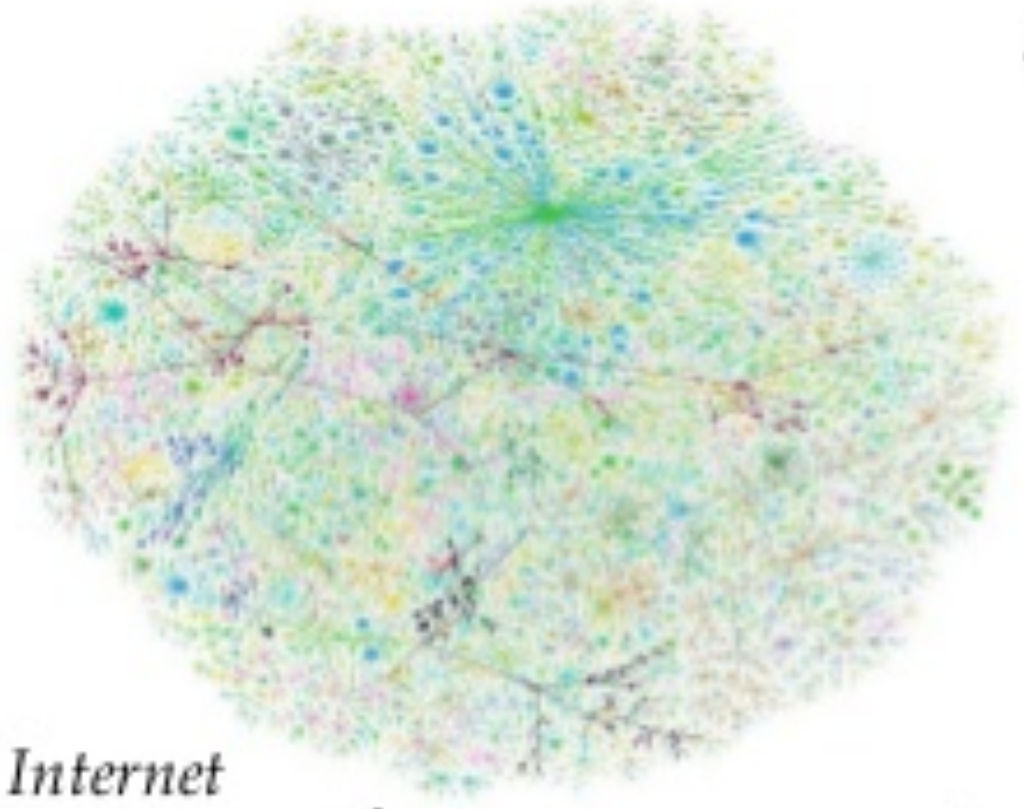
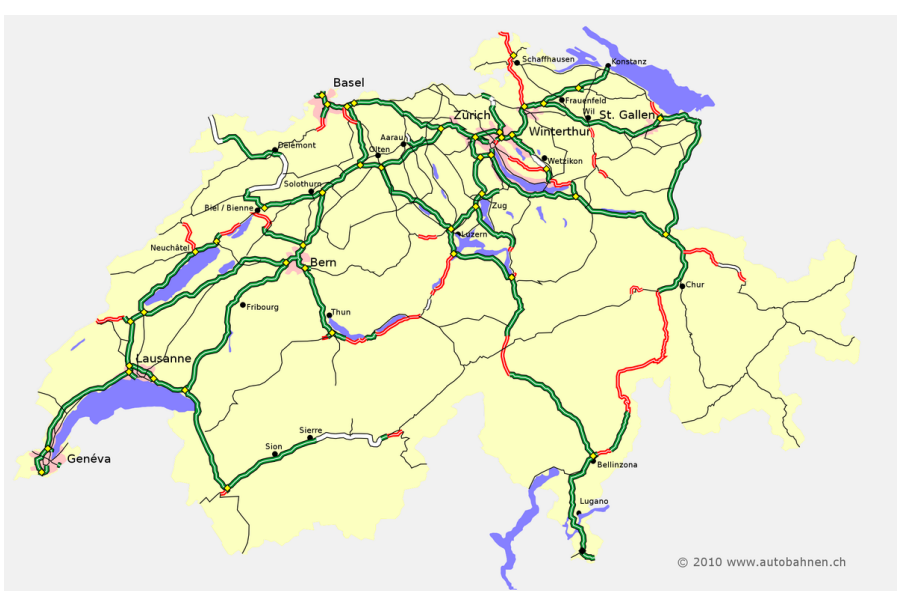


16 - 21 June 2016
Colony EC1

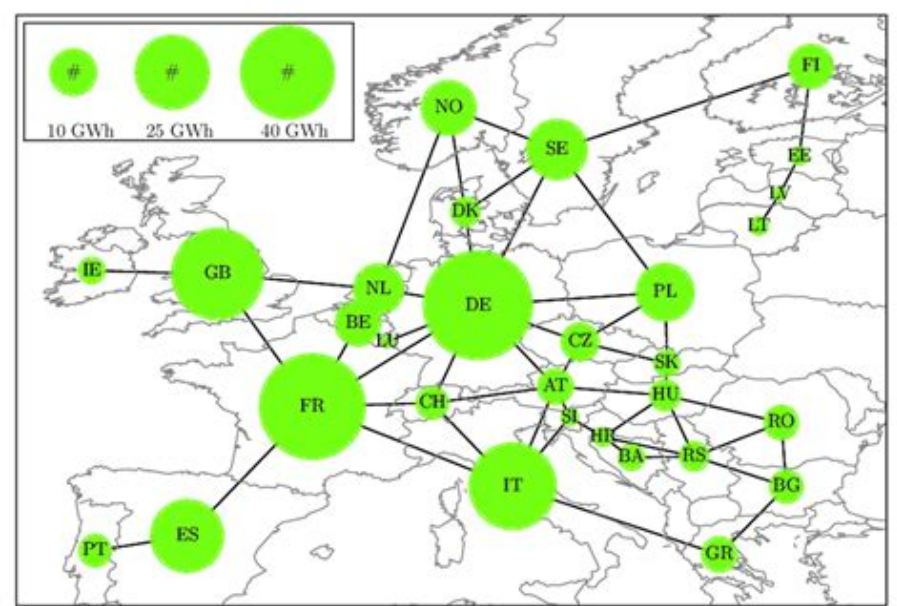
- Node acting as junction
- Possible node not used
- Different plant
- Same plant
- Dead end
- 16 June
- 19 June
- 20 June
- 21 June



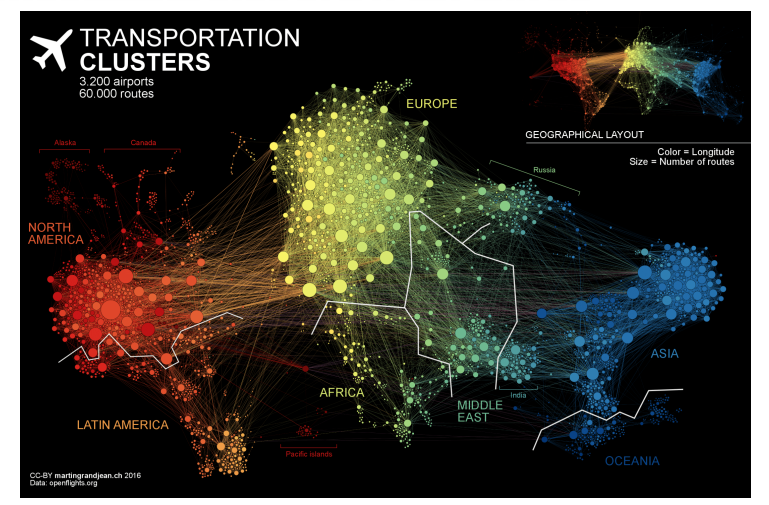
- <1.5k
- 1.5k-20k
- 20k-146k
- 146k-4.5m
- 4.5m-8.6m
- >8.6m



Internet structure



TECHNOLOGICAL



NATURAL

food webs

cell metabolism

neural networks

ant nests

DISEASE SPREAD

innovation flows

co-authorship networks

railway networks

urban road networks

WWW

airport networks

Internet

software maps

sexual partnerships

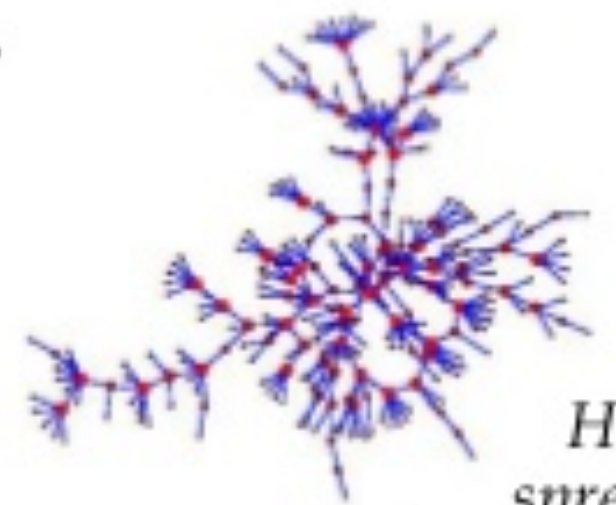
family networks

telephone calls

E-mail patterns

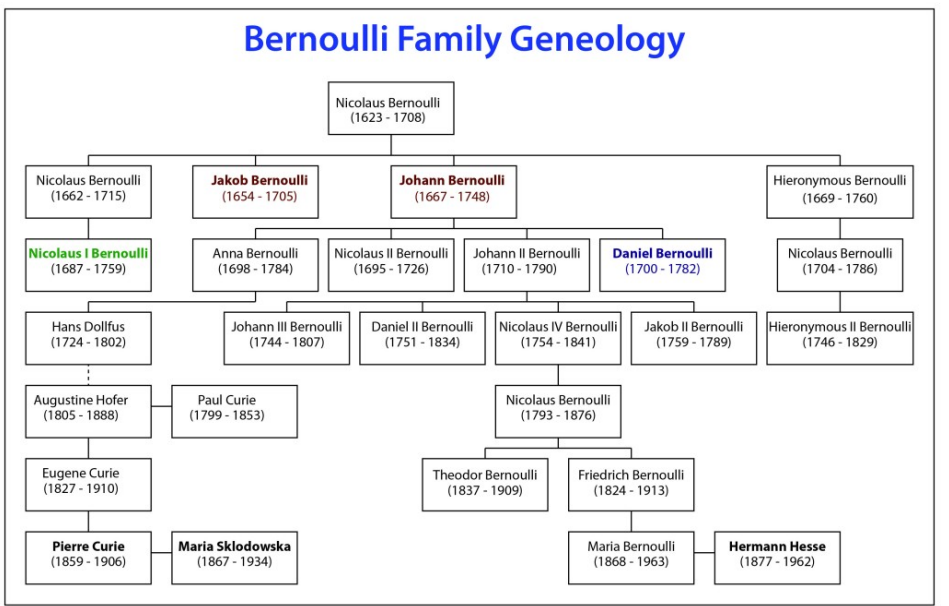
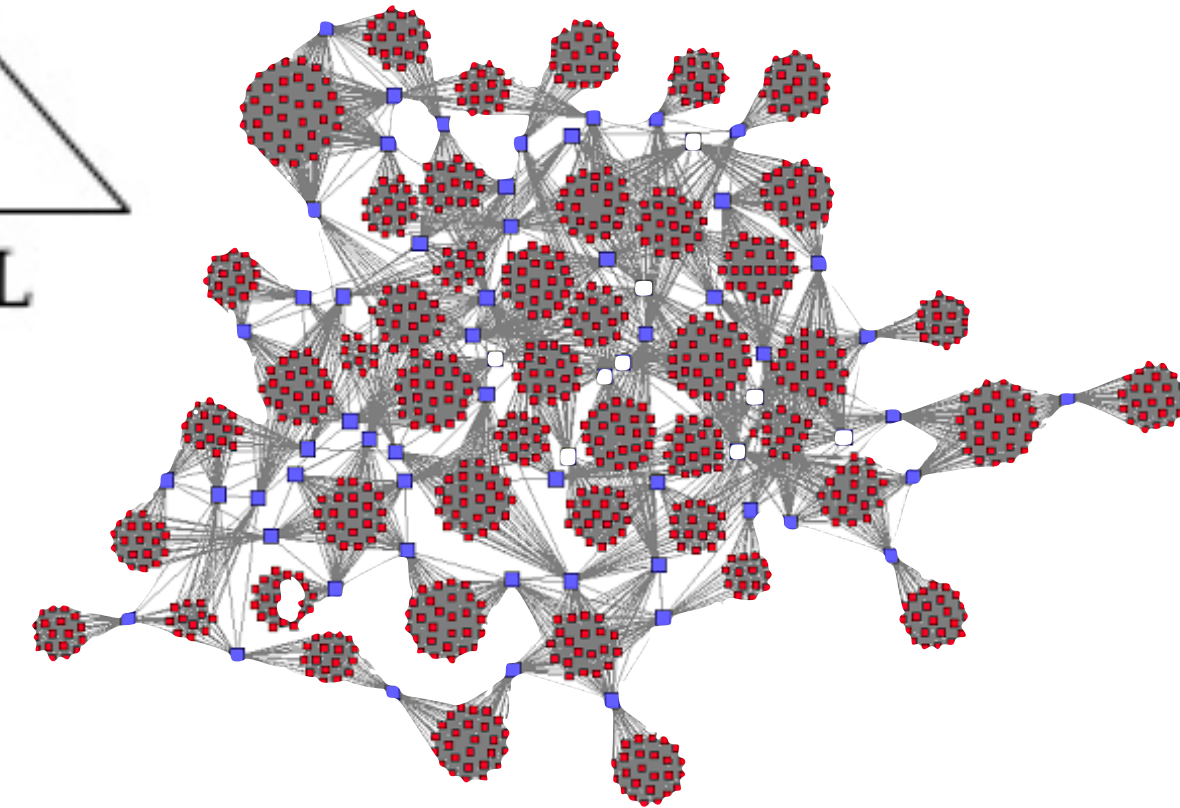
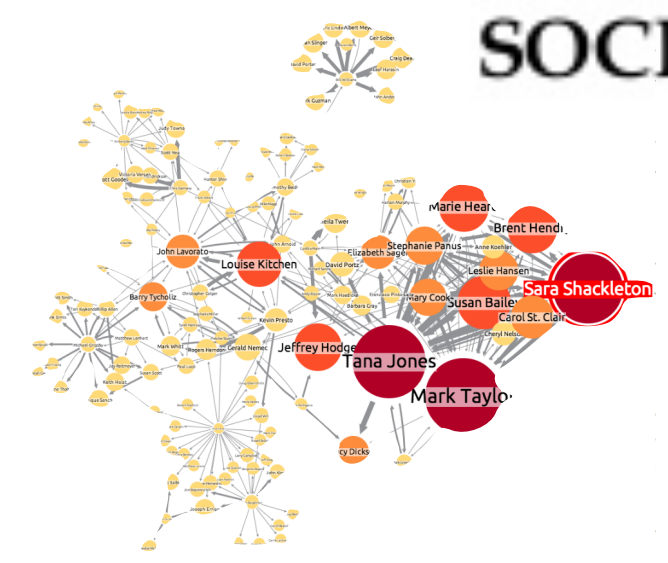
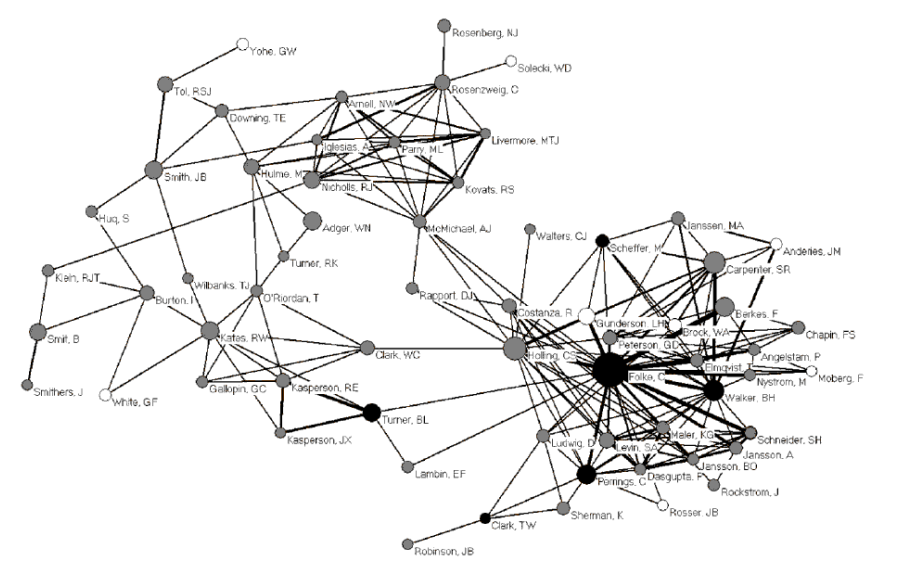
committees

Food web of Little Rock Lake, Wisconsin, US



HIV spread network

SOCIAL



What is/are social/political networks?

What is/are social/political networks?



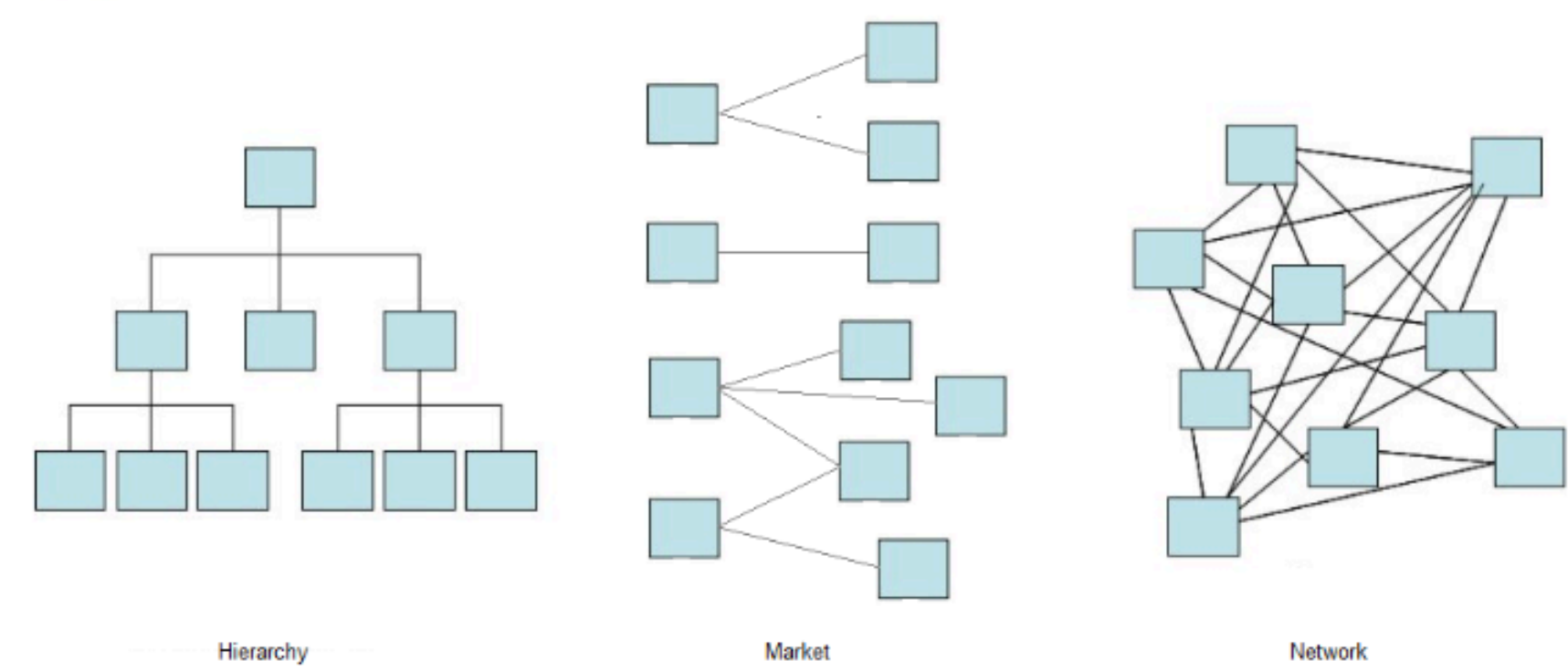
- Not a social network
 - not a type of actor, but structures

What is/are social/political networks?



- Not a social network
 - not a type of actor, but structures

- Not a social **network**
 - not a type of structure, but any structure

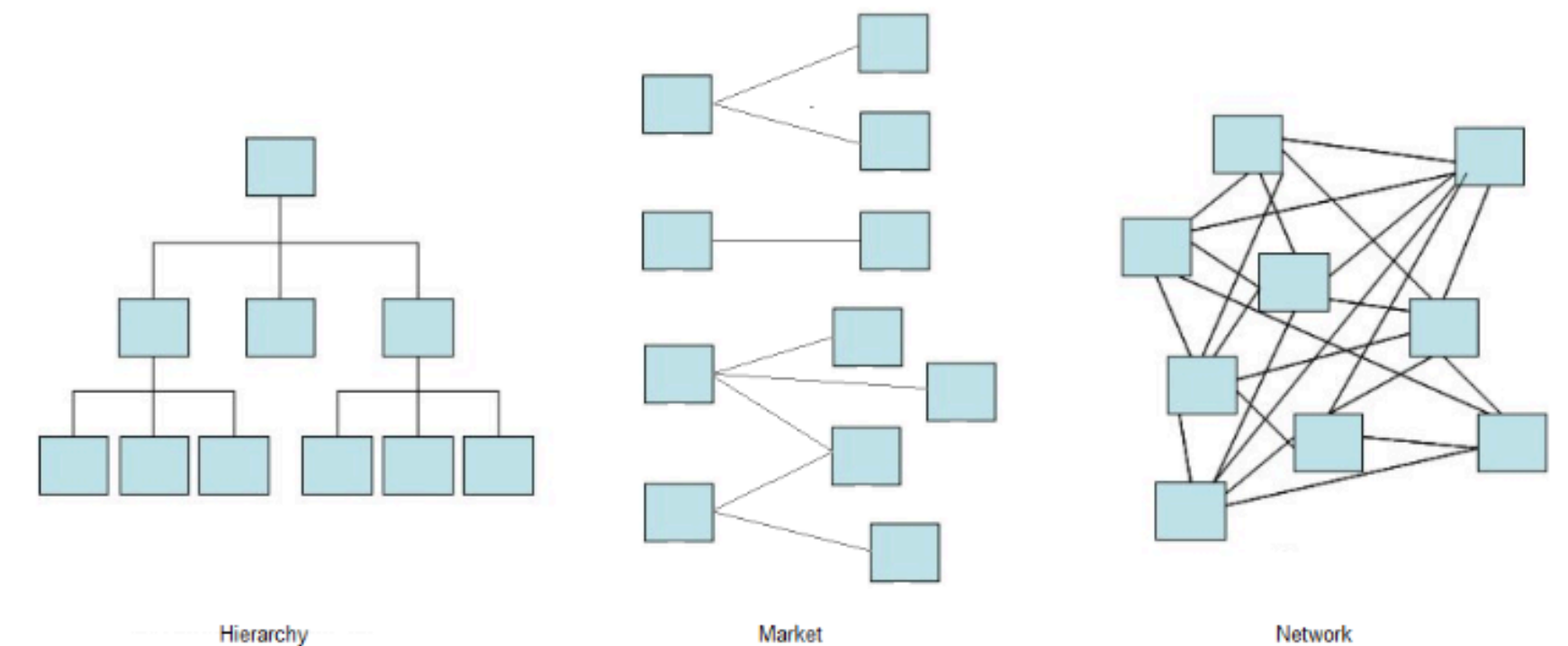


What is/are social/political networks?



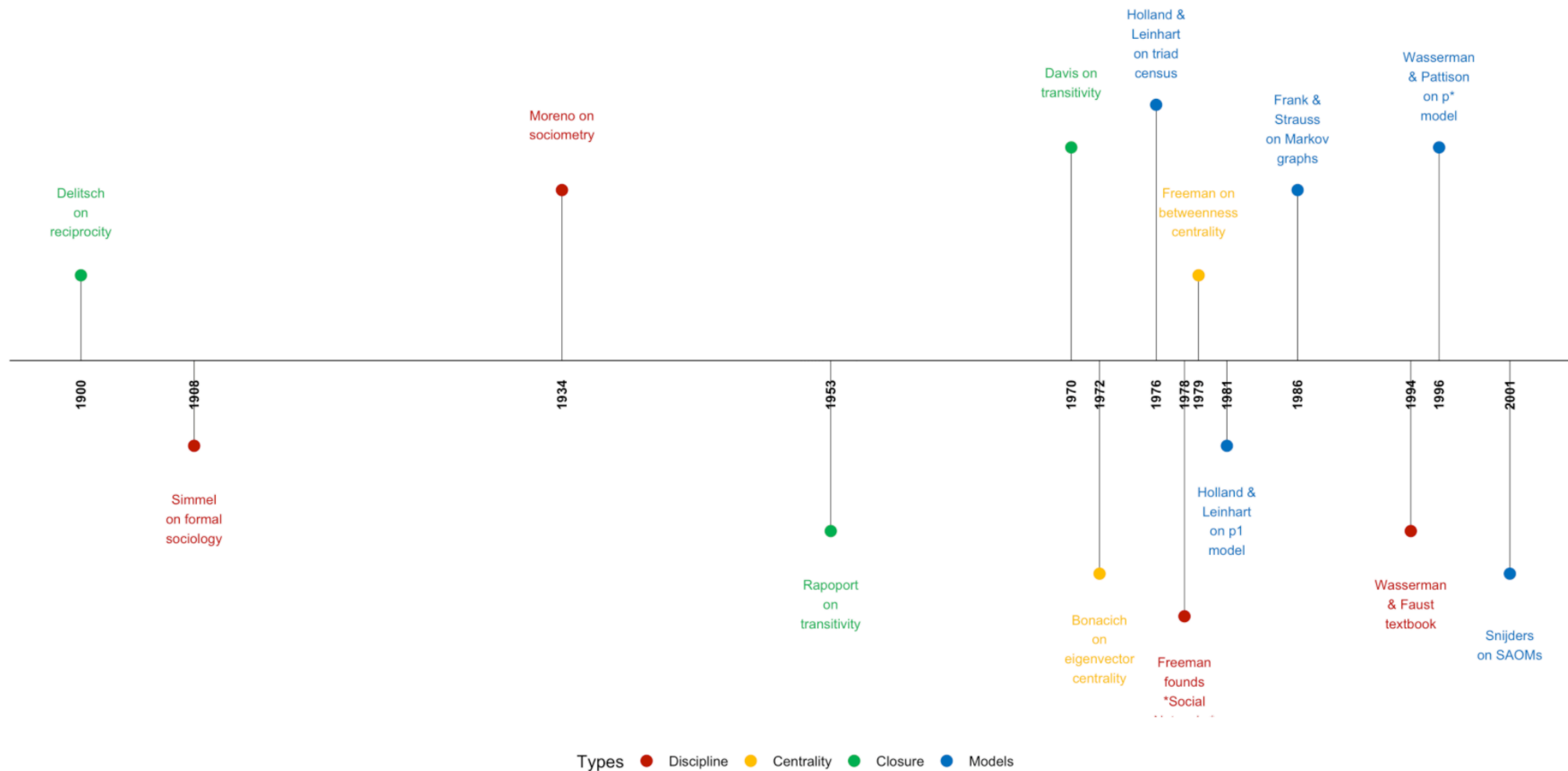
- Not a social network
 - not a type of actor, but structures

- Not a social **network**
 - not a type of structure, but any structure



- Not a **social** network
 - not any structure of a specific type of relation, but structures of any relations

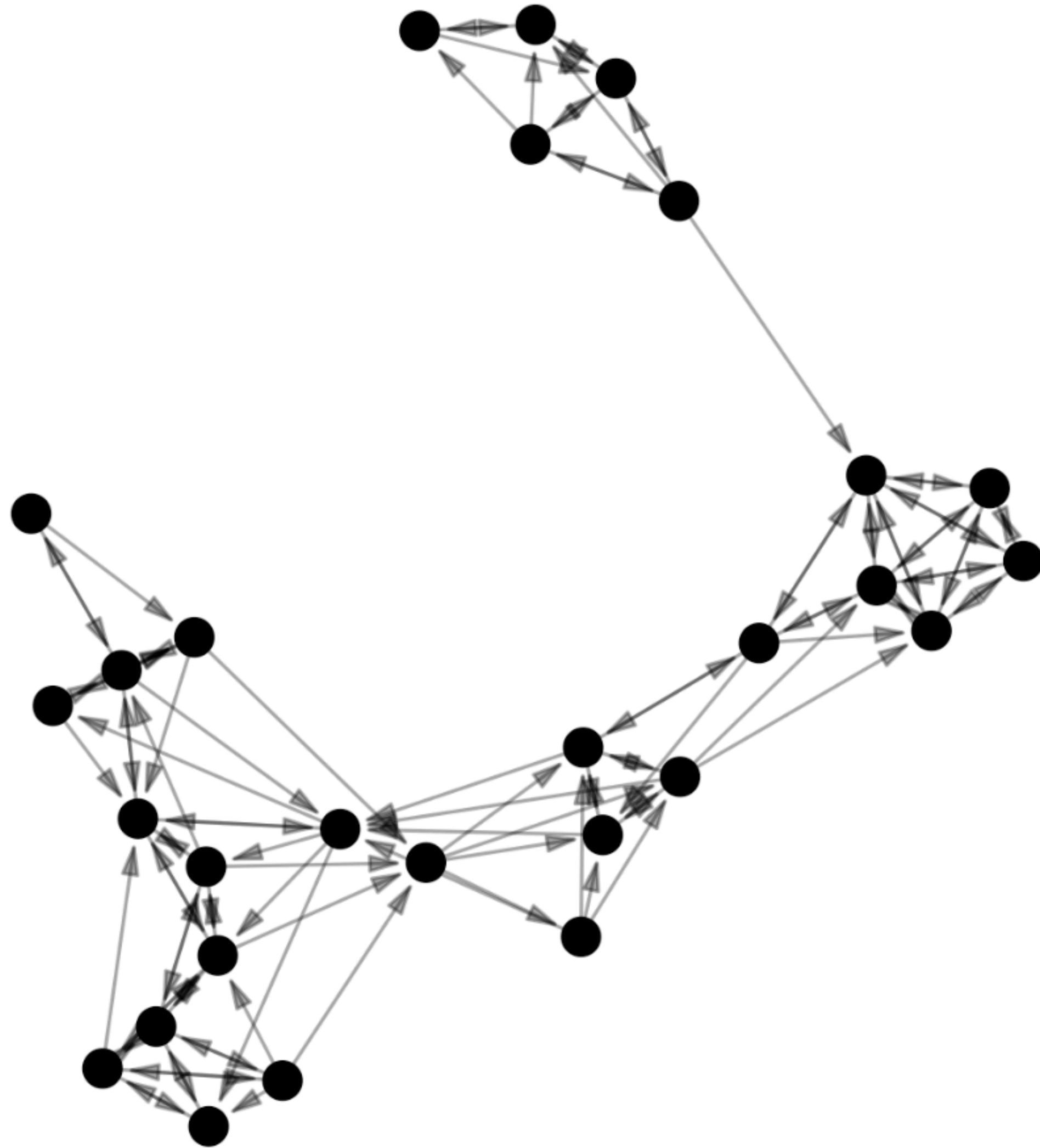
An abbreviated history of SNA



Lesson # 1:

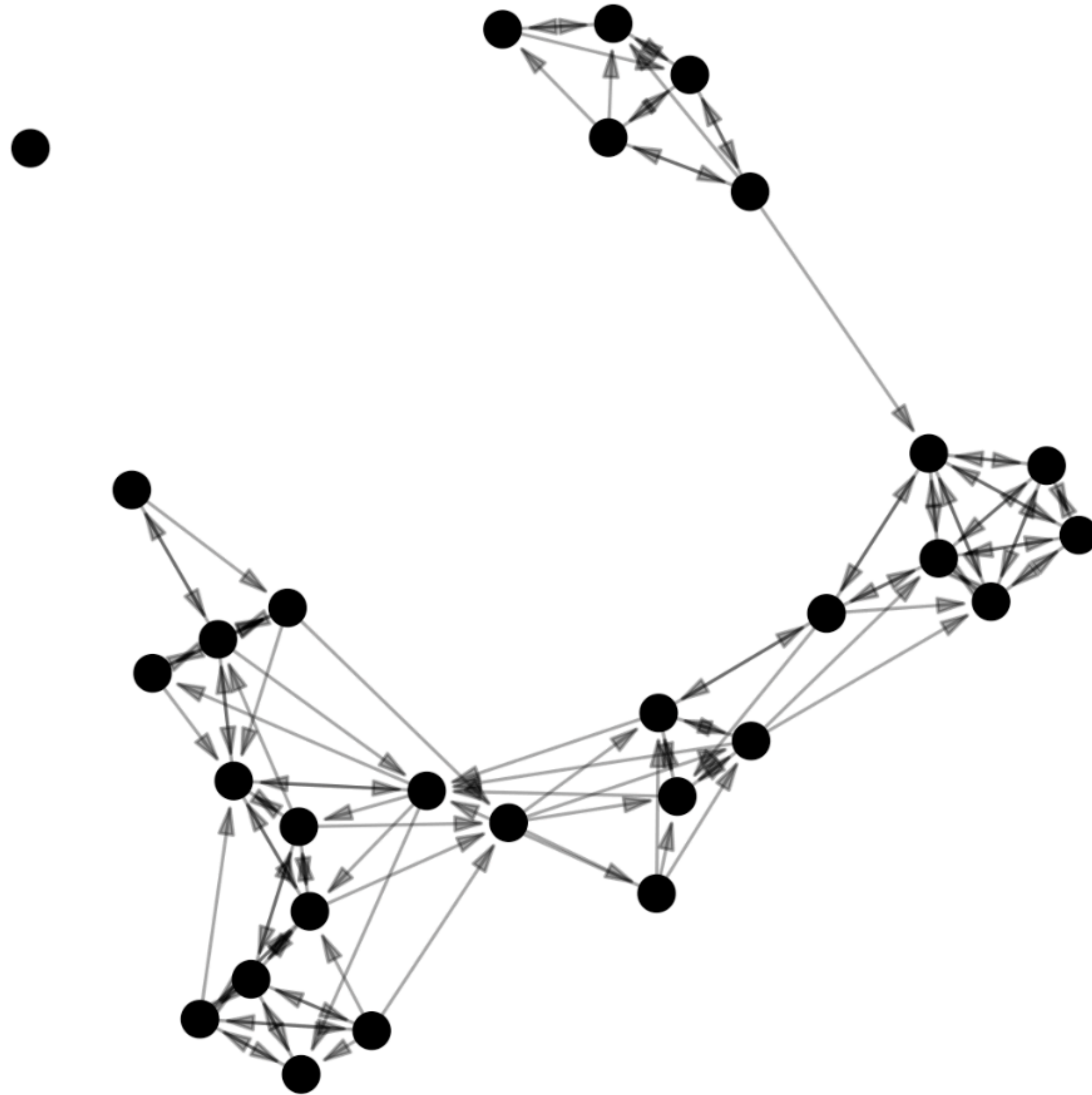
Abstraction allows application

Describing networks



- *what could this network be of?*
- *describe the structure...*
- *describe the position of nodes...*
- *describe the situation of ties...*

Describing networks



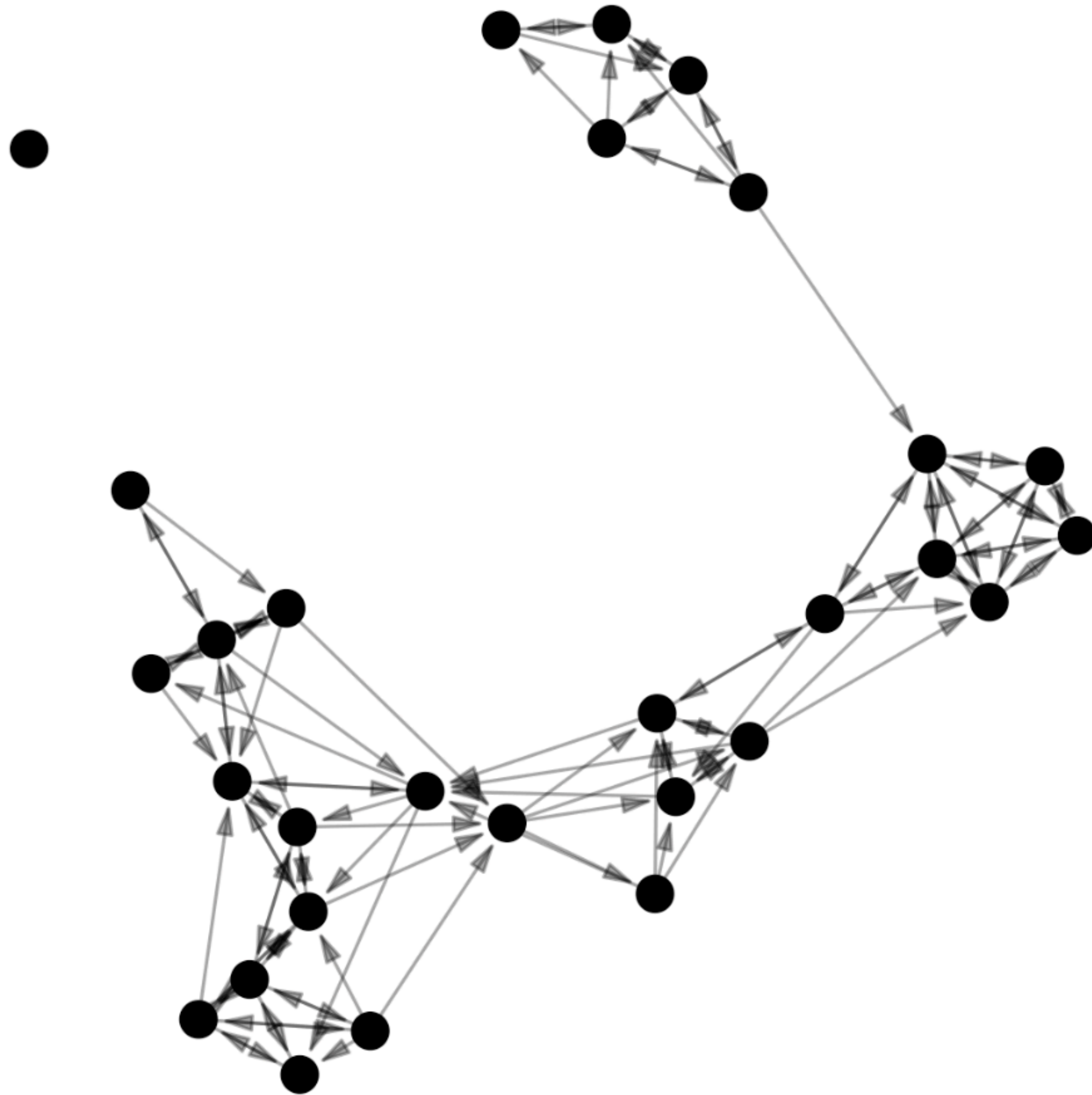
- *what could this network be of?*
 - type/format of network
 - dimensions/density/diameter

- *describe the structure...*
 - centralisation/core
 - components/communities

- *describe the position of nodes...*
 - isolates/centrality
 - brokerage and other roles

- *describe the situation of ties...*
 - reciprocal or asymmetric
 - transitive/cyclical embedded

Levels of analysis

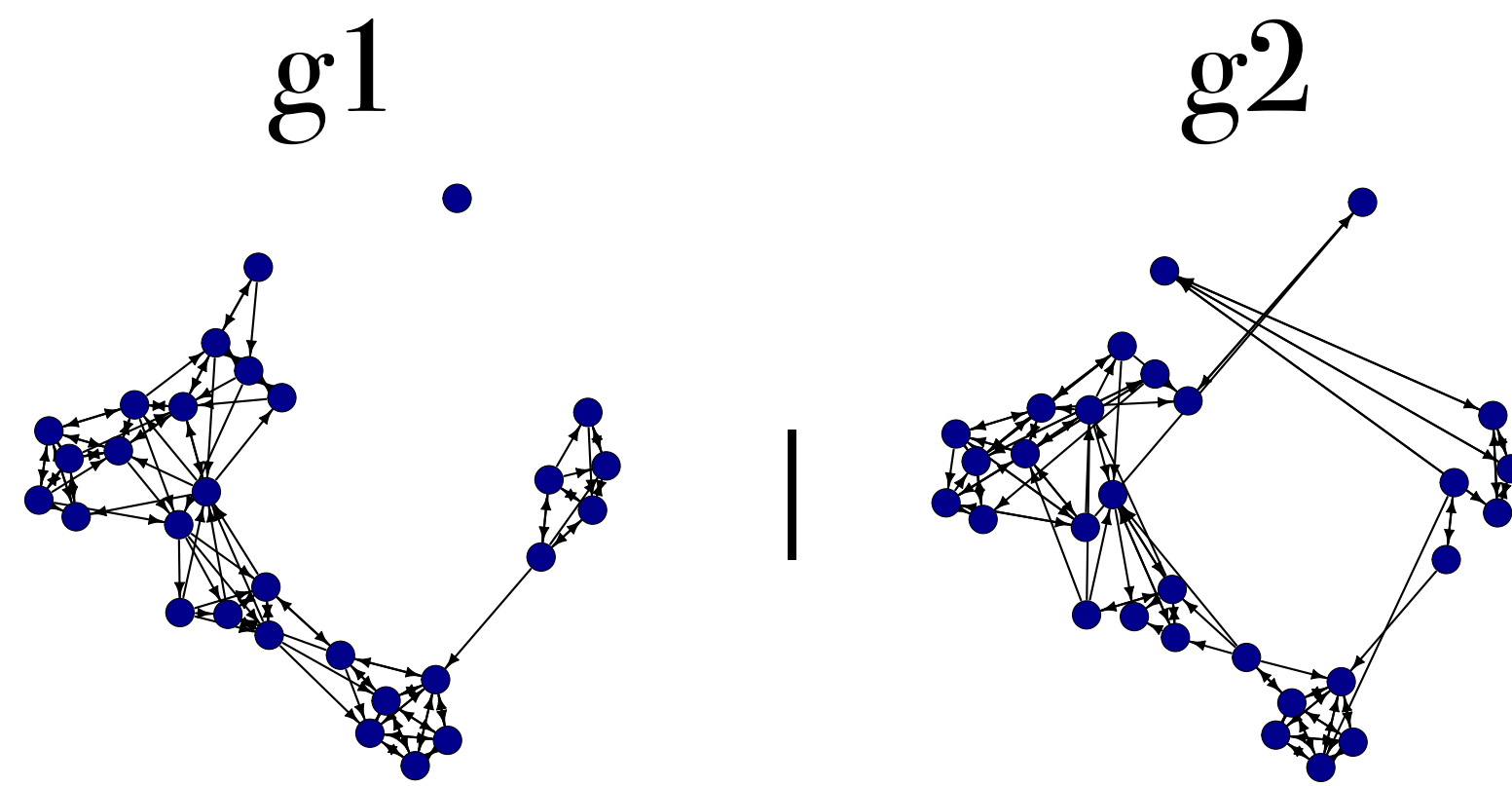


- **Network level** ($O = 1$)
 - e.g. is this network centralized?
- **Dyad level** ($O = n(n - 1)/2$)
 - e.g. are similar nodes connected?
- **Node level** ($O = n$)
 - e.g. are some nodes more popular than others?

Types of analysis

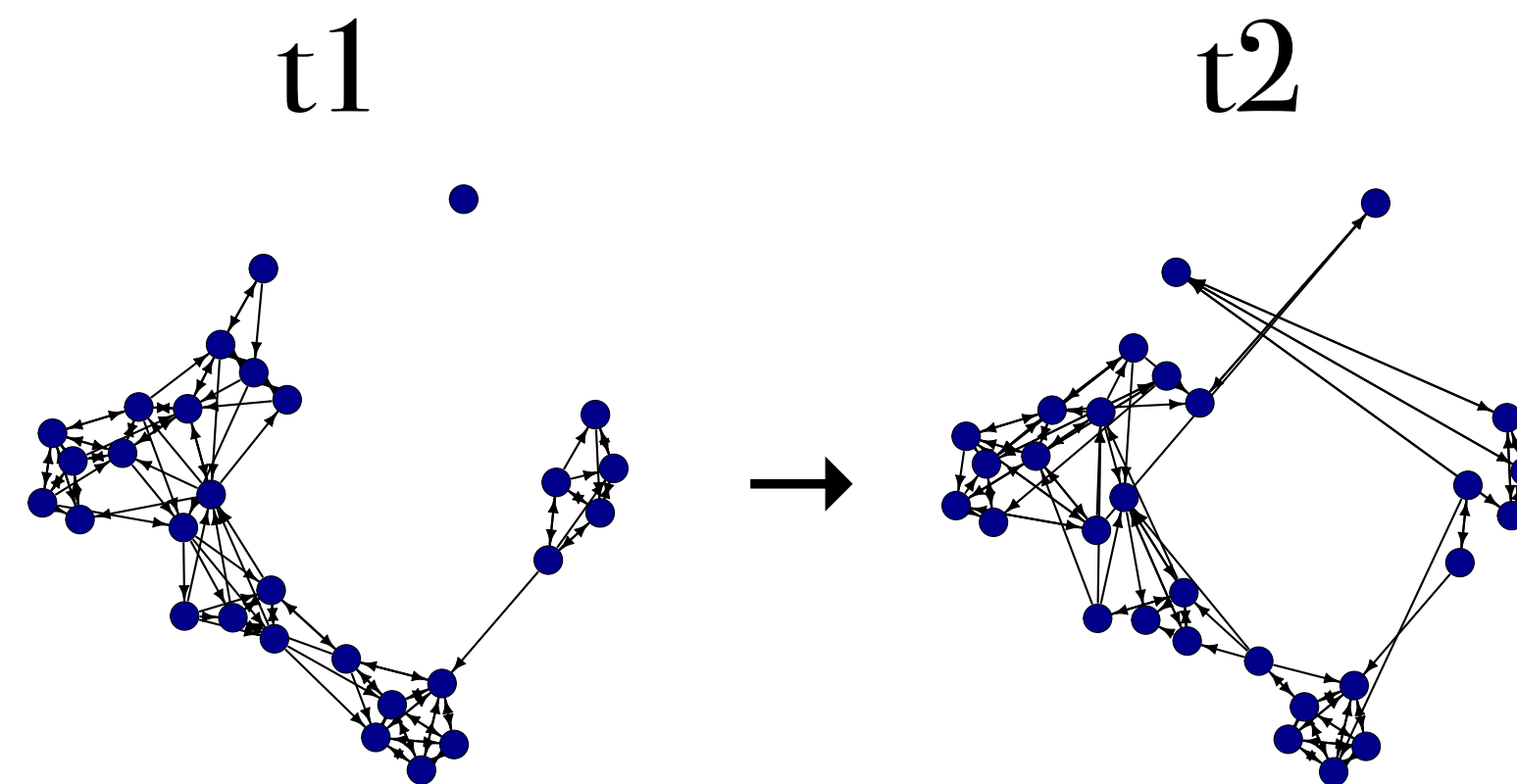
IV.DV	Node	Ties	Network
Node	e.g. does centrality drive success?	e.g. are friendships formed through attraction/homophily?	e.g. are networks clustered around diversity?
Ties	e.g. do unequal exchanges drive success?	e.g. are friendships formed through propinquity?	e.g. are networks clustered around balance?
Network	e.g. do brokerage positions drive success?	e.g. are friendships formed through transitivity?	e.g. are networks coevolving into clustering?

Cross-sectional (settings)



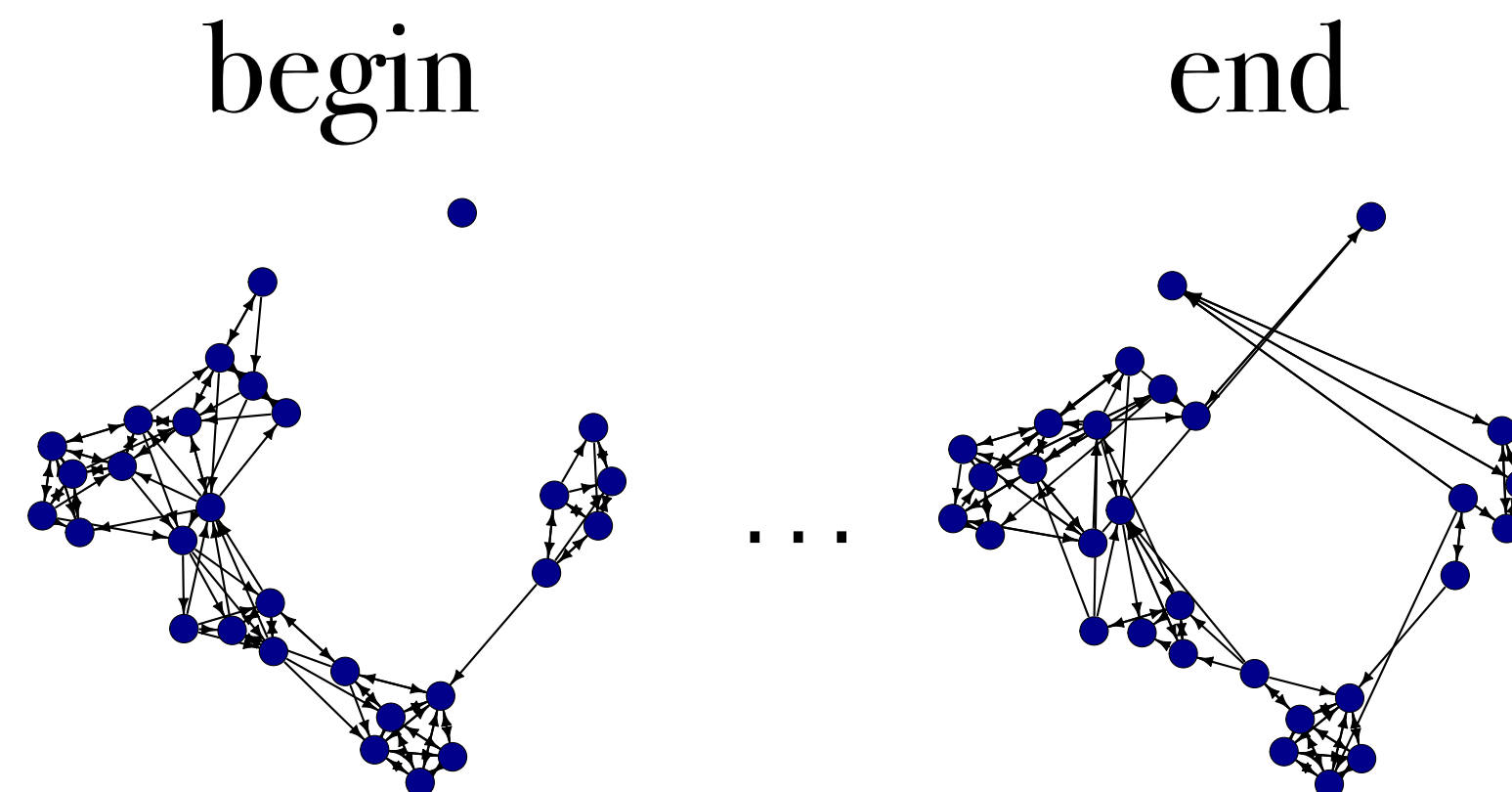
e.g. what makes $g1$ similar/different to $g2$?

Longitudinal (panels)



e.g. what explains $t1$ changing to $t2$?

Continuous (events)



e.g. what drives change from *begin* to *end*?

Questions about position

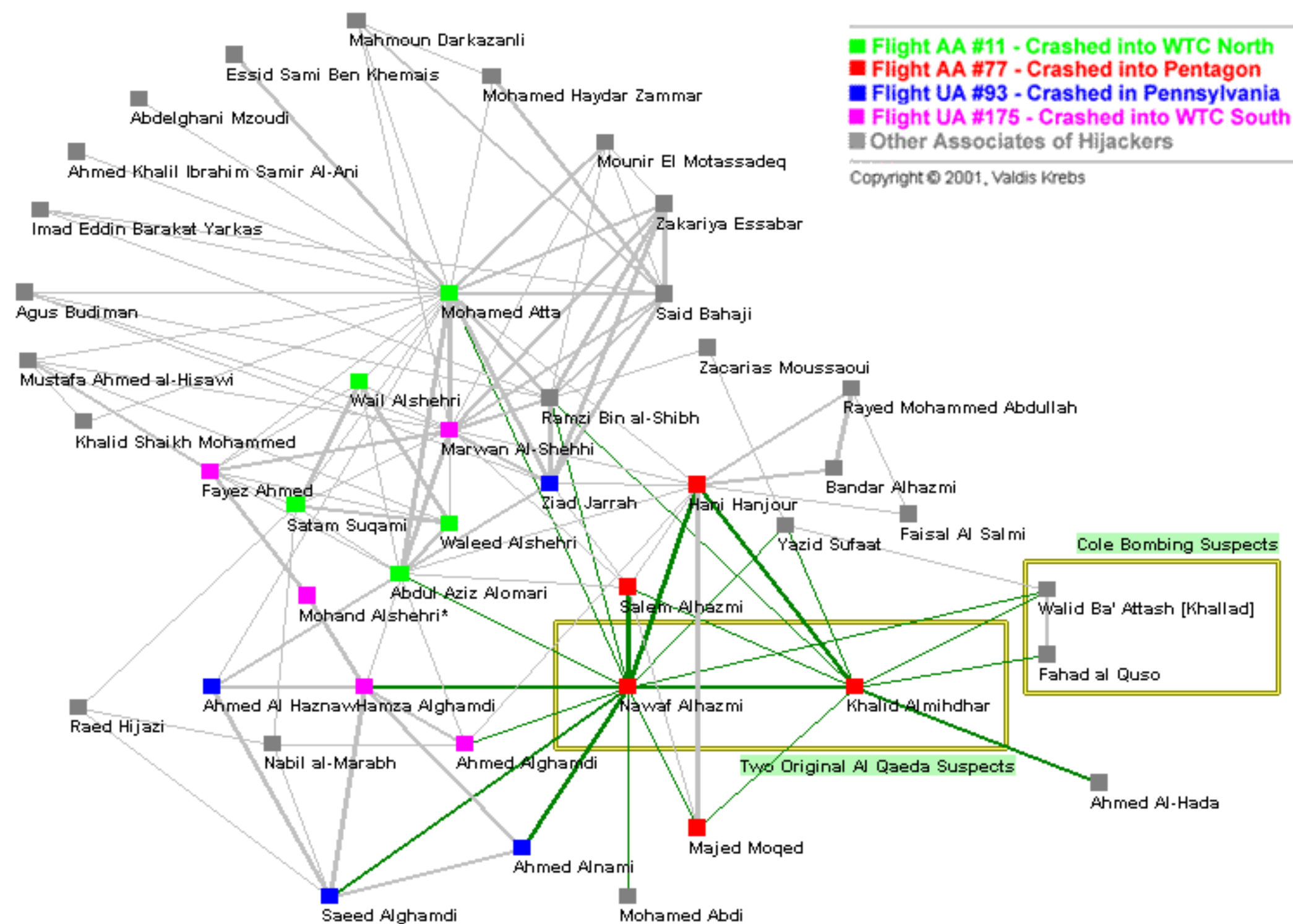
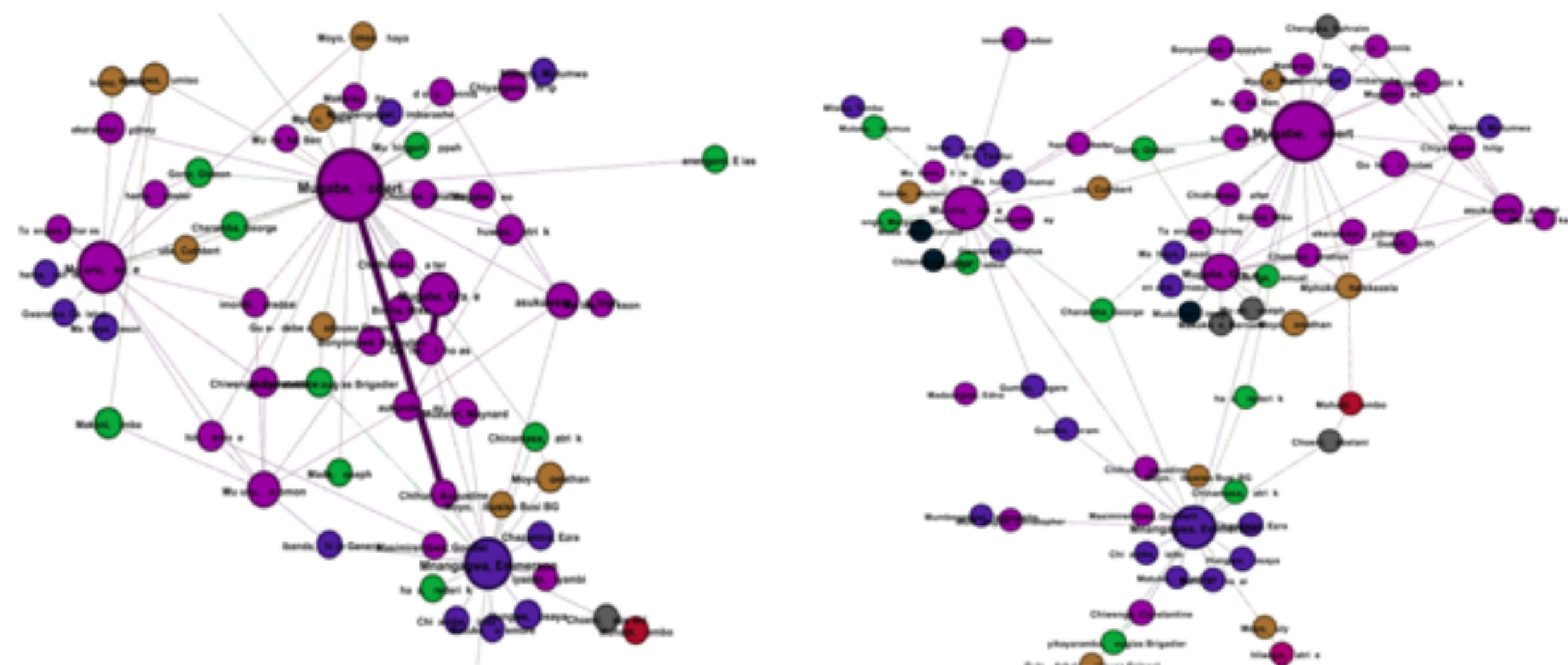


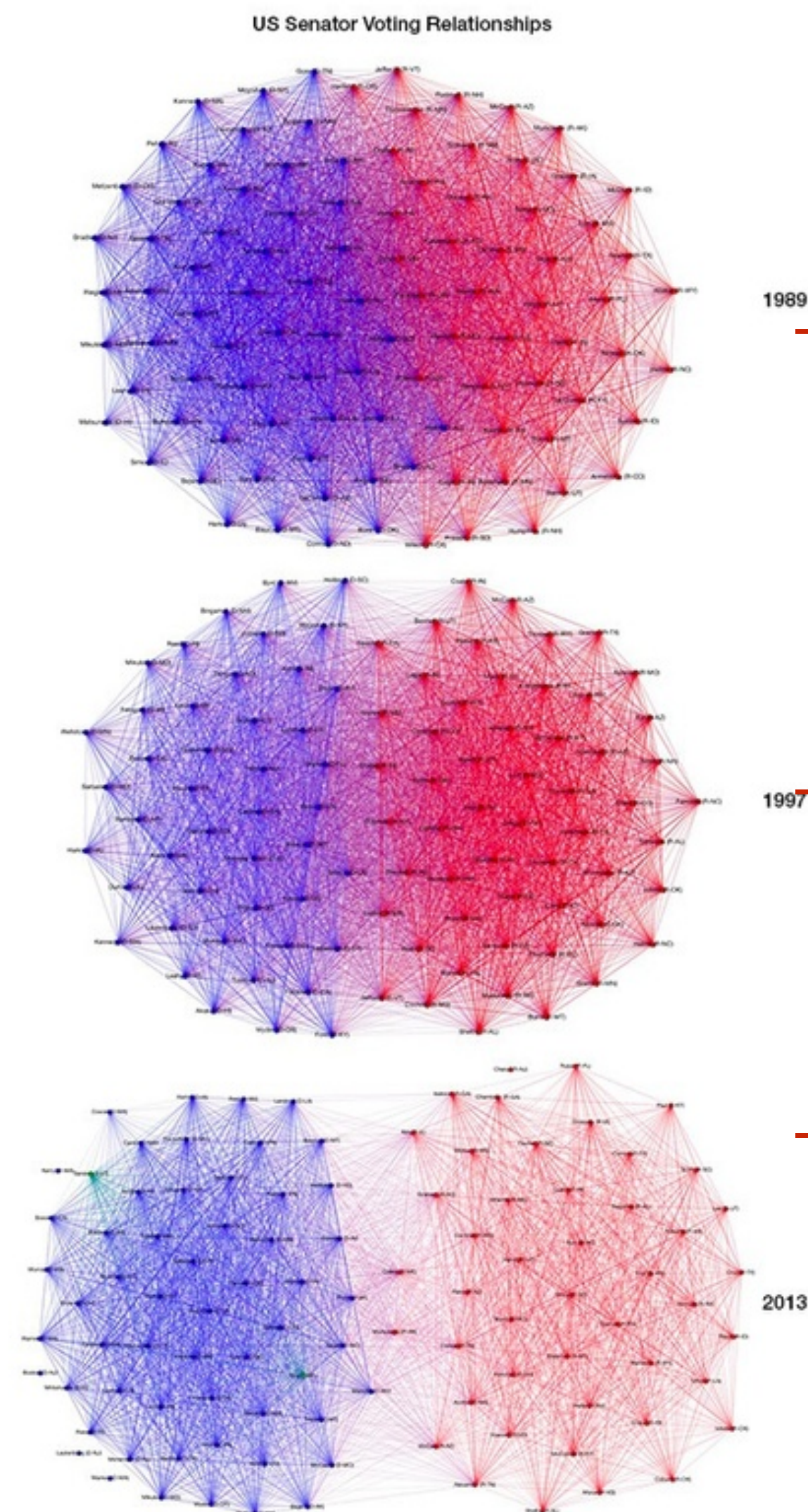
Figure 3 - All Nodes within 2 steps / degrees of original suspects

- Questions about nodes: e.g. *who is in a more central position and are central positions associated with certain outcomes?*
- Questions about networks: e.g. *what kinds of roles are there in the network and how have (membership in) these roles changed?*



Mugabe's Inner Circle in 2008 and then 2016. Nodes are colored by clan affiliation.

Questions about clustering

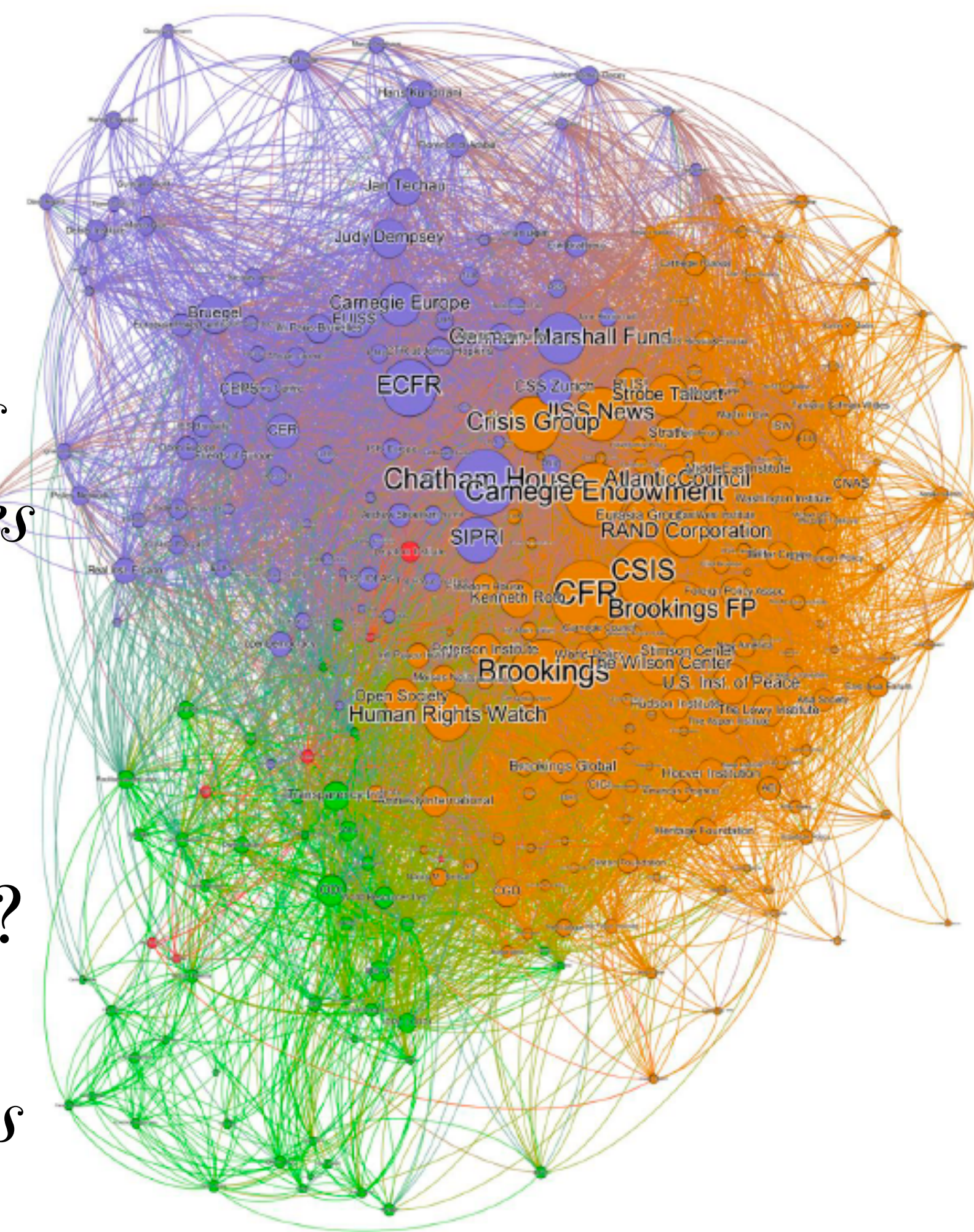


- Descriptive questions, e.g. *how cohesive is a network and how embedded are the nodes in a network?*

- Deductive questions, e.g. *is a structure divided into two (or more) distinct factions?*

- Inductive questions, e.g. *how many groups are there and which are their members?*

Figure 2. Global political influencer network

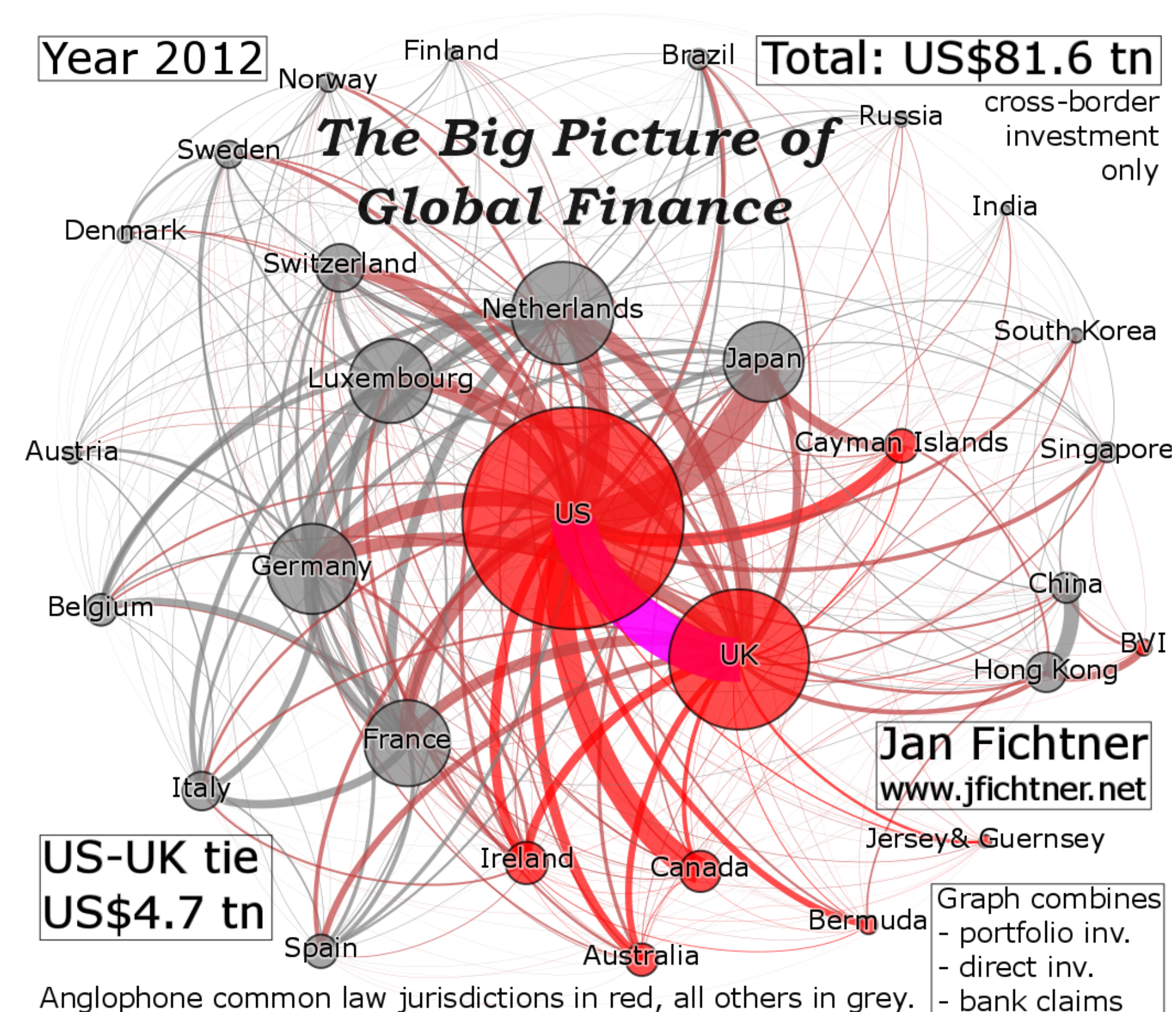
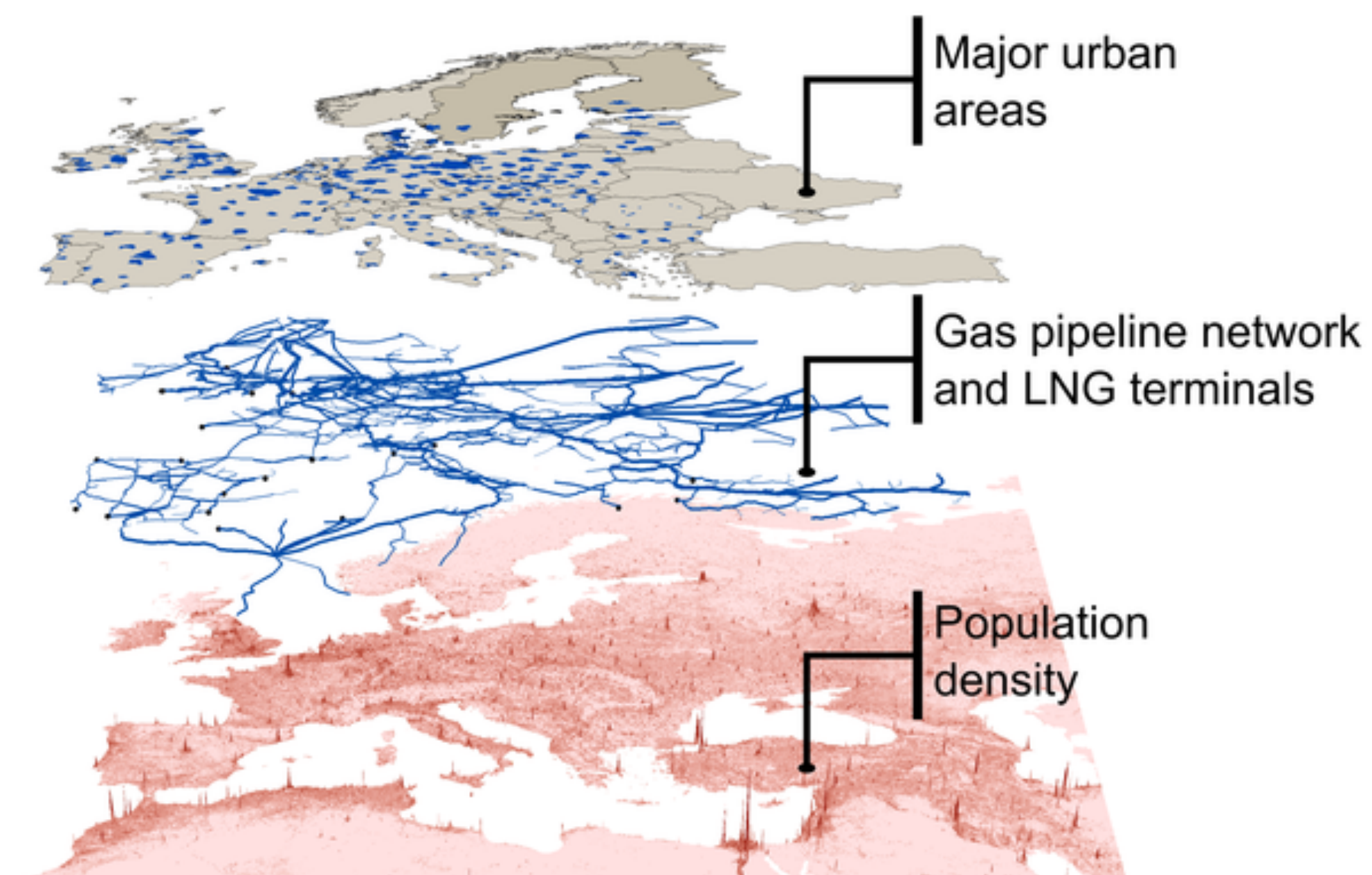


1. American Cluster 2. European Cluster 3. British Cluster 4. Russian Cluster 5. Latin American Cluster

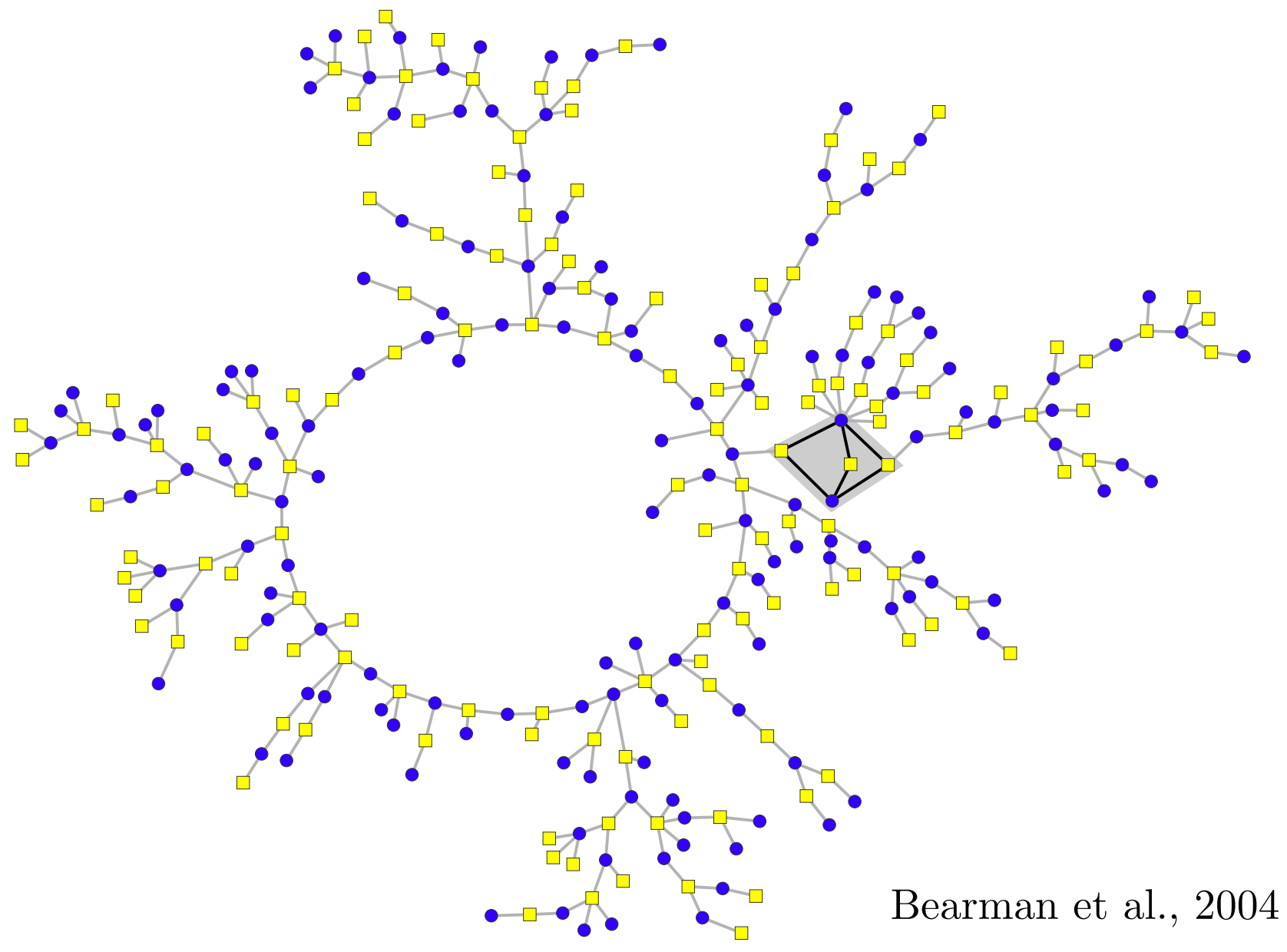
Source: thinktanks.institutoelcano.org

Questions about topology

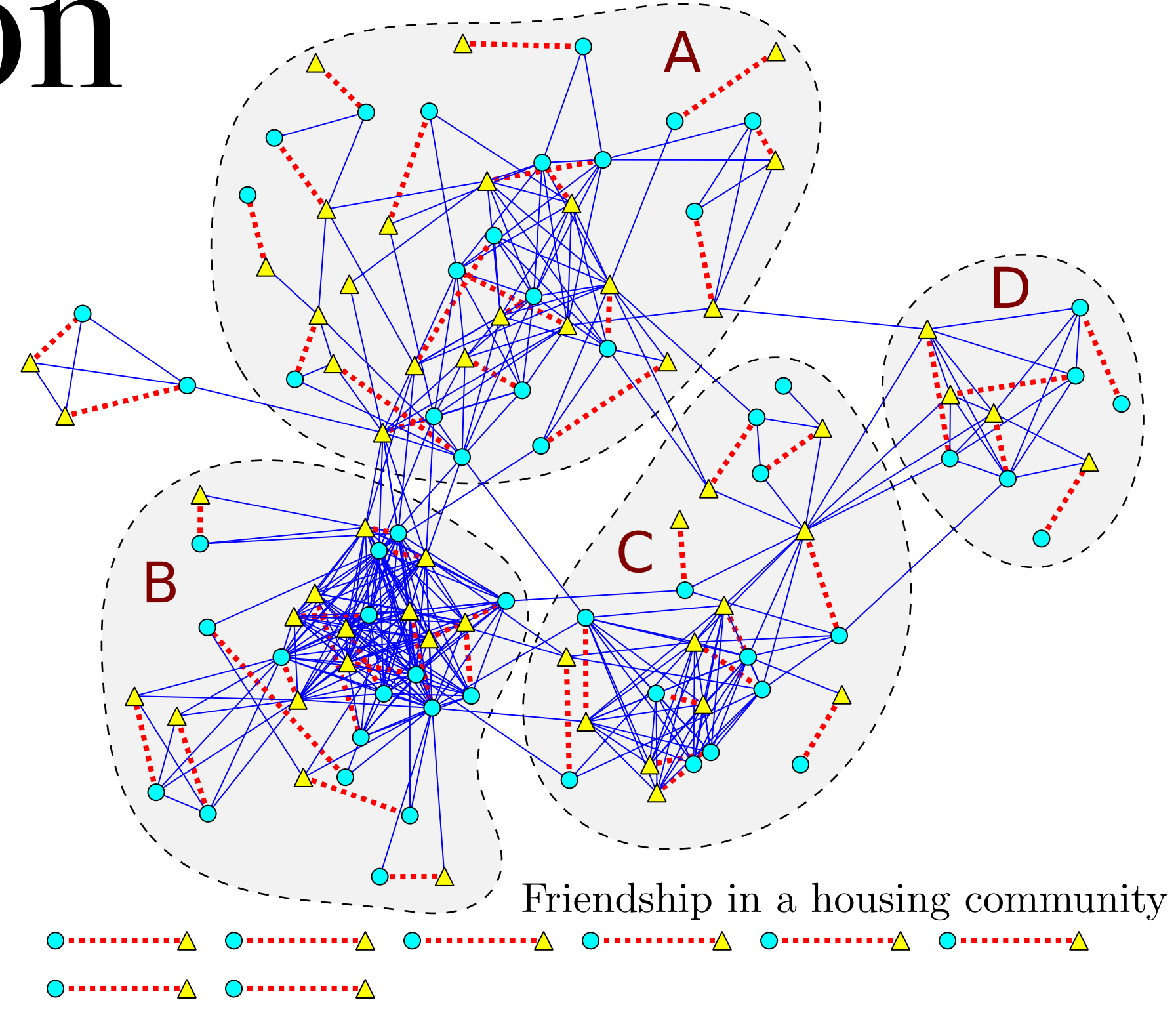
- Descriptive questions, e.g. *is there a discernible core-periphery structure?*
- Analytic questions, e.g. *how resilient is this network to disruptions?*



Questions about selection



Bearman et al., 2004



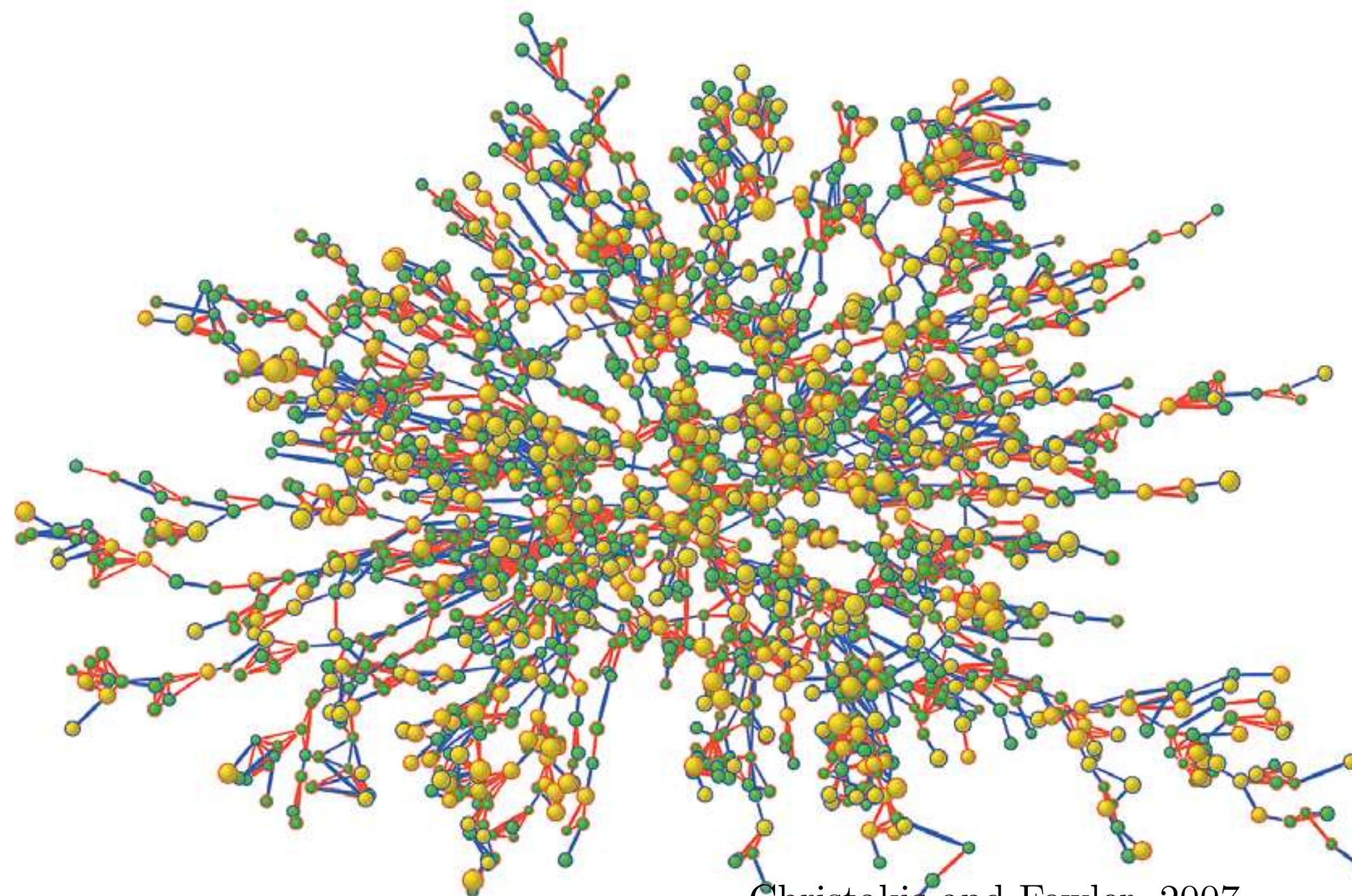
Friendship in a housing community

- Questions about structural selection: *are the most popular being selected and are connections connections being selected?*

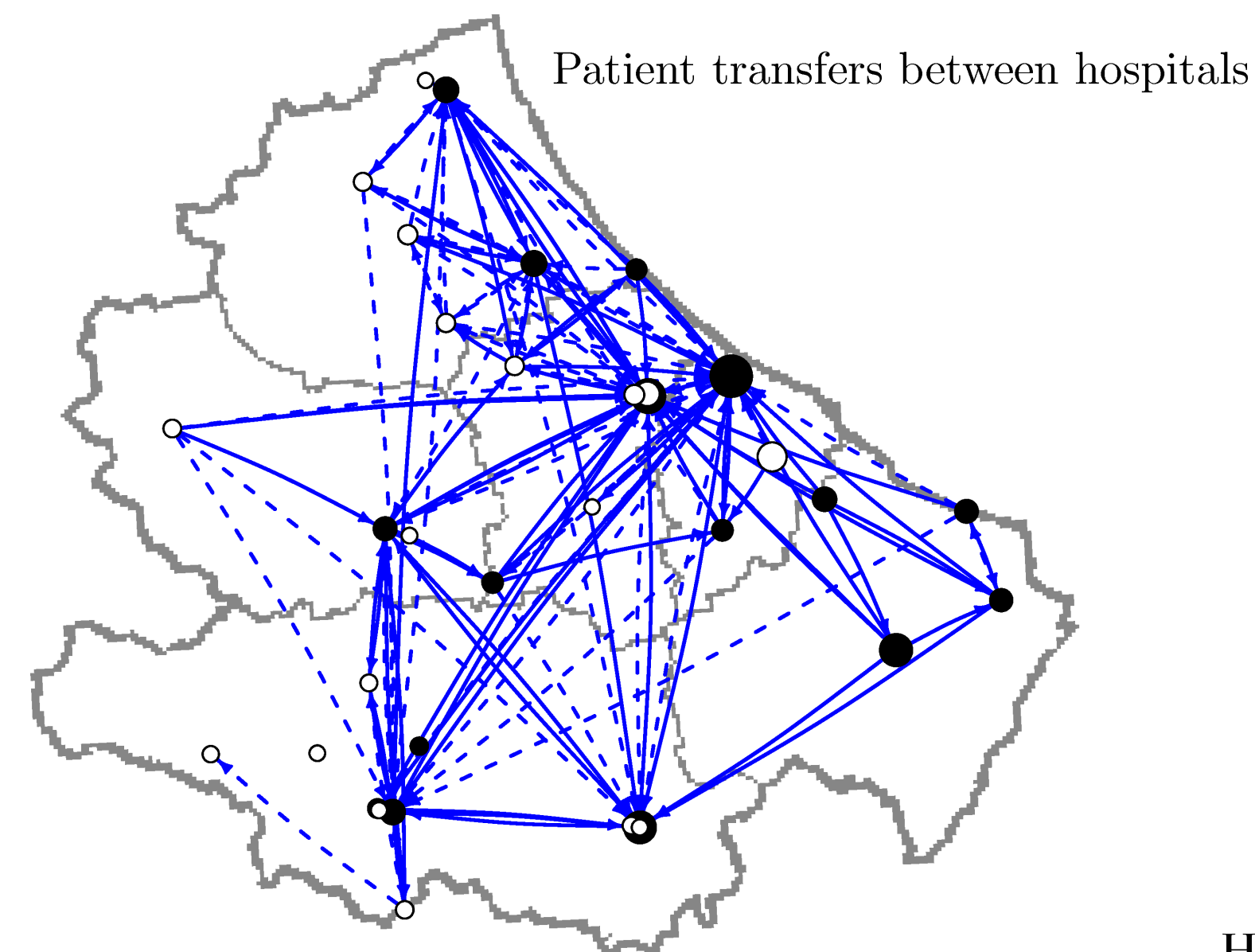
- Questions about multiplex selection: *does one network explain the other and are networks balanced?*

Questions about influence

- Questions about diffusion: e.g. *how does behavior spread and what seeds and structures help or hinder the process?*
- Questions about peer influence: e.g. *how are outcomes influenced by what connections are doing?*



Christakis and Fowler, 2007

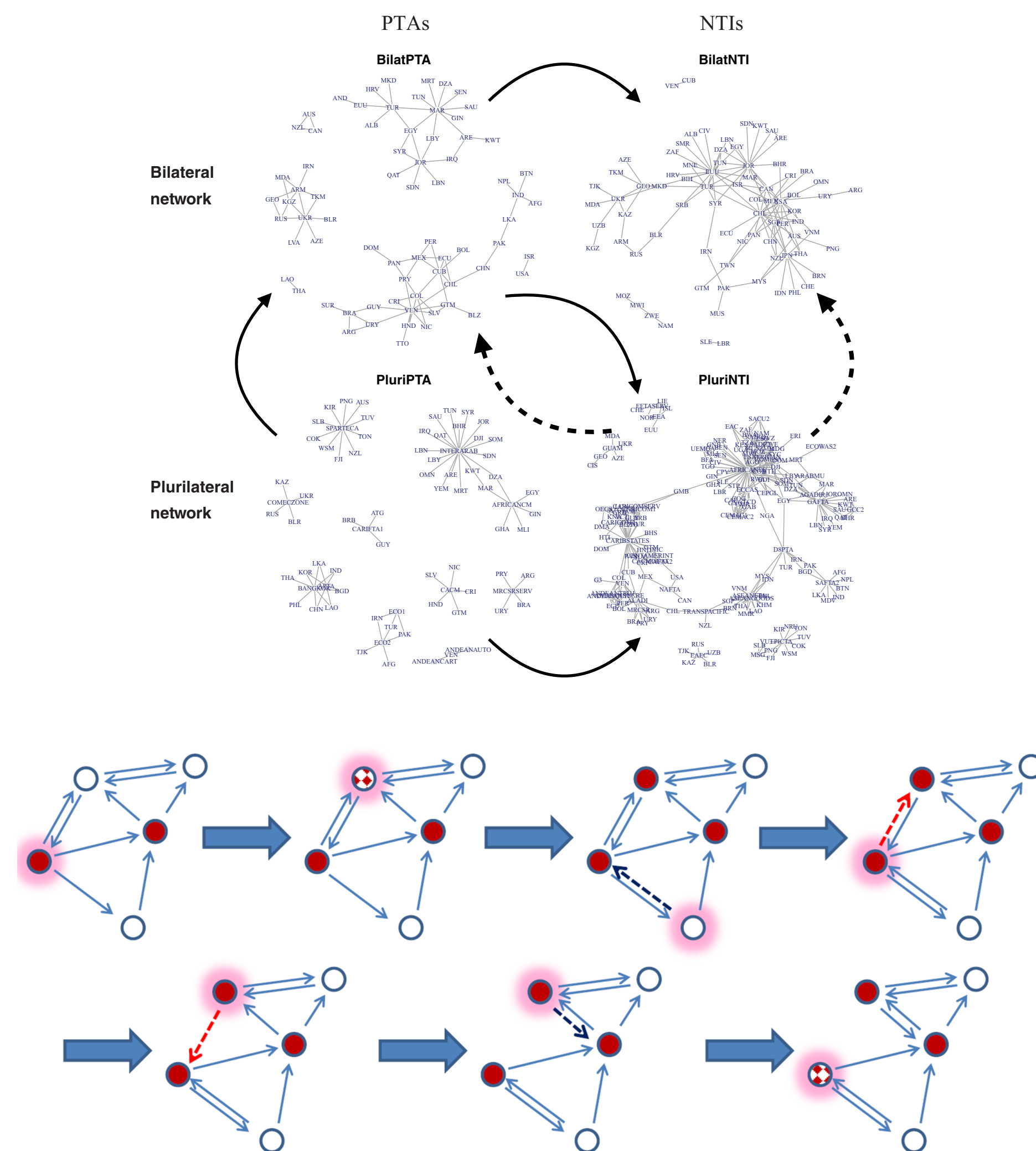


Patient transfers between hospitals

Hollway et al 2017

Questions about coevolution

- Questions about coevolution of networks: e.g. *which choices initialise interdependency?*



- Questions about coevolution of networks and behaviour: e.g. *how path dependent are our choices?*

Lesson #2:
Questions are key

Social Networks

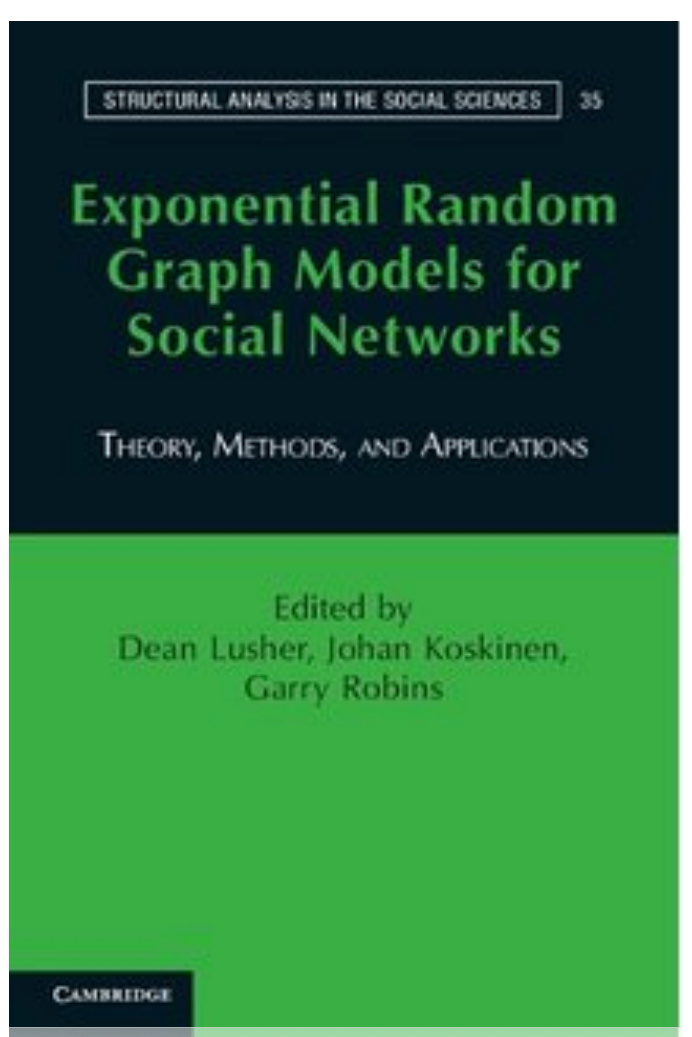
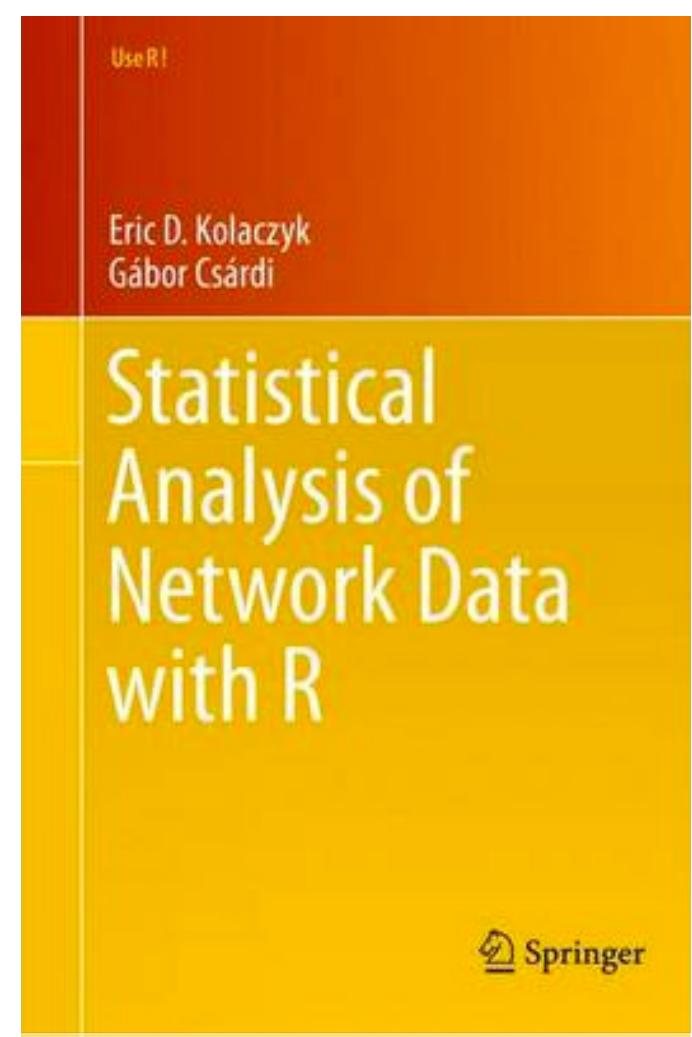
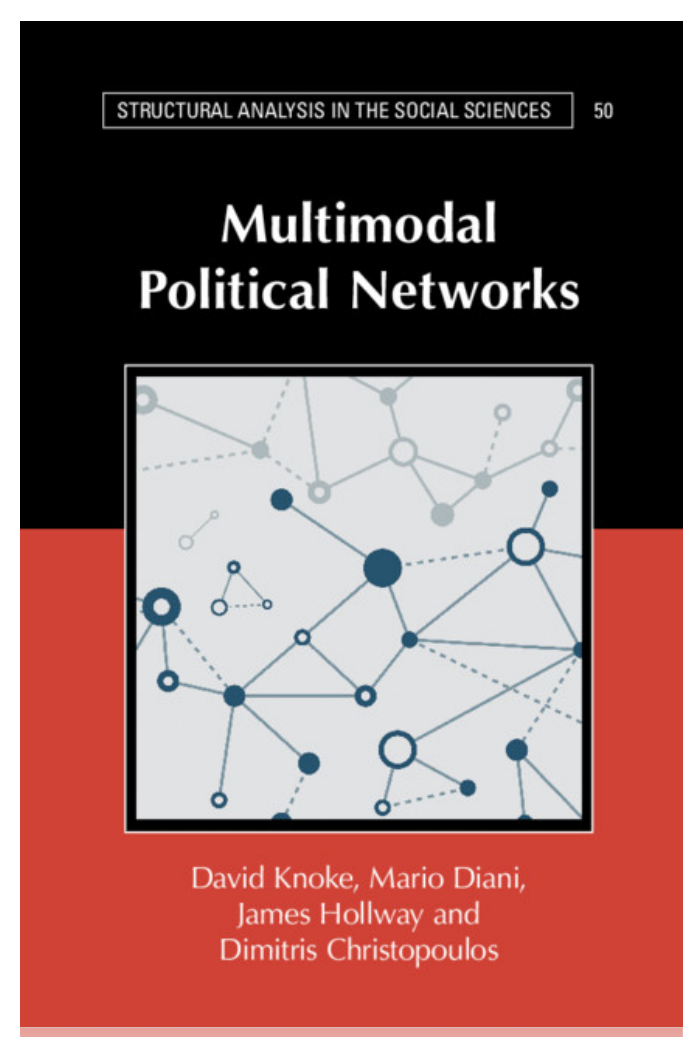
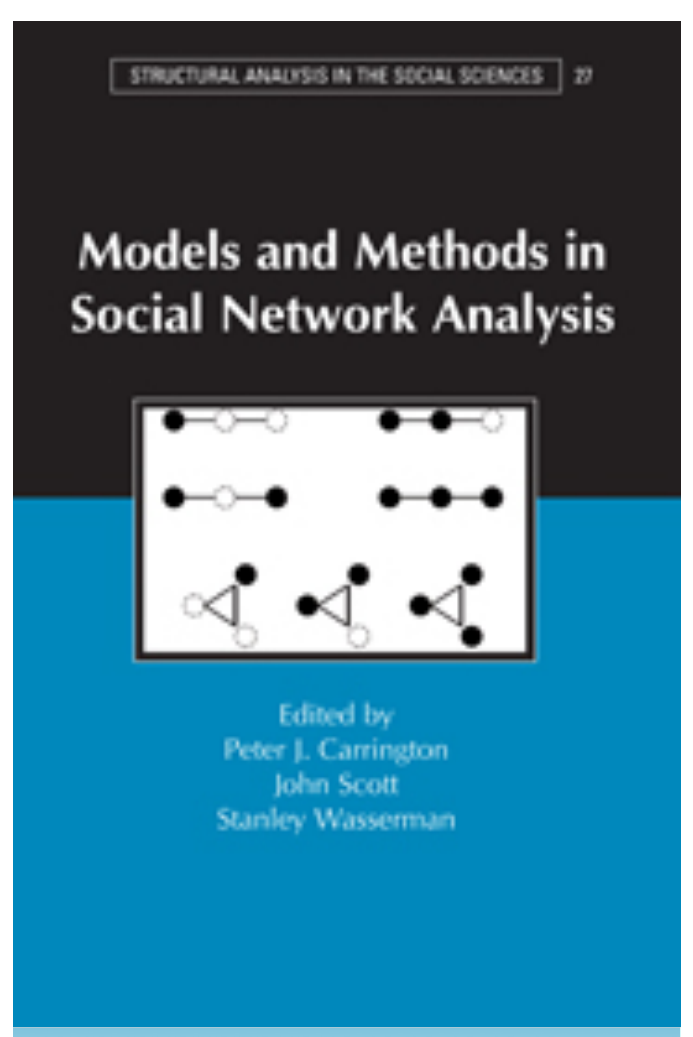
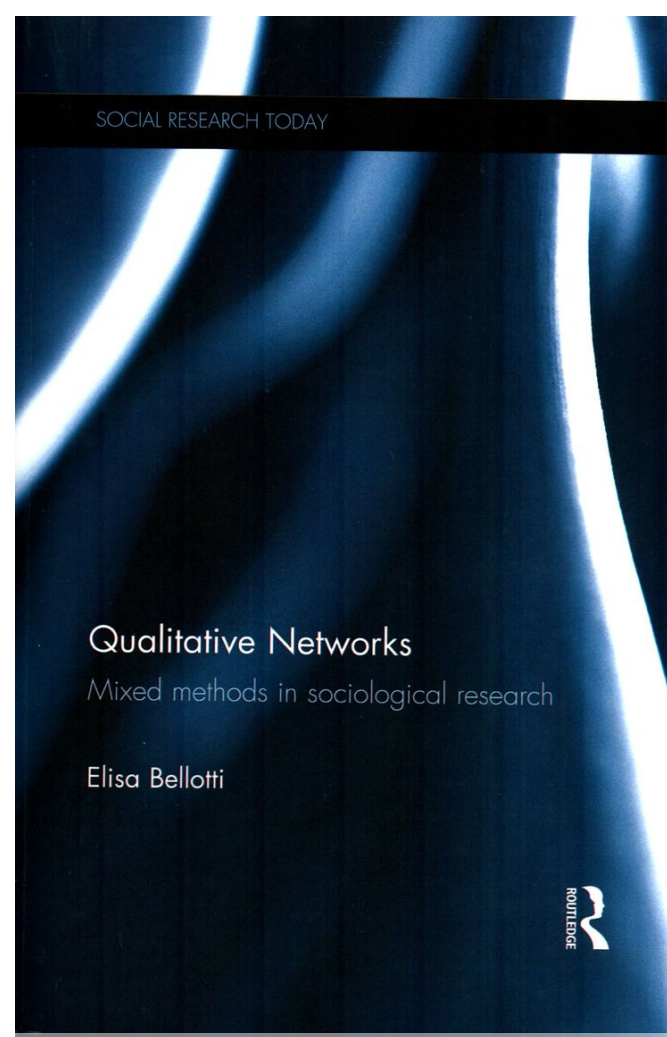
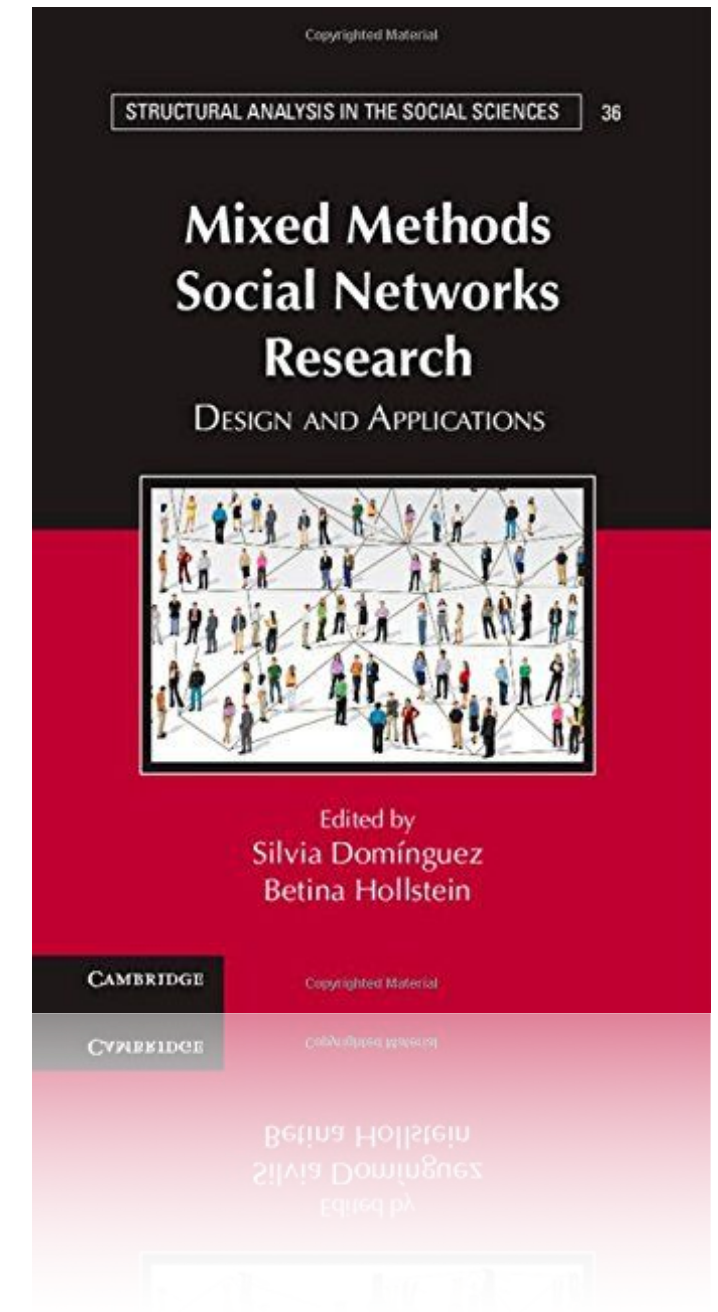
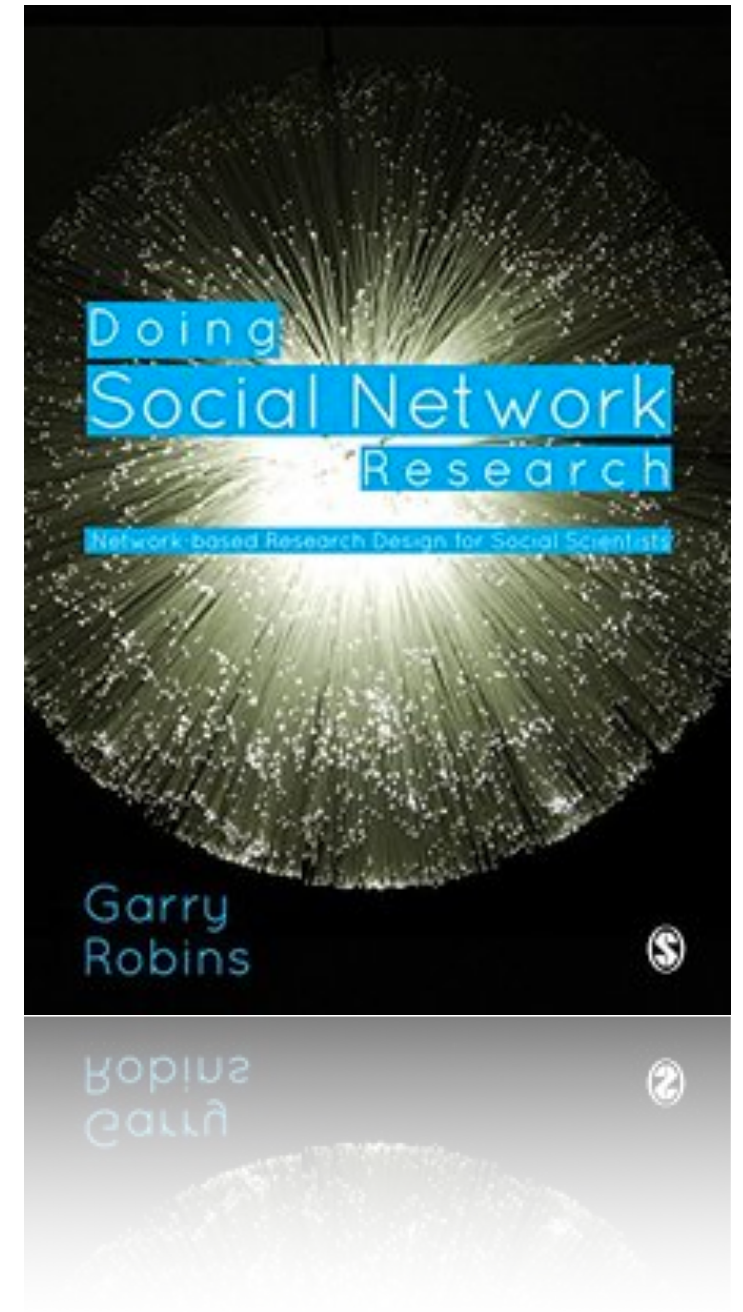
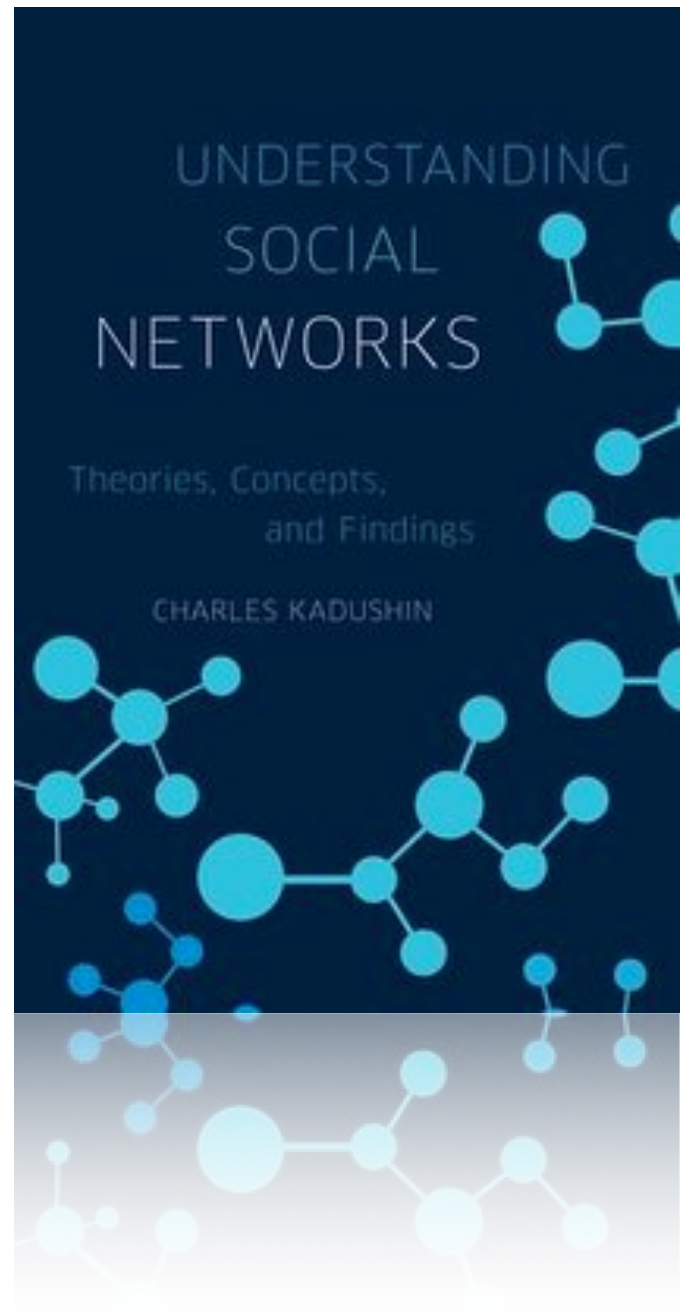
Network Theory

Network Analysis

Network Modelling

Course Evaluation

- **20% - Weekly exercises and participation**
 - Complete the weekly tutorial exercises through the packages
 - Ask and answer questions on Moodle
- **30% - Mid-term report**
 - Uploaded to Moodle
 - Data and further details released
- **50% - Blog post(er)**
 - Present results of a modelling exercise
 - Use MRQAP, SEIS, ERGM, or SAOM on own/others data



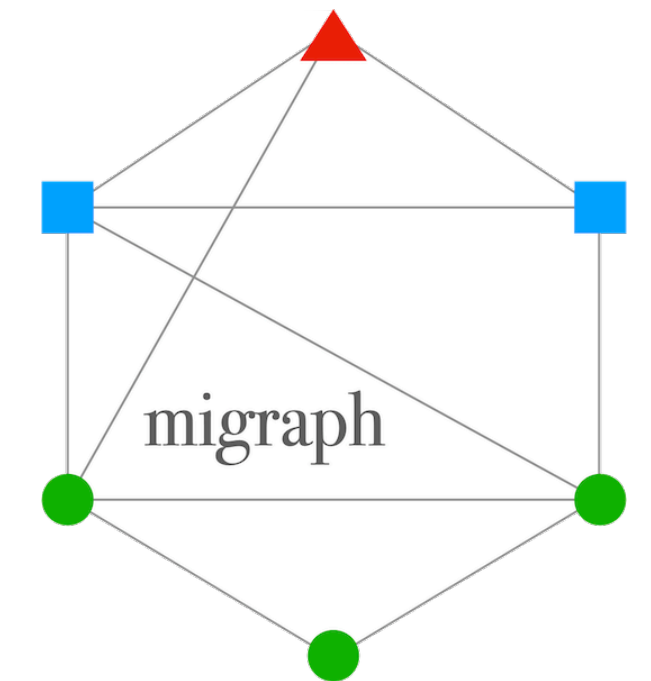
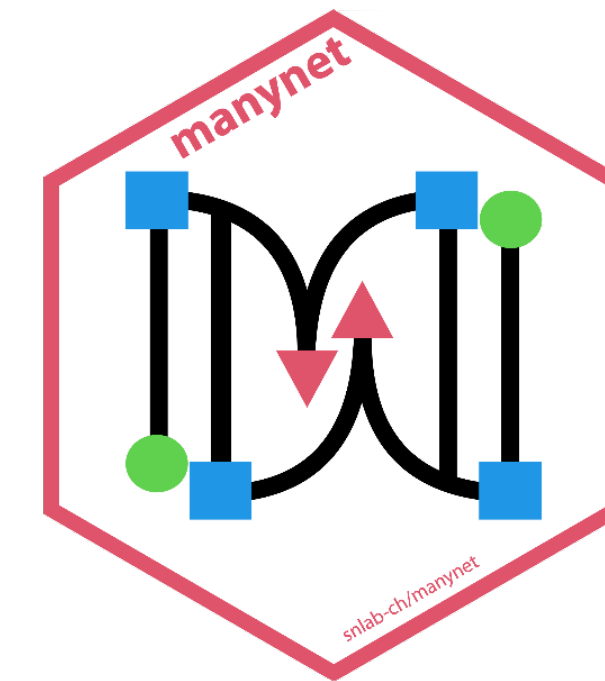
Some Journals

- *Social Networks*
- *Network Science*
- *Journal of Social Structure*
- *Social Forces*
- *Sociological Methodology*
- *Political Analysis*
- *Policy Studies Journal*
- *Journal of Statistical Software*
- *Ecology and Society*
- *Journal on Complex Networks*
- *Computational Social Networks*
- *Applied Network Science*
- *Journal of Mathematical Sociology*
- *Physical Review E*
- *American Journal of Sociology*
- *American Sociological Review*
- *Annual Review of Sociology*
- *Physica A*
- *PLOS ONE*
- *Social Network Analysis and Mining*
- *Science / Nature*

Why R?



- Open Source. Interdisciplinary. Extensible. Free. Valuable.
- Integrated statistics and network analysis for data science
- New specialised packages constantly added
 - We will use primarily `manynet` + `migraph`
- Documentation
 - Offline: often great, but depends on the package
 - Online: usually excellent, forum posts for everything in e.g. StackOverflow or CrossValidated



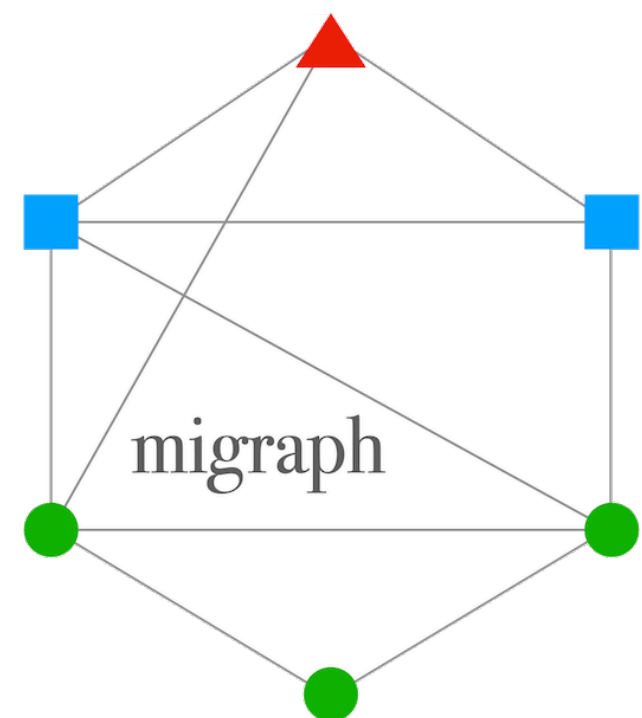
Getting started



- Download and install R (click download R and then select closest mirror): <https://www.r-project.org/>



- Download, install and open RStudio (you don't need to open R): <https://www.rstudio.com/products/rstudio/#Desktop>



- Install migraph (you don't need to install any other packages) by typing `install.packages("migraph")` or use point+click

So, social networks...

- **Assumption:** social life is associative, and relations are meaningful
- **Premise:** how social entities are connected matters
- **Argument:** more interdependent and contextual than traditional quantitative or qualitative work
 - By taking context and dependencies into account, even making them central to the explanation, networks goes beyond traditional statistics
 - By using graph theoretic concepts and formal measures, even making them central to the explanation, networks goes beyond traditional case studies
- **Promise:** to help understand social, political, relational life.

Some advice

Don't "do networks" to

- join **hot research area** (though it is)
- present **fancy pictures** (seldom enough)
- present **fancy analysis** (depends on data quality)
- **explain more variance** (not simply an add-on)
- **explain everything** (empirical settings are messy)
- use **big data** (RQ and theory relationship required)
- use **networks expertise** (clear motivation required)

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Do "do networks" to

- **describe social structures**, both local and global
- **identify individuals** in special positions
- correlate **positions with individual outcomes**
- correlate **structures with global outcomes**
- explain **how individuals affect social structure**
- explain **how social structure affects individuals**
- understand **how micro and macro outcomes relate**
- understand **how different networks relate**
- understand **how different mechanisms change or sustain social systems**