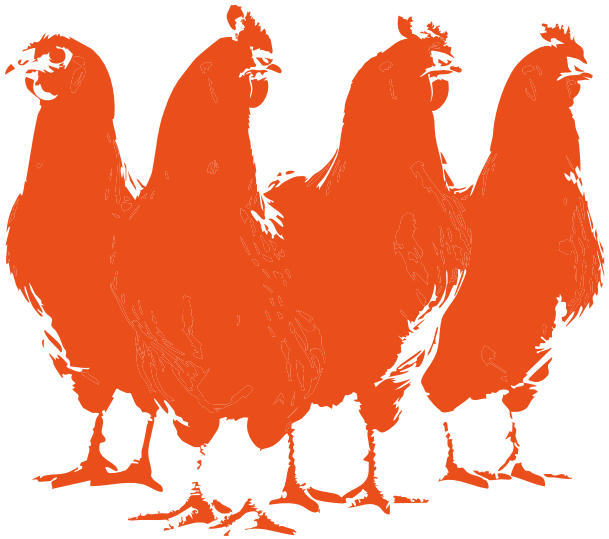

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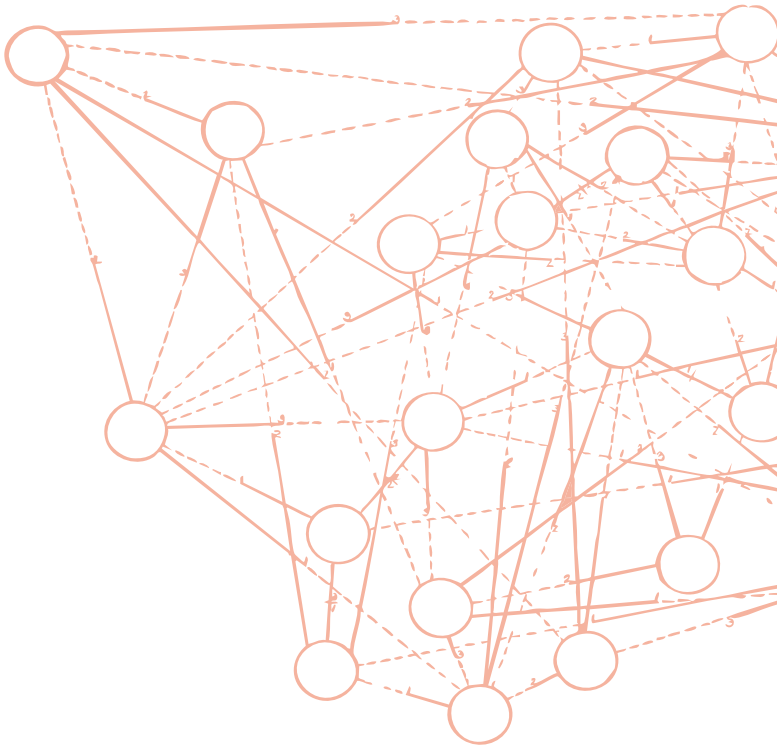


# *Agent based chicken simulation*

Nicolas Blumer, Emilis Guzys, Ioannis Soulis




*Case Report*

# Do Laying Hens Form Stable Social Networks?—A Case Study

**Louise Hedlund, Dominic Wright and Per Jensen ***

IFM Biology, AVIAN Behavioural Physiology and Genomics Group, Linköping University, 581 83 Linköping, Sweden; louise.hedlund@liu.se (L.H.); dominic.wright@liu.se (D.W.)
* Correspondence: per.jensen@liu.se


# What is Social Network Science?

## Key Concepts:

- Nodes
- Edges
- Network structure

## Why It Matters:

- Helps reveal how information, behaviors, or resources flow through a group

## In Animal Studies:

- Used to understand dominance, cooperation, and social bonding
- Still underutilized in species like poultry

# Chicken

## Why Laying Hens?

- Potential to form subgroups, like their ancestor, the Red Junglefowl
- Large industrial flocks; unclear if true social bonds persist
- Conflicting evidence from previous studies
- Little known about genetics, individual roles, or social structure
- Study explores whether they form stable affiliations and how individual variation shapes social networks

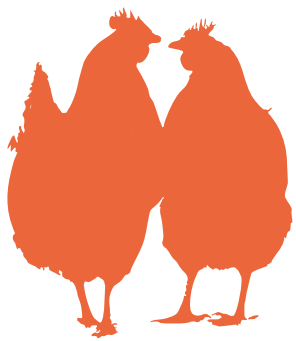
# Chicken

## Main Question:

- Do laying hens maintain stable social positions in a group over time?

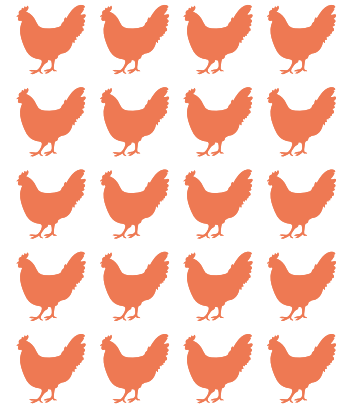
## Objectives:

- Apply Social Network Analysis (SNA) to poultry behavior
- Measure network stability across 4 weeks (20 days)
- Examine individual consistency in social roles
- Evaluate potential for using SNA to inform welfare improvements



# Chicken

## Methodology



Subjects: 20 laying hens in a controlled setting

Observation period: 4 weeks (20 days)

Data Source:

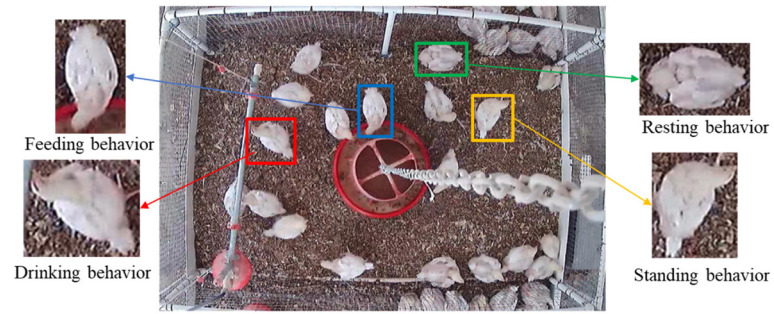
- Video tracking (20 days; 3h per day; every 5 min)
- Interaction = distance of one body length or less

Network Construction:

- Weekly social networks built from co-location events

Used key metrics:

- Degree centrality
- Clustering

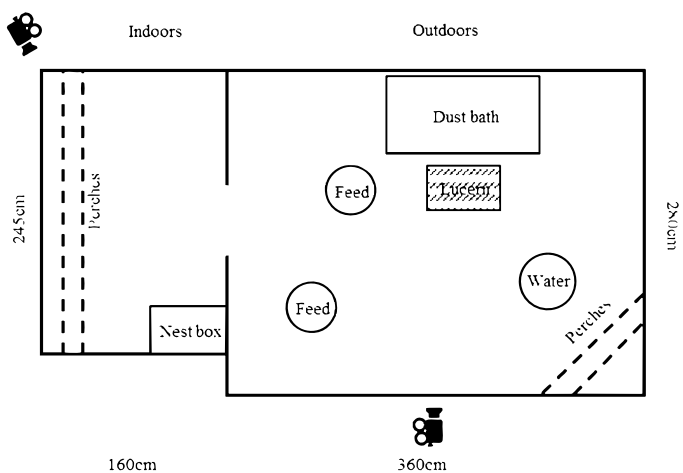



An example of broiler behaviors sample segmentation on d16. (Monitoring Behaviors of Broiler Chickens at Different Ages with Deep Learning; by Yangyang Guo, Samuel E. Aggrey , Peng Wang, Adelumola Oladeinde and Lilong Chai)

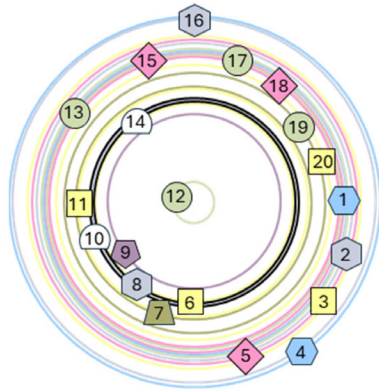
Chicken

# Results

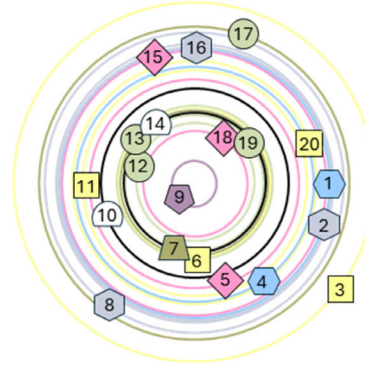
- Networks showed moderate stability over time
- Some hens consistently occupied central positions
- Individual roles (central vs. peripheral) remained fairly stable
- Suggests presence of social preferences or bonds



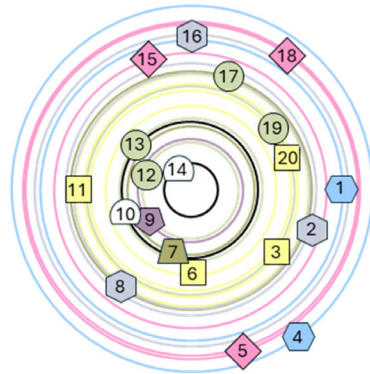
# Chicken



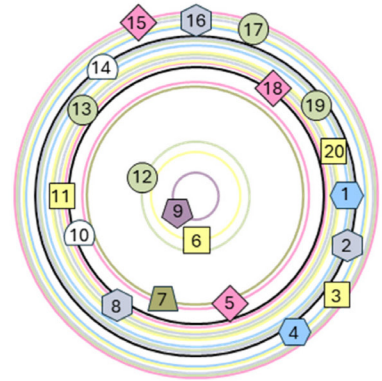
Week 1



Week 2

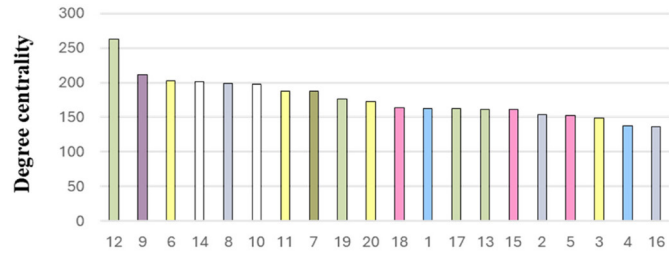


Week 3



Week 4

Chicken


Degree centrality
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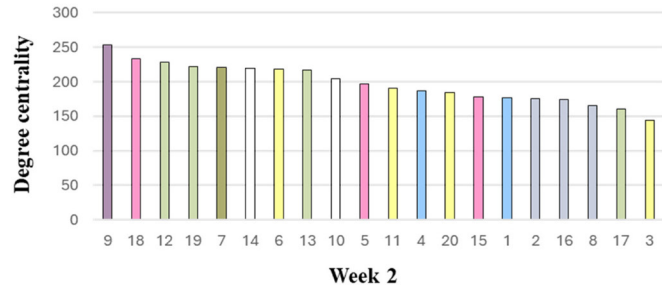
0
12 9 6 14 8 10 11 7 19 20 18 1 17 13 15 2 5 3 4 16
Week 1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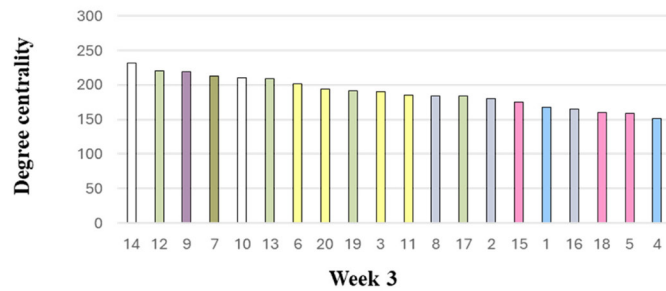
Week 2


Degree centrality
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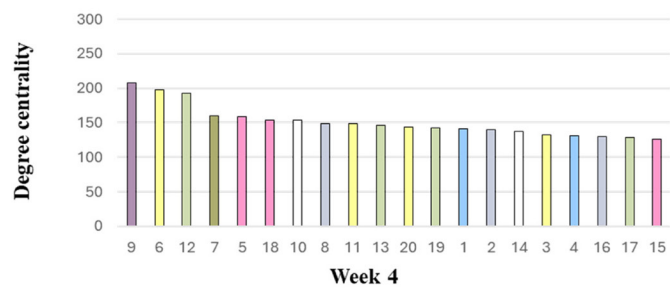
Week 3


Degree centrality
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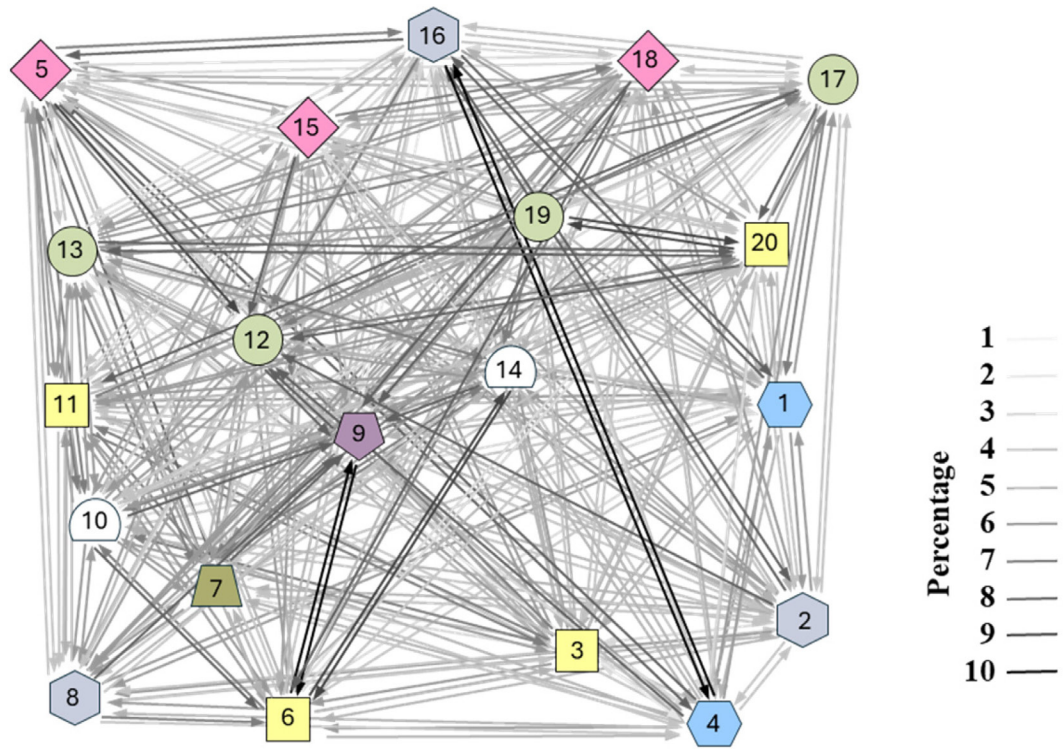
Week 4

# Chicken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5
18
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20
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12
14
11
1
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Percentage
1
2
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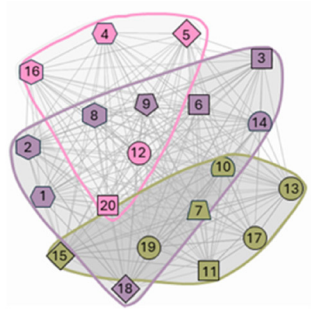
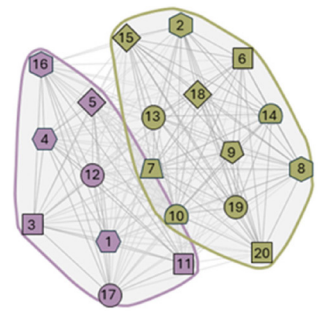
5
6
7
8
9
10

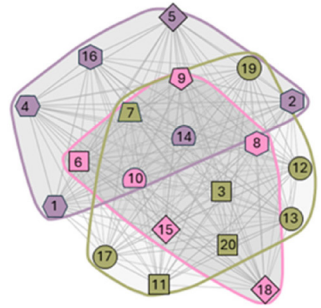
Chicken



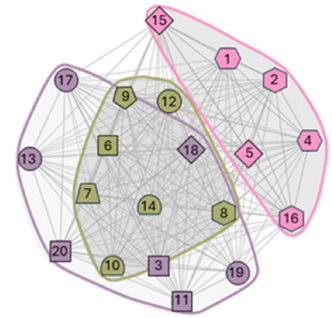
Week 1



Week 2



Week 3



Week 4

# Chicken

## Strengths

- Strong data depth.
- Uses established Social Network Analysis metrics
- Known genetic relationships among hens to explore how it affects social ties
- Insights that could inform flock management in commercial settings


## Limitations

- Small sample size (n = 20)
- Limited to one housing environment
- Only one type of interaction analyzed (proximity)
- Potential bias in defining “social” proximity
- Didn‘t assess impact on welfare outcomes

# Chicken

## How could research be improved?

- Expand sample size and include multiple flocks
- Combine proximity with behavior studies
  - Quality of relationships
  - Aggression
  - Food
- Compare different housing systems (e.g., enriched vs. conventional)

# Chicken

Journal: Poultry – Open access, peer-reviewed

Publisher: MDPI (Multidisciplinary Digital Publishing Institute)

Critical context:

- MDPI is prolific and fast in publication turnaround
- Criticized for potential pay-to-publish incentives
- Some journals under MDPI have been delisted from rankings
- Readers should critically evaluate methodology and peer-review rigor

*Chicken*

# Cocluding

- Laying hens do form moderately stable social networks
- Some individuals maintain consistent roles
- SNA can improve understanding of flock dynamics
- Insights could support:
  - Welfare-driven design of housing systems
  - More socially compatible flock groupings
  - Better management to reduce stress

# Chicken

We reached out to the authors for more data

Unfortunately, they did not have the data available

Therefore, we are motivated to:

- Design and launch our own study
- Apply similar Social Network Analysis (SNA) techniques
- Generate data collection to our goals (behavior, welfare, housing design)

# Chicken

## Assumptions for Simulation

- Chicken need food, water, bath
- Chicken consume these ressources
- Ressources are infinite
- Humans dont want them to starve
- From paper + agent based modeling
  - » chicken move somewhat randomly

Chicken

## Assumptions for Simulation

- Grid world
- 1 chicken of distance = 1 hex
- Map has been designed to look similar to real environment to be close to experiment
- Same number of measurements as in paper
  - » 180 datapoints; every 10th step (1 step = 30 sec.)

# Chicken

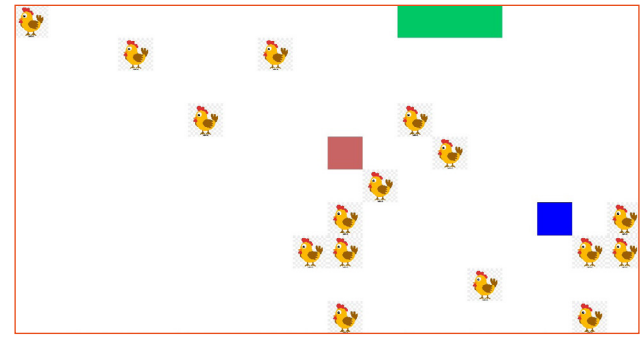
## Our simulation

how often are chickens close to each other

20 chickens

3 different types:

- Random chicken
- Random weighted chicken
- Follower chicken



» collect data and find possible cluster of friend groups

Chicken

# Adjacency matrix

| | | |
|---|---|---|
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 0 | 1 | 0 |

| | | |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 0 | 0 |
| 1 | 0 | 0 |

| | | |
|---|---|---|
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 0 | 0 | 0 |

# Normalized average adjacency matrix

| | | |
|---|---|---|
| 0 | 2/3 | 1/3 |
| 2/3 | 0 | 1/3 |
| 1/2 | 1/2 | 0 |

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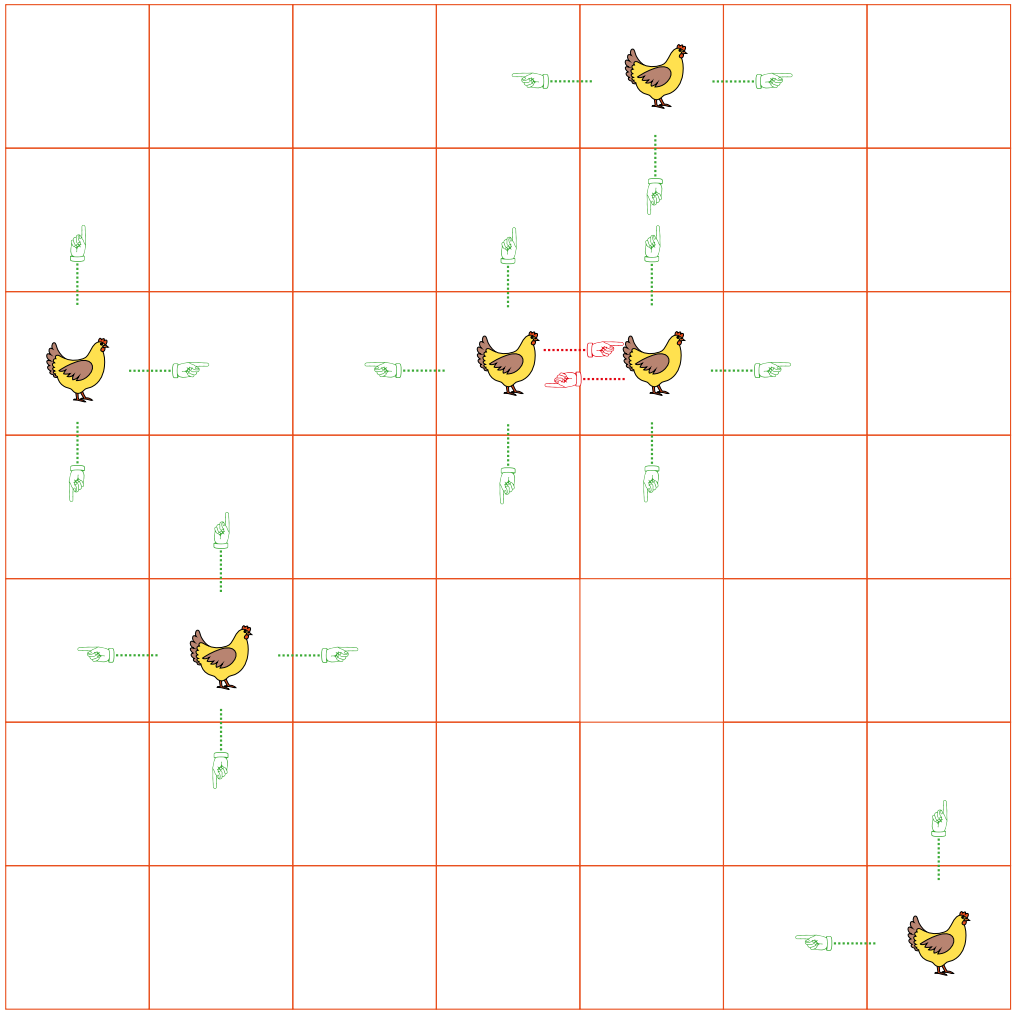
# Chicken



## Random chicken

4 possible moves 

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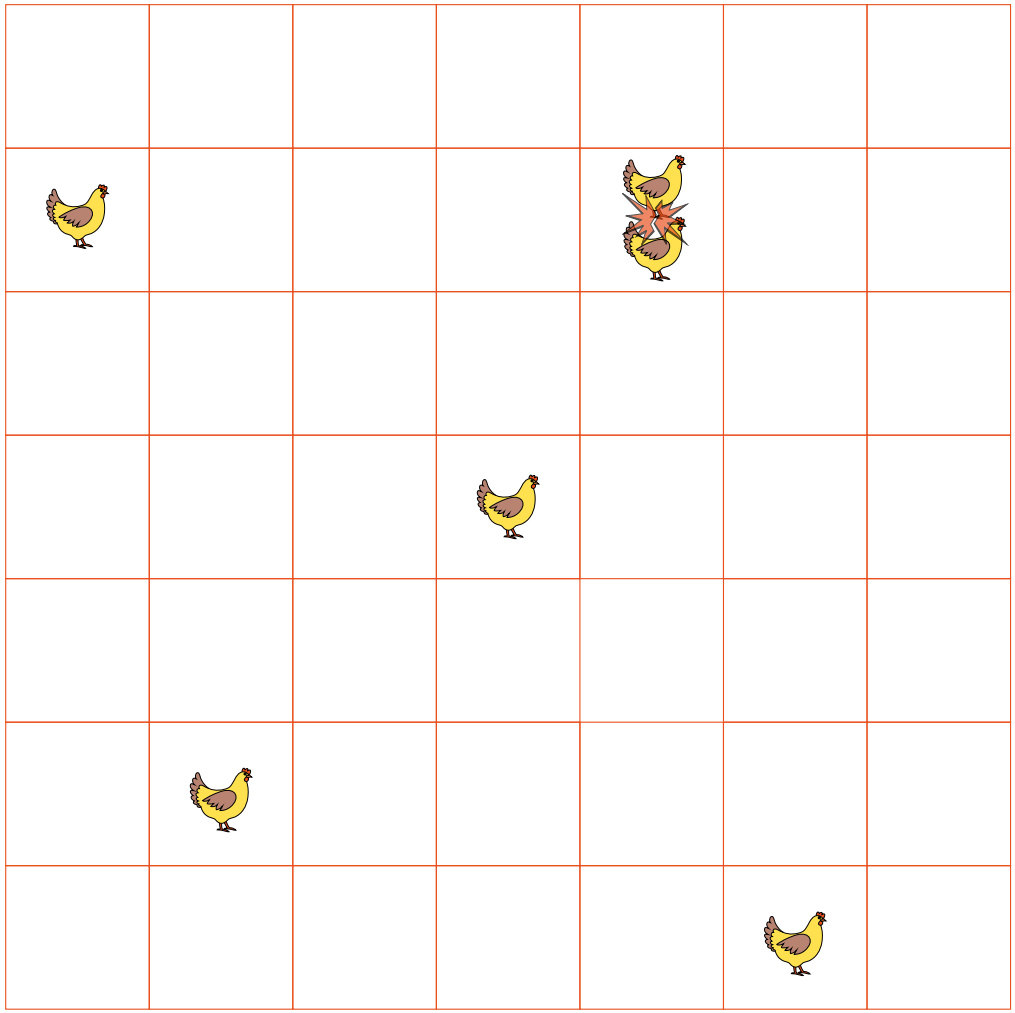
# Chicken

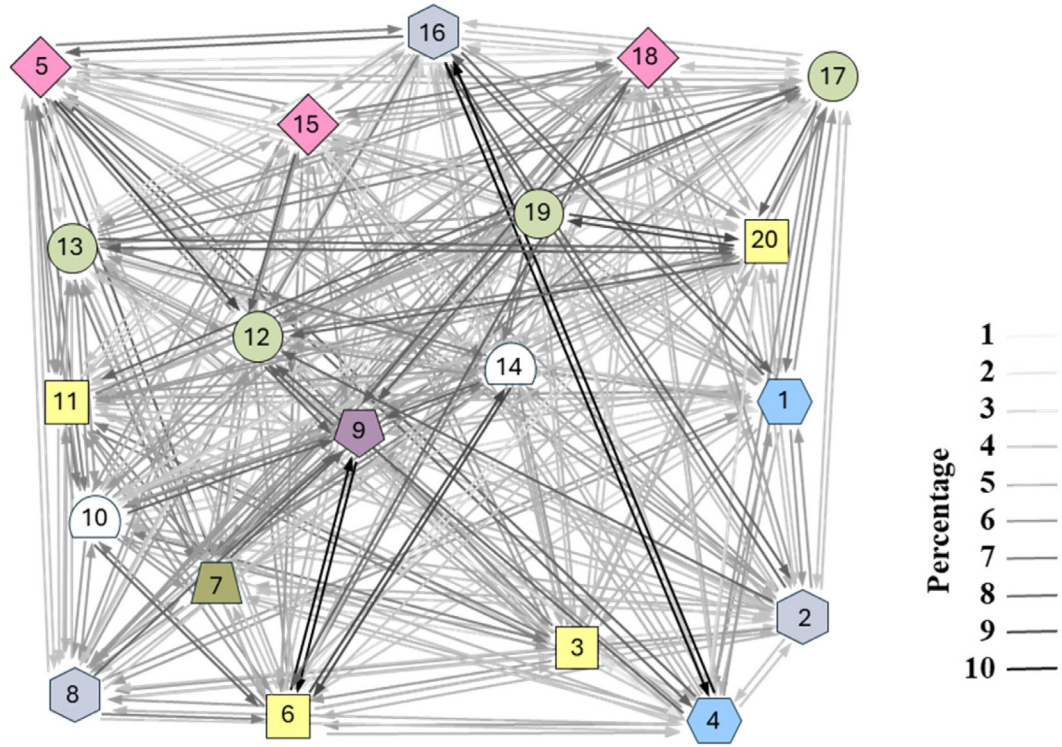


## Random chicken

4 possible moves 

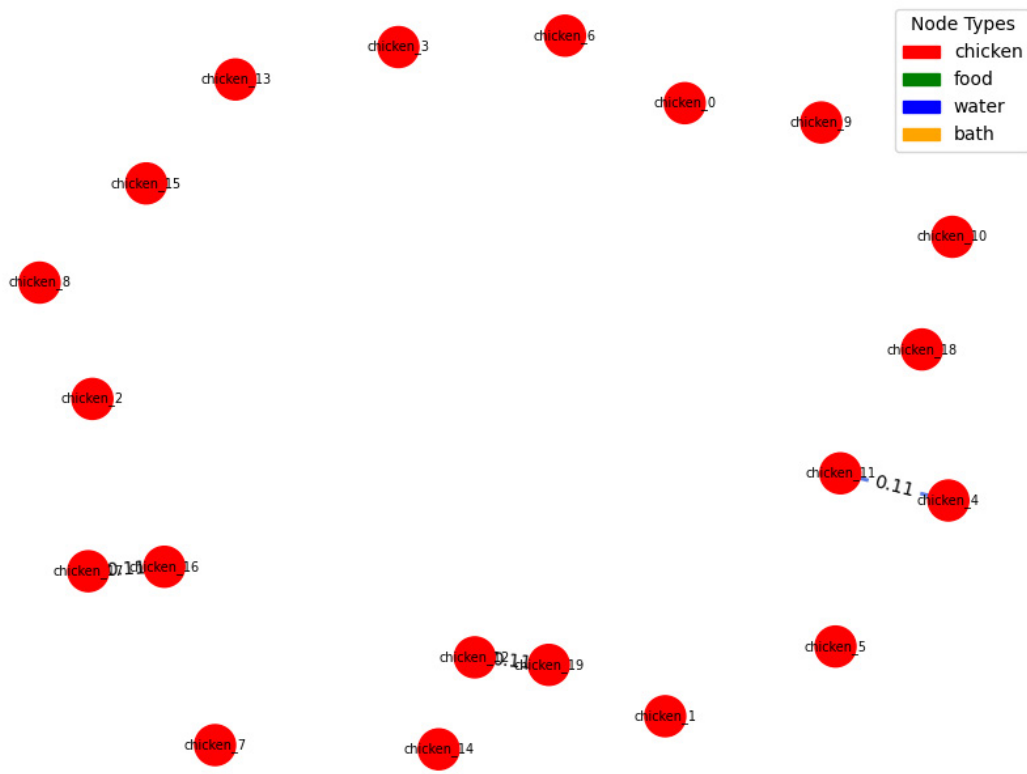
Chicken

# Real Chicken Network (Paper)



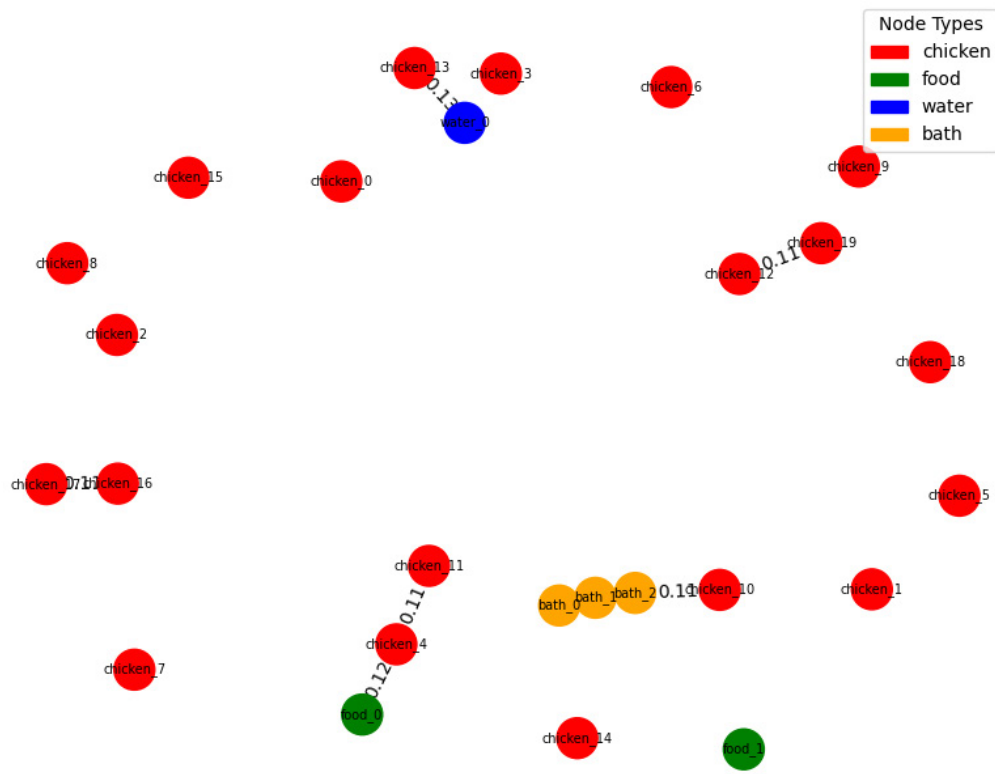
Chicken

# Random Chicken Network (edgeweight >=0,11)



Chicken

# Random Chicken Network with objects (edgeweight >=0,11)

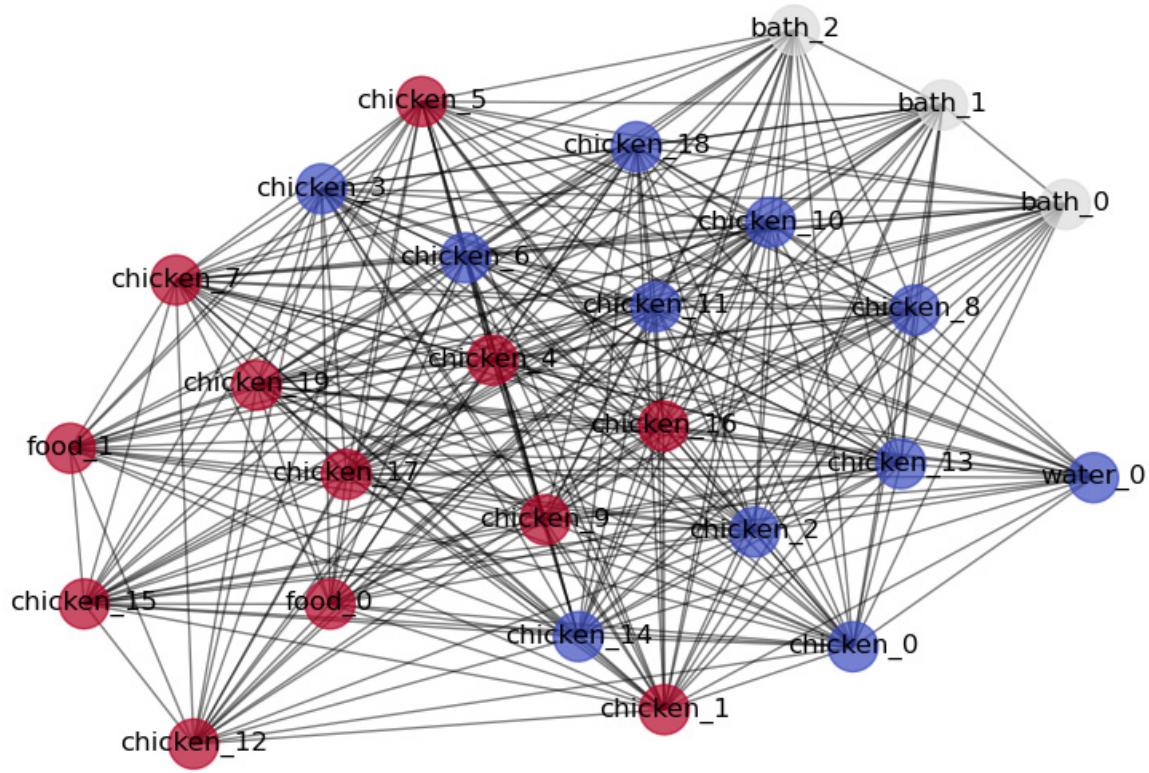



## Comparison to result from Paper

- Simulation produced comparable results to Real chicken
- Very few strong connections found

Chicken

# Random Chicken Clustering




# What if there are Chicken with social relations?

# Chicken

## Assumptions

- Chickens have friends, enemies, bullies
- Actively seek out for food when hungry
- don't want to revisit the same field repeatedly

# Chicken

## Weighted random chicken


food


water


dust

- prioritizes ressources depending on needs
- less likely to visit field if alredy visited

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# Chicken

## Weighted random chicken


food


water


dust

- prioritizes ressources depending on needs
- less likely to visit field if alredy visited

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# Chicken

## Follower Chicken

Friend

Enemy

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# Chicken

## Follower Chicken

Friend

Enemy

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# Chicken

## Follower Chicken

Friend

Enemy

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# Chicken

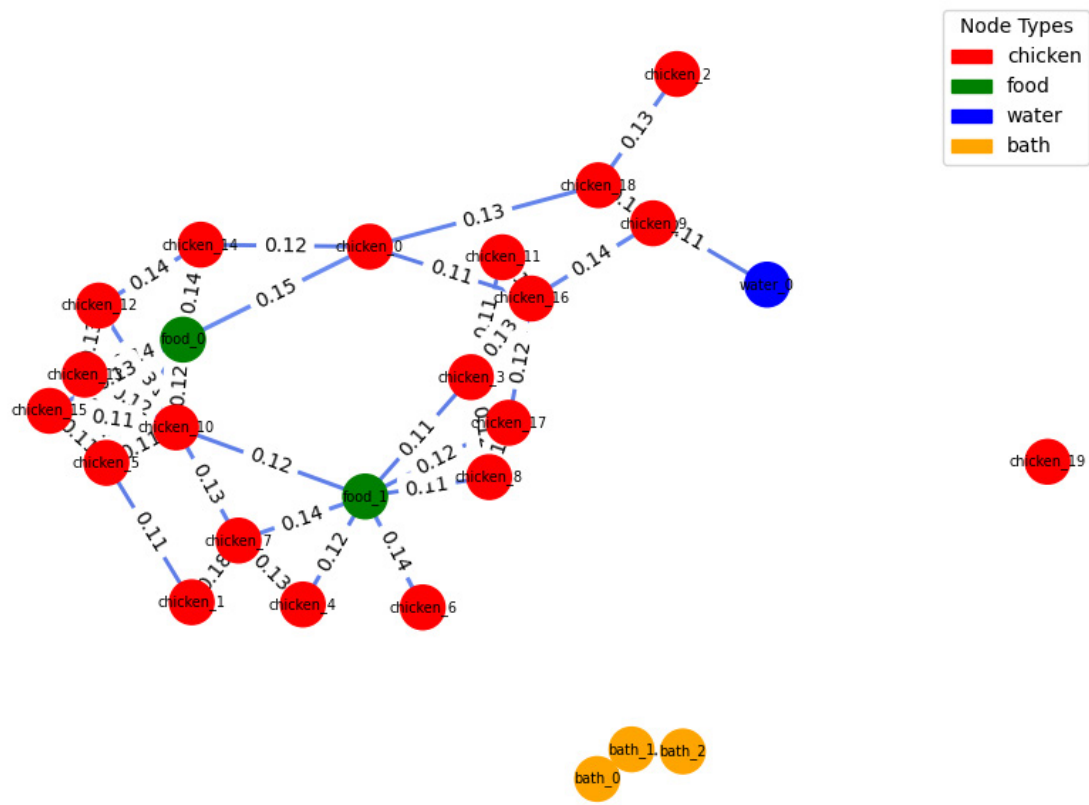
## Follower Chicken

Friend

Enemy

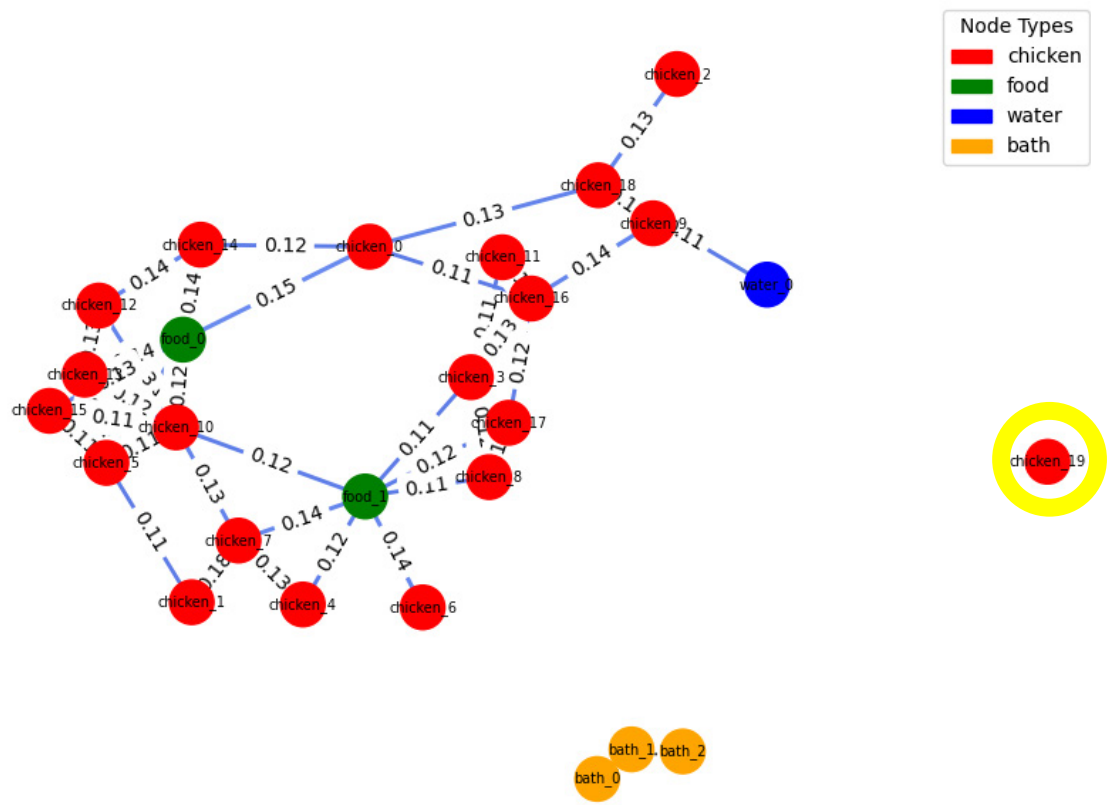
Chicken

# Follower Chicken Network (edgeweight >=0,11)



Chicken

# Follower Chicken Network (edgeweight >=0,11)

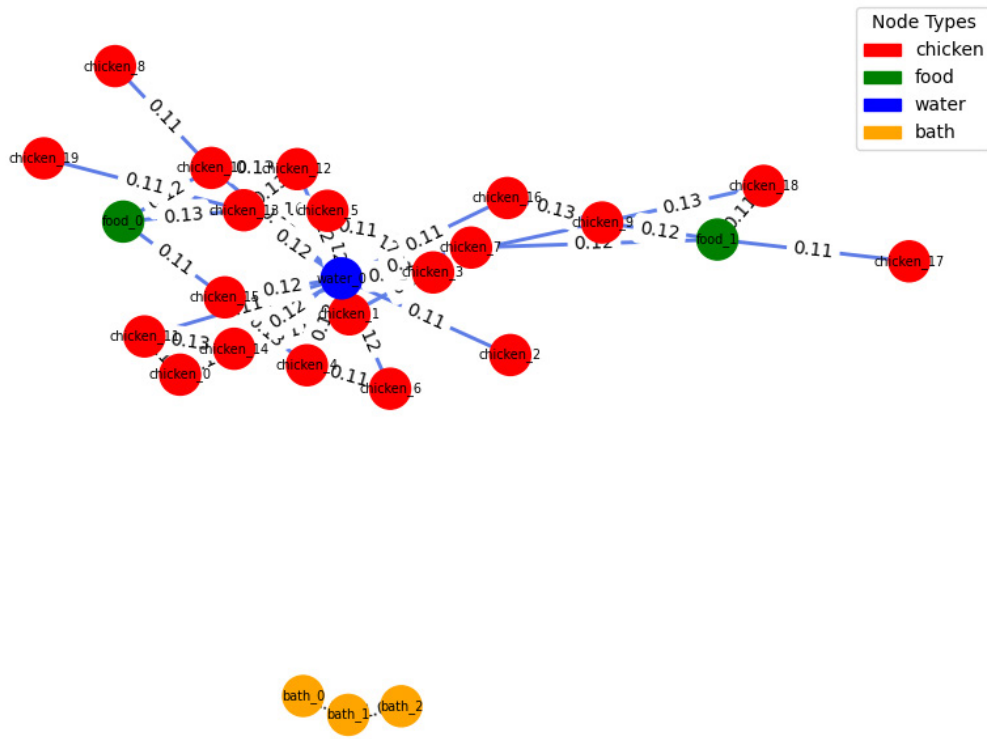



## Is the experimental setup valid?

- Many of the relationships could not be replicated
- What if we run the simulation for longer?
- 180*5=900 datapoints

Chicken

# Random Chicken Network: More Data (edgeweight >=0,11)



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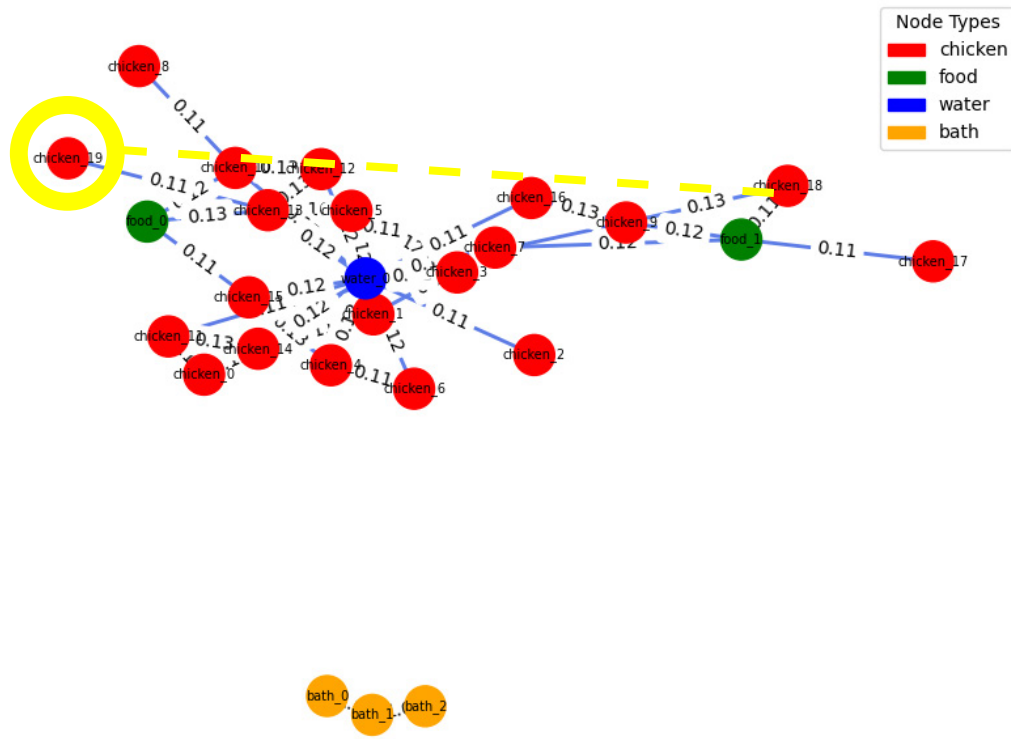
Chicken

# Random Chicken Network: More Data (edgeweight >=0,11)

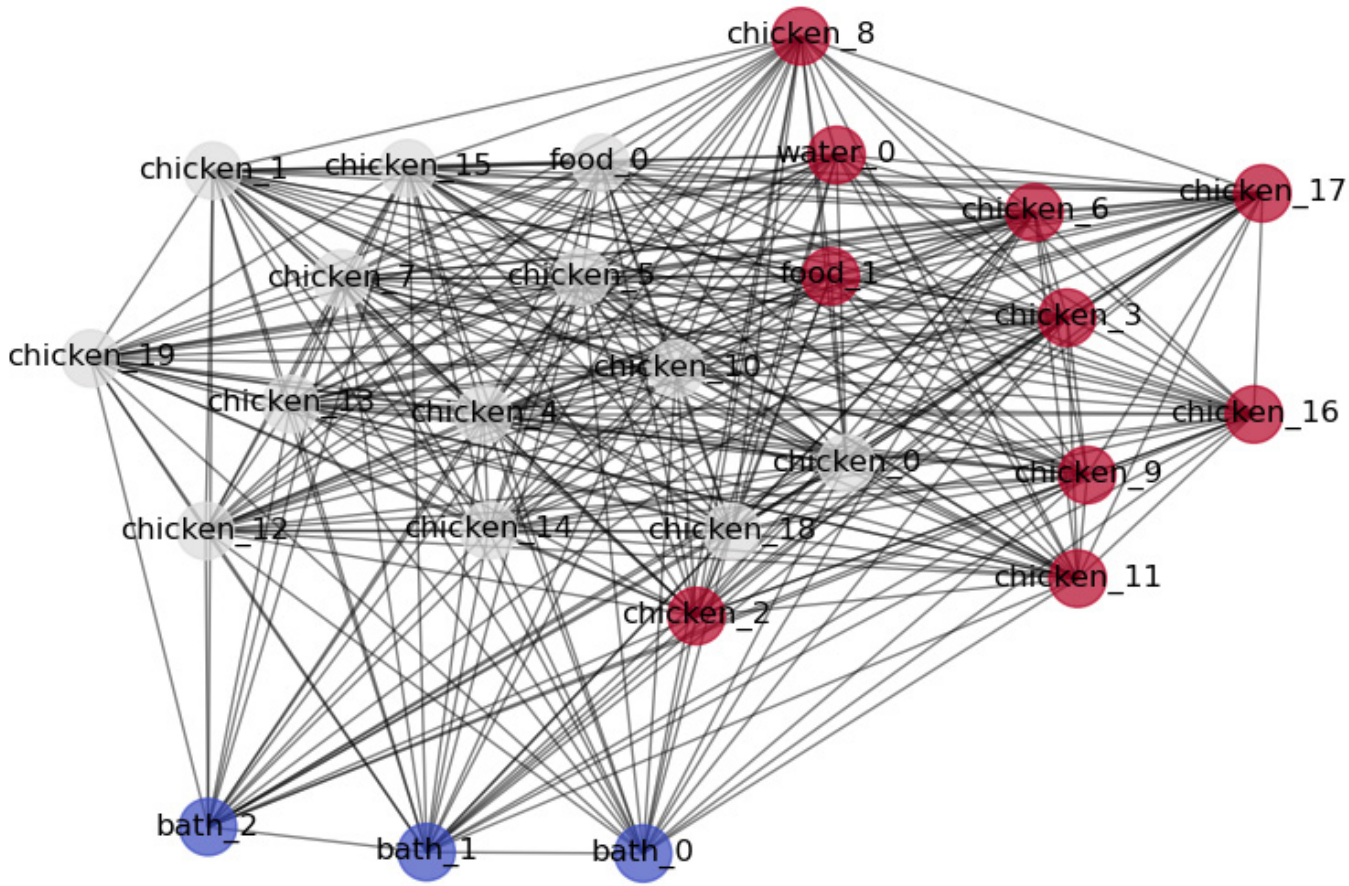



## Is the experimental setup valid?

- Most of the relationships could not be replicated
- What if we run the simulation for longer?
- 180*5=900 datapoints
- Relationships were found more consistantly

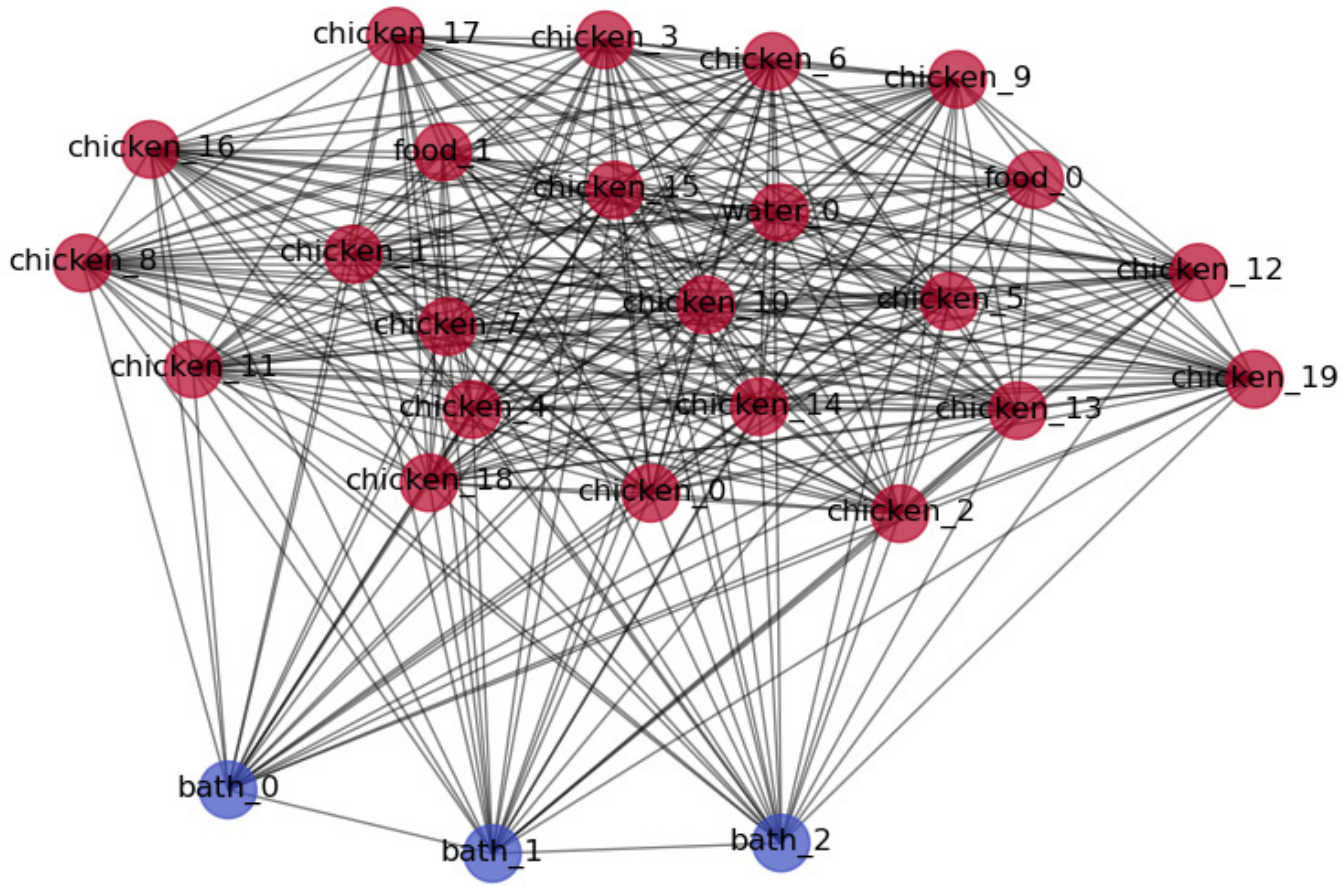
Chicken

# Clustering of Follower Chicken



Chicken

# Clustering of Follower Chicken (x5 data)

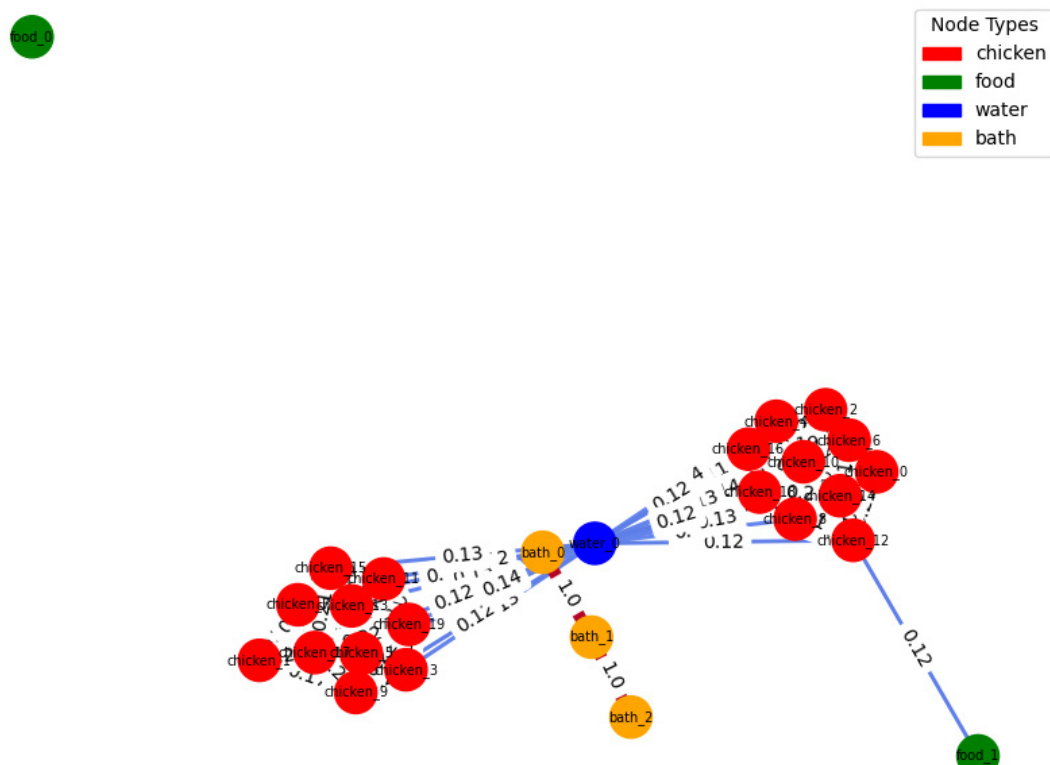



## Clustering

- No interesting results
- Can we find clusters within simulation?
- All even and all odd id chicken are friends

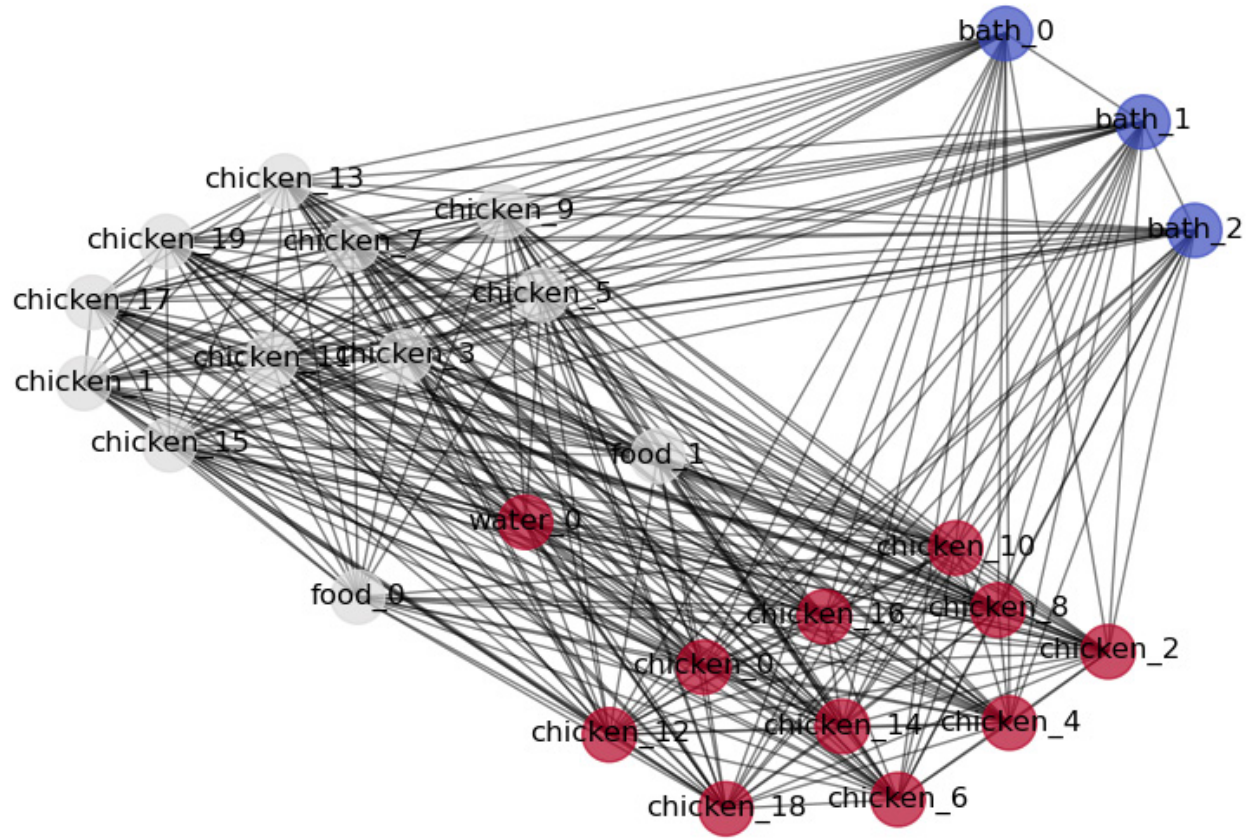
Chicken

# Follower Chicken Network with Groups (edgeweight >=0,11)



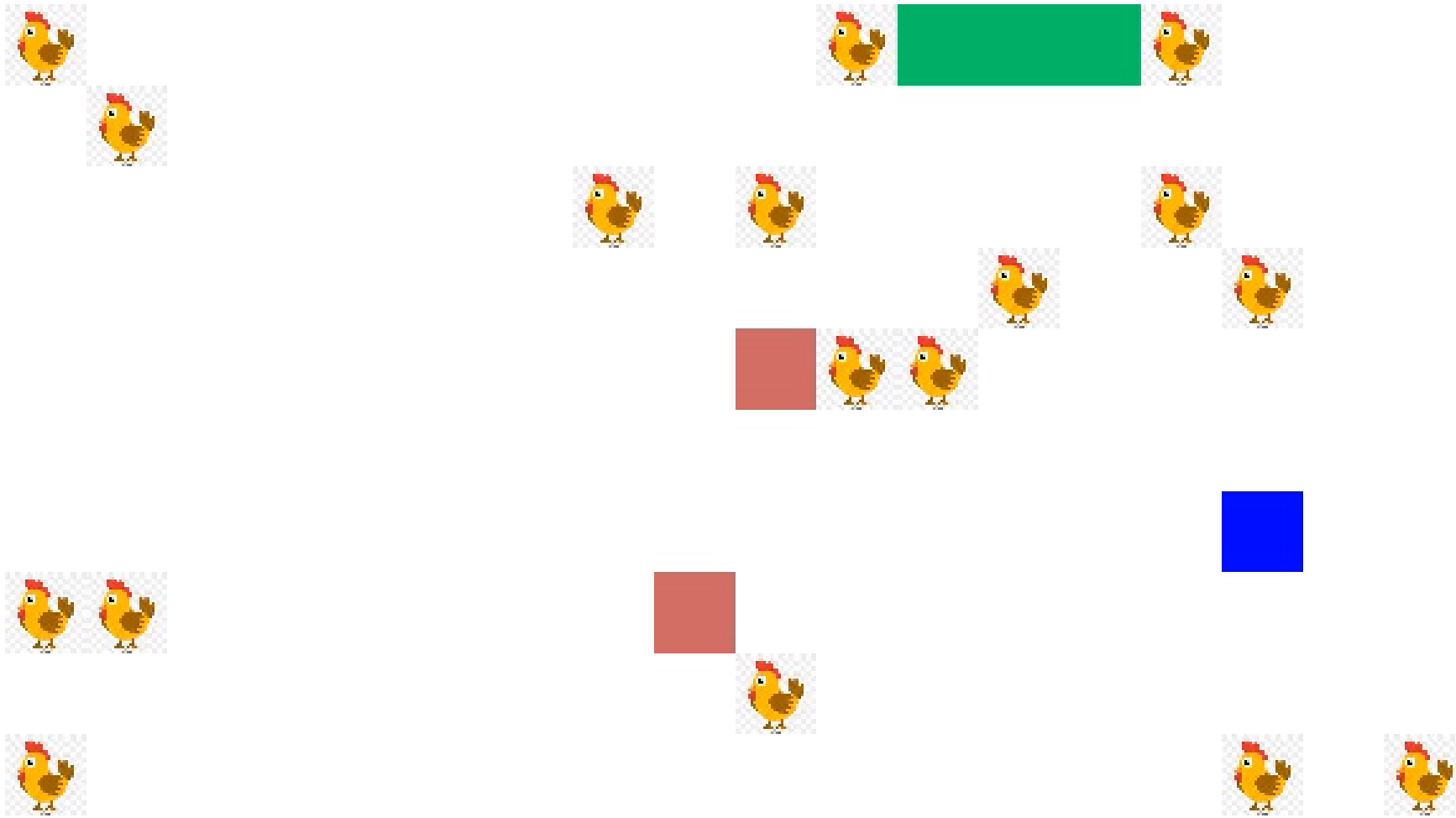
Chicken

# Clustering with Groups



# Final thoughts

# Chicken



Chicken

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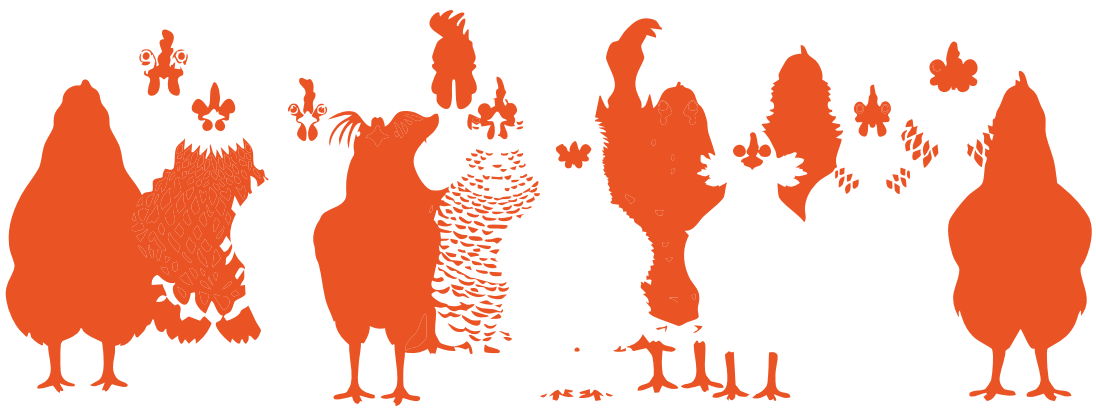
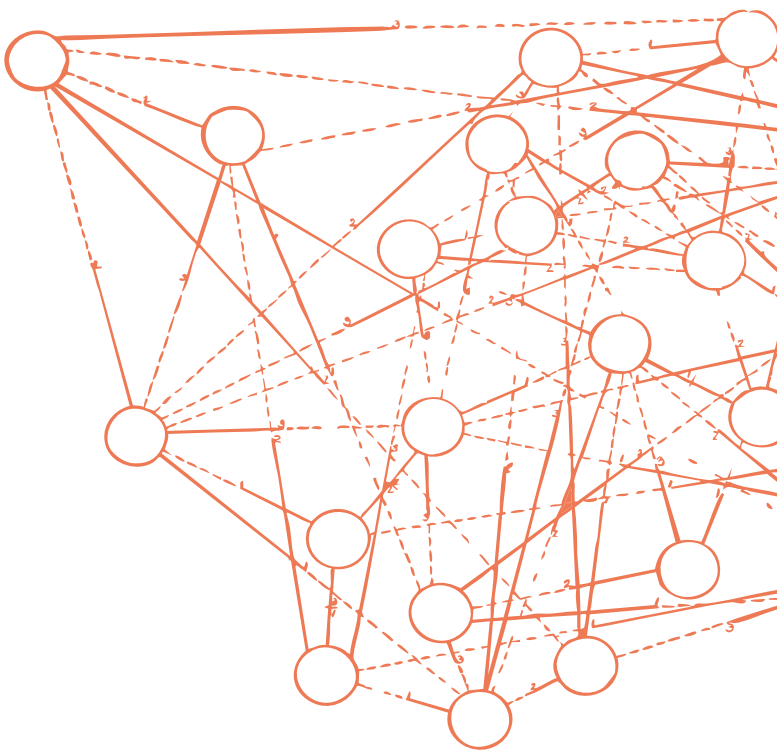
# *Thank you!*





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Chicken

# Modularity

$$Q = \frac{1}{2m} \sum_{ij} \left( A_{ij} - \frac{k_i k_j}{2m} \right) \delta(c_i, c_j)$$