STRUCTURAL REASONING OF NETWORKS

Larisa Survilo

Department of Systems Theory and Design
Riga Technical University
Riga, Latvia

Larisa.Survilo@rtu.lv

Research context

- **Doctoral thesis are devoted to**
  - structural modeling methodology
    - systems structure, behavior and functions, and causal knowledge
  - analysis of structural models
    - qualitative and quantitative analysis
  - complexity evaluation
  - automatization of processes

Content

- **expansion of networks**
- **structural reasoning and network analysis**
  - structural modeling methodology
  - social network analysis
  - etc.
- **application of SNA**
- **conclusions and future work**

Expansion of networks

- extensive investigations in order to understand and explain network effects
  - computer networks, social networks, citation networks, hyperlink networks etc.;
- interdisciplinary investigations
  - building of network models => empirical studies of networks
  - reading and processing of models => using of mathematical and statistical analysis
  - modelling => to make predictions about the behavior of network as a function of the parameters affecting the system

Complexity evaluation

- Network theory. Systems theory. Complexity theory.

  - the qualitative (relational) point of view:

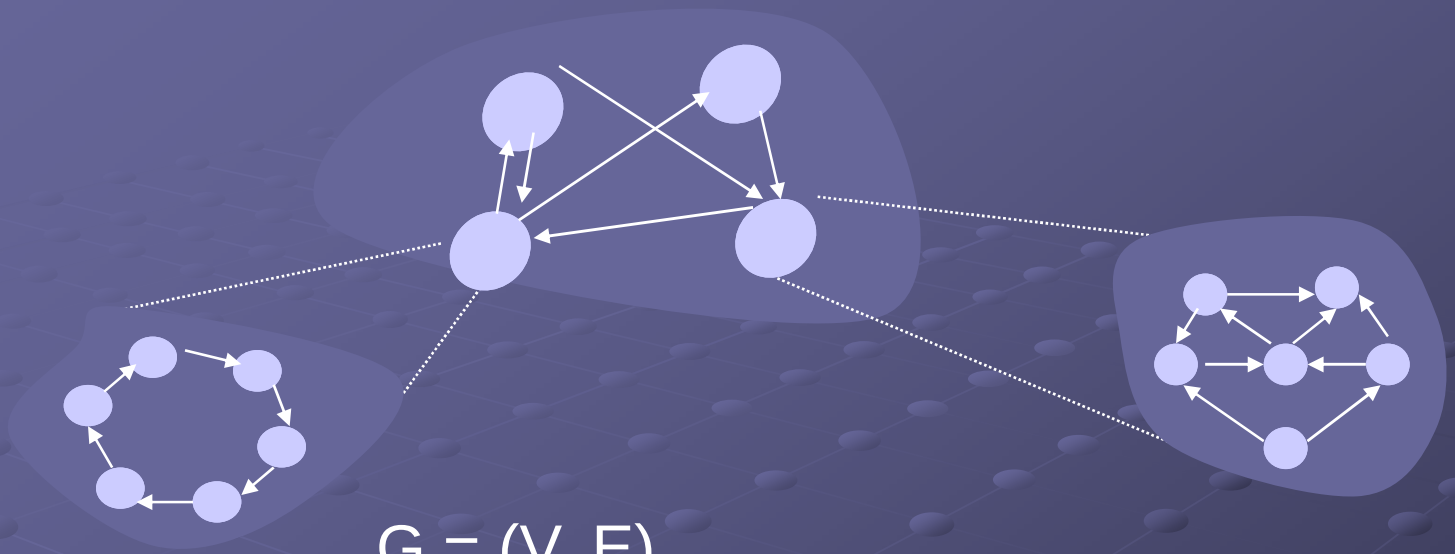
    insight on the individual agents and their properties

  - the quantitative (systemic) point of view:

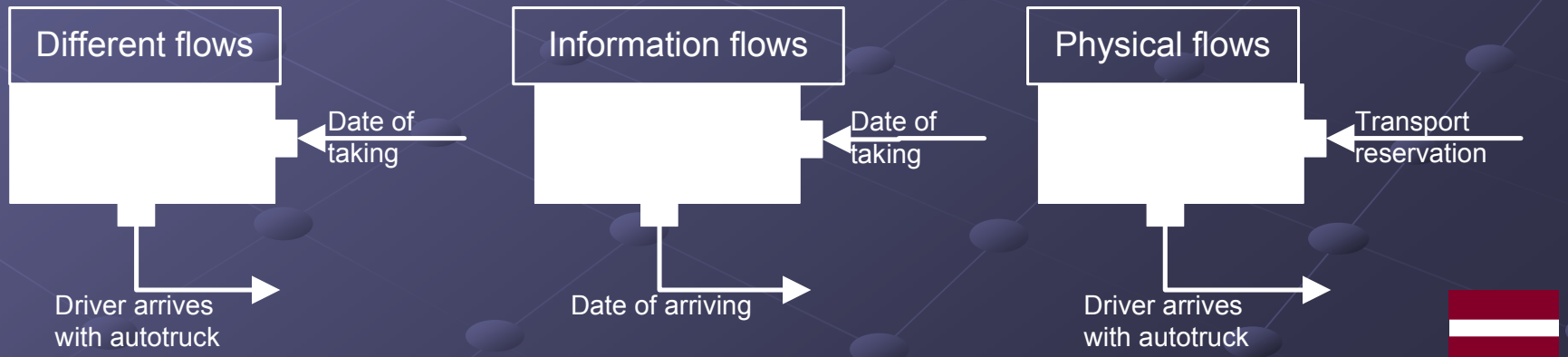
    comparison of different kind of structures

If You cannot measure smth., You have not it engineered!

Structural reasoning



G = (V, E)
V – set of vertices
E – set of edges connecting the vertices in V



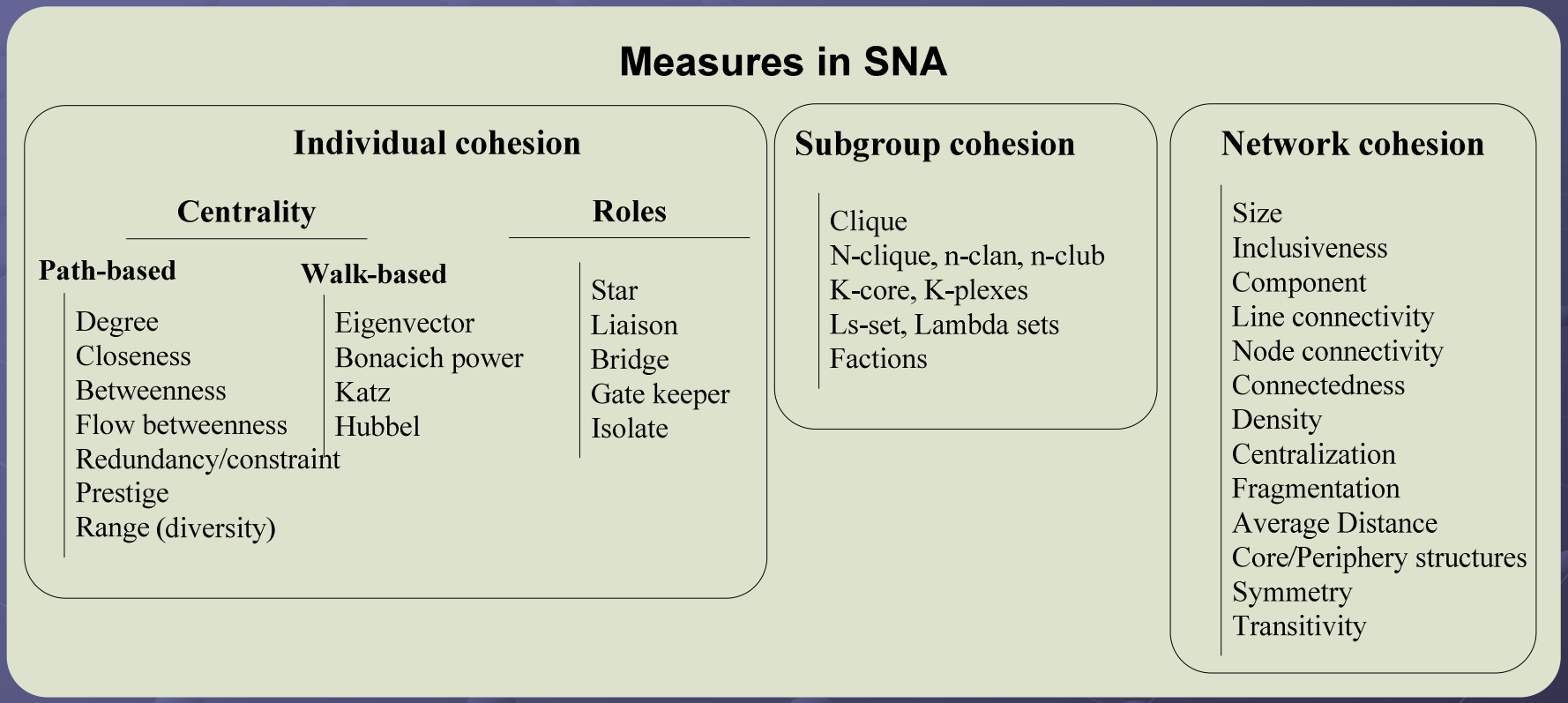
The study of networks

- empirical studies of networks
  - the goal of such studies is to create a picture of the connections between objects.
- applying mathematical or statistical analyses for a network, namely the quantitative analysis of network data
- mathematical modeling of networked systems

Social network analysis

- information flow analysis (to determine the direction and strength of information flows through the network);
- calculation of centrality measures (to determine individual roles within a network);
- hierarchical clustering (to uncover cliques whose members are fully or almost fully connected);
- the block modeling (to discover key links between different subgroups in a network);
- calculation of structural equivalence measures (to identify network members with similar characteristics);

Measures in SNA

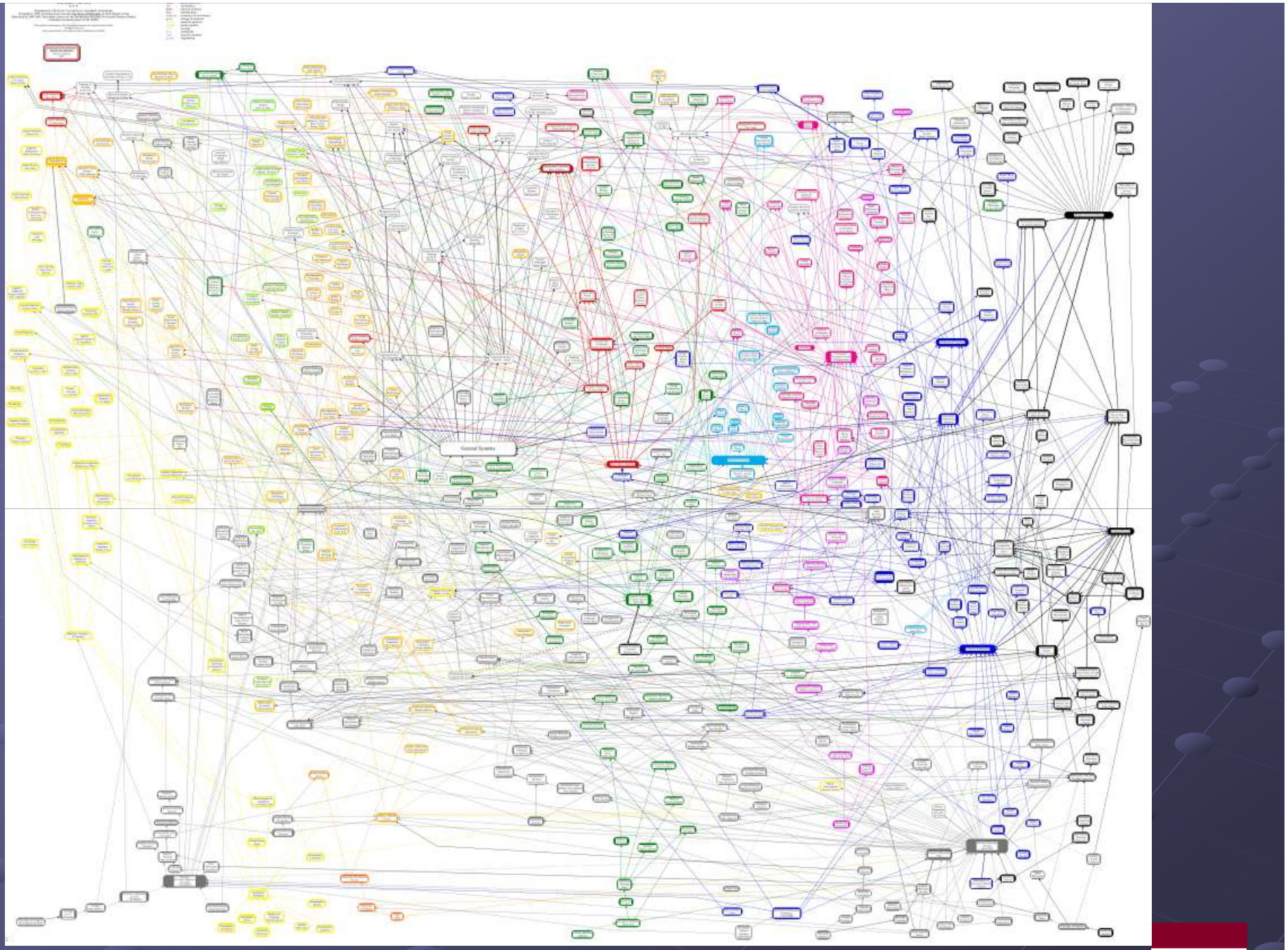


Summary of measures in SNA (Borgatti 1998; Brass 1998).

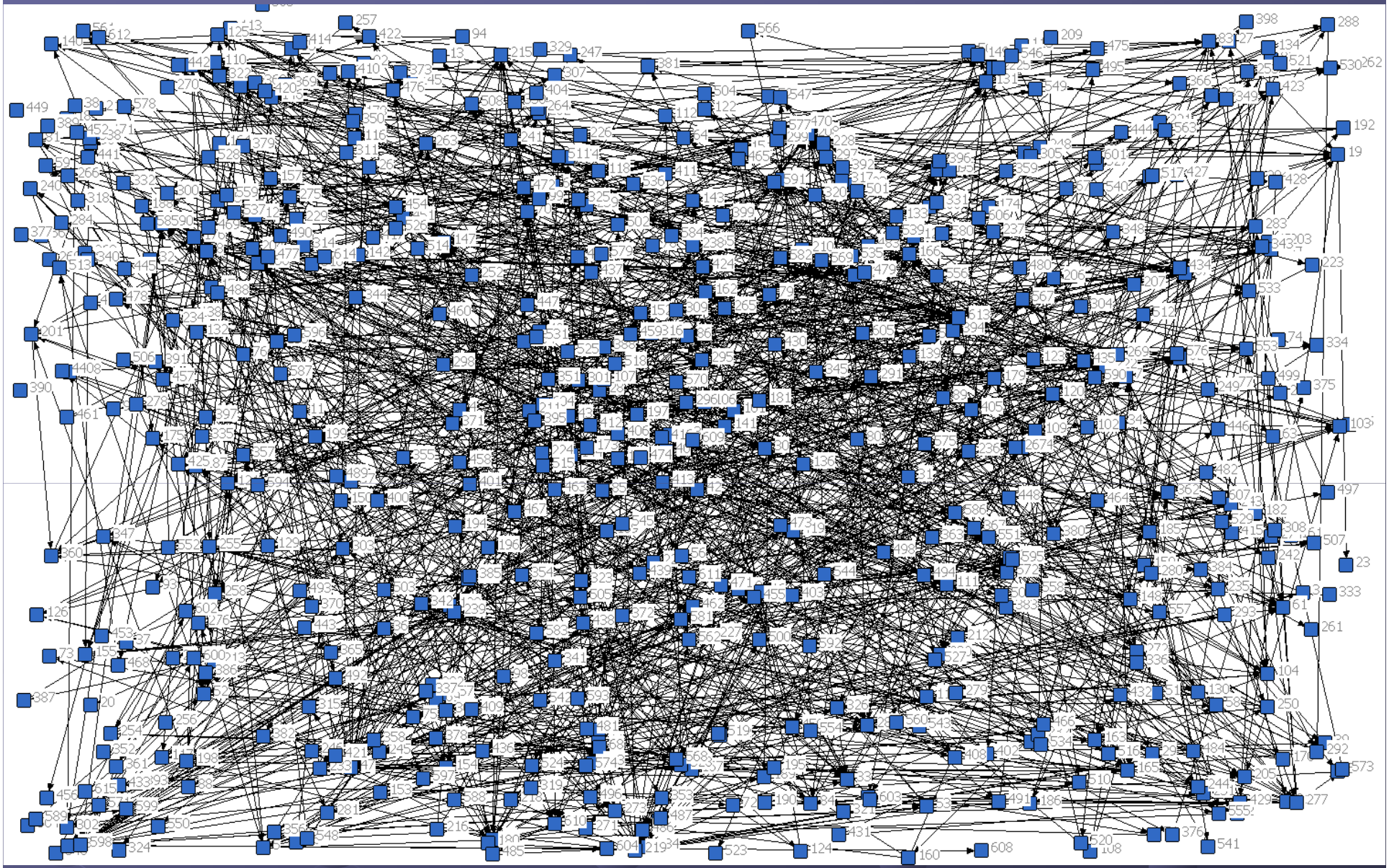
Centrality measures defined by Freeman

- degree (local centrality): degree/n-1
- closeness (global centrality): geodesic paths
- betweenness centrality: locations on geodesics

The relational analysis of the structure



IIGSS. (2001). Genealogy: A family tree of systemic thinking.
Retrieved from web address http://www.iigss.net/gPICT.pdf, accessed 8 April 2009



Borgatti, S.P. (2002). NetDraw: Graph Visualization Software. Harvard: Analytic Technologies

Network under investigation

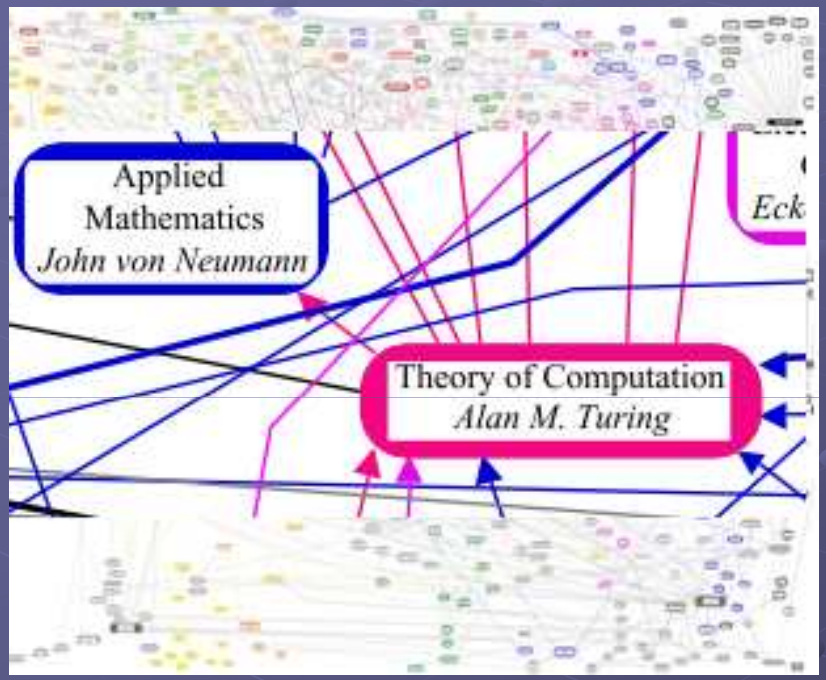


Figure 1. Some streams of systemic thoughts [10].

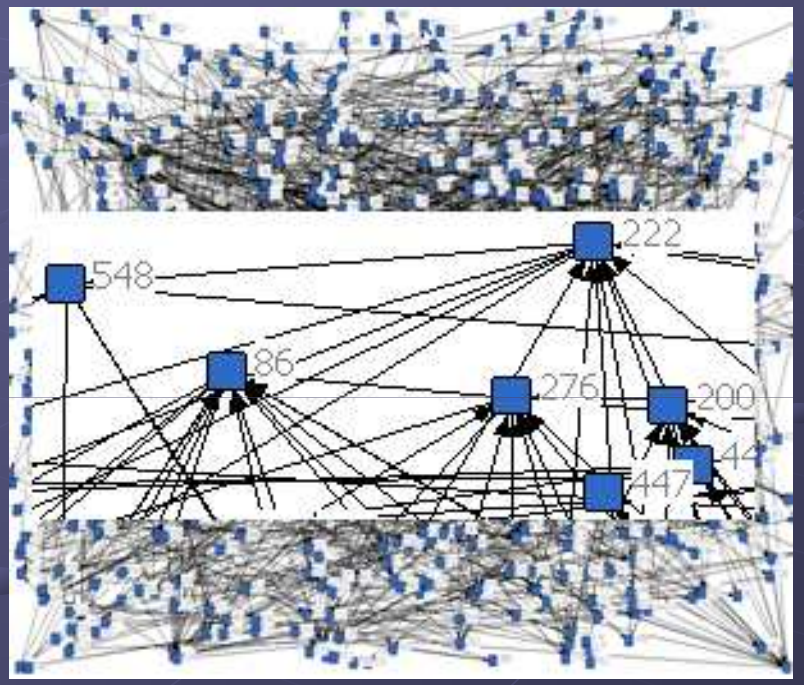


Figure 2. Visualization of network using NetDraw [11].

Analysis of results

Measure	Value
Number of nodes	615
Number of links	1288
Number of isolated nodes	37
Number of internal nodes	409
Number of input nodes	50
Number of output nodes	119
Number of strongly related subcomponents (with 2 or more members)	24

Table 1. The core information about the network under investigation.

Borgatti, S.P., Everett, M.G. and Freeman, L.C. (2002). Ucinet 6.0 for Windows: Software for Social Network Analysis. Harvard: Analytic Technologies.

Degree (local centrality)

In-Degree	Out-Degree
InD = 13: Classical mathematics (n_9); Informatics (Computer Science&Engineering) (n_{208}); InD = 12: Management cybernetics (n_{147}) ; InD = 11: Structuralist mathematics (n_7); InD = 10: Natural evolution(n_{156}); Human science(n_{187}); Rational philosophy (n_{219}); Geometrodynamics (n_{290}); Classical physics (n_{581}); etc.	OutD = 31: General systems (n_{47}); OutD = 23: Operations research (n_{613}); OutD = 21: Rational philosophy (n_{219}); Modern theoretical physics (n_{598}); OutD = 16: Informatics(Computer Science & Engineering) (n_{208}); etc.

Table 2. Nodes with the highest in-degree and out-degree.

Borgatti, S.P., Everett, M.G. and Freeman, L.C. (2002). Ucinet 6.0 for Windows: Software for Social Network Analysis. Harvard: Analytic Technologies.

Closeness (global centrality)

In-Closeness	Out-Closeness
Systemic Perspectivism (n_{258}); Topology of Meaning (n_{176}); Cyber-semiotics (n_{360}); Socio-Cybernetics (n_{202}); General Systemology (n_{121}); Social Cybernetics (n_{173}); Teleonics (n_{100}); Cybernetic Epistemology (n_{451}); etc.	Astronomy (n_{489}); Philosophy of Regularity (n_{488}); Philosophy (Anaxagoras) (n_{482}); Naturalism (n_{240}); Heroic Legends (n_{484}); Law (n_{341}); Reciprocities (n_{239}); Unity & Stasis (n_{216}); Apocalyptic Dualism (n_{481}); etc.

Table 3. Nodes with the highest in-closeness and out-closeness.

Borgatti, S.P., Everett, M.G. and Freeman, L.C. (2002). Ucinet 6.0 for Windows: Software for Social Network Analysis. Harvard: Analytic Technologies.

Betweenness centrality

Betweenness (SNA)
Classical mathematics (n_9); Mathematical logic(n_8); Operations Research (n_{613}); General systems (n_{47}); Mechanistic Physics (n_{277}) ; Mathematical Nominalism (n_{86}); Informatics (Computer Science & Engineering) (n_{208}); Rational Philosophy (n_{219}); Logical Positivism (n_{33}); Sructuralist Mathematics (n_7); etc.

Table 4. Betweenness centrality of nodes.

Borgatti, S.P., Everett, M.G. and Freeman, L.C. (2002). Ucinet 6.0 for Windows: Software for Social Network Analysis. Harvard: Analytic Technologies.

Qualitative vs. Quantitative

Measure	Value
Density	0,0034
Mean (for in-degree and out-degree)	2.094
Range (min...max for in-degree and out-degree)	0…13 and 0…31
Standart deviation (for in-degree and out-degree)	2.132 and 2.953
Variance (for in-degree and out-degree)	4.544 and 8.723
Network Centralization (based on in-degree and out-degree)	1.779% and 4.715%
Network Centralization Index	2.82%

Table 6. Results of quantitative/systemic analysis of network.

Conclusions

- the most well-known measures of relational process of analysis were discussed
- **SNA can be applied to analysis of specific, non-typical social structures**
- ‘short-term’ and ‘long-term’ perspective
  - *Classical mathematics, Computer Science&Engineering, General systems, Operations Research* etc.
- ‘long-term’ perspective
  - *Rational Philosophy, Fluxation&Unified Opposites, Idealistic philosophy* etc.

Future work

- deeper analysis of this structure to find any interesting consequences and hidden knowledge
- application of SNA to other ‘non-typical” social network structures
- the use of social networks analysis ideas in software engineering

Thank You for Your attention!