

Fundamentals of (social) network analysis

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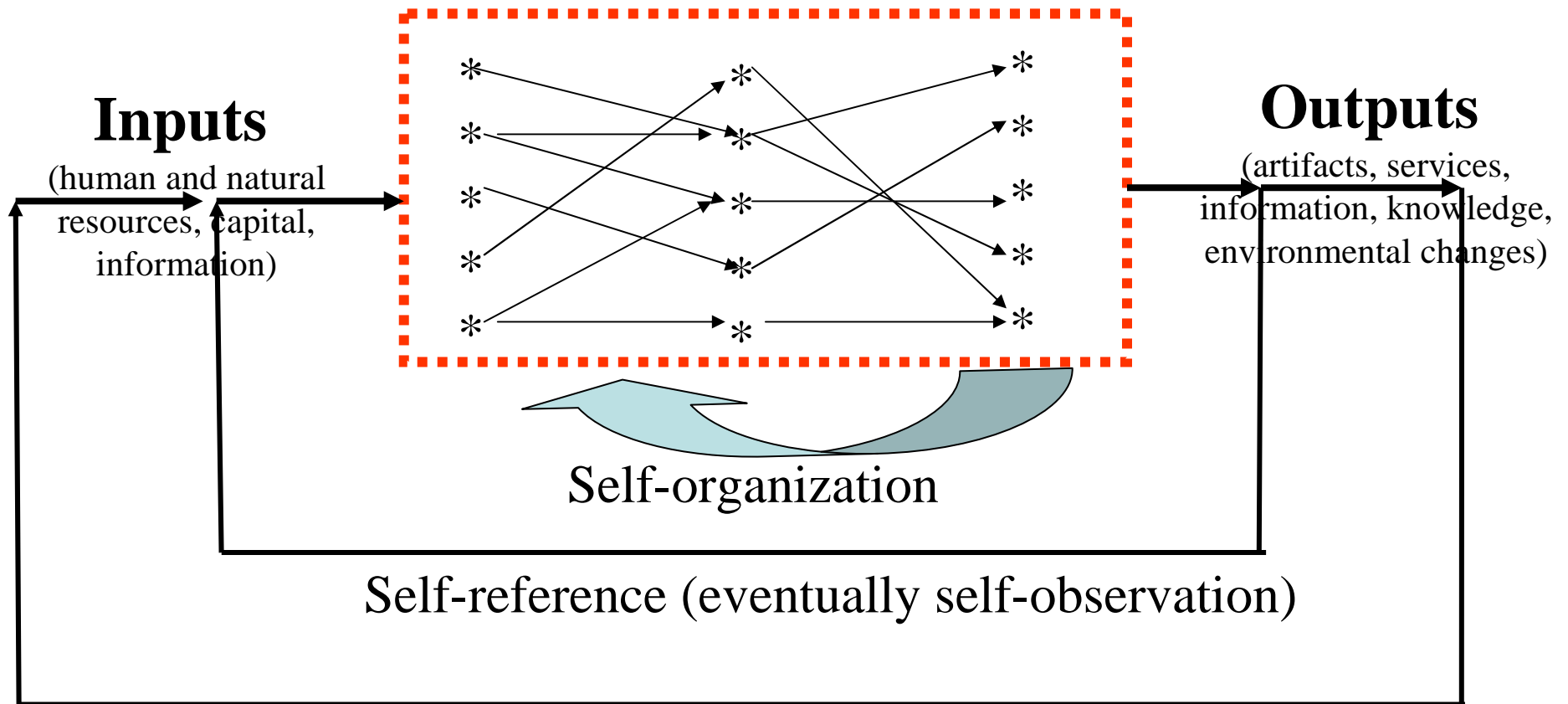
Initial main purposes

- Attribute-free properties of nodes and networks
- Micro-analytical structures: opening the black-box
- Alternative approach to systems theory
- Incompatibility with standard statistics

More recent main purposes

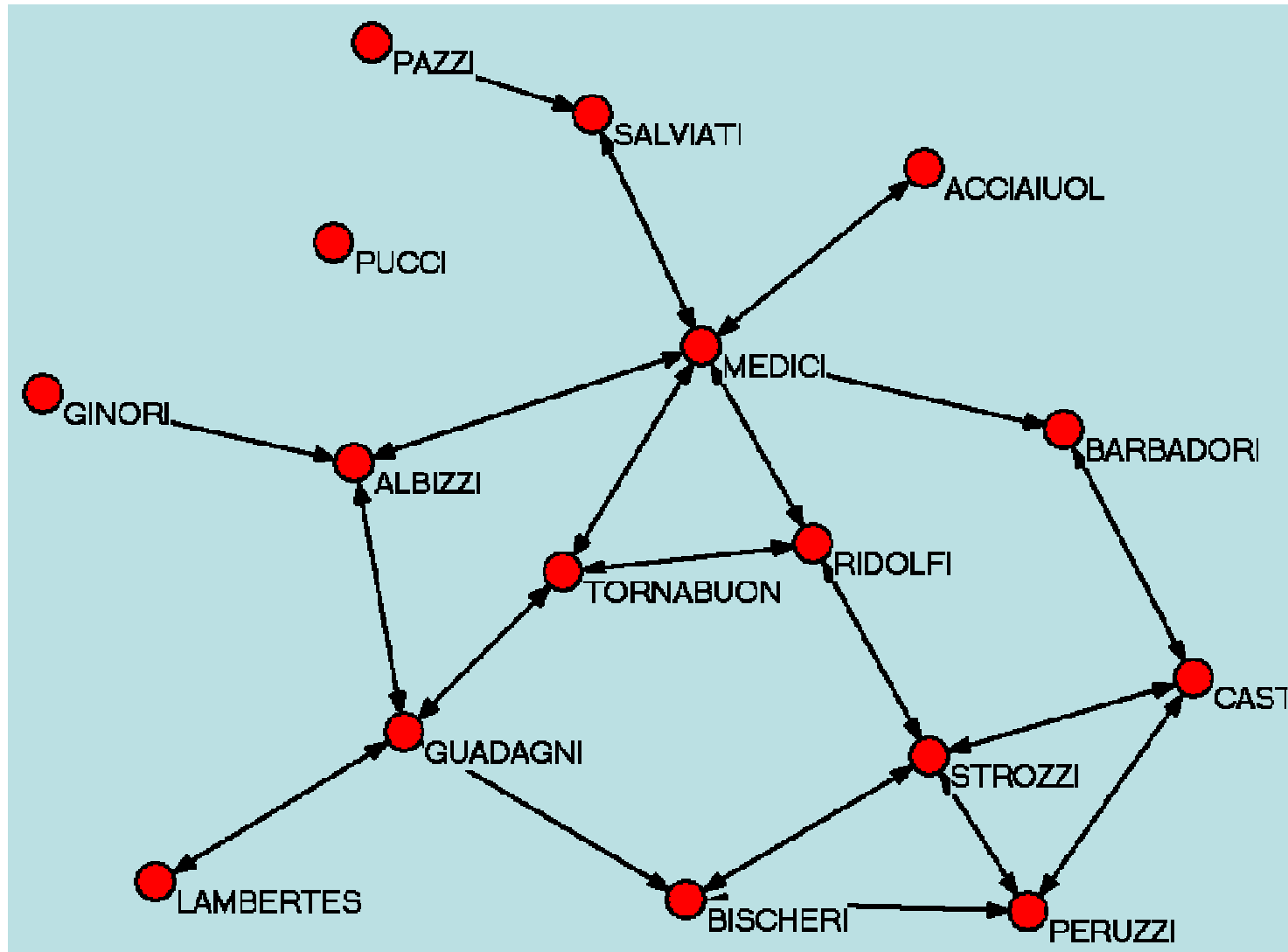
- Mix attributive and positional data
- Complementarity with systems theory
- Development of specific statistical tools

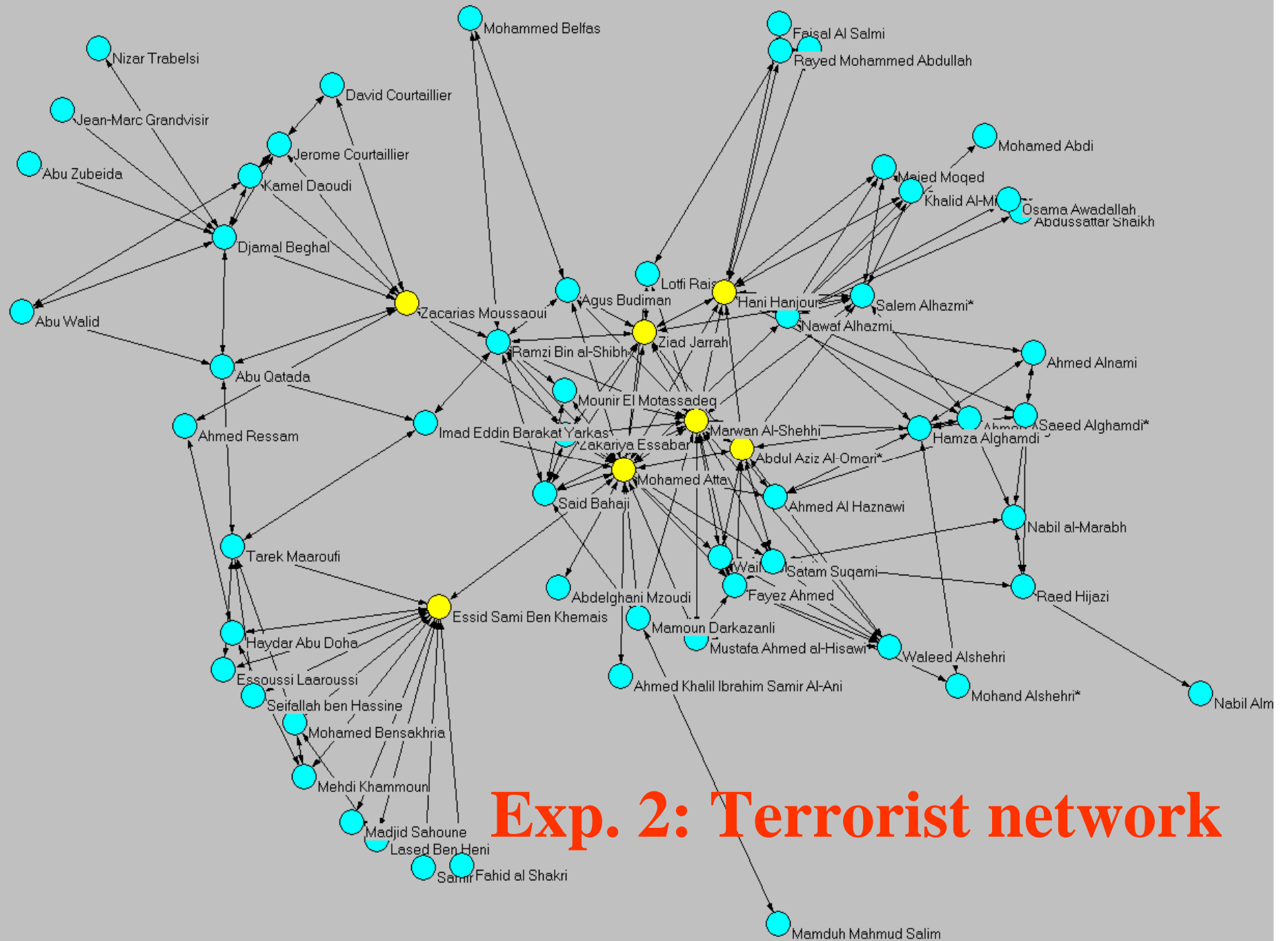
The system/network dualism



Inter-organizational connections (system/environment interactions)

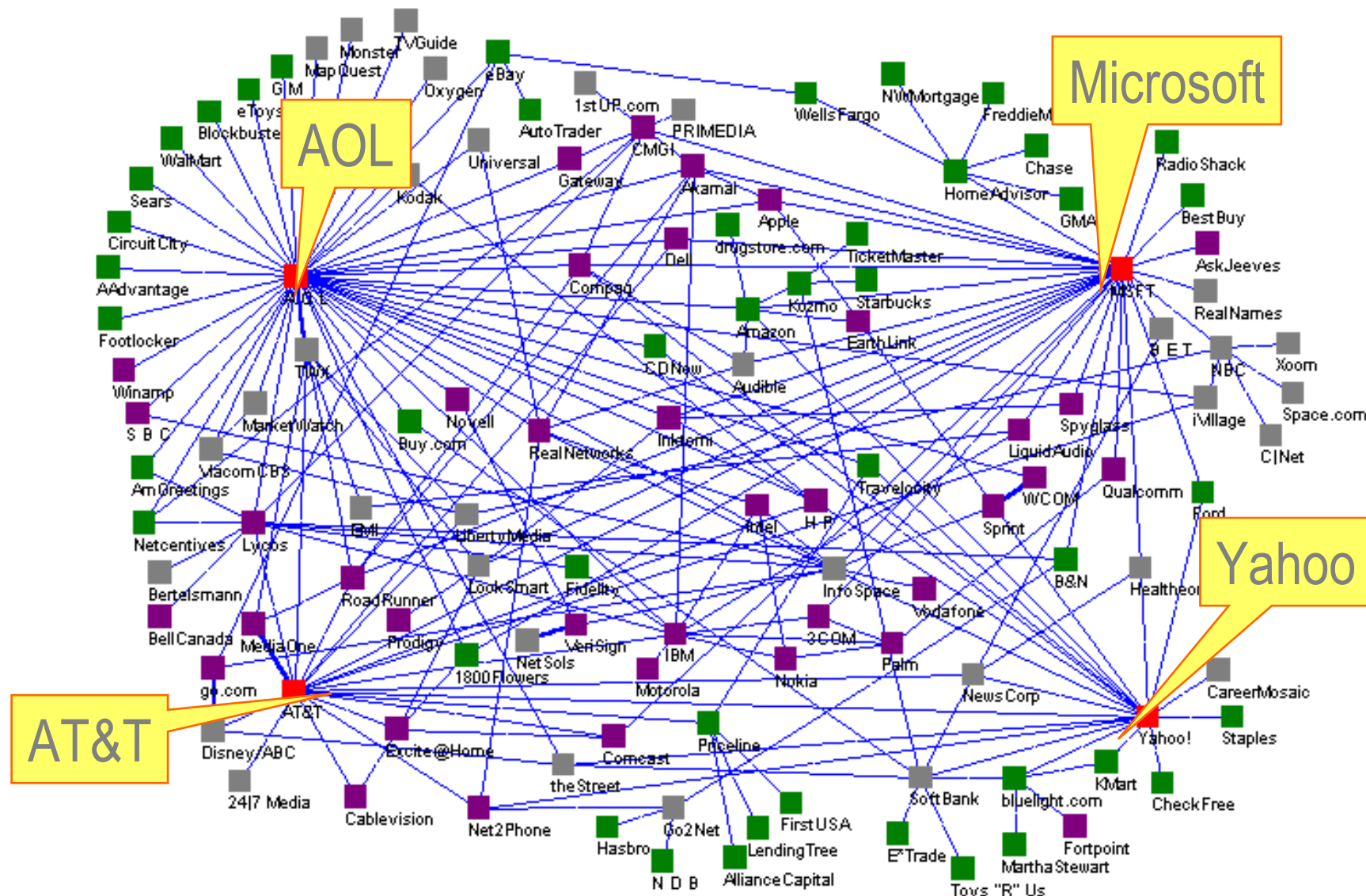
Example 1: marriage relationships among among Florentine aristocratic families in XVI cen.



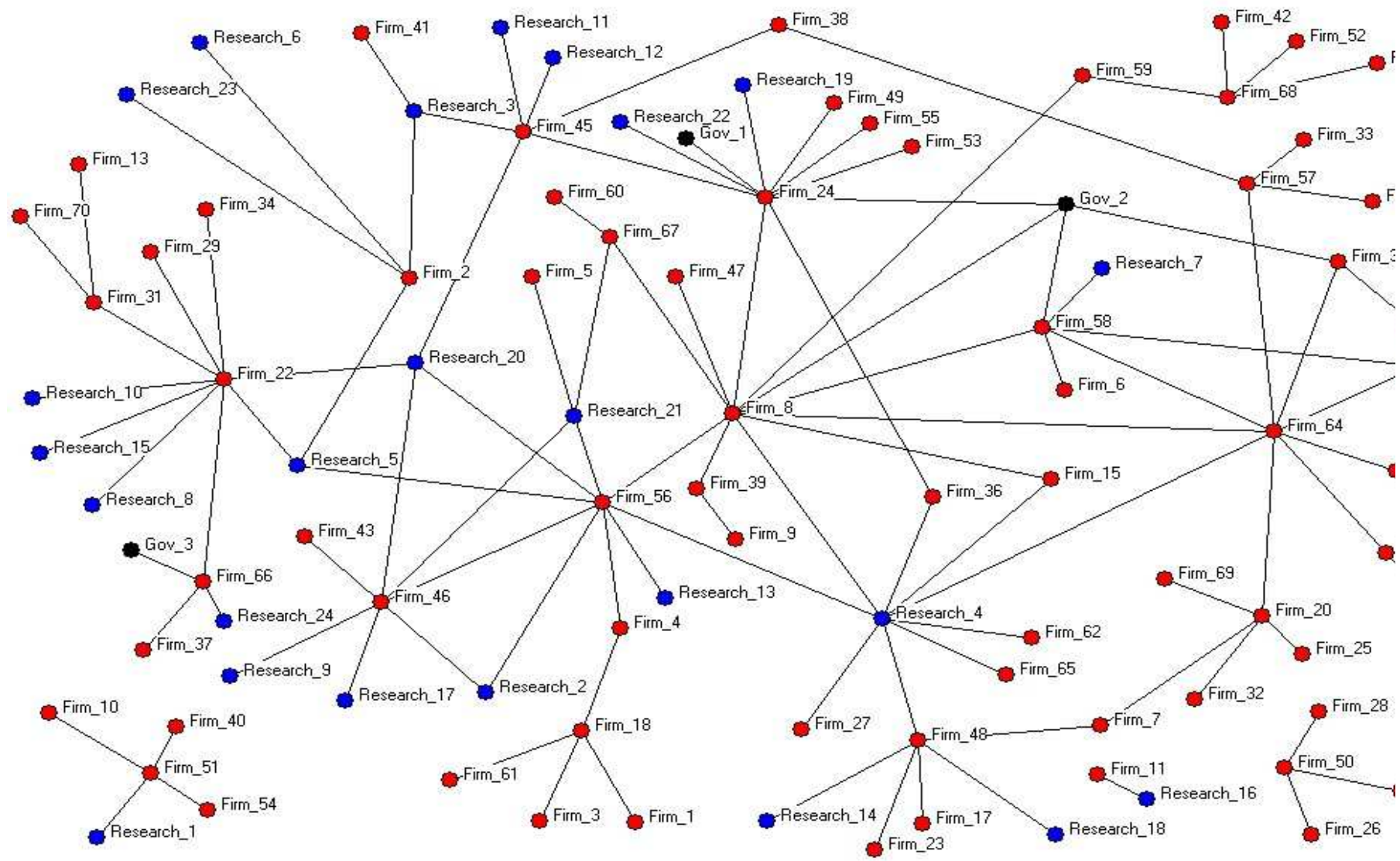


Exp. 2: Terrorist network

Example 3: Internet alliances

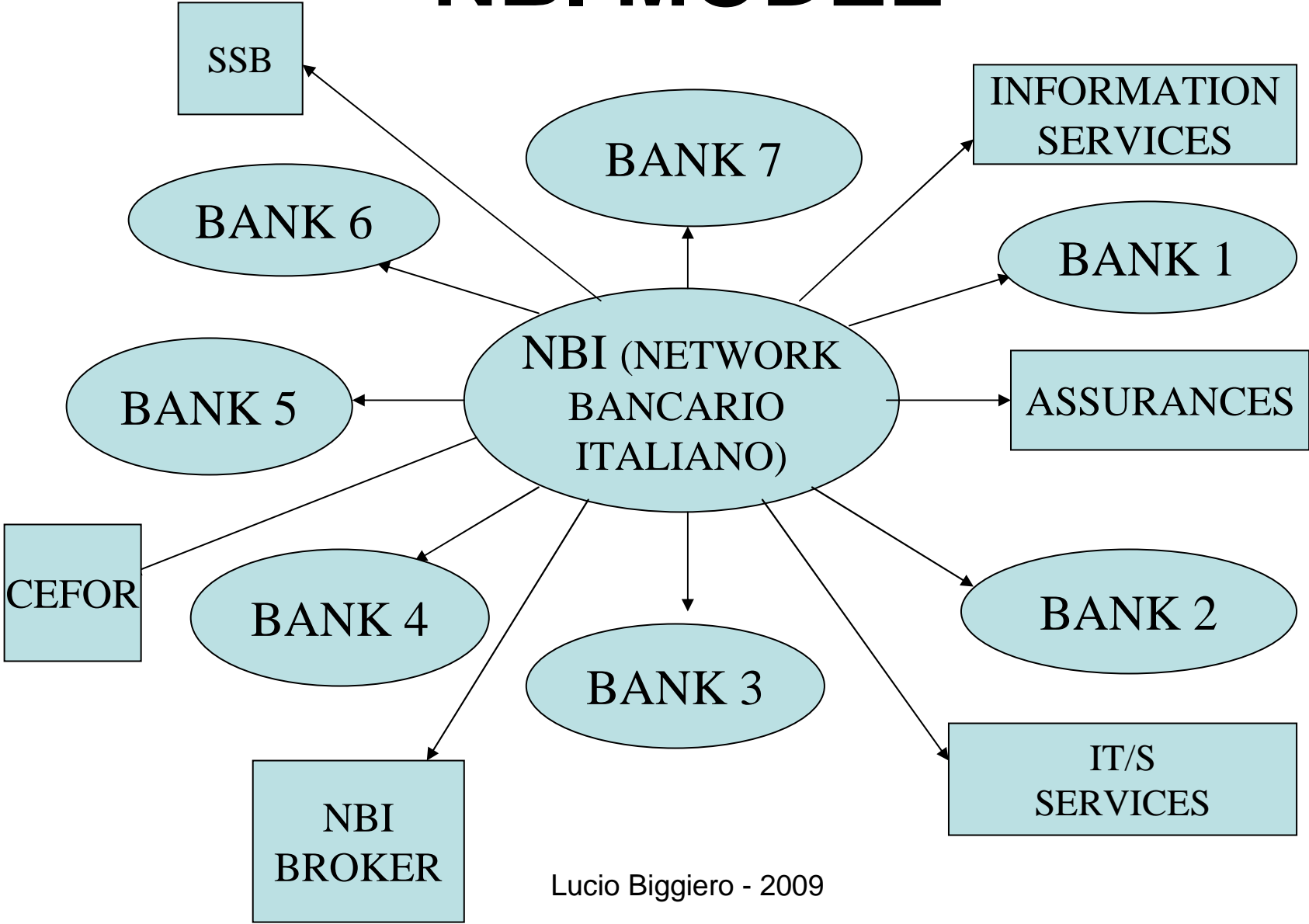


The network of collaborations for innovation in the AS IC of Lazio Region (IT)

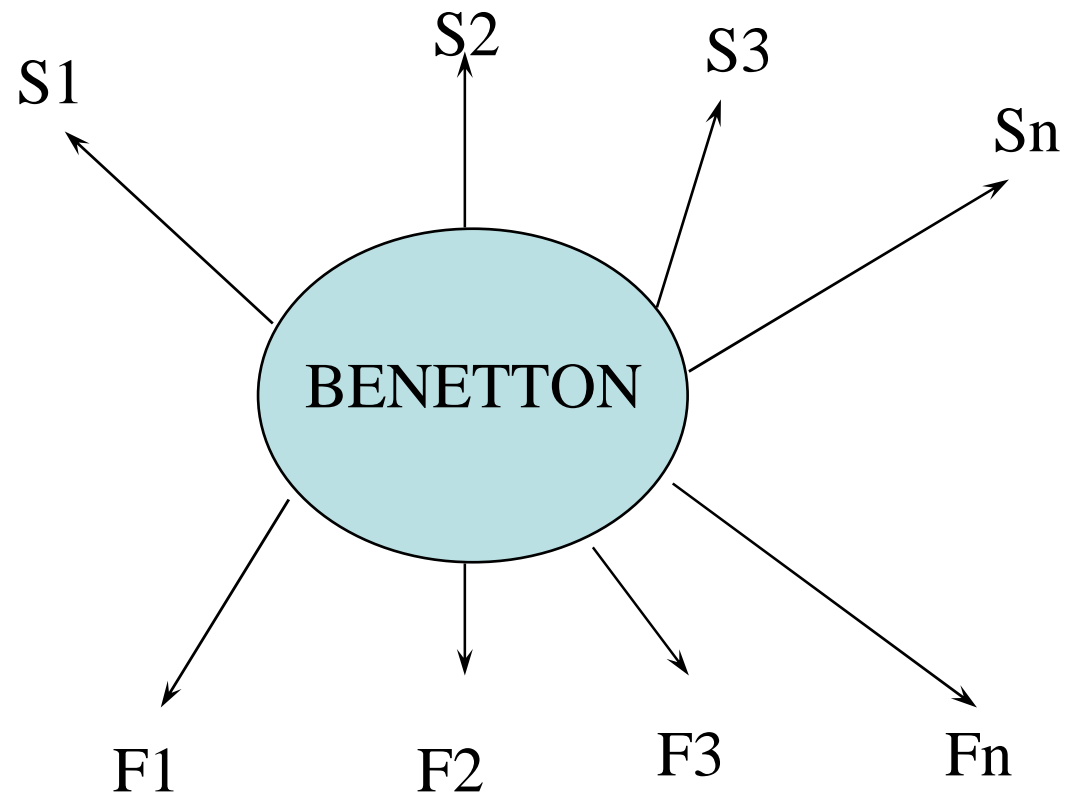


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red = industry; blue = university & research centres; black = (local) government

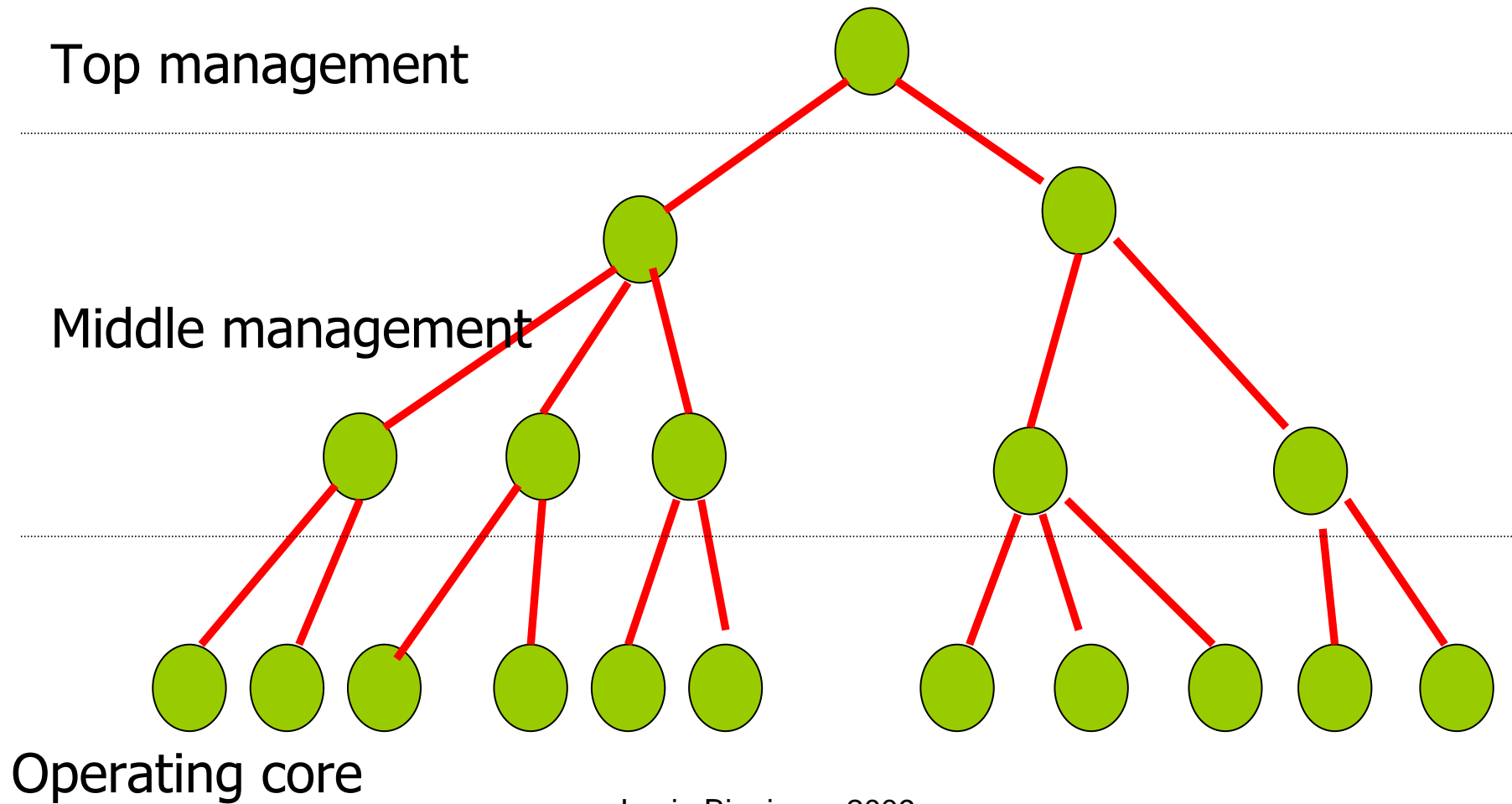
NBI MODEL



Benetton's network structure



Organizational hierarchy



Types of network

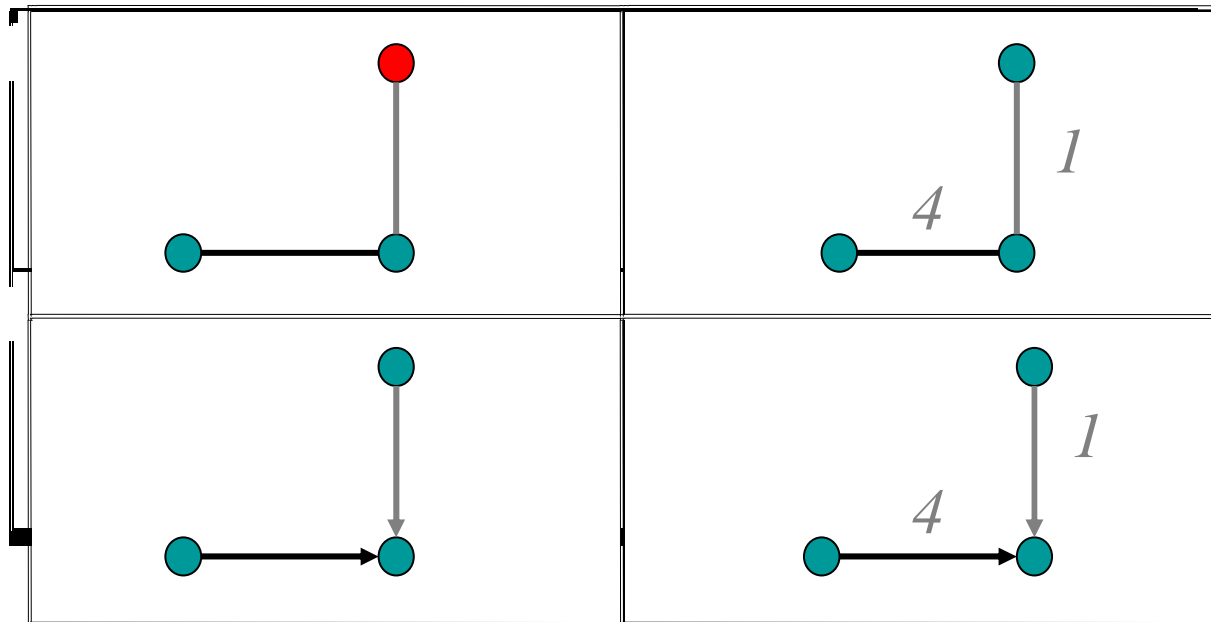
Non binary

Binary

(value)

Non
directed

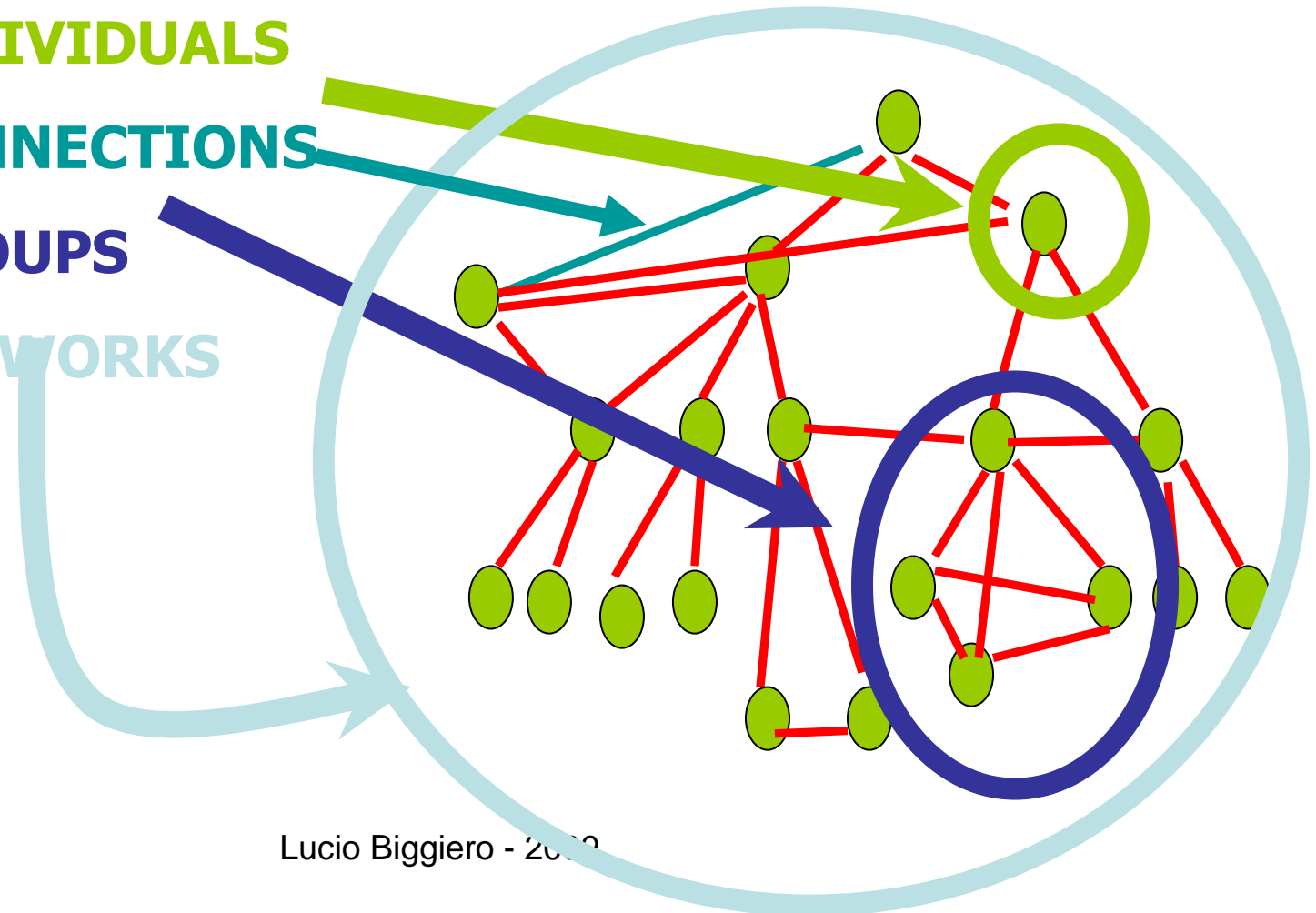
Directed



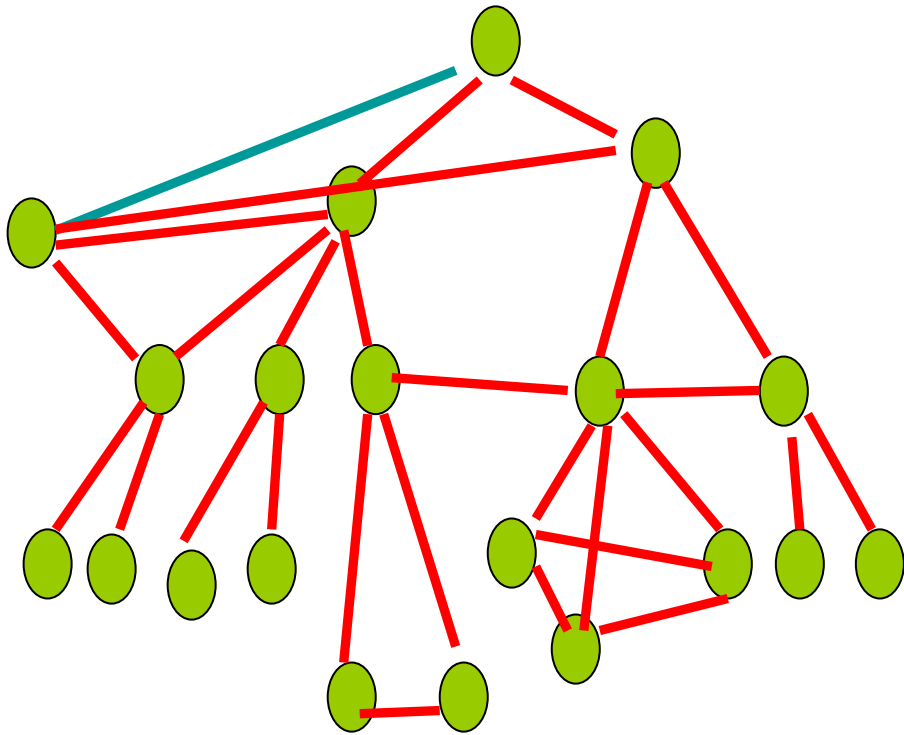
Social Network Analysis

Four levels of analysis:

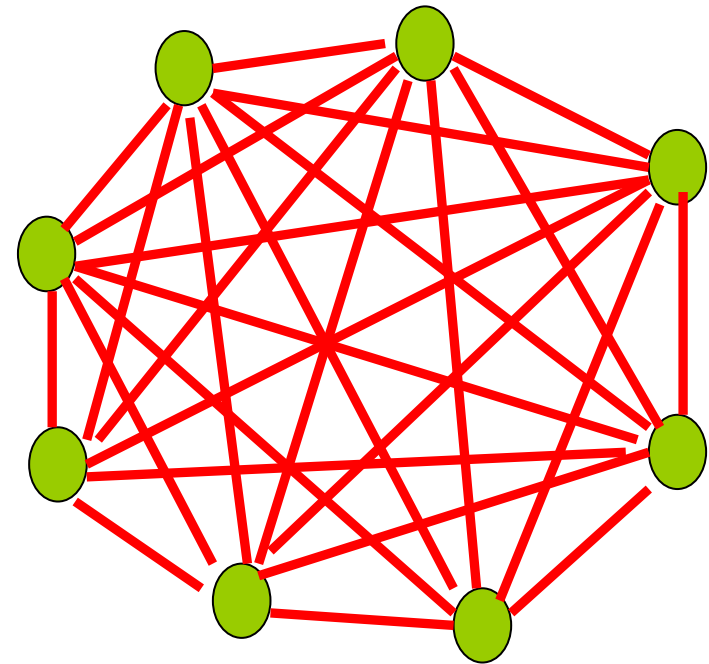
- **INDIVIDUALS**
- **CONNECTIONS**
- **GROUPS**
- **NETWORKS**



Non-fragmented networks

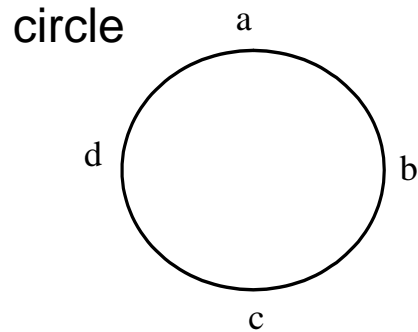
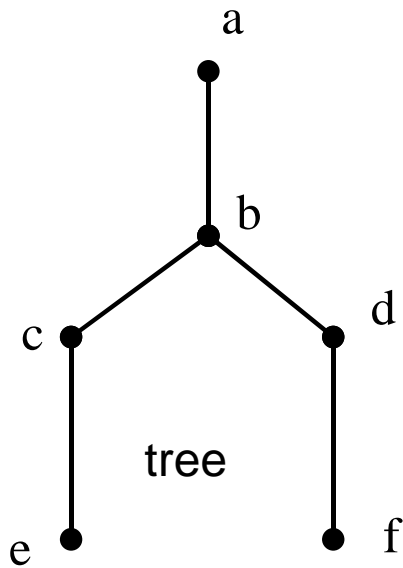
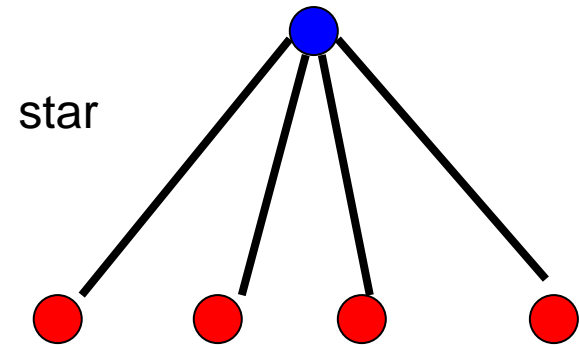
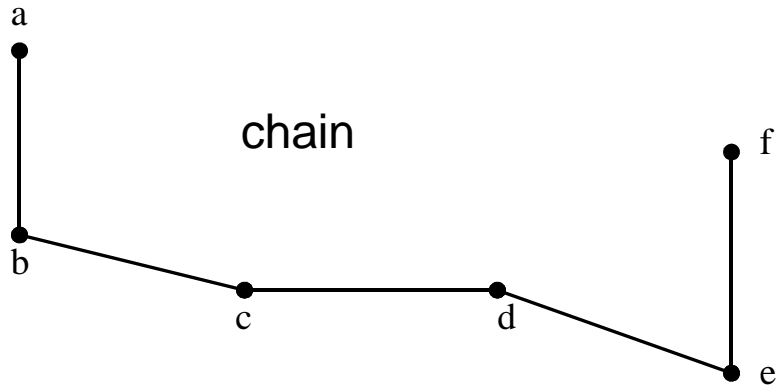


Cluster network

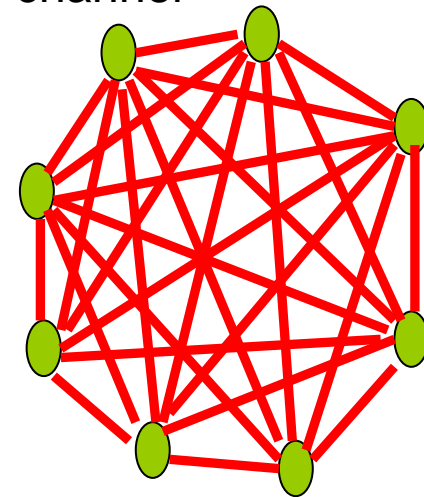


All channel network

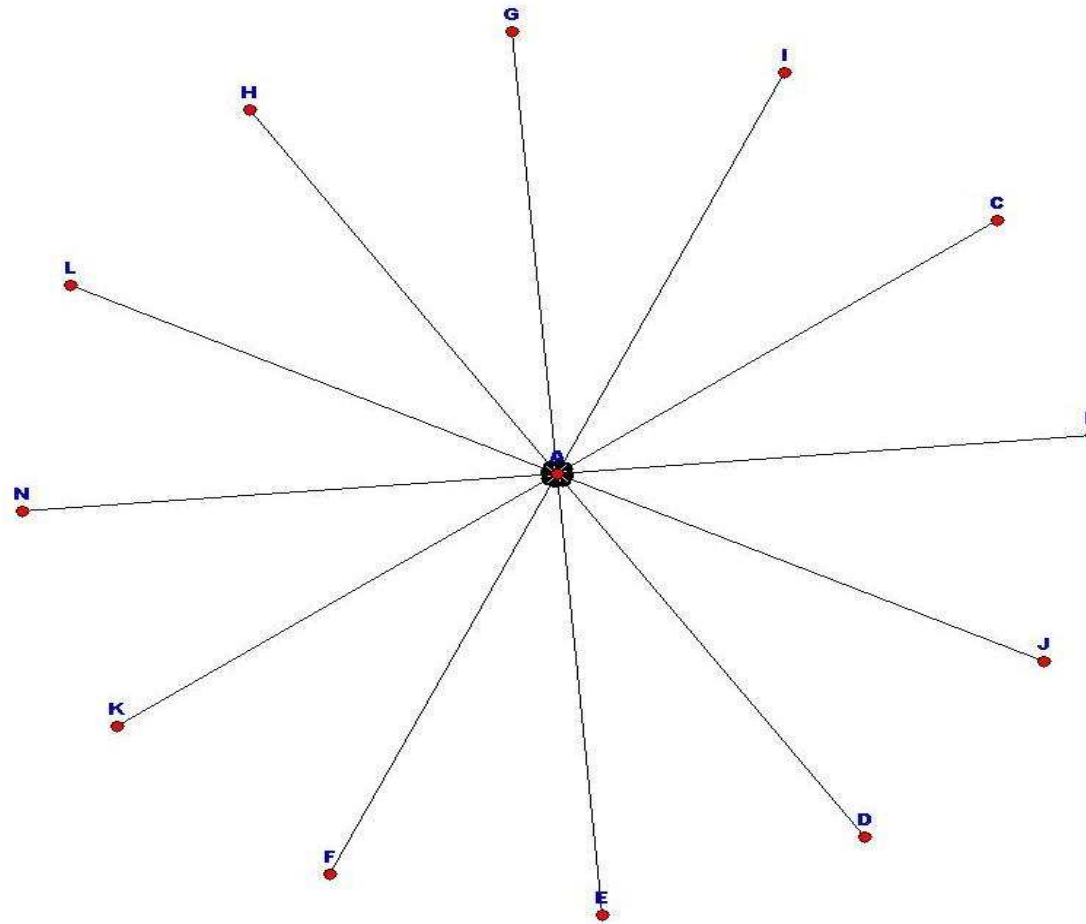
Prototypical forms



All channel

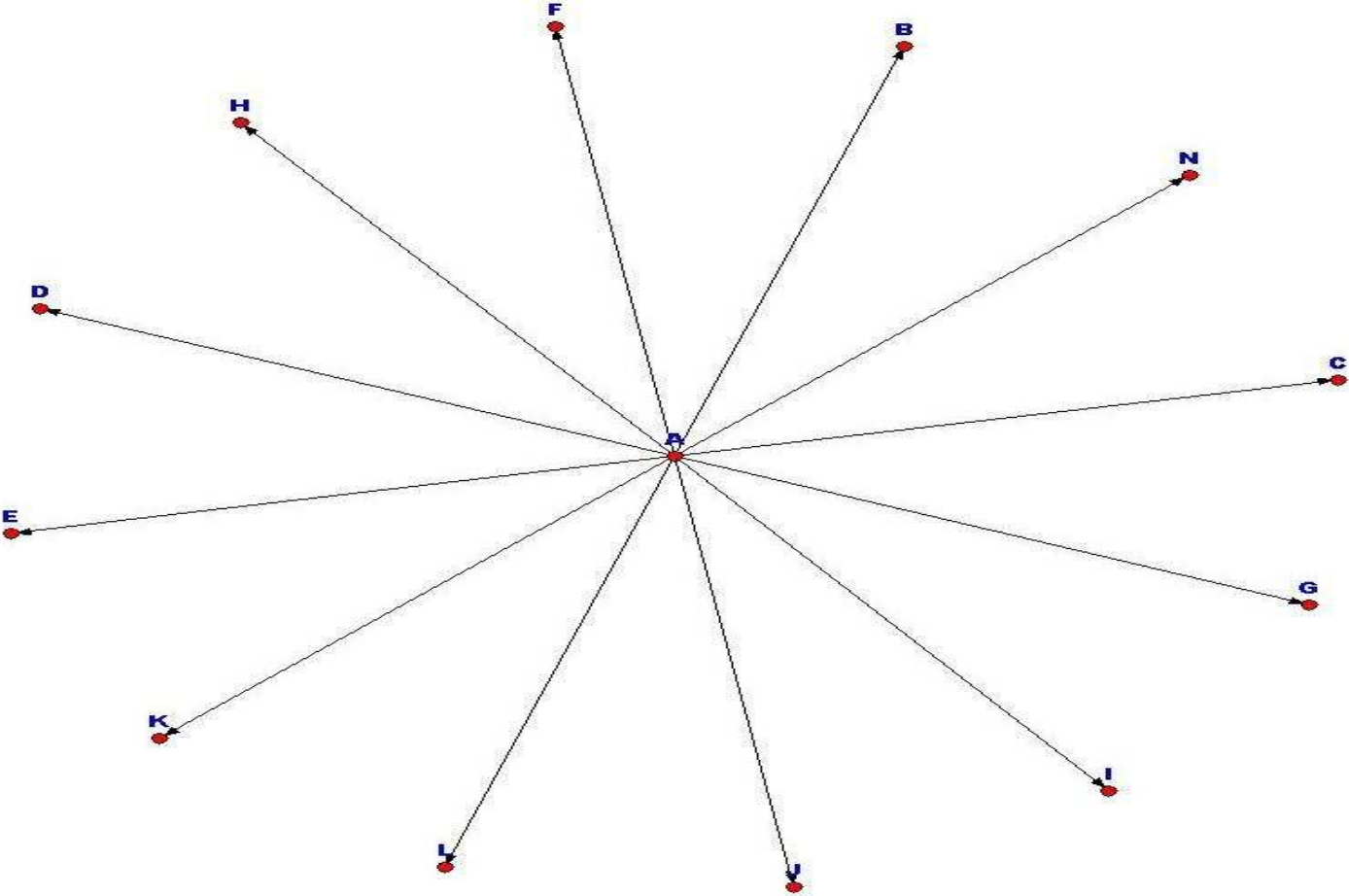


Star-in

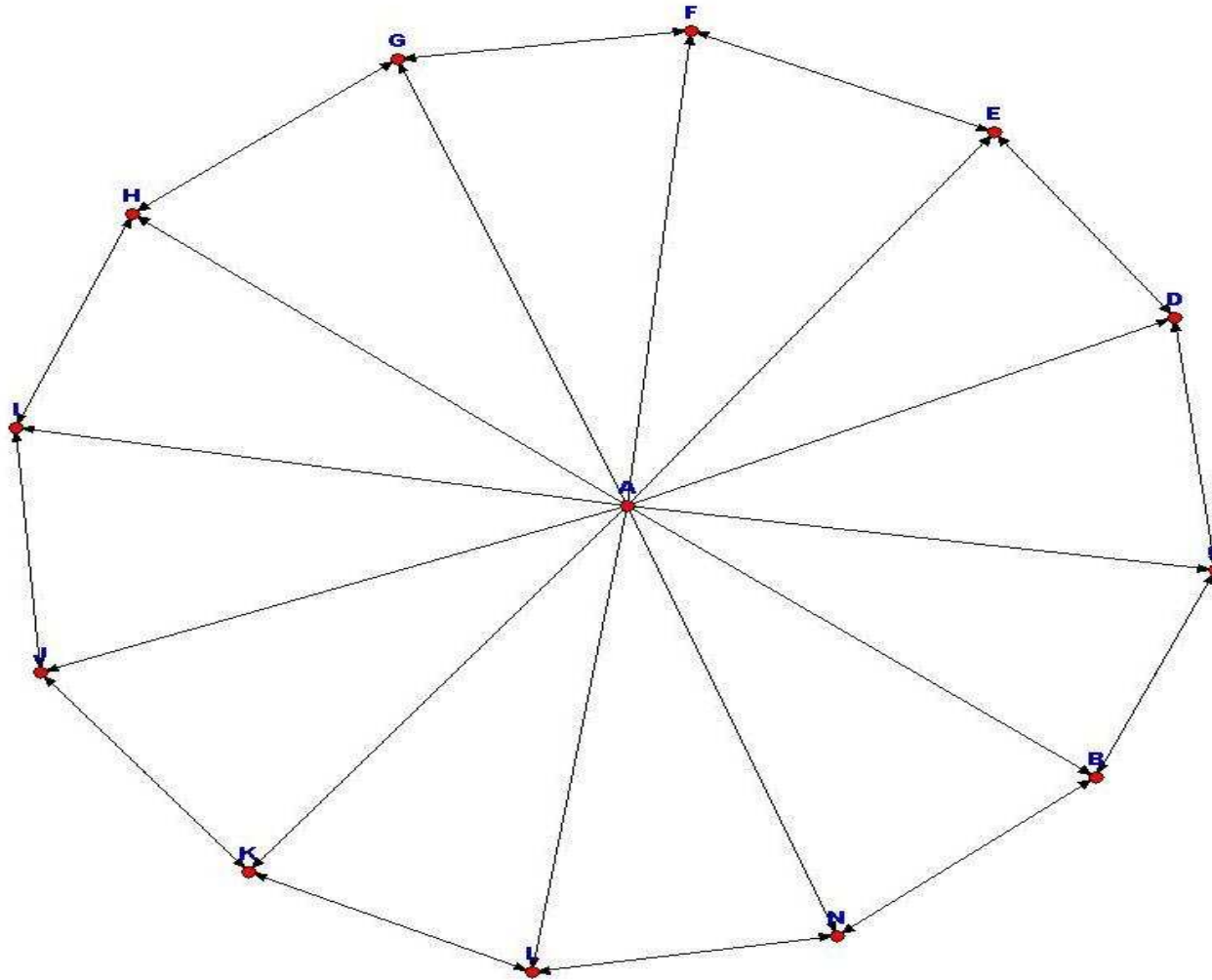


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Star-out



Hybrid-out

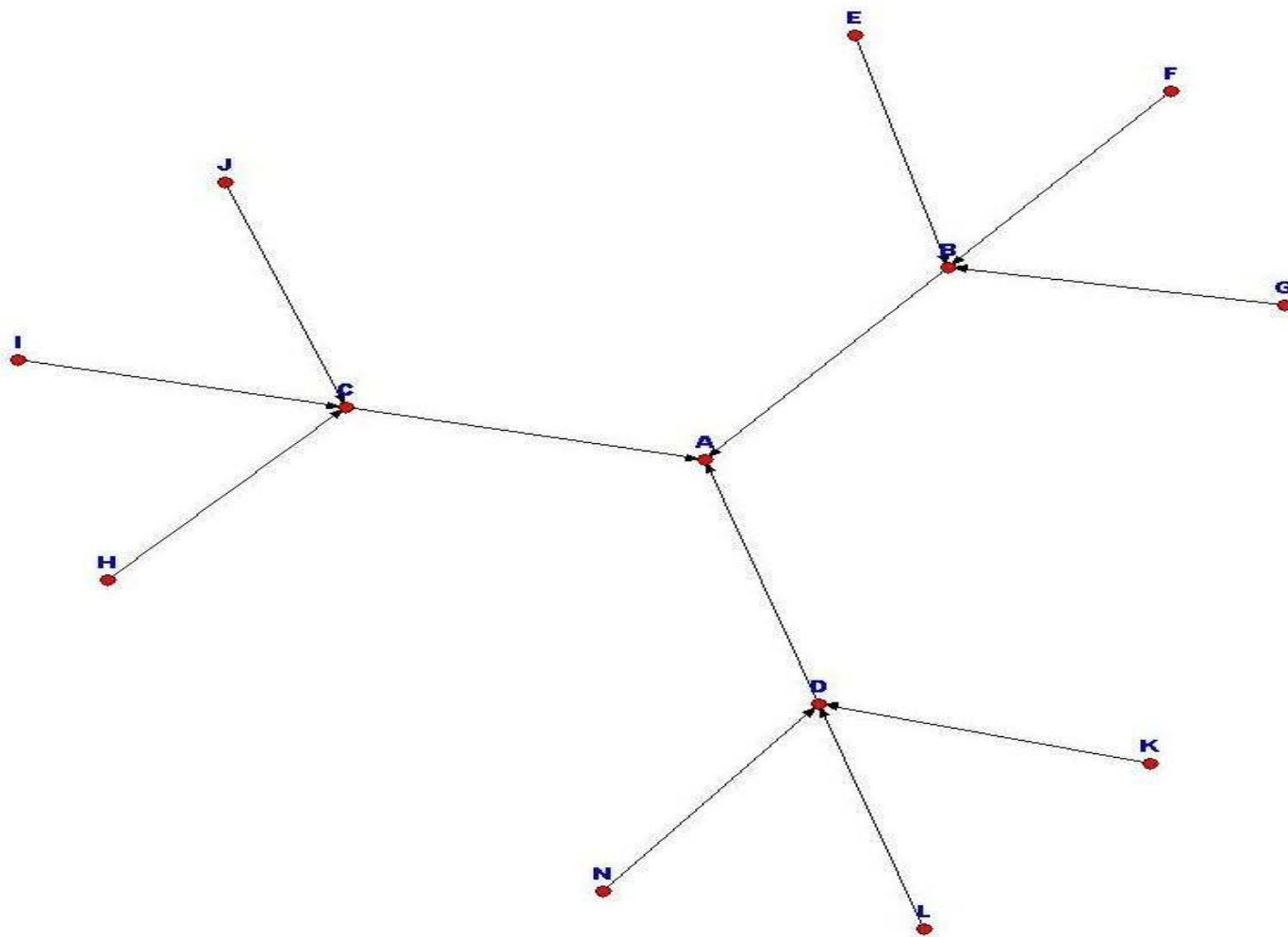


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Types of chain

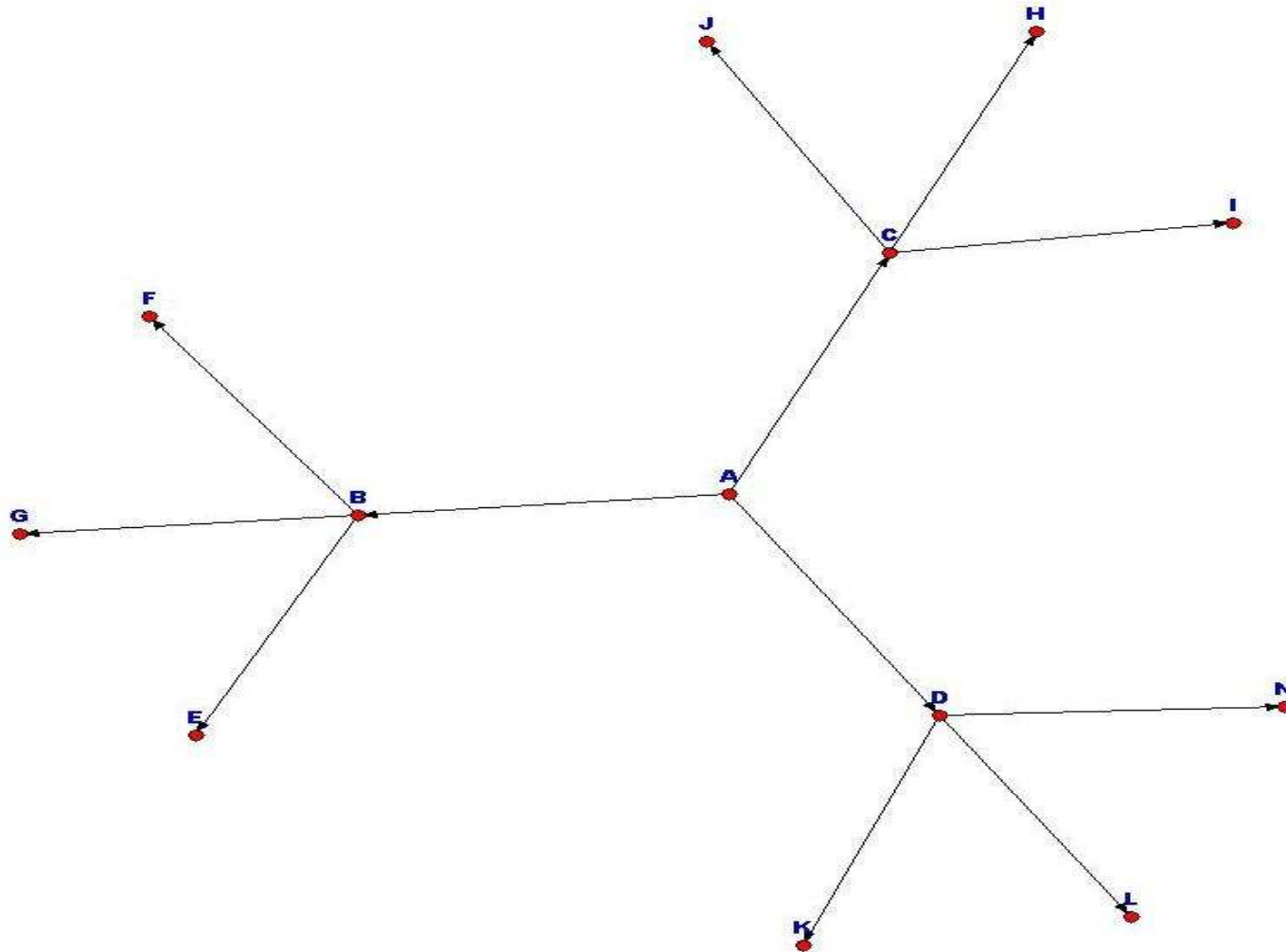


Tree-in

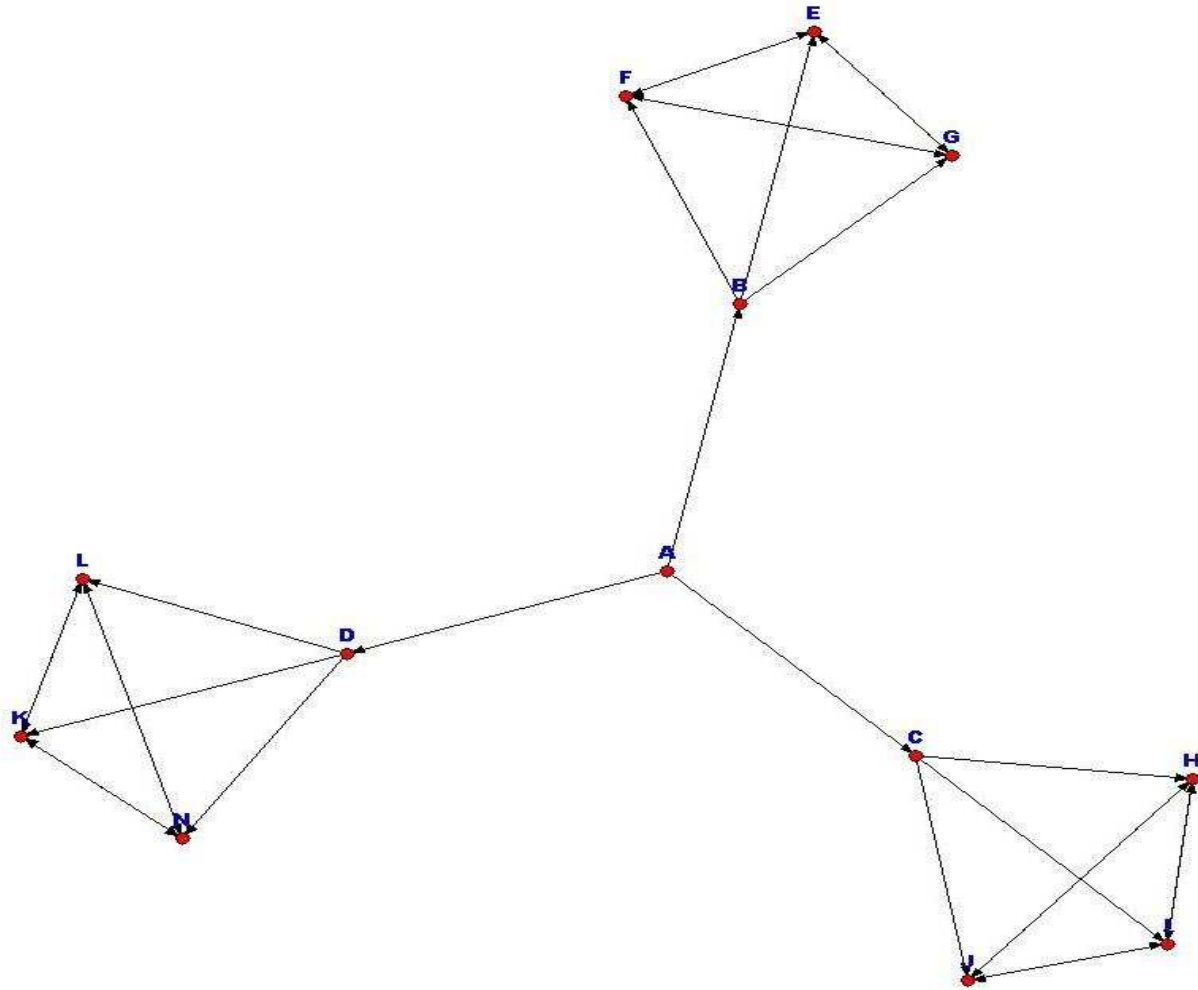


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Tree-out



Tree-out with hybrid base



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Matrix representations

- One-mode matrix: connections within the same set of nodes
- Two-mode matrix: connections between two sets of nodes (exp: affiliation networks)
- Adjacency matrix: nodes adjacency
- Incidence matrix: incidence of links on the same node

The tree-out matrix

	A	B	C	D	E	F	G	H	I	J	K	L	N
A	-	1	1	1	0	0	0	0	0	0	0	0	0
B	0	-	0	0	1	1	1	0	0	0	0	0	0
C	0	0	-	0	0	0	0	1	1	1	0	0	0
D	0	0	0	-	0	0	0	0	0	0	1	1	1
E	0	0	0	0	-	1	1	0	0	0	0	0	0
F	0	0	0	0	1	-	1	0	0	0	0	0	0
G	0	0	0	0	1	1	-	0	0	0	0	0	0
H	0	0	0	0	0	0	0	-	1	1	0	0	0
I	0	0	0	0	0	0	0	1	-	1	0	0	0
J	0	0	0	0	0	0	0	1	1	-	0	0	0
K	0	0	0	0	0	0	0	0	0	0	-	1	1
L	0	0	0	0	0	0	0	0	0	0	1	-	1
N	0	0	0	0	0	0	0	0	0	0	1	1	-

Other aspects

- Matrix order (size): rows per columns
- Self-reference: usually it is excluded, but it can be necessary (warning: effects on the indexes)
- Symmetry: binary networks are expressed by symmetric matrixes

Ordering in terms of descending information content

- Directed valued
- Non-directed valued
- Non-directed binary (non-valued)

Measures	Definitions
Size	Number of nodes
Absolute density	Actual number of nodes
Relative density	Actual number of nodes divided per maximum number of nodes
Reachability	Direct and indirect paths
Symmetry	Rate of symmetric over actual links
Average centrality	Rate between links and nodes
Centralization	Concentration of centrality in few nodes

Structural equivalence (strongest form)	Nodes perfectly interchangeable (in the same position with the rest of the network)
Automorphic (or isomorphic) equivalence	Nodes with the same patterns of links
Regular equivalence (weakest form)	Nodes playing the same “role”

Simplest measures

N = size = number of nodes

D = absolute density = number of links

Ds = D/n(n-1)/2 = 2D/n(n-1)

relative (standardized) density (dichotomized and symmetrized)

Dc = absolute centrality

= number of links of a given node

Cs = Dc/(n-1) relative (standardized) centrality

Cm = 2D/n average centrality

Comparing the prototypical forms

forms	Hk	Eff	LUB	*Dc	*In-Dc	*Out-Dc	*Bc
star	0.0	91.7	100.0	91.7	-	-	100.0
star-in	100.0	100.0	0.0	-	100.0	0.7	0.0
star-out	100.0	100.0	100.0	-	0.7	100.0	0.0
tree	0.0	91.7	100.0	19.4	-	-	61.4
tree-in	100.0	100.0	13.6	-	18.8	0.7	1.9
tree-out	100.0	100.0	100.0	-	0.7	18.8	1.9
chain	0.0	91.7	100.0	1.4	-	-	23.0
closed chain	0.0	99.3	100.0	-	0.0	0.0	0.0
one-way chain	100.0	100.0	100.0	-	0.7	0.7	11.5
centered chain	100.0	100.0	45.5	-	9.7	0.7	3.0
team	0.0	0.0	100.0	0.0	-	-	0.0
hybrid (star-out with chain)	15.4	83.3	100.0	-	2.1	83.3	1.6
tree with hybrid base	0.0	79.2	100.0	6.9	-	-	62.5
tree-out with hybrid base	70.0	87.5	100.0	-	6.3	6.3	1.9

*centralization degree

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Limits of SNA

- Static analysis: longitudinal analysis is NOT a dynamic analysis
- Poor attributes of nodes
- Poor attributes of connections
- Network size (a): being characterized by combinatorial properties, most algorithms face with computational intractability
- Network size (b): it is terribly hard gathering squared empirical data of large phenomena

References

A simple introduction to the subject can be found in J. Scott 1991. *Social network analysis: a handbook*. London: Sage.

Borgatti, S.P. and Foster P.C. 2003. The Network Paradigm in Organizational Research: A Review and Typology. *Journal of Management*. 29: 991-1013.

For an advanced treatment, see:

Wasserman, S. and Faust, K. 1994. *Social network analysis: methods and applications*. Cambridge University Press, Cambridge.

For advancements in social and behavioral sciences, see:
Wasserman, S. and Galaskiewicz, J. (eds.) 1994. *Advances in Social Network Analysis: Research in the Social and Behavioral Sciences*. Thousand Oaks (CA): Sage.

Specialized Journals

Social Networks

Journal of Social Structure

Computational and Mathematical

Organization Theory

Journal of Mathematical Sociology

Journal of Artificial Societies and Social
Simulation

Software

UCINET is the best and most diffused software.

KRACKPLOT is cheap and has the merit to allow drawing a network and then getting the corresponding matrix.

NETWDRAW is free and rather user friendly.

PAJEK is free, rich of options, but not user friendly.

NETMINER is the most advanced and well done