Part I

CENTER FOR ANIMAL DISEASE MODELING AND SURVEILLANCE (CADMS),
SCHOOL OF VETERINARY MEDICINE, UC DAVIS

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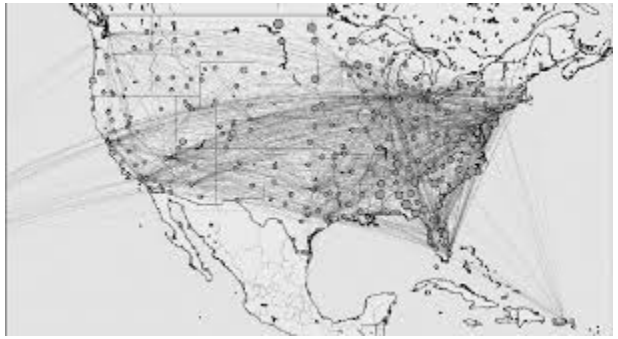
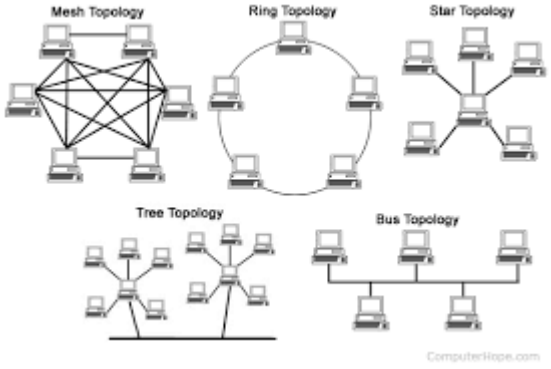
CADMS

Contents

- What is a network?
- Elements of a network
- Data sources
- Sampling methods

What is a network?

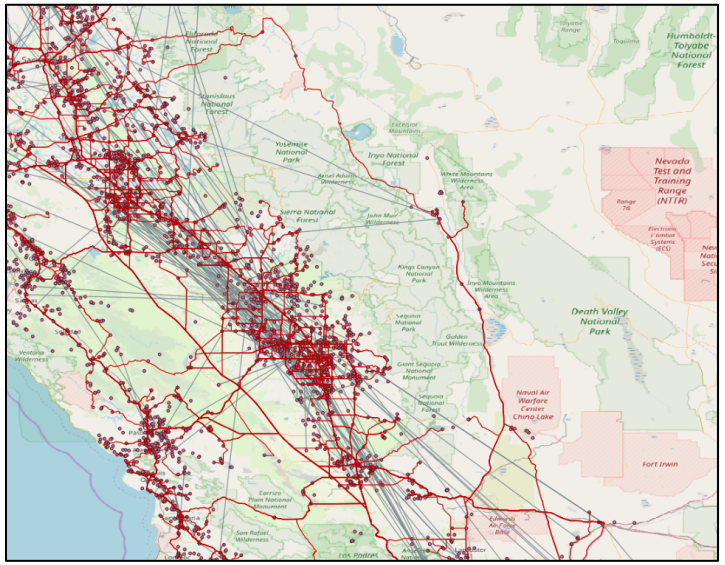




Graph theory

What is a graph? (in the contect of network analysis)

"Mathematical repesentation of a network"



$$G = (V, E)$$

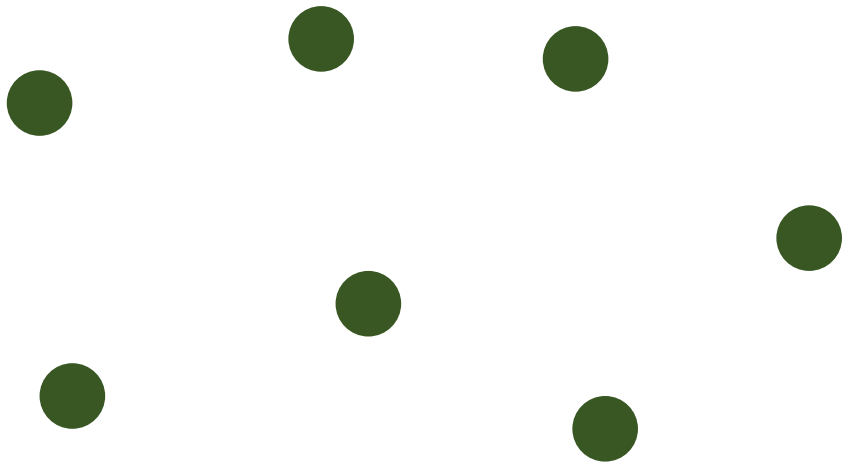
Where:

V = Vertice

E = Edge

Elements of a network

Nodes (vertices)

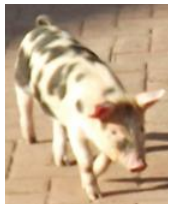


Agents or individuals forming a network

$$V = \{1, 2, 3, \dots, i\}$$

Elements of a network

Nodes (vertices)



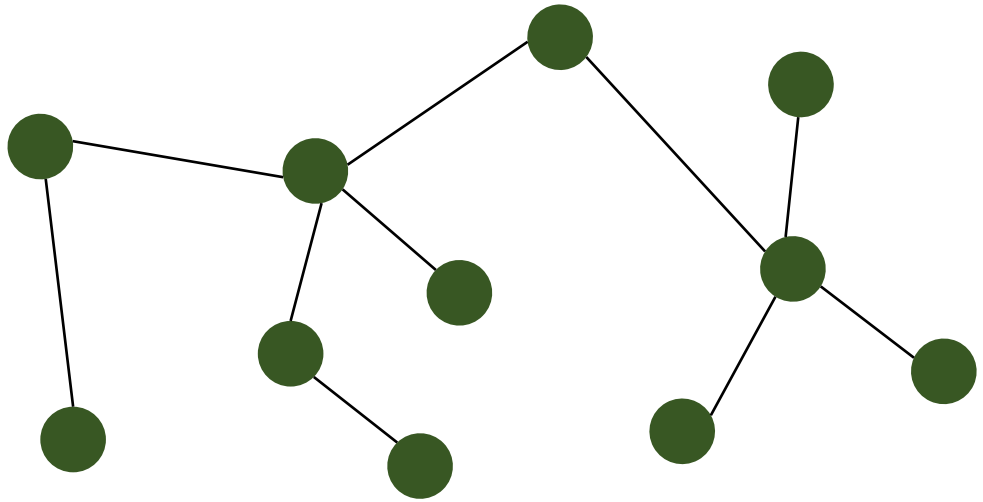


Agents or individuals forming a network:
farms, animals, humans, markets

$$V = \{1, 2, 3, \ldots, i\}$$

Elements of a network

Edges (links)



Connection between a pair of nodes (dyad)

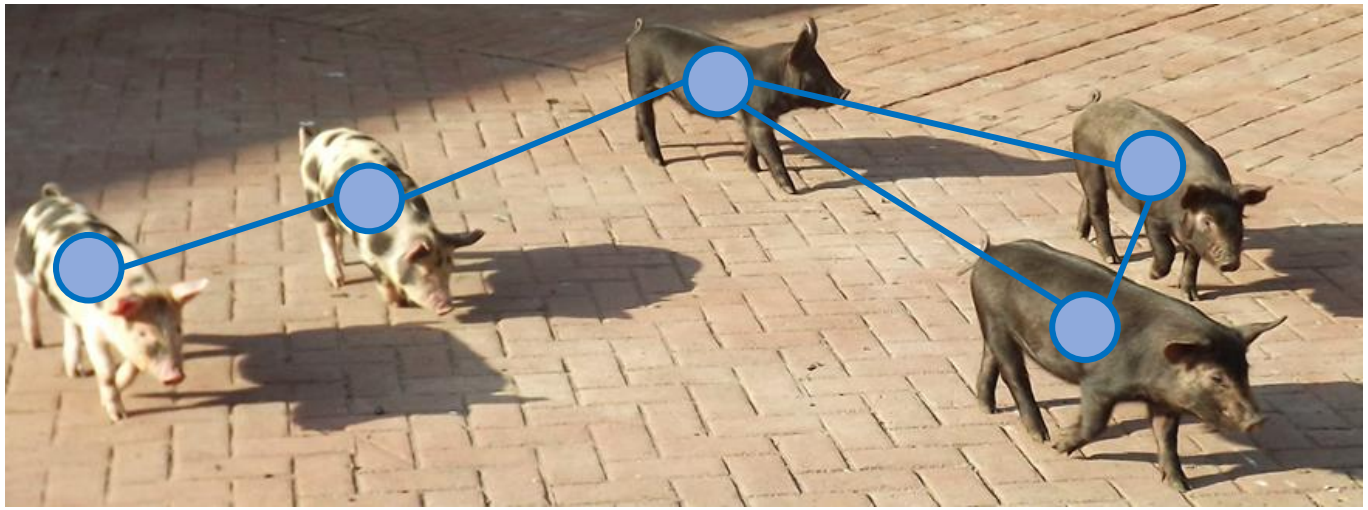
$$E = \{(1, 2), (1, 3), \ldots, (i, j)\}$$

In a network, connected nodes are considered as **neighbours**

Each of the connected nodes belongs to a **neighborhood**

Elements of a network

Edges (links)



Connection between a pair of nodes (dyad):
Animal shipments, human movements, social contacts

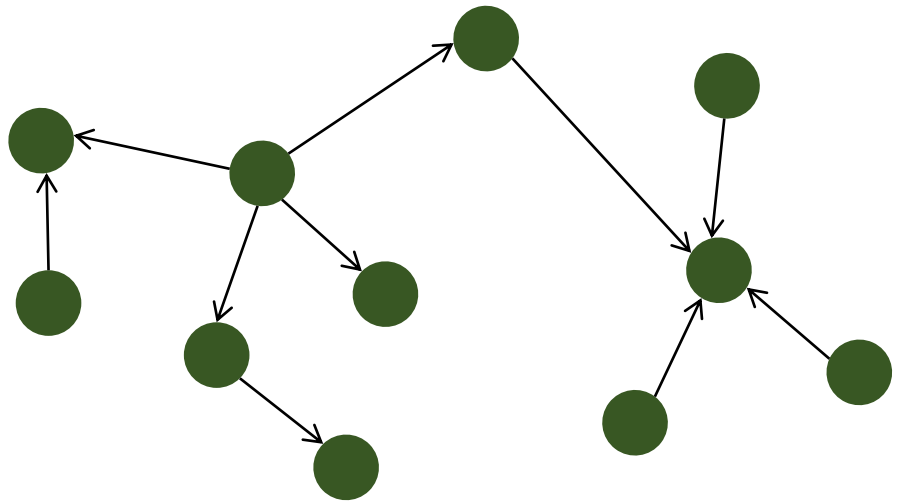
$$E = \{(1, 2), (1, 3), \ldots, (i, j)\}$$

In a network, connected nodes are considered as **neighbours**

Each of the connected nodes belongs to a **neighborhood**

Elements of a network

Directionality



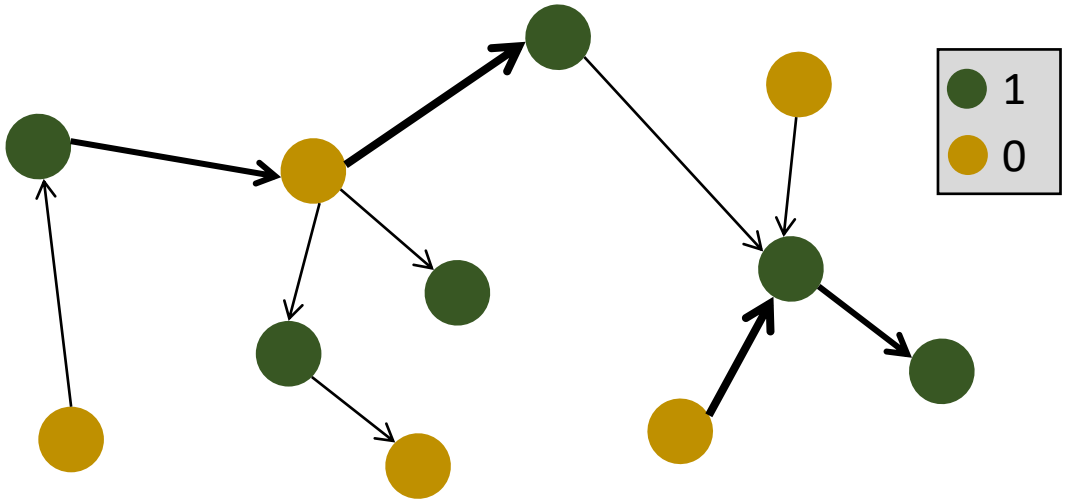
$E = \{(1 \rightarrow 2), (1 \rightarrow 3), \ldots, (i \rightarrow j)\}$

Elements of a network

Atributes

Nodes: farm size, type…

Edges: movement size, cause…



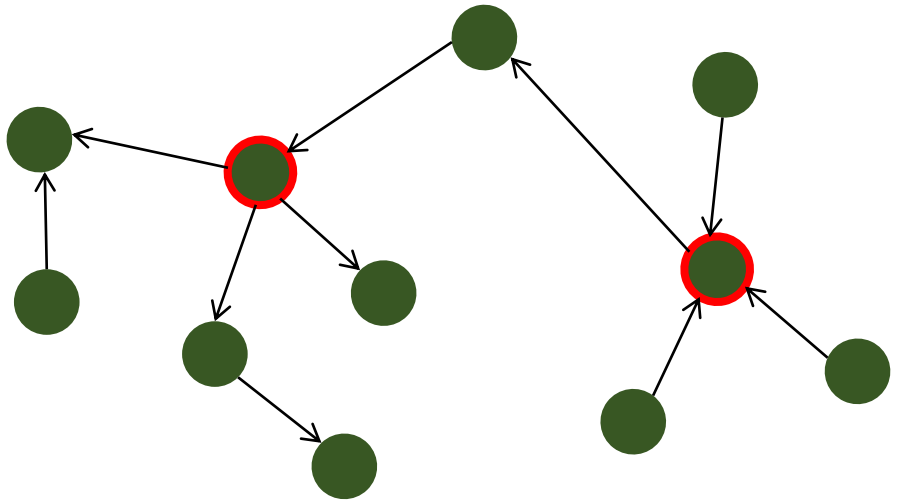
$V = \{0, 1, 0, \dots, i\}$

$E = \{(1), (3), \dots, (x_i)\}$

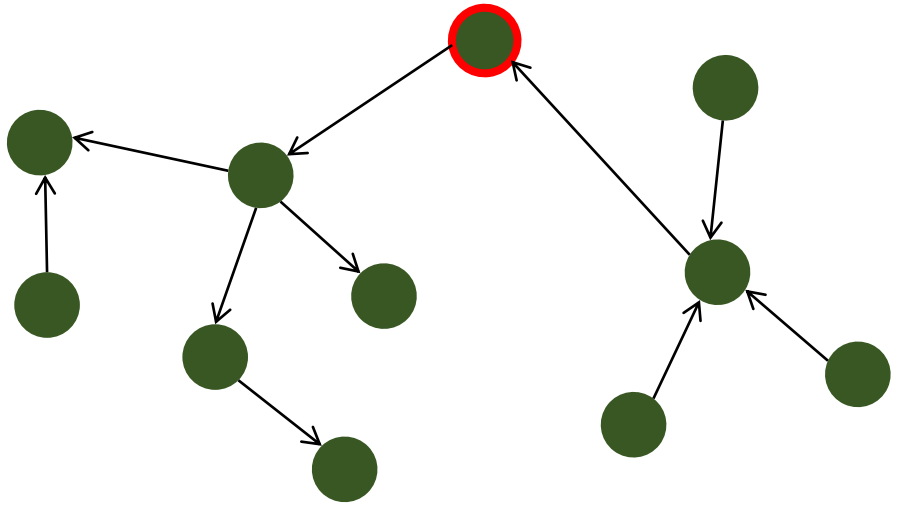
Why represent events in a network?

To describe contact dynamics

Identify individuals that are very active



Identify individuals that are intermediate

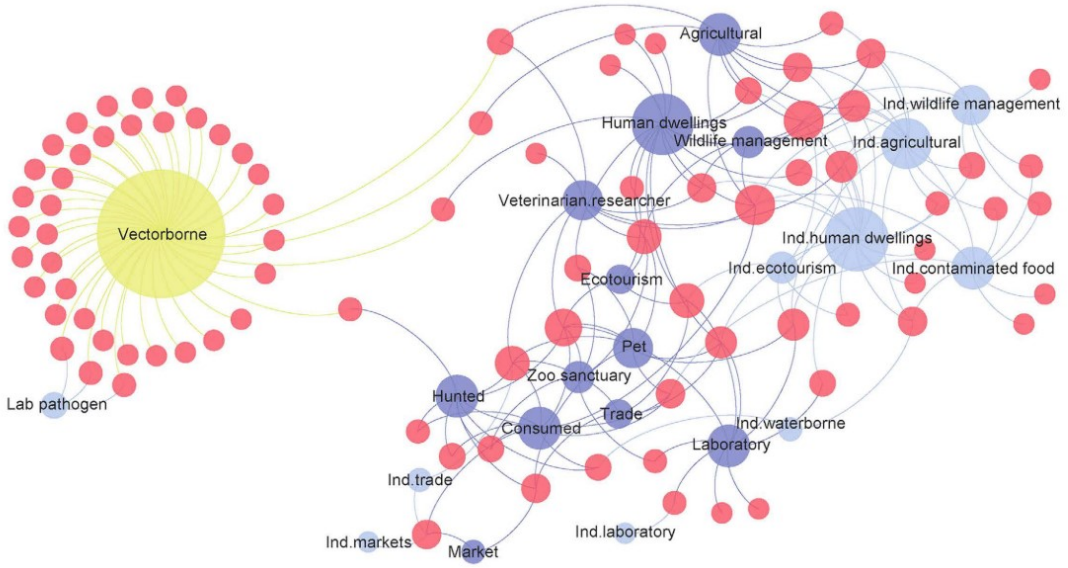


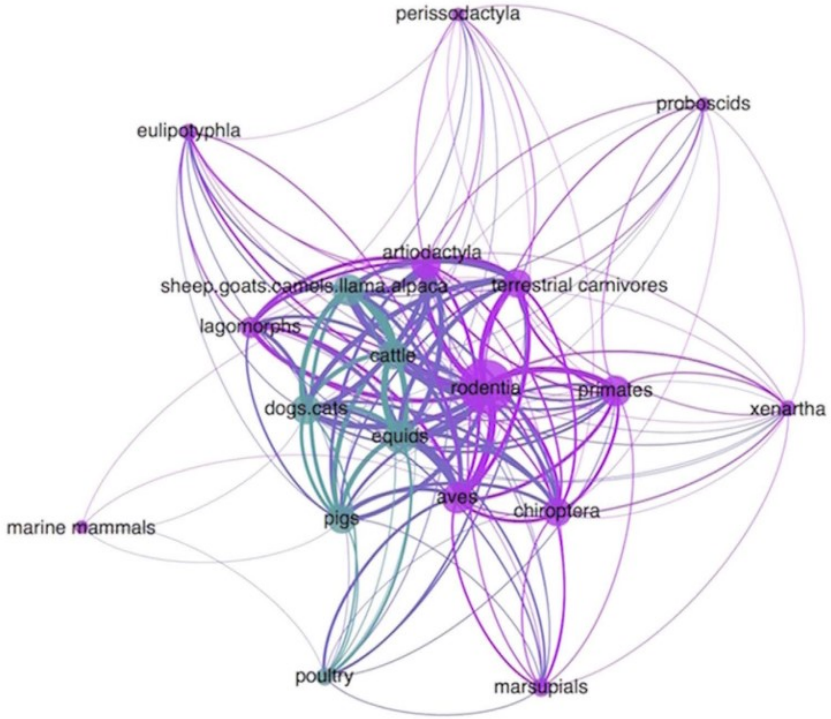
Example

Kreuder Johnson et al, 2015

- Examin the transmission mechanisms and hosts involved in zoonotic transmission
- Identify viruses with “high plasticity”

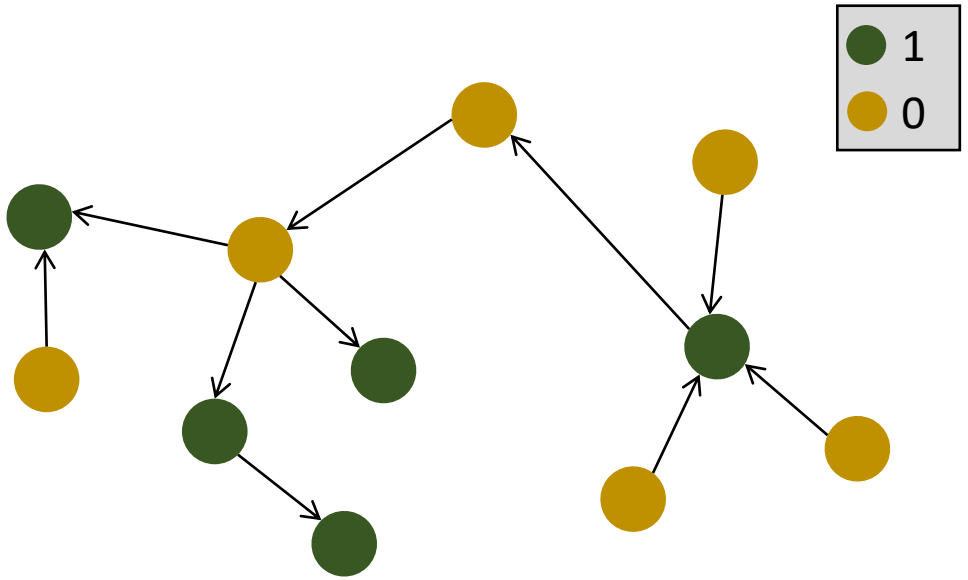
Poisson regression predicting virus host plasticity (number of host groups)[a]			
	Incidence Rate Ratio	**P value**	**(95% CI)**
Transmission from domestic animals to humans	1.97	<0.001	(1.56–2.49)
Transmission by direct contact with wildlife at markets	2.00	0.040	(1.03–3.88)
Transmission by direct contact with wild animals kept as pet or in zoos or sanctuaries	1.55	0.039	(1.02–2.34)
Transmission by vector	3.01	<0.001	(2.32–3.91)
Logistic regression predicting human-to-human transmissibility[b]			
	Odds Ratio	**P value**	**(95% CI)**
Host plasticity (number of host groups)	1.20	0.039	(1.01–1.44)
Transmission by direct contact with wild animals hunted or consumed*	10.43	0.004	(2.10–51.80)
Ordered logistic regression predicting geographic spread[c]			
	Odds Ratio	**P value**	**(95% CI)**
Host plasticity (number of host groups)	1.22	0.001	(1.08–1.37)
Transmission by direct contact with wild animals in trade or laboratories	6.14	0.014	(1.45–26.10)





Why represent events in a network?

Model contact dynamics:



- Inference: Associations between attributes and activities in a network
- Prediction: Are there reproducible patterns that we can predict?

Applications in Preventative Veterinary Medicine

- Surveillance, Prevention and Control
  - Define strategic nodes for intervention
    - Surveillance: Diagnostic testing, road checks
    - Prevention: Education and information campaigns
    - Control: Vaccination or treatment campaigns
  - Define cost-effective risk-based targeted approaches
  - Modelling of disease introduction and spread
- Risk Factor Analysis
- Outbreak investigation
  - Traceability of the outbreak's origin
- Compartimentalization
  - *Define high-risk groups?*
- Other uses in the animal world
  - Behavioral studies in social animals: i.e. contact patterns in a herd of cattle

Data sources

Define **nodes**:

- What is the unit of analysis (e.g. farm, animal, etc)

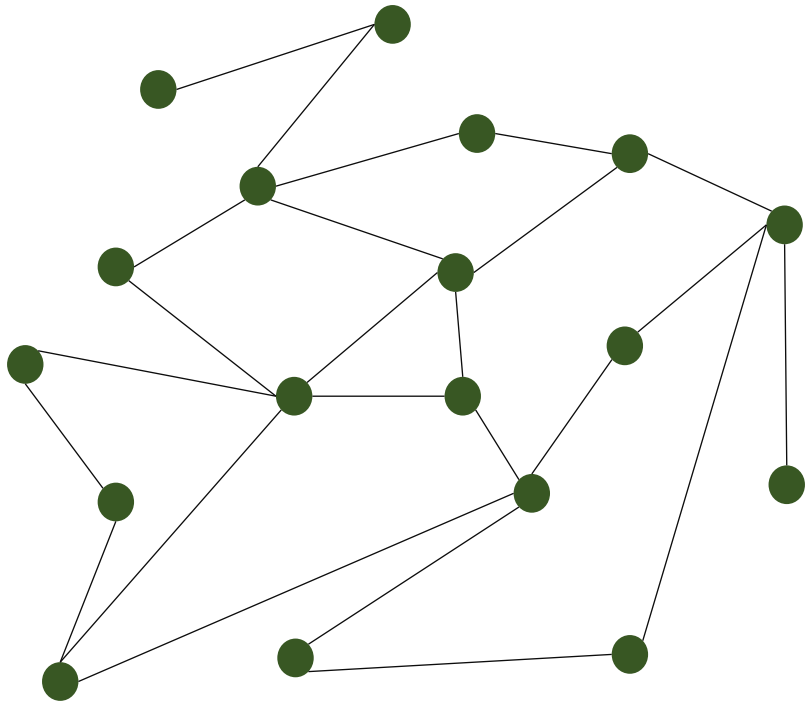
Define **edges**:

- Frequency of contacts
- Duration of contacts

Data sources

Passive Surveillance

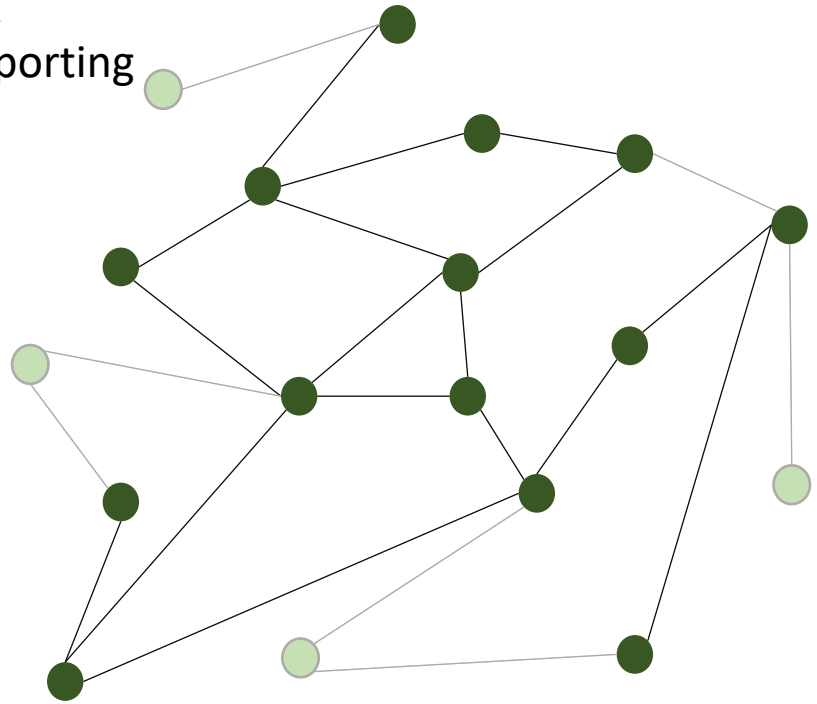
- Madatory movement registries
- Population census
- GPS data (entire population)
  - ➢ Complete network



Data sources

Passive Surveillance

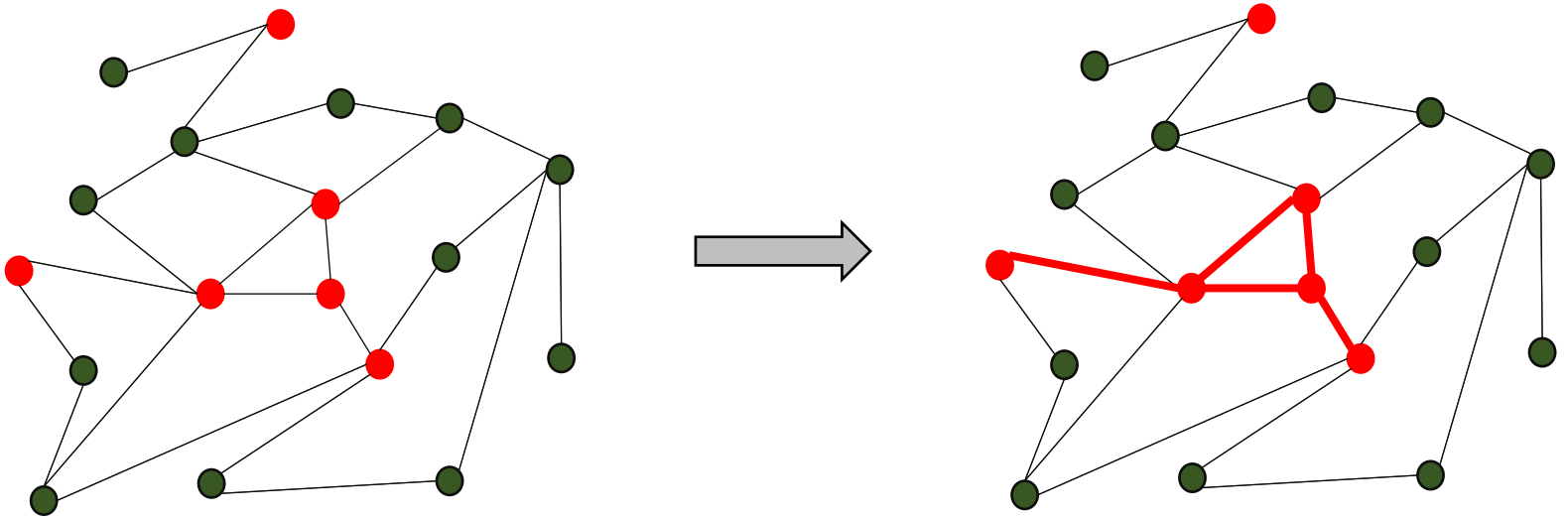
- Madatory movement registries
- Population census
- GPS data (entire population)
  - Complete network
  - Impact of underreporting



Data sources

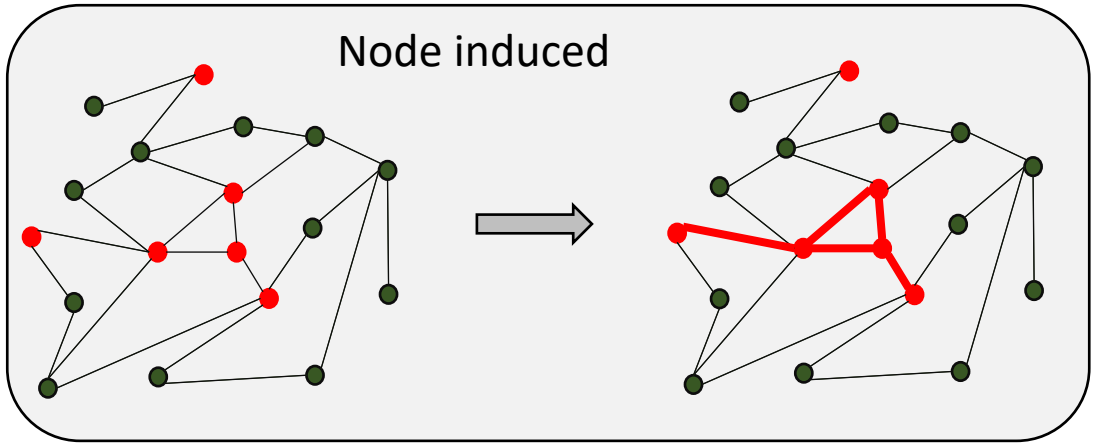
Active surveillance

- Surveys
- Observation of a sample of the population
  - ➢ Subgraph sampling and incomplete network

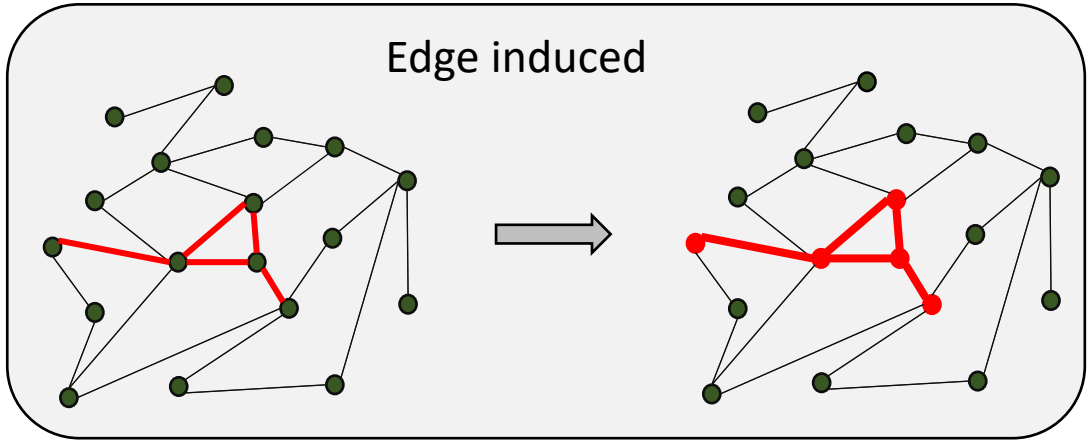


Sampling method

Random Sampling Methods



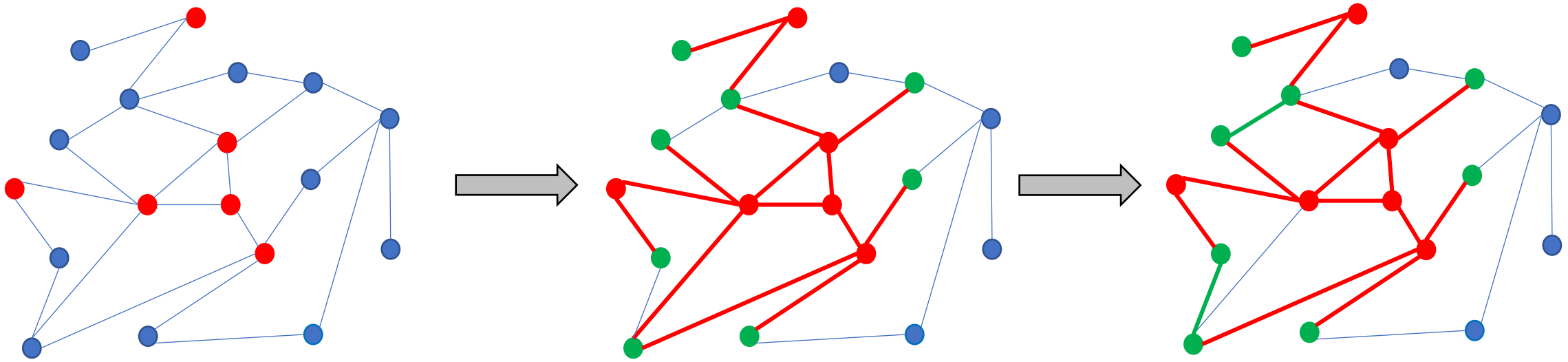
- Sample a group of nodes
- Identify all contacst between these nodes



- Sample a group of edges
- Identify all nodes connected to these edges

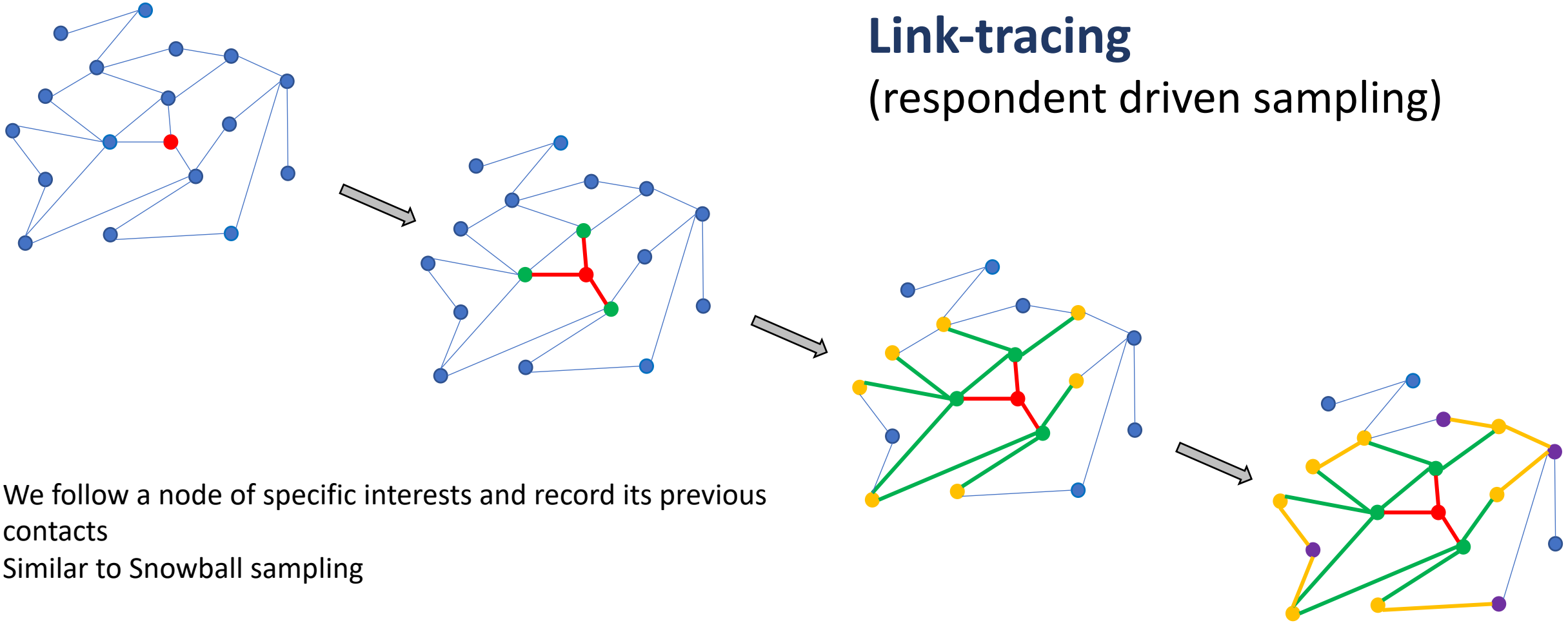
Sampling method

Egocentric Sampling



- Sample a group 1 of nodes
- Identify all contacts linked members of group 1
- Identify all nodes (group 2) directly connected to group 1
- identify all contacts between members of group 2

Sampling method



Link-tracing
(respondent driven sampling)

We follow a node of specific interests and record its previous contacts
Similar to Snowball sampling

Medicion de los conctactos

- **Retrospective**
  - National movement records
  - Farm registry and population census
  - Surveys
- **Prospective**
  - Visual observation
  - Tracking with GPS or PIT (Passive Intergrated Transporter) systems

Estructura de los datos

Nodes dataset

ID	Farm	Farm size	Farm type
1	Swine and company	800	fattening farm
2	Les Cochonets	1200	sow farm
3	The farmhouse	50	small-scale farm
4	The Boar	20	reproductive males
5	Ham & sausage	65	slaughterhouse
6	The trading post	0	market

Edges dataset

ID_origin	ID_destination	Shipment size	Date	Reason
2	6	10	02-25-2018	Sale of adult sows
2	1	15	03-12-2018	Piglets for fattening
4	1	1	10-15-2017	Insemination
1	5	100	06-30-2018	Slaughter
6	3	2	07-10-2018	Sale of adult sows
2	1	100	02-15-2018	Piglets for fattening

Questions?

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