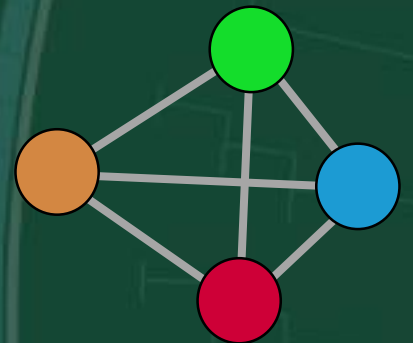


Social network analysis

Hector Marina

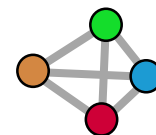


- A **social network** can be constructed from **relational data** and can be defined as a set of social **entities**, such as people, groups, and organizations, with some relationships or interactions between them. These networks are usually modelled by graphs, where vertices represent the social entities and edges represent the **relationships** established between them

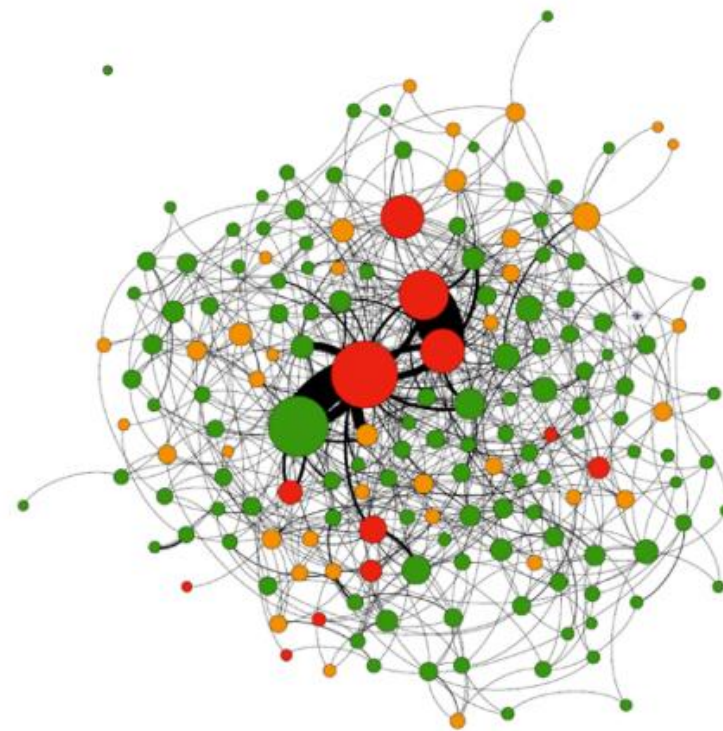


(Tabassum et al., 2018)

What is SNA?

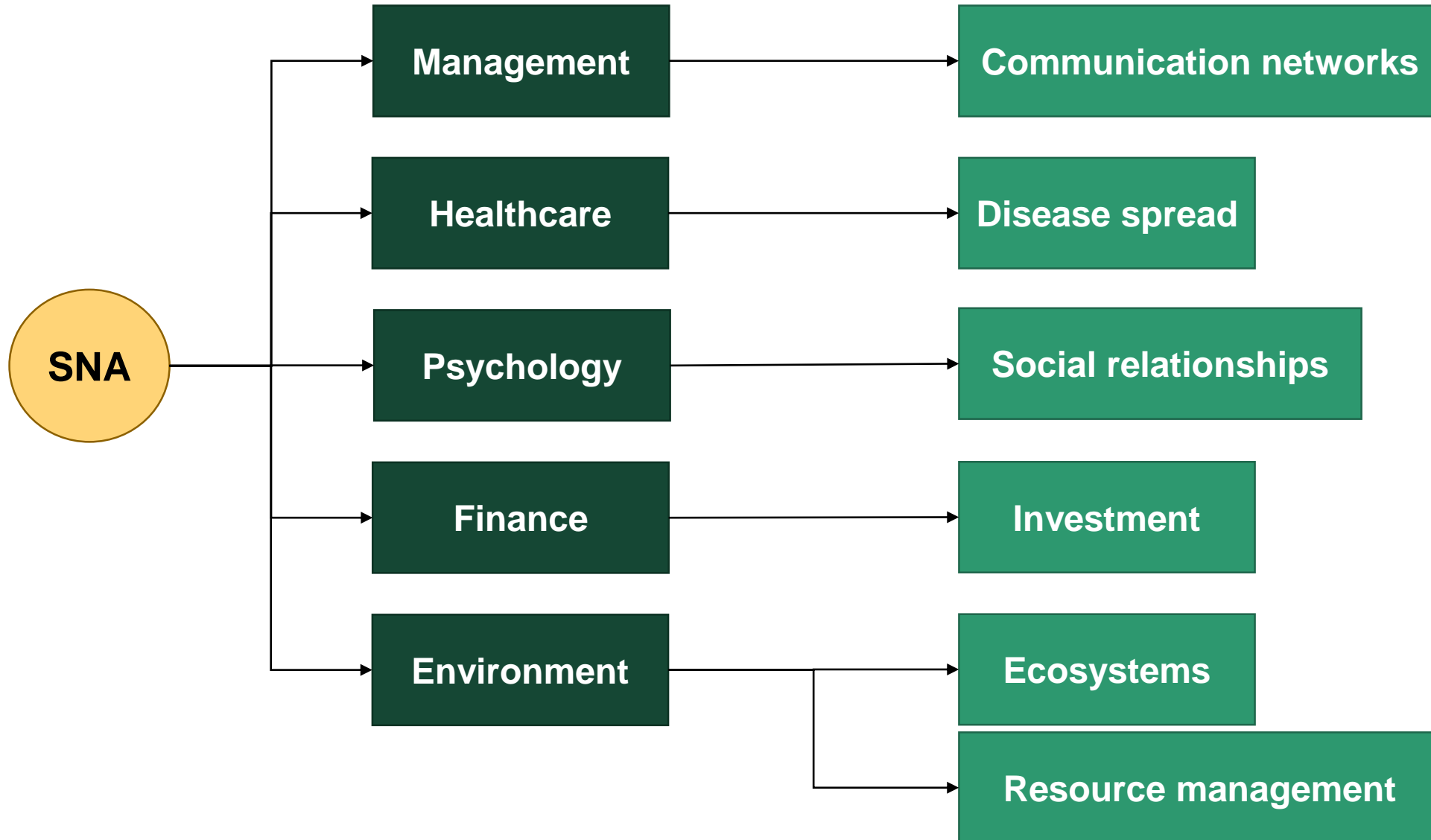


- **Social network analysis** studies structures of relationships linking individuals and interdependencies in behaviour or attitudes related to configurations of social relations

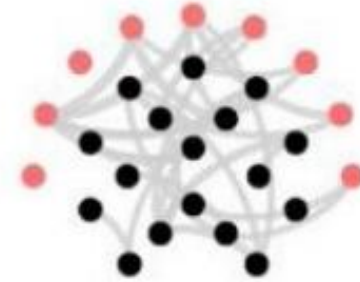
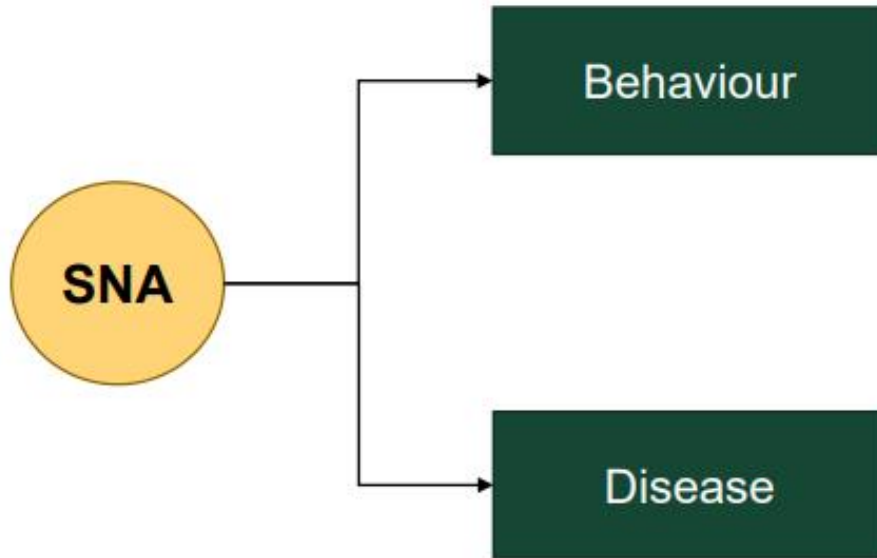


(de Freslon et al., 2019)

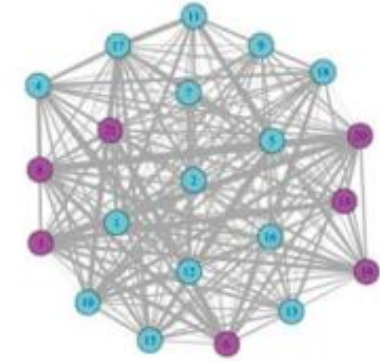
SNA applications



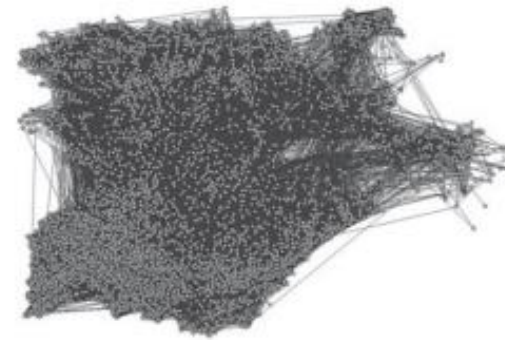
SNA applications in animals



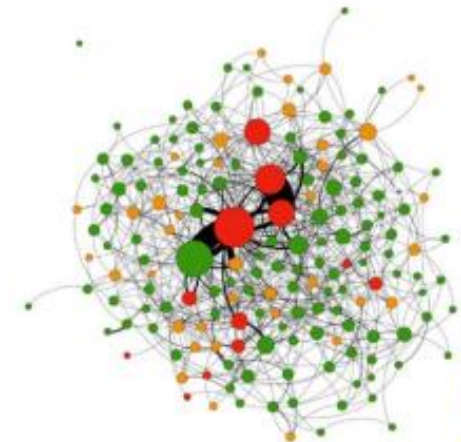
(Rocha et al., 2020)



(Chen et al., 2015)



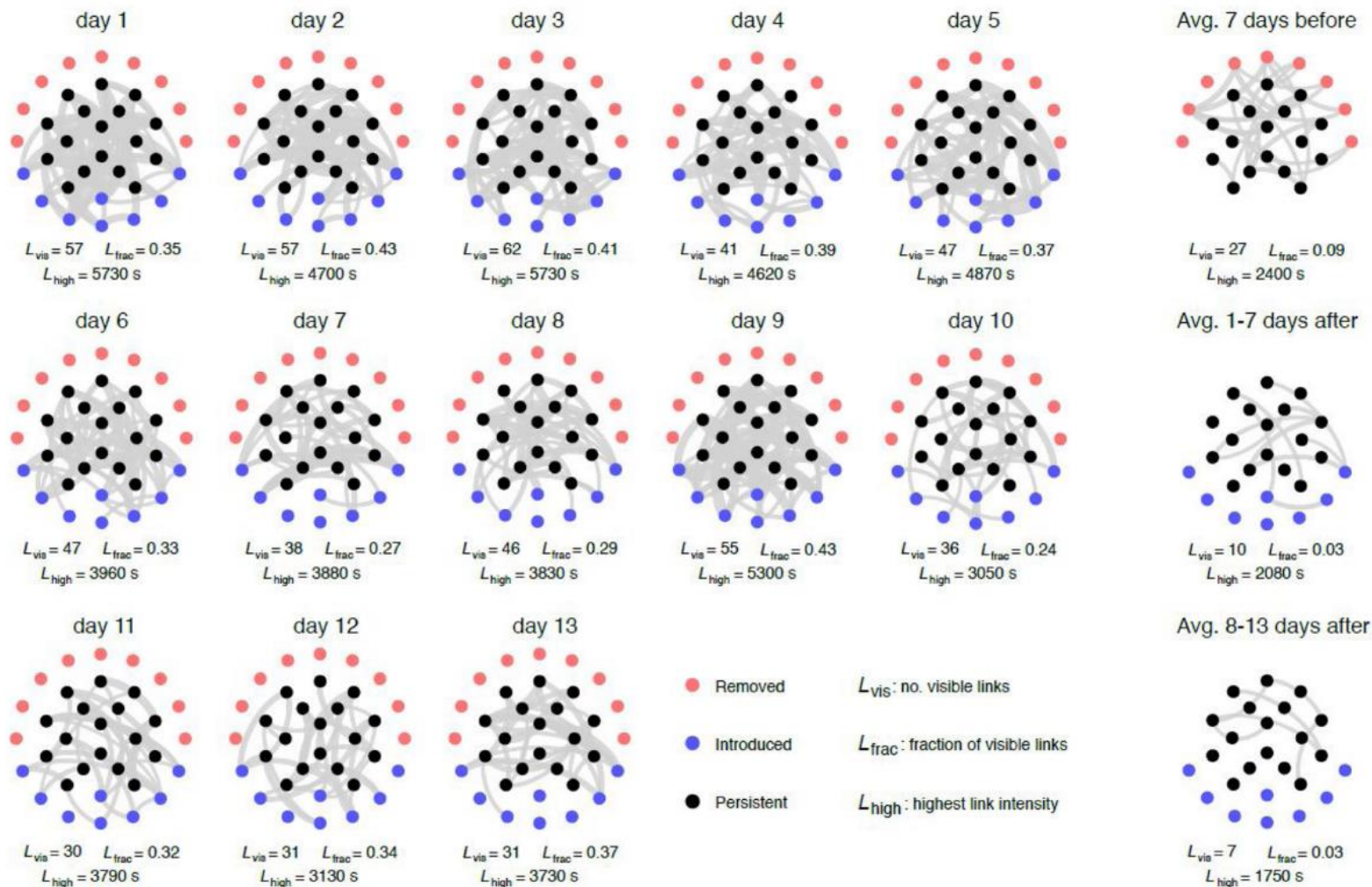
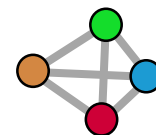
(Martínez-López et al., 2009)



(Freslon et al., 2019)



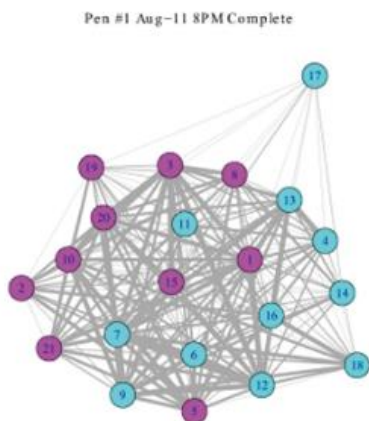
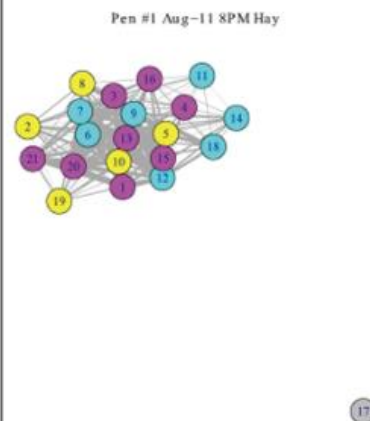
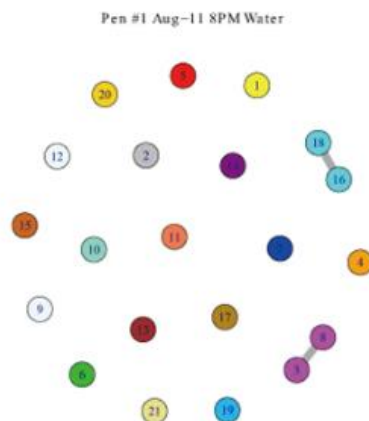
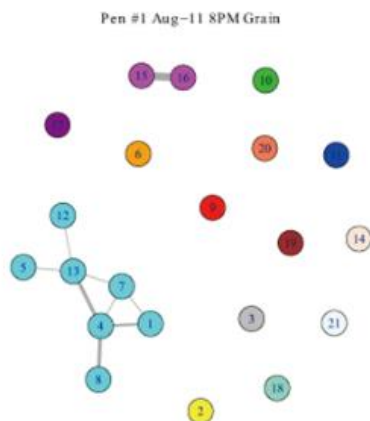
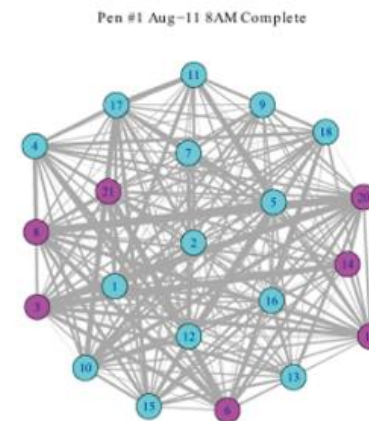
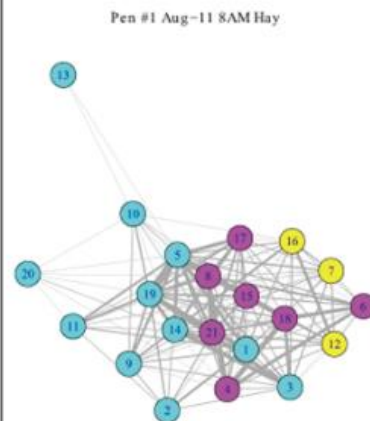
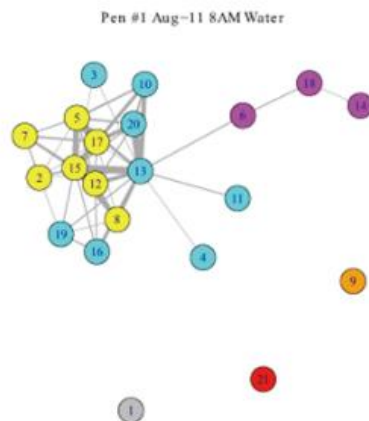
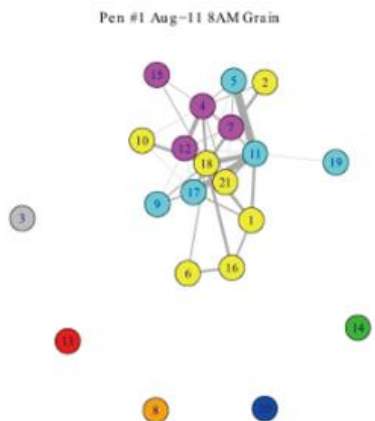
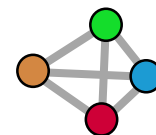
SNA applications in animals



Suggested that each cow has its **own sociality** independent of the group and tend to establish relations with **specific partners** when the population is fixed

(Rocha et al., 2020)

SNA applications in animals

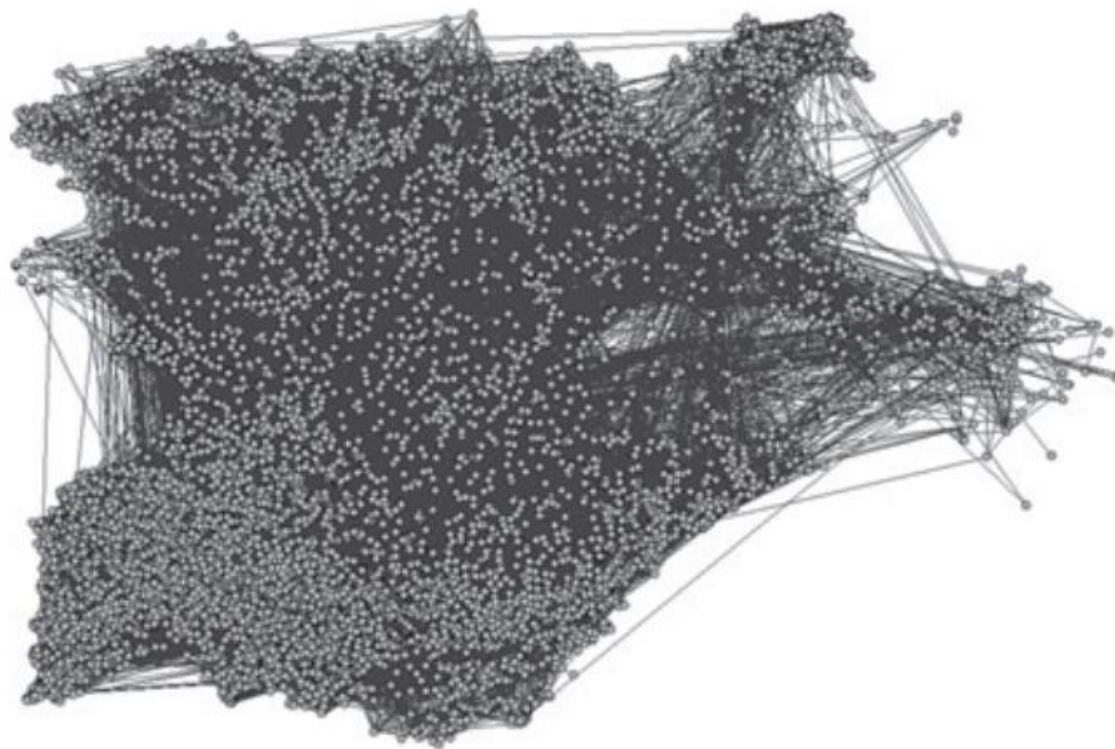
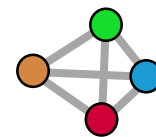


From left to right: networks around grain, hay, water, and complete network in the pen

(Chen et al., 2015)



SNA applications in animals



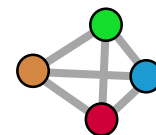
Network of cattle movements in the Spanish region of CyL in 2005.

SNA offers important benefits for the assessment of epidemiological conditions, factors and forces associated with **risk for animal disease spread**

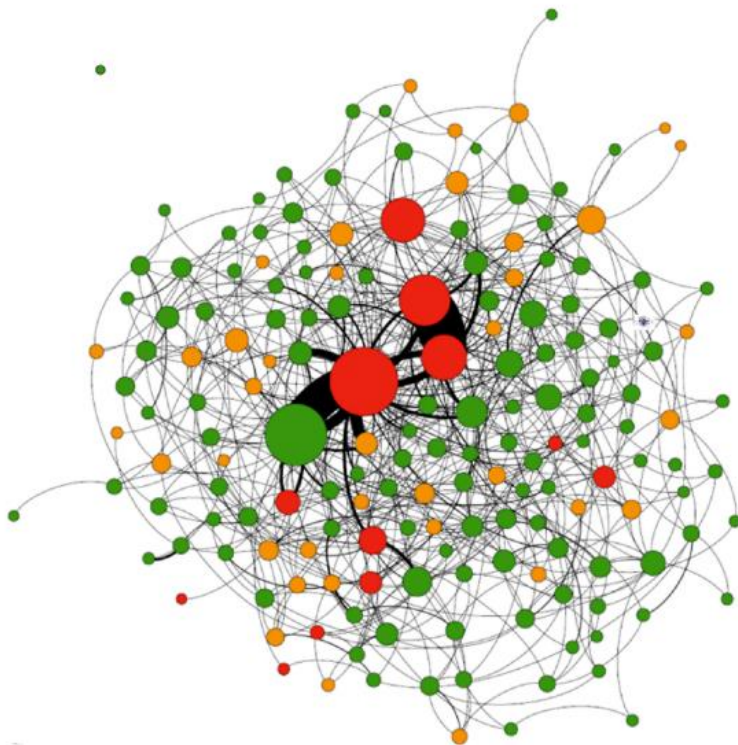
(Martínez-López et al., 2009)



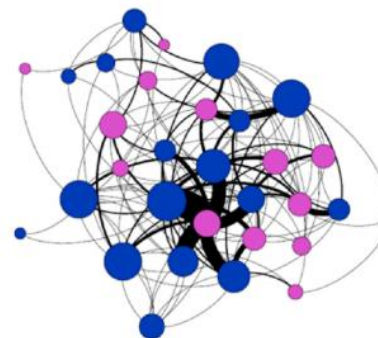
SNA applications in animals



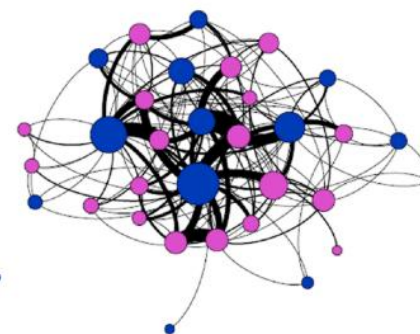
COW



CALF1



CALF2



Focused on three contact behaviours that may lead to transmission of pathogenic *Leptospira* spp.: **sniffing, licking and rubbing the face** on the genital area of another animal

(de Freslon et al., 2019)



Behav Ecol Sociobiol (2009) 63:989–997

DOI 10.1007/s00265-009-0742-5

REVIEW

Potential banana skins in animal social network analysis

Richard James • Darren P. Croft • Jens Krause

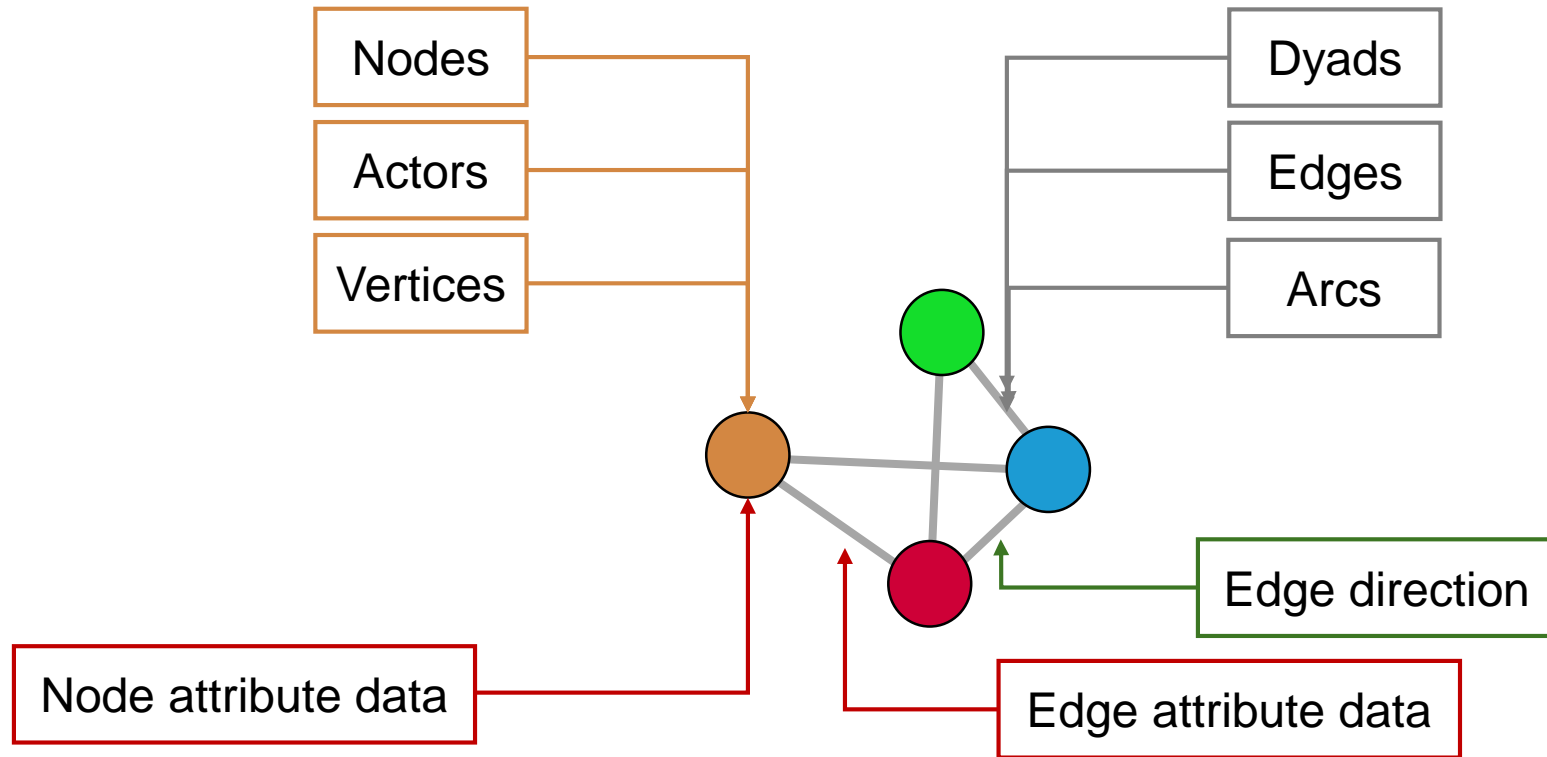
- Observation errors
- Choice of statistical tests
- Is our interpretation appropriate?



(James et al., 2009)

What is a network?

Part of the networks



Ways to represent networks

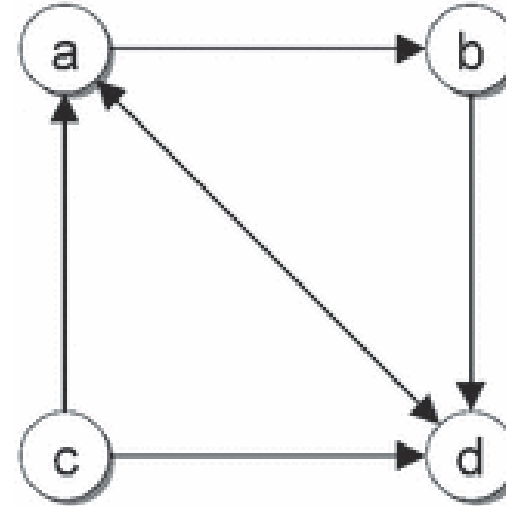
Adjacency matrix

	a	b	c	d
a	0	1	0	1
b	0	0	0	1
c	1	0	0	1
d	1	0	0	0

Notation

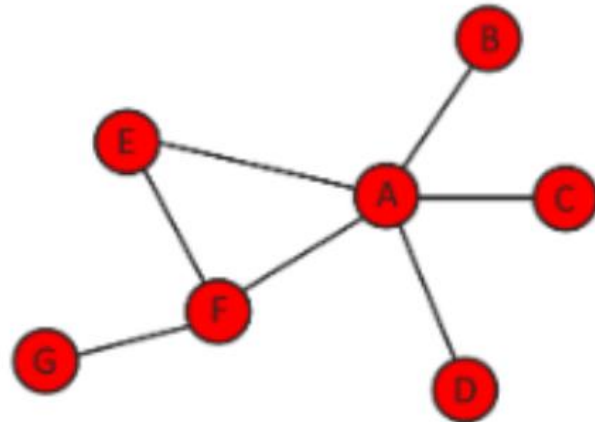
$$G = \{(a, b), (a, d), (b, d), (c, a), (c, d), (d, a)\}$$

Graph



Ways to represent networks

A	B
A	C
A	D
A	E
A	F
E	F
F	G

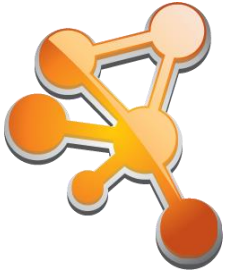


	A	B	C	D	E	F	G
A	0	1	1	1	1	1	0
B	1	0	0	0	0	0	0
C	1	0	0	0	0	0	0
D	1	0	0	0	0	0	0
E	1	0	0	0	0	1	0
F	1	0	0	0	1	0	1
G	0	0	0	0	0	1	0

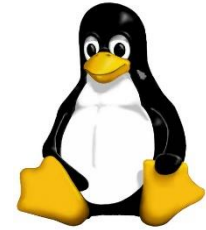
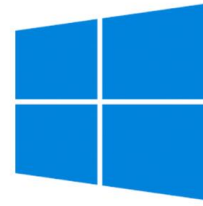


Software

Network analysis software



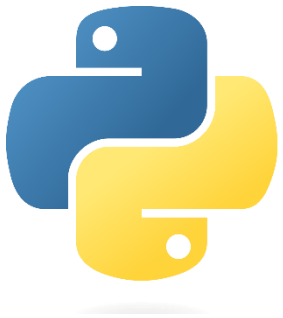
Cytoscape



sna

igraph

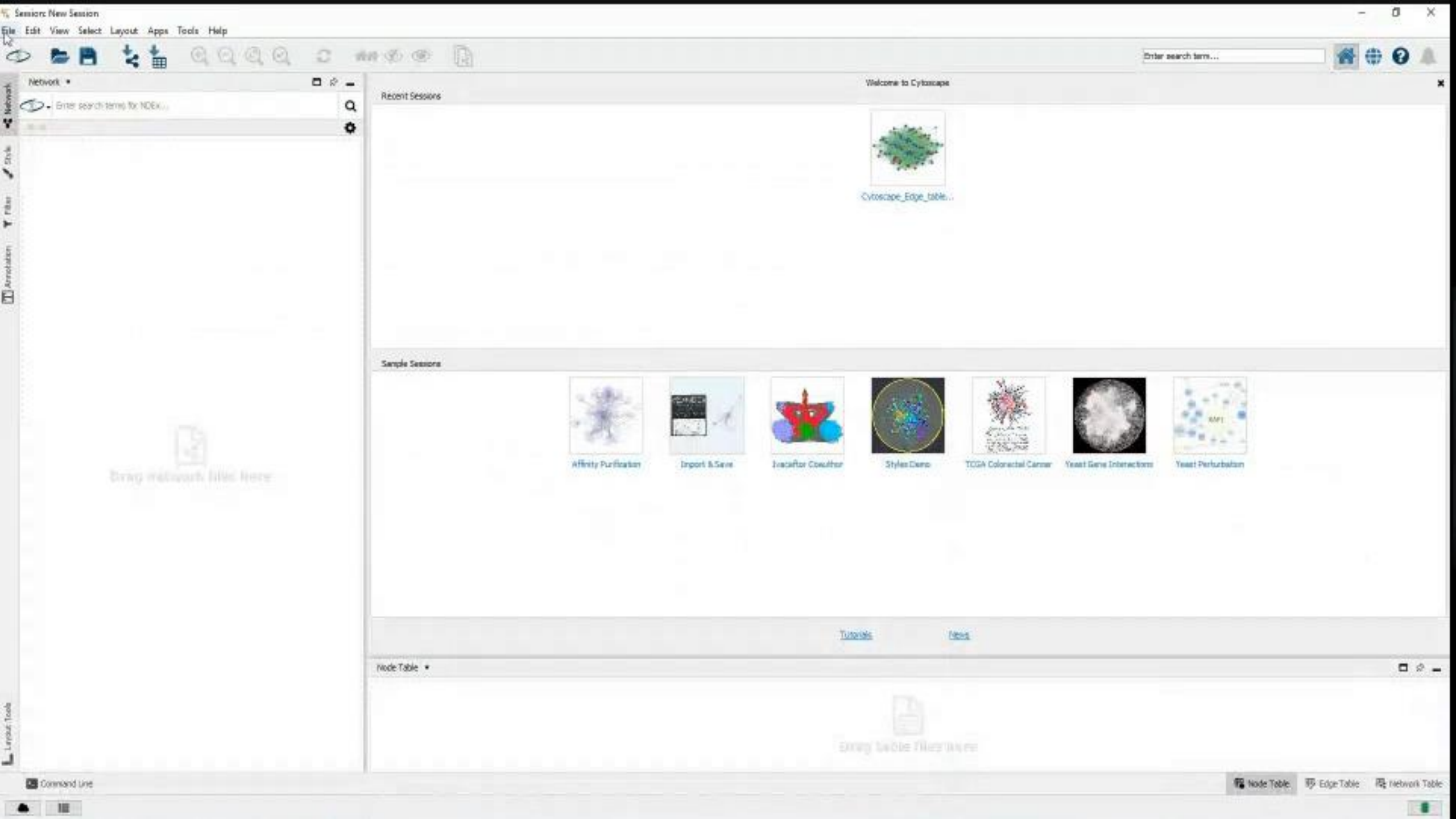
network



networkX

igraph



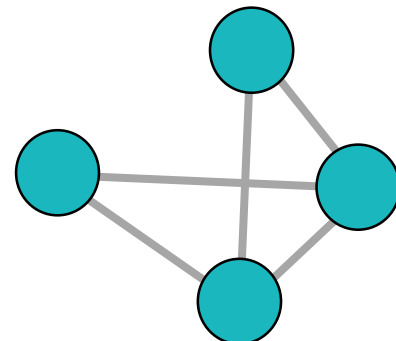


Descriptive properties of networks

Ways to analyze the information

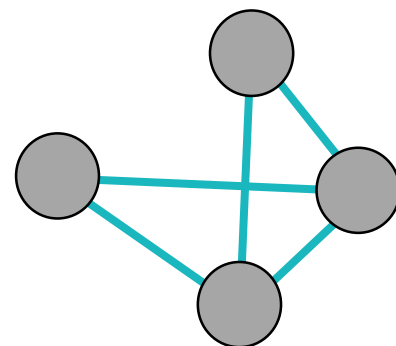
individual- level models

focuses on an **individual-level outcome**, network data are used to define explanatory variables

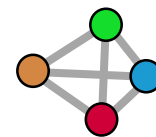


relational-level models

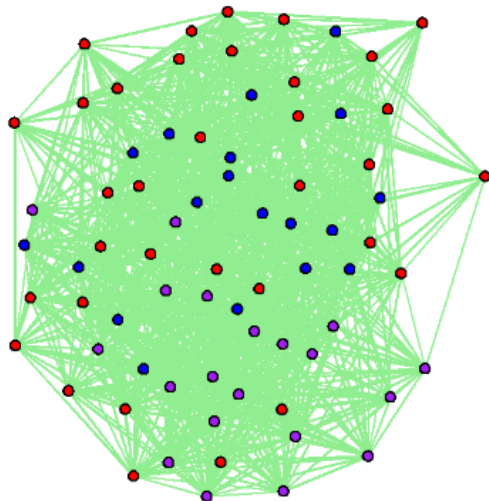
focuses on an **dyad-level**, analyse the **relationship** rather than a characteristic of particular individuals



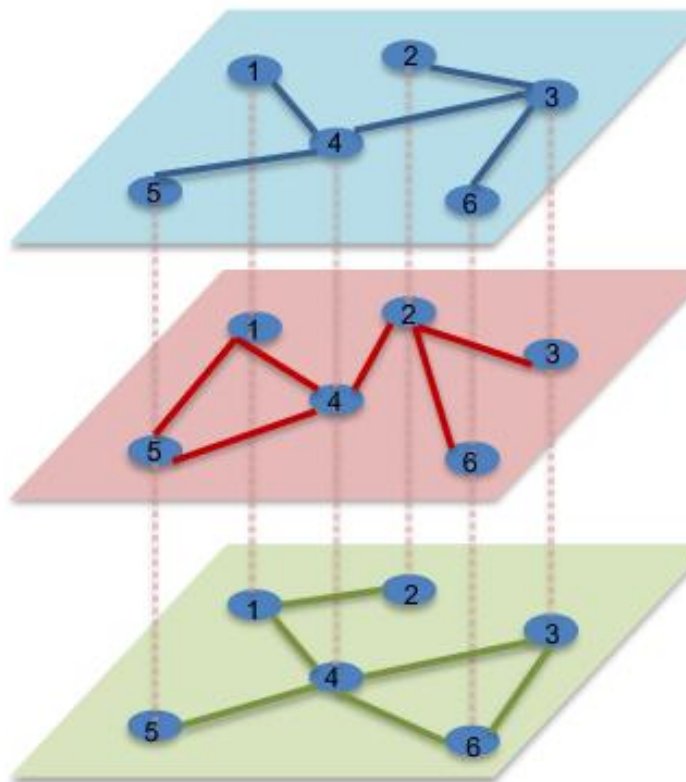
Network dimensions



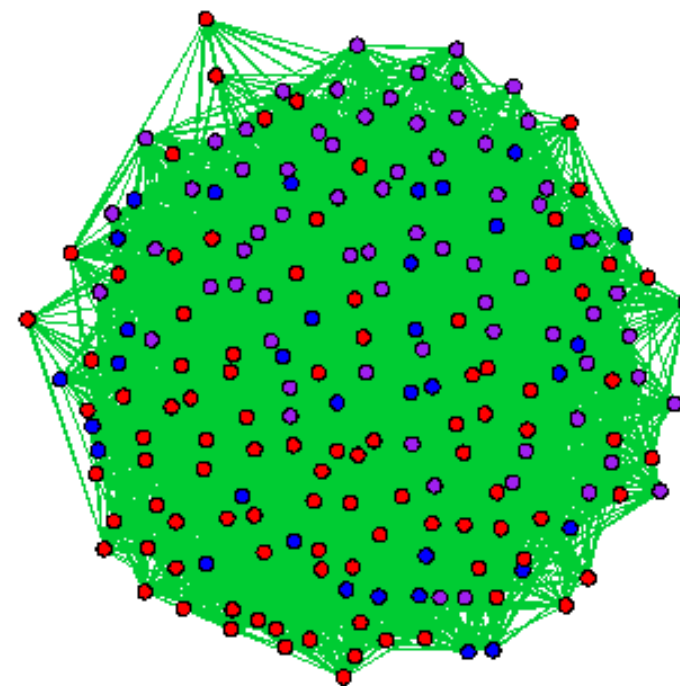
Unidimensional
data



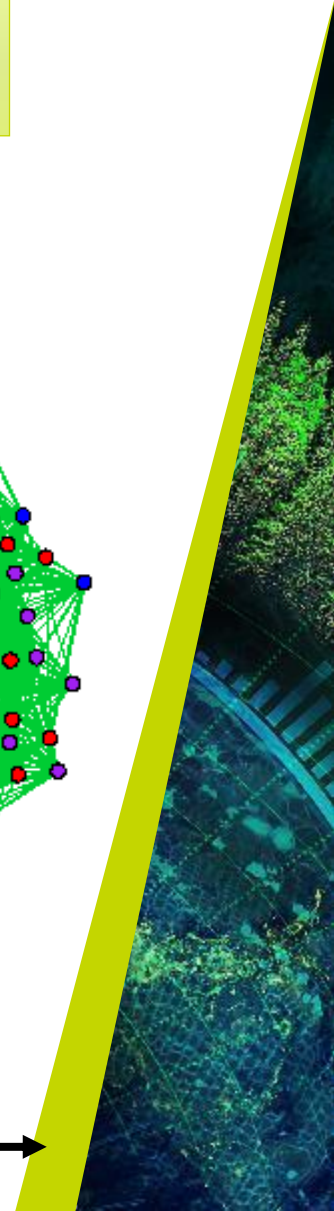
Multidimensional
data



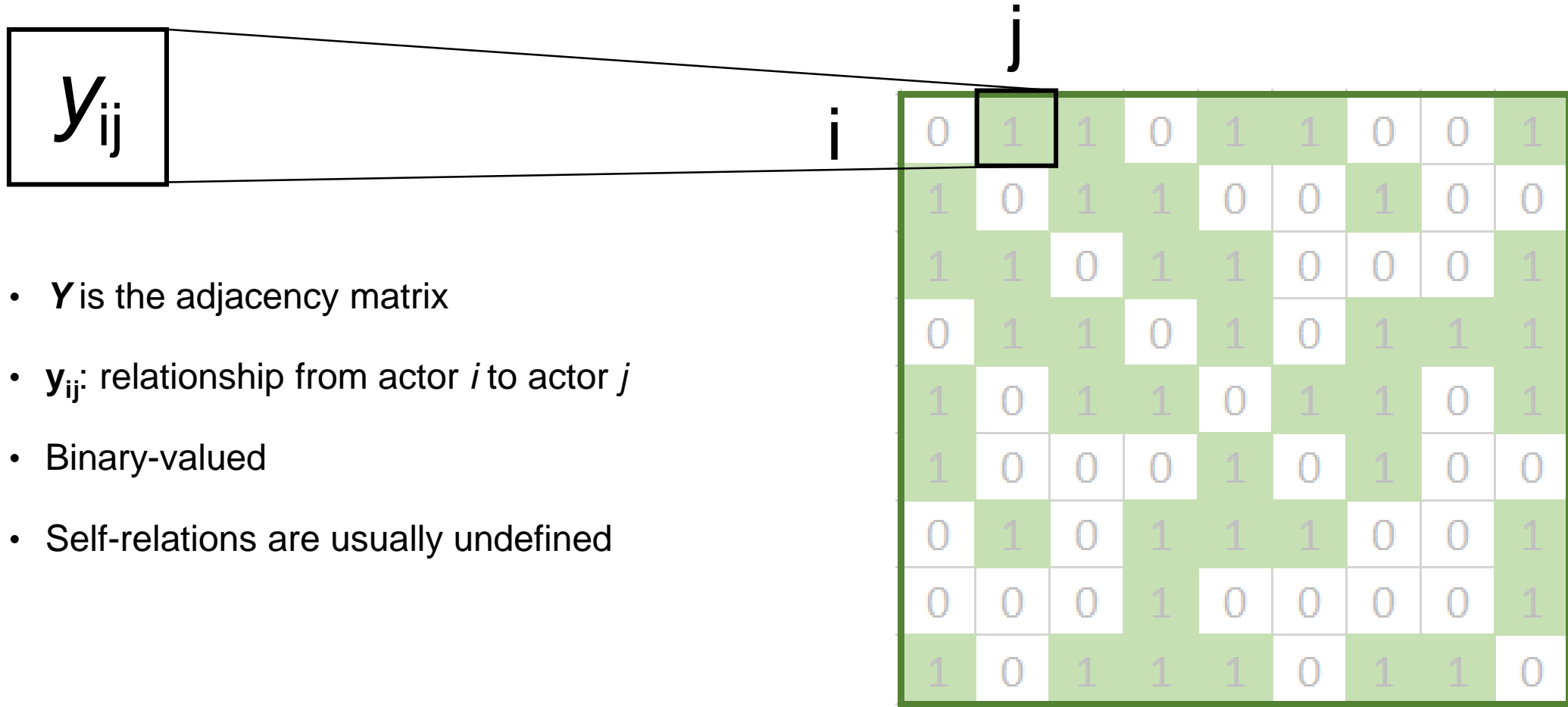
Longitudinal data



Time

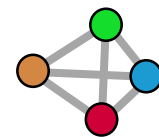


Descriptive properties of networks



- Y is the adjacency matrix
- y_{ij} : relationship from actor i to actor j
- Binary-valued
- Self-relations are usually undefined

Descriptive properties of networks

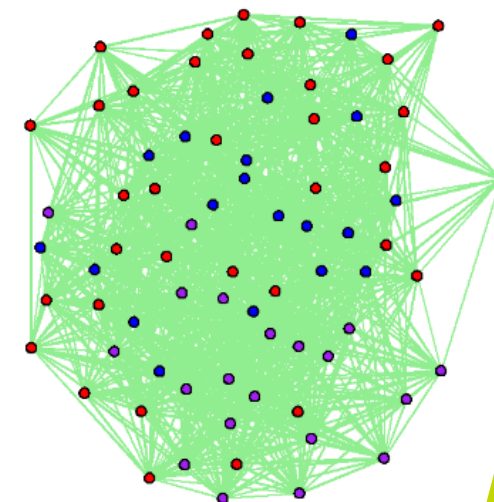


1) Size and density of the network

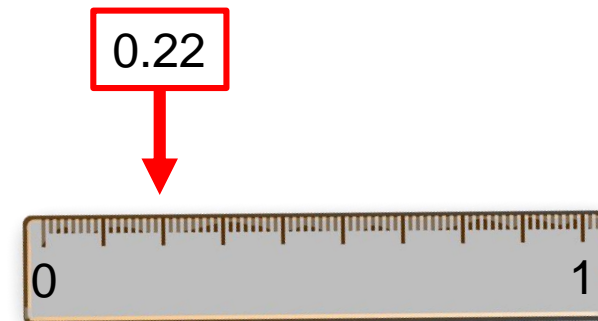
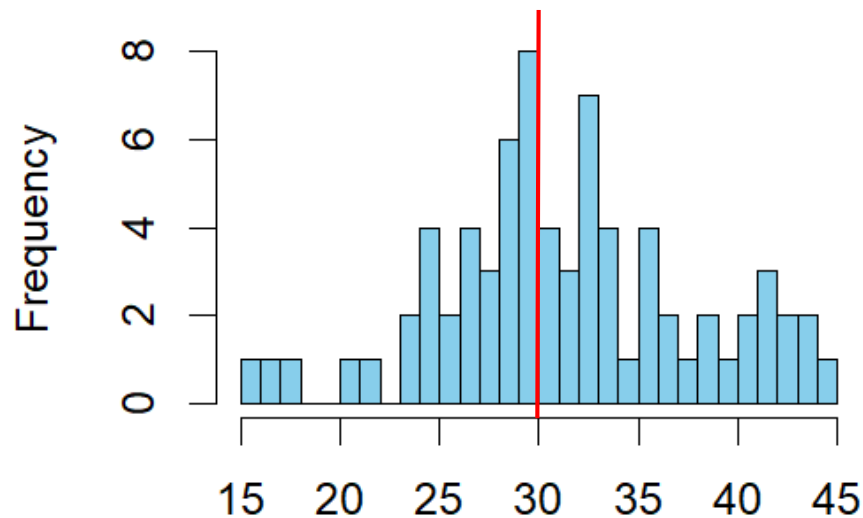
$$(L = \sum_{i,j} y_{ij})$$

$$L/(N(N - 1))$$

Feeding area

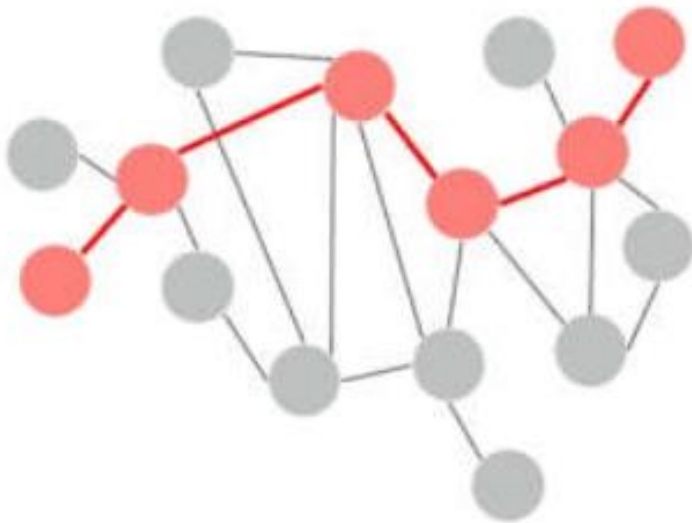


2) Degree and the degree distribution



Descriptive properties of networks

3) Geodesic distance:



Diameter

2

1.5

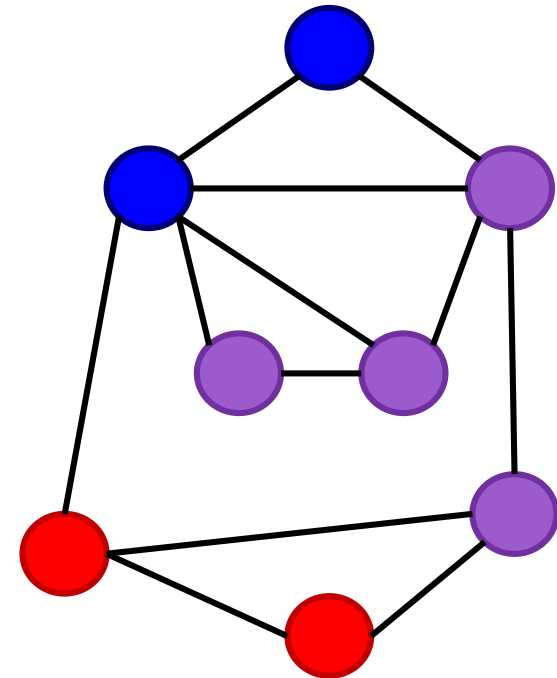


Descriptive properties of networks

4) Centrality parameters:

Degree:

- The simplest is based on an actor's degree
- Reflects an actor's level of network activity or involvement



Descriptive properties of networks

4) Centrality parameters:

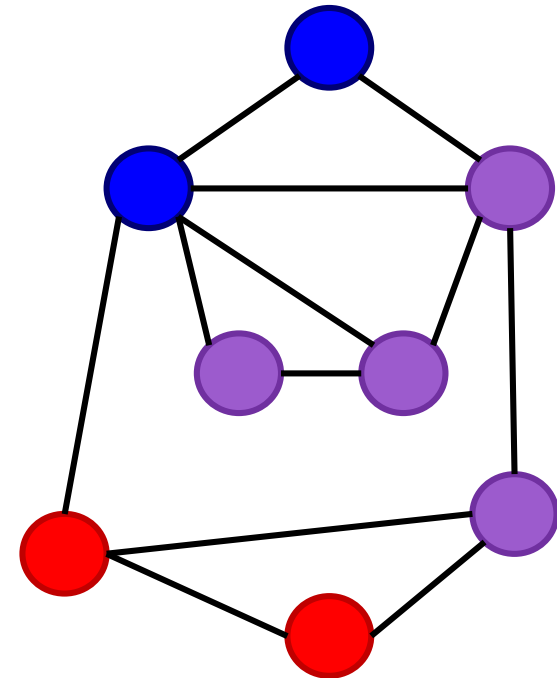
Betweenness:

- Number of times a node acts as a bridge along the shortest path between two other nodes

Shortest path from s->t
that cross through v

$$g(v) = \sum_{s \neq v \neq t} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

Shortest path from s->t



Descriptive properties of networks

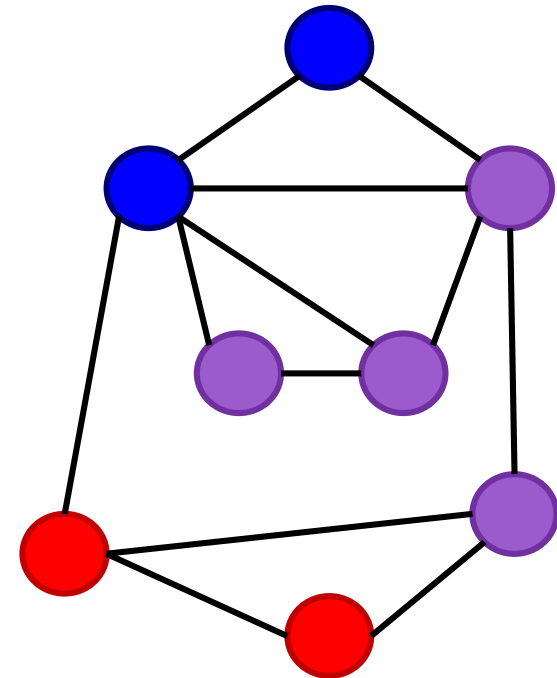
4) Centrality parameters:

Closeness:

- Sum of the length of the shortest paths between the node and all other nodes in the graph

$$C(v) = \frac{N - 1}{\sum_u d(u, v)}$$

← Number of nodes in the graph
 ← Distance between vertices u and v

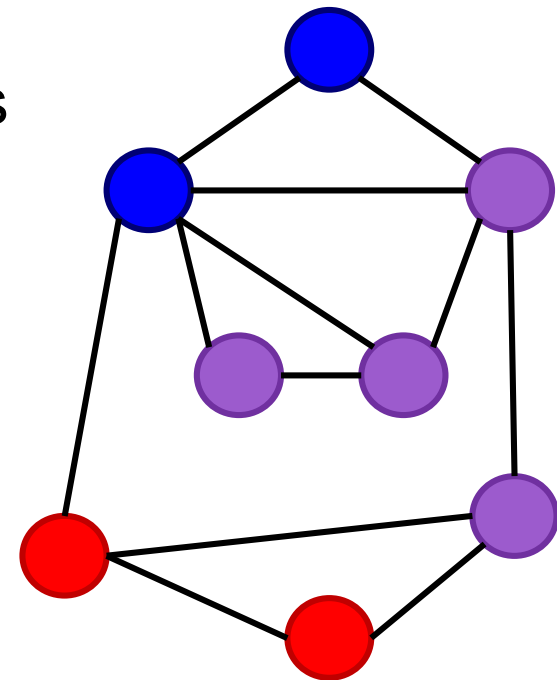


Descriptive properties of networks

4) Centrality parameters:

Eigenvector:

- Principal eigenvector using the adjacency matrix
- Measures a node's importance while giving consideration to the importance of its neighbors

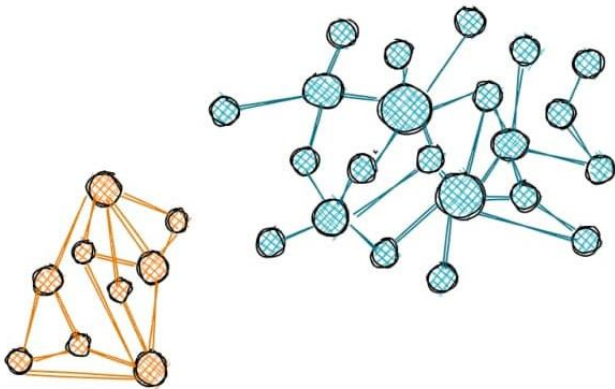


Descriptive properties of networks

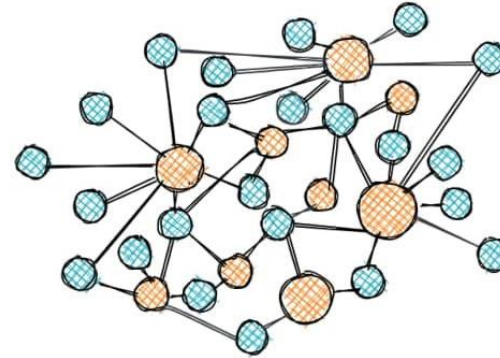
5) Homophily:

- Represents the propensity of individuals to interact with others of similar characteristics

Homophily



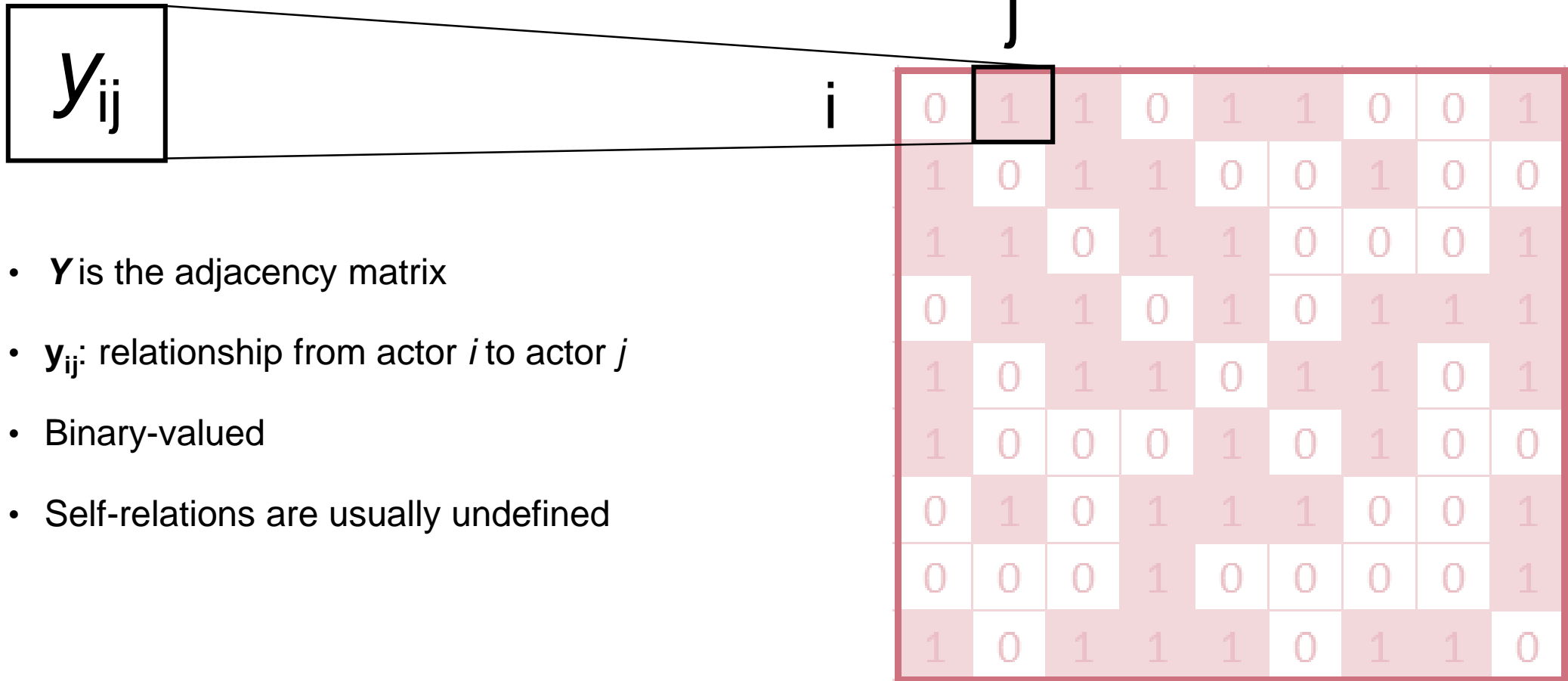
Heterophily



Dyad-level models

Relational or dyad-level models

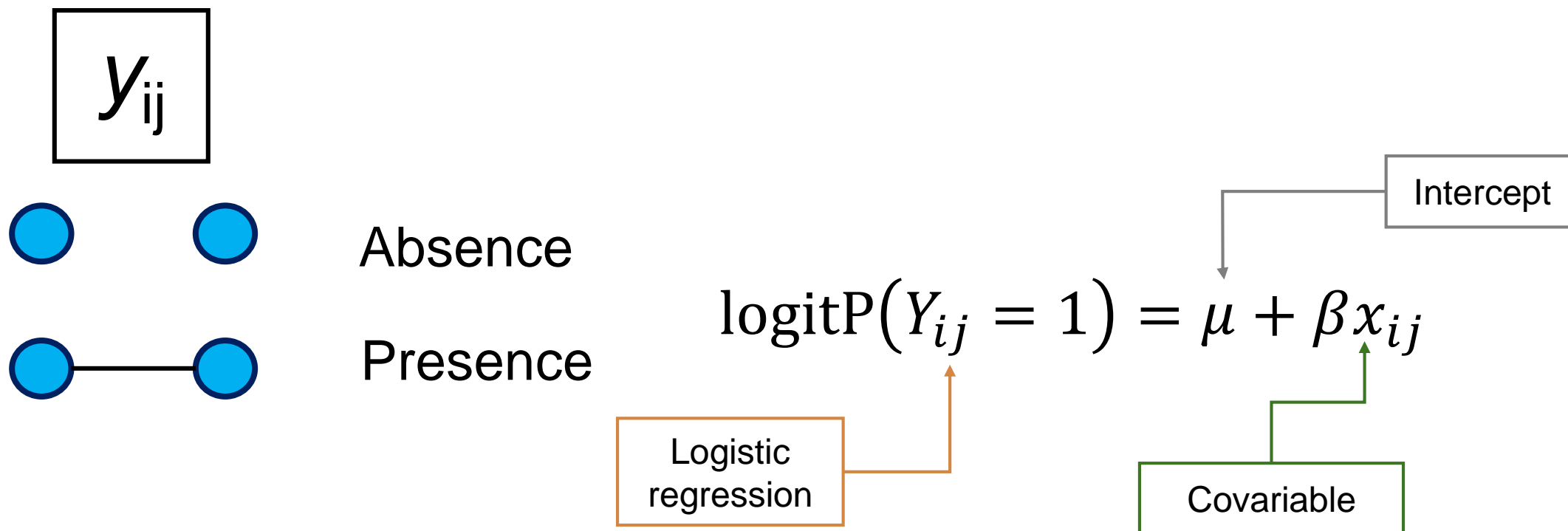
- Exponential random graph models (ERGMs):



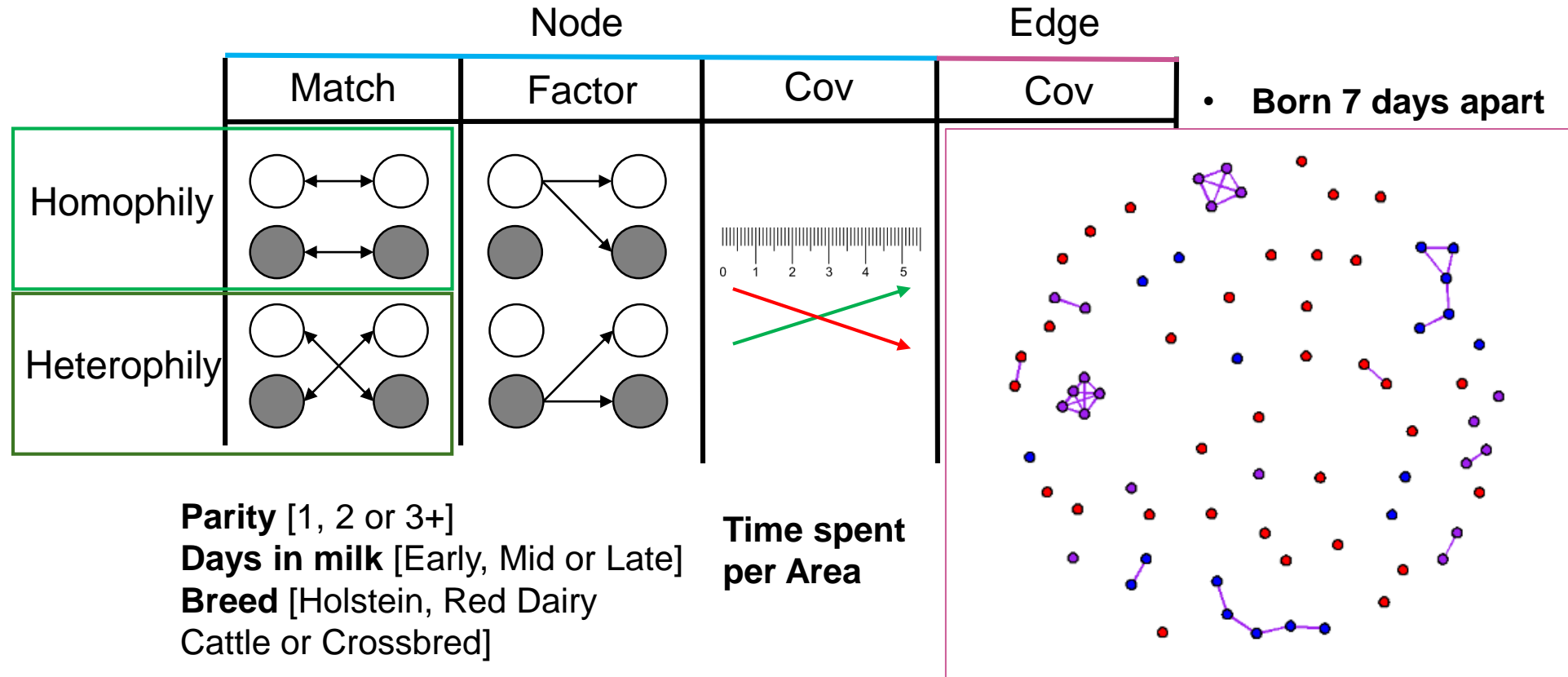
- Y is the adjacency matrix
- y_{ij} : relationship from actor i to actor j
- Binary-valued
- Self-relations are usually undefined

Relational or dyad-level models

- Exponential random graph models (ERGMs):











Relational or dyad-level models






Relational or dyad-level models

- Exponential random graph models (ERGMs):

		Parity		TimeInArea		AGEnet
			Match	Factor		Cov
		$Y_{ij} = 0$	1	0	0	0.22+0.43
		$Y_{ik} = 0$	0	0	1	0.22+0.33
		$Y_{jk} = 1$	0	1	1	0.56+0.33
		$Y_{im} = 1$	1	0	0	0.22+0.13

Parity

-  1
-  2
-  3+

Animal information

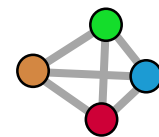
Social interactions

Ultra-Wide Band technology

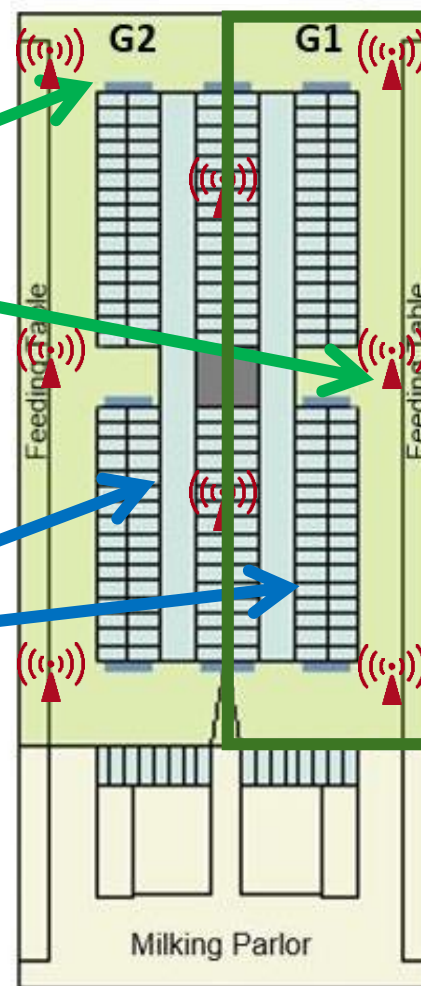
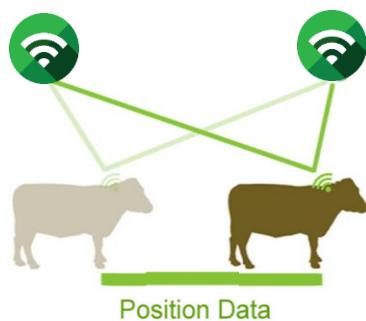


- Collecting positions of all cows every second
- Spatial interactions
- Real time information

Spatial interactions

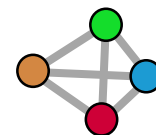





Real-time Location System

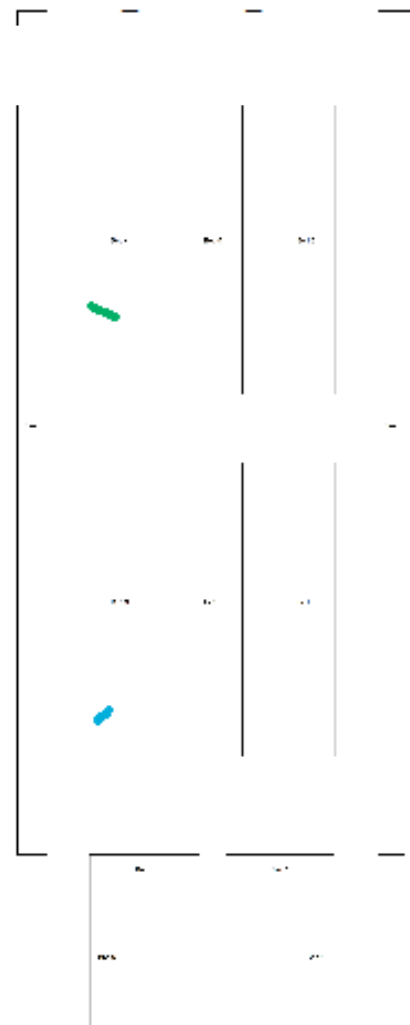
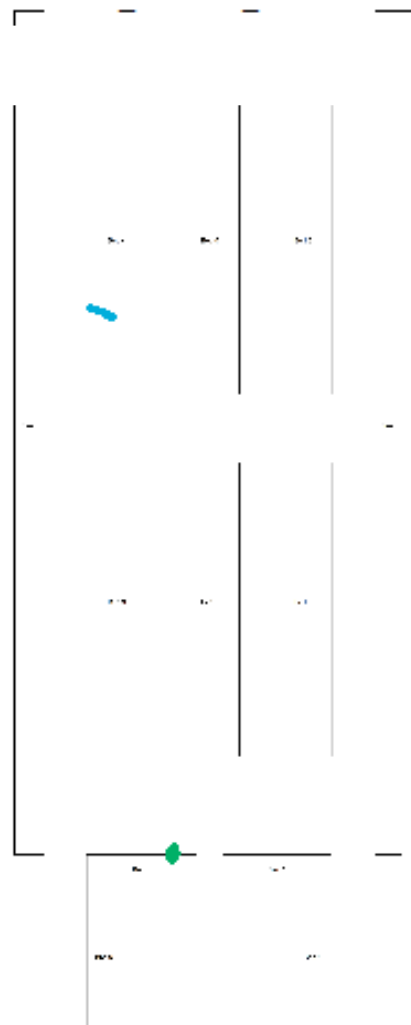


-  Feeding Area
-  Resting Area
-  Water trough
-  Feed boxes (not in use)

Spatial contacts

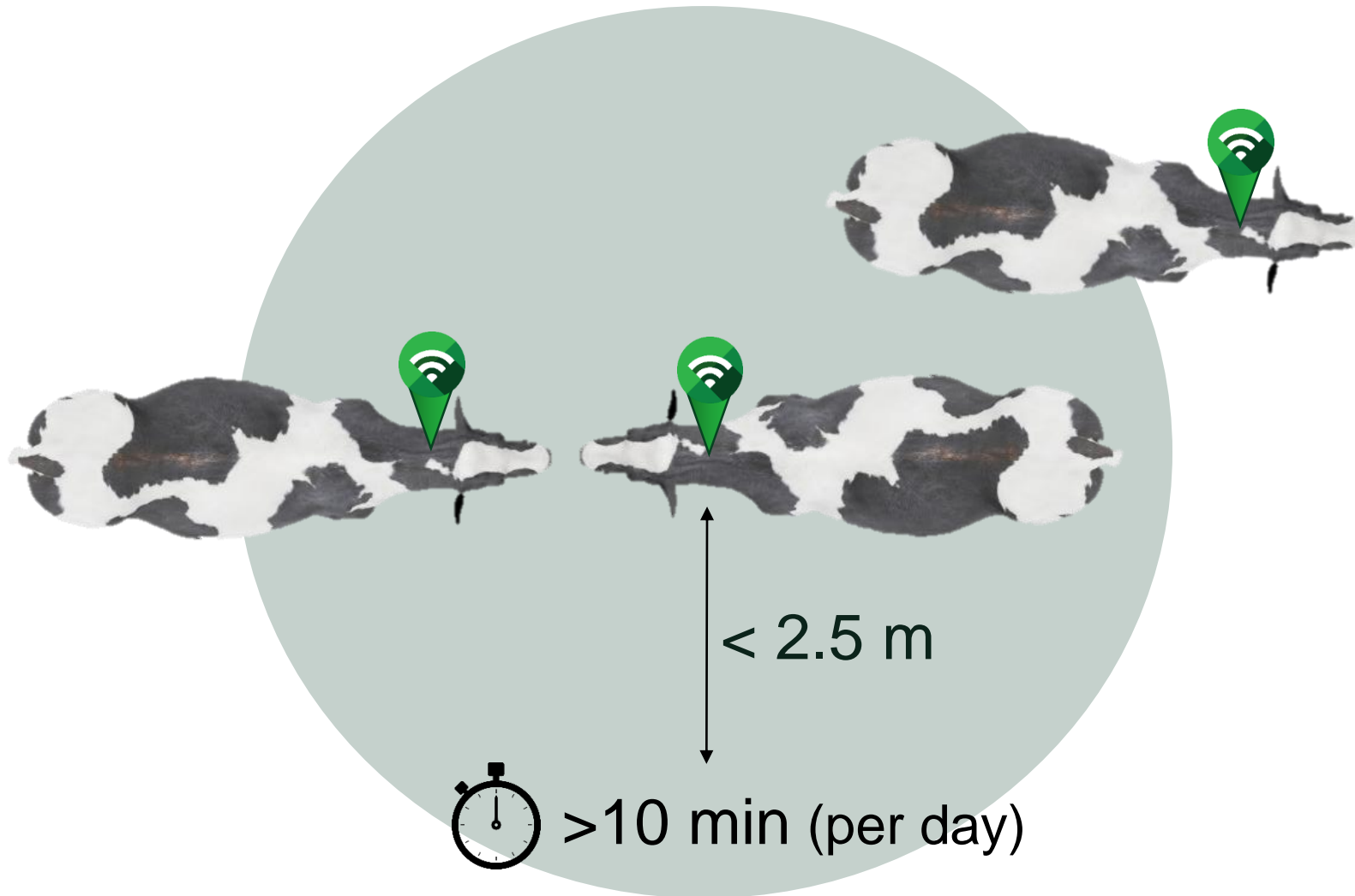


-  Cow: 1
-  Cow: 2
-  Spatial interaction

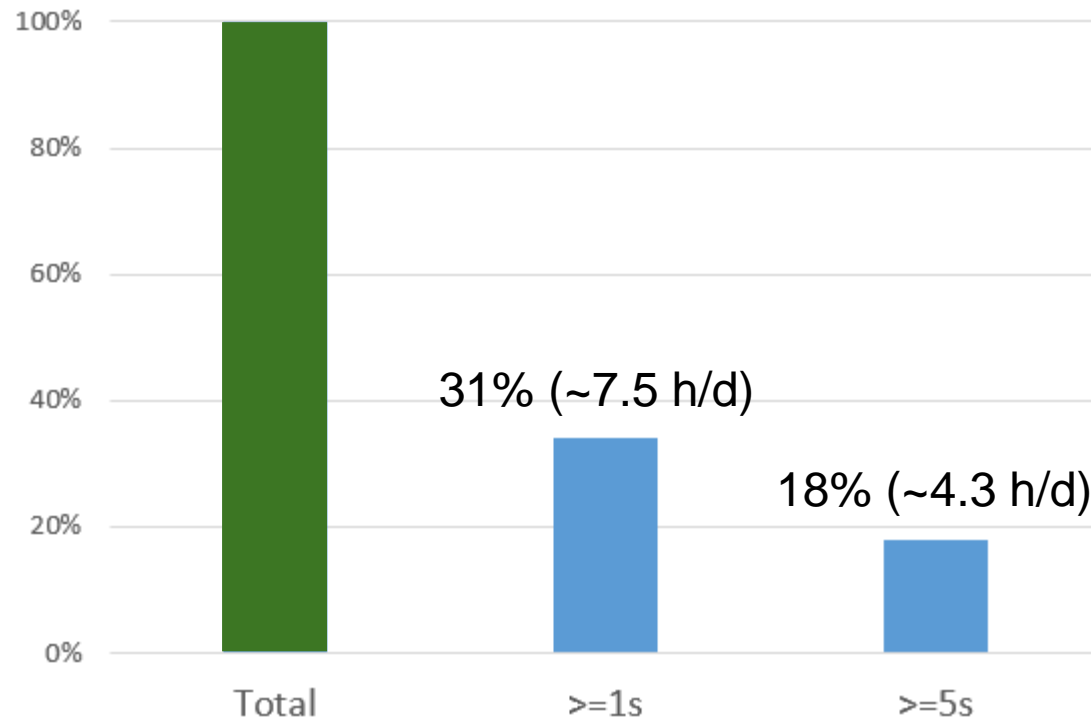
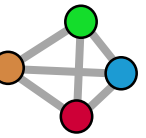


Spatial contacts

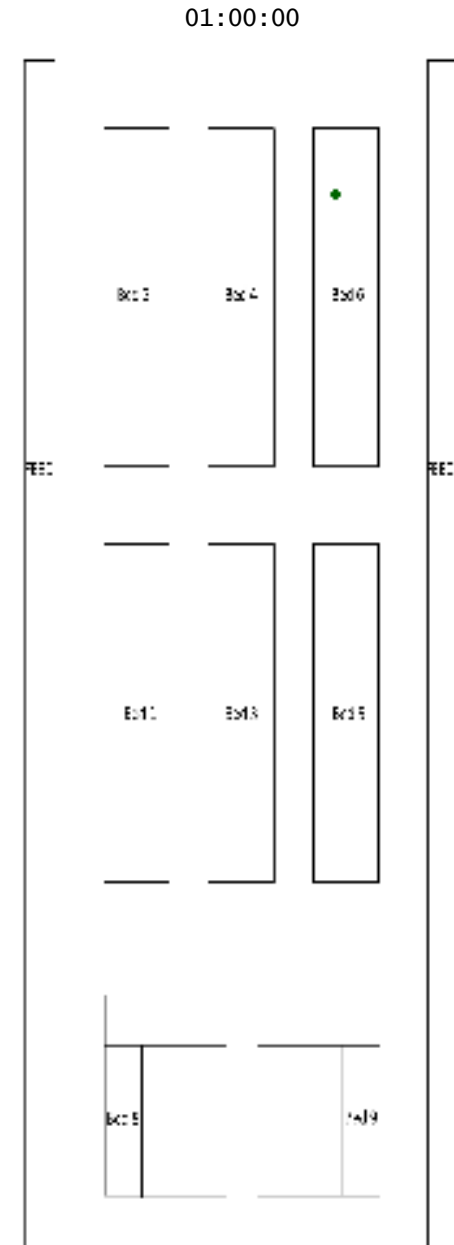
What was consider as social contact?



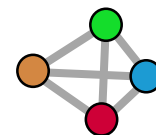
Interpolation






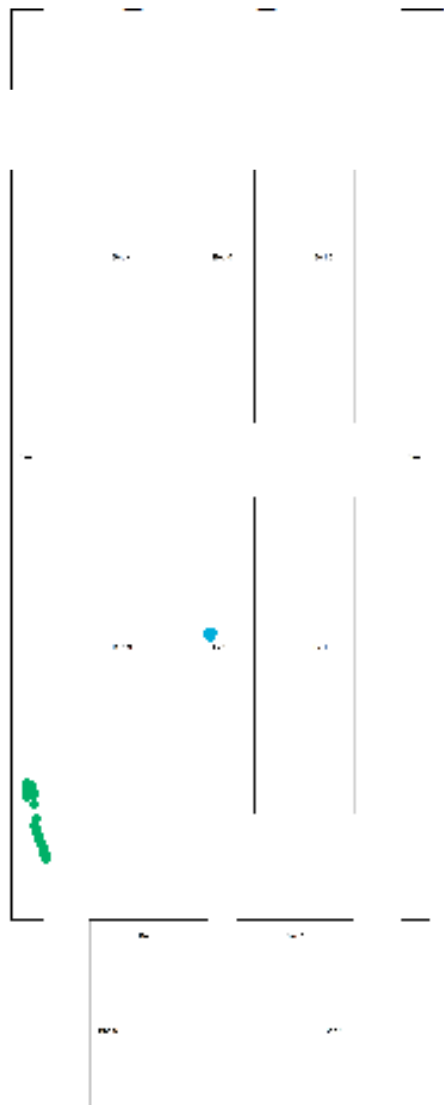
(Ren et al., 2021)



Spatial contacts



-  Cow: 1
-  Cow: 2
-  Spatial interaction



Spatial contacts

0	1	1	0	1	1	0	0	1
1	0	1	1	0	0	1	0	0
1	1	0	1	1	0	0	0	1
0	1	1	0	1	0	1	1	1
1	0	1	1	0	1	1	0	1
1	0	0	0	1	0	1	0	0
0	1	0	1	1	1	0	0	1
0	0	0	1	0	0	0	0	1
1	0	1	1	1	0	1	1	0

0	1	1	0	1	1	0	0	1
1	0	1	1	0	0	1	0	0
1	1	0	1	1	0	0	0	1
0	1	1	0	1	0	1	1	1
1	0	1	1	0	1	1	0	1
1	0	0	0	1	0	1	0	0
0	1	0	1	1	1	0	0	1
0	0	0	1	0	0	0	0	1
1	0	1	1	1	0	1	1	0

0	1	1	0	1	1	0	0	1
1	0	1	1	0	0	1	0	0
1	1	0	1	1	0	0	0	1
0	1	1	0	1	0	1	1	1
1	0	1	1	0	1	1	0	1
1	0	0	0	1	0	1	0	0
0	1	0	1	1	1	0	0	1
0	0	0	1	0	0	0	0	1
1	0	1	1	1	0	1	1	0

Absence

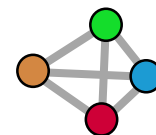
Presence



hands
on



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