Hierarchical organization versus self-organization

Eva Busseniers

UGent

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Table of contents

Hierarchy

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- Unequality
- Order: some are "higher" then others
- Unequal relations: one has power over the other (local)

Hierachy vs self-organization

- Organization = structure with function

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- Hierarchical organization vs self-organization

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  - different way in achieving goal

Hierachy vs self-organization

- Organization = structure with function
- Hierarchical organization vs self-organization
- Two ways to approach it:
  - difference on structure
  - different way in achieving goal
- see how the two agree

Network

- Structure $\rightarrow$ by network/graph

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- Graph $=$ 'nodes' connected by 'edges'

Network

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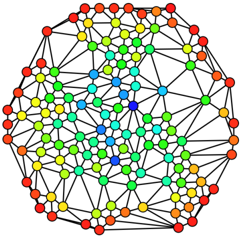
- Graph = 'nodes' connected by 'edges'
- $G(V, E)$:
  - V = set of vertices/nodes
  - E set of edges (pair of nodes)



Degree

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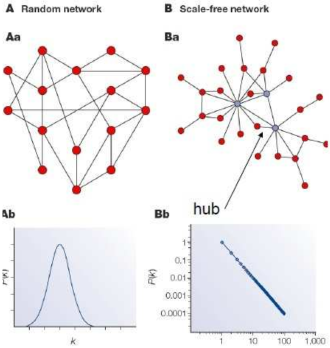
- $P(k)$ =probability of degree k

Random network vs scale-free network



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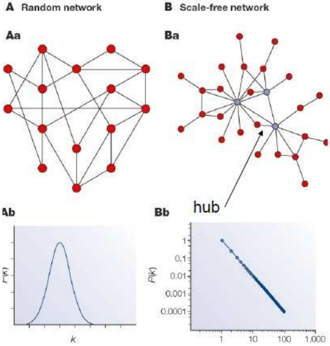

- random: $P(k)$ normally distributed
- scale free: $P(k) \sim k^{-\lambda}$: power-law

Clustering coefficient

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Clustering coefficient

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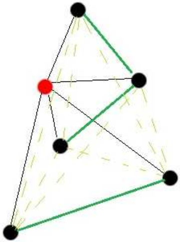
- Looking at clustering coefficient $C(v)$ of node v: how good neighbours are connected

Clustering coefficient

$$C(v) = \frac{|\text{edges between neighbours}|}{|\text{total possible edges between neighbours}|} = \frac{n_v}{\frac{k(k-1)}{2}}$$

with $n_v = |\text{edges between neighbours}|$; $k =$number of neighbours.



Hierarchical vs scale-free

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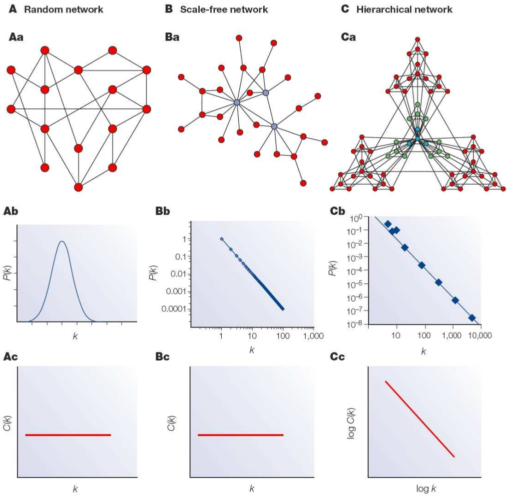
- hierarchical network: higher degree, lower clustering coefficient
- scale-free network: clustering coefficient the same for every degree

Summary


A Random network
B Scale-free network
C Hierarchical network
Aa
Ba
Ca
Ab
Bb
Cb
P(k)
k
1
0.1
0.01
0.001
0.0001
10
100
1,000
10,000
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Failure and attack

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- Civil war: attack in hierarchical network →fall apart → new highest fight for leadership. Not because hierarchy is necessary, but because hierachical structure is still present

Changing network

Find easiest way from hierarchical to scale-free network

- two networks with same number of nodes (and edges)

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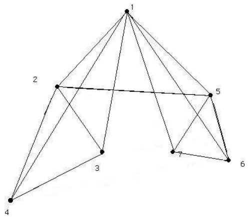
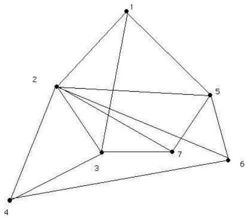
- Find best mapping from nodes of one network to the other
- best= least edges to add/remove





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  - $C(v) > C(b)$: create edge between v and neighbour of b not yet connected with v
- algoritm still needs to be optimized and implemented/tested

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- Start from small graph

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- Add nodes, with m edges (m mostly between 1 and 5)

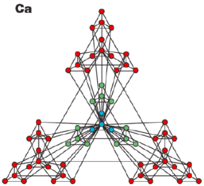
Changing network

Build scale-free network

- Start from small graph
- Add nodes, with m edges (m mostly between 1 and 5)
- Preferable attachment: more chance to connect with nodes with higher degree

Changing network

- Build hierarchical network: Leader of cluster connected with everything in cluster and leader of other clusters, rest not connected with other clusters



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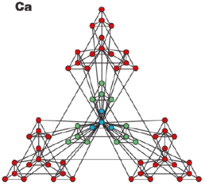
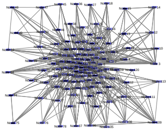
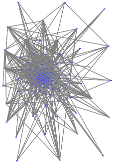
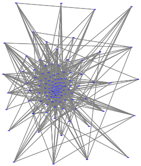


- Build random network: randomly choose two nodes and connect it, repeat for the number of edges you want

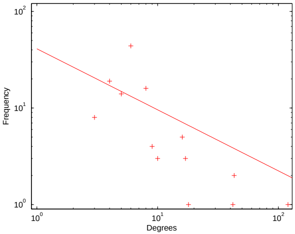
Networks

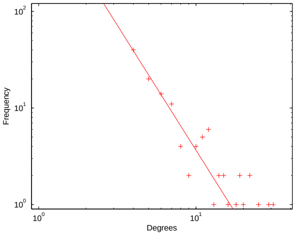






PLplot


Frequency
Degrees
10^0
10^1
10^2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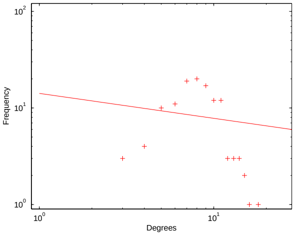
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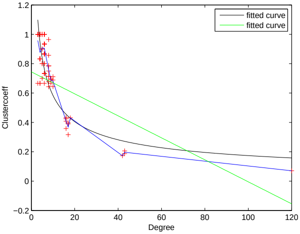
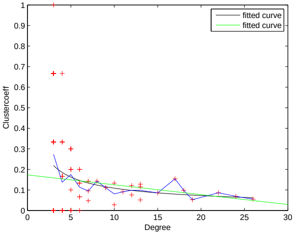
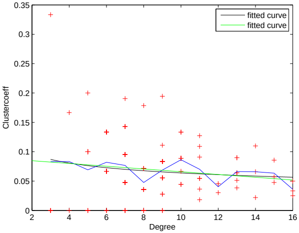
Degree-Clustercoefficient







Organization

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  $\rightarrow$ reach a global goal, global pattern

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  $\rightarrow$ reach a global goal, global pattern
- Self-organization: function, global activitity arise spontaneously: by local interactions, common goal put by collective
- Hierarchical: structure and function (organization) decided from above, 1 agent put the common goal

Coordination

- Coordination: structuring of actions to
  - minimize friction
  - maximize synergy

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- $\rightarrow$ 4 processes:
  - alignment
  - division of labor
  - workflow
  - aggregation

Alignment

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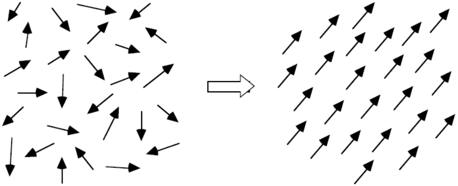

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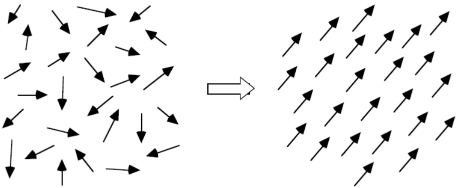

  - Hierarchical: agents adapt towards one leader

Model

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$$n_i = n_i + \frac{\sum_{j \in N_i} (n_j - n_i)}{2 \cdot |N_i|}$$

- higher fitness if less variation with neighbours (less friction)

$$f(n_i) = \sqrt{\frac{|N_i|}{\sum_{j \in N_i} (n_i - n_j)^2}}$$

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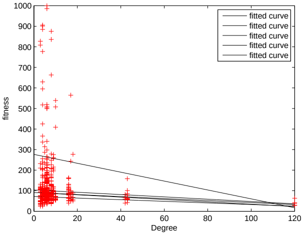
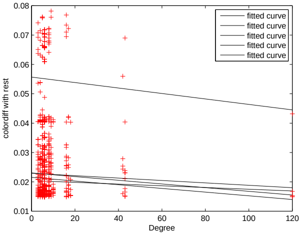
- create plots with degree/clustercoeff against fitness/difference in color between node and rest

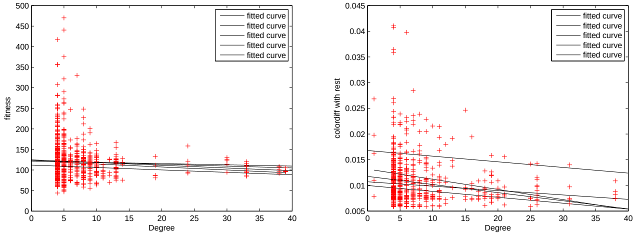
Degree-hierarchical network





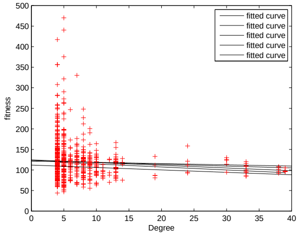
- Higher degree, lower fitness and colordifference

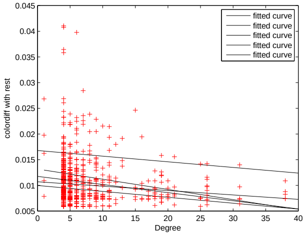
Degree-scale-free network



- Fitness independent of degree

Degree-scale-free network





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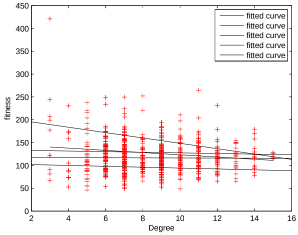
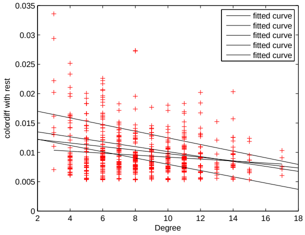
Degree-random network





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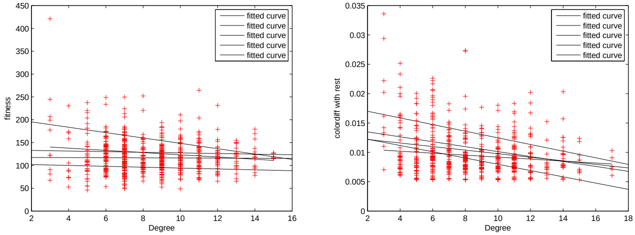

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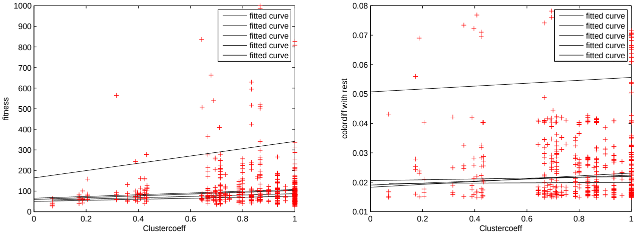
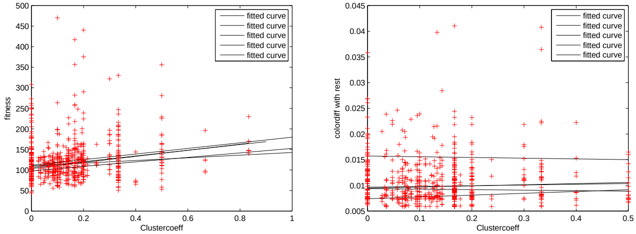
Clustercoeff-hierarchical network



- Higher clustercoefficient, higher fitness and colordiff

Clustercoeff-scale-free network



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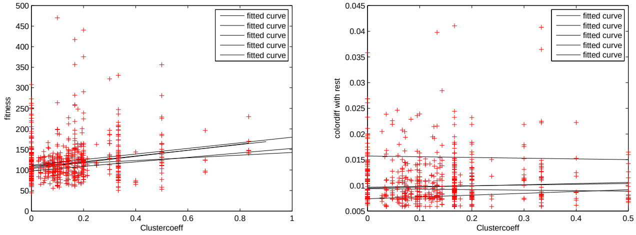
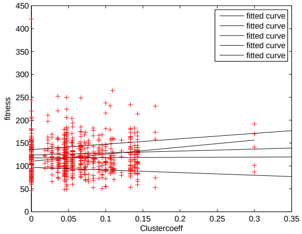
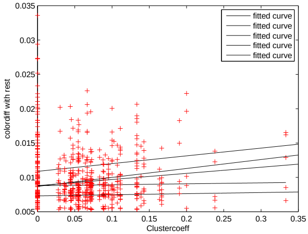


- Higher clustercoefficient, higher fitness
- Colordiff independent of clustercoeff

Clustercoeff-random network





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Some numbers

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- standard deviation difference in color: 0.0090; 0.0048; 0.0039 for resp hierarchical, scale-free and random network → more variation in colordiff for hierarchical network

Summary

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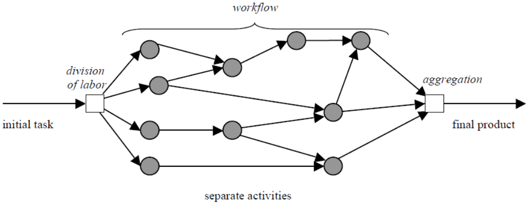
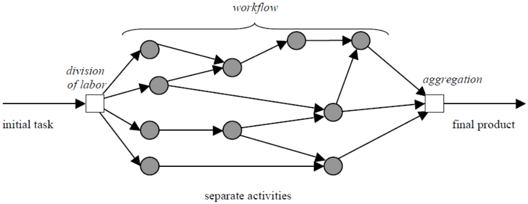
Maximize synergy



- Division of labor

Maximize synergy



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- Workflow

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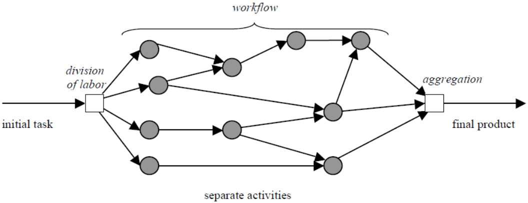

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    - aggregation: random interaction, best are selected

Model

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- with these two vectors, we can generate a garbagevector for each node

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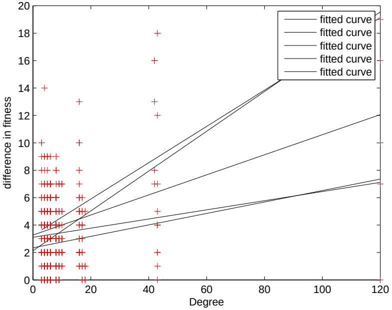
- the bigger your fitnessdifference, the more you got stronger

Degree-hierarchical network



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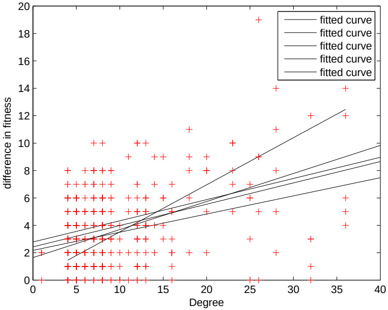
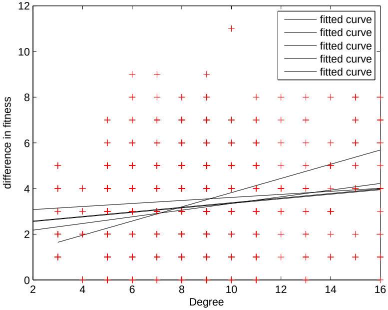
Degree-scale-free network



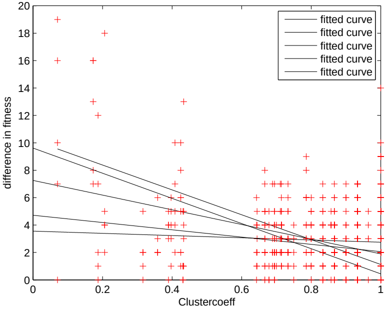
- Higher degree, higher difference in fitness, but less then hierarchical

Degree-random network



- Higher degree, a little bit higher difference in fitness

Clustercoeff-hierarchical network



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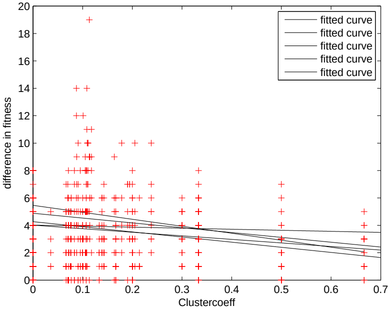
Clustercoeff-scale-free network



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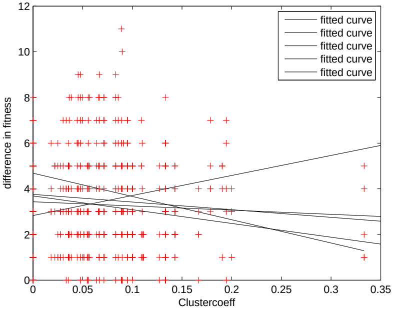
Clustercoeff-random network



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Some numbers

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- standard deviation difference in fitness: $3.15; 2.58; 2.24$ for resp hierarchical, scale-free and random network $\rightarrow$ a bit higher for hierarchical network

Summary

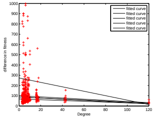
- Higher degree, higher difference in fitness; more if hierarchical network, and only a little bit for random network

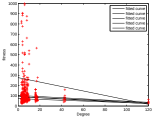
Summary

- Higher degree, higher difference in fitness; more if hierarchical network, and only a little bit for random network
- Higher clustercoefficient, lower difference in fitness; only a little bit for scale-free and random

Why not look at...

- Difference in fitness (fitness in beginning different?)? Equivalent to fitness:





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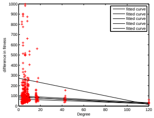
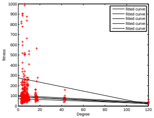
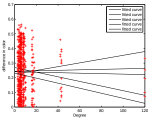
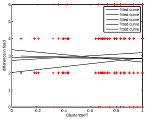




- Difference in color/food between end and beginning? Independent of degree/clustercoeff:





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- So intuition that hierachical network= more unequality, holds.

Influence

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Influence

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  a little bit higher for hierarchical network, particulary lower for random network
- Unequality of infuence: higher in hierarchical network
- So while nodes in a hierarchical network agree more with their neighbours, they do less with the whole network

Strange things

- Higher degree/lower clustercoeff $\rightarrow$ lower fitness in hierarchical network of 1st model: clusters evolve independent, leading node is 'in between' (only local problem)

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- Higher degree/lower clustercoeff $\rightarrow$ lower fitness in hierarchical network of 1st model: clusters evolve independent, leading node is 'in between' (only local problem)
- Hierarchical properties of scale-free network: the network used isn't completely scale-free

Normal things

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Normal things

- Higher degree $\rightarrow$ lower colordifference in first model: Leaders differ less with rest
- Higher degree/Lower clustercoeff $\rightarrow$ higher fitness in second model: Leaders become fitter, particulary in hierarchical network

Further research

- Work with directed graph;
  - Hierarchy= graph represents order
  - Look at what it does in the models

Further research

On second model:

- Use something else then fooddiff (garbage in it)

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- Avoide friction: fitness lower if garbage is used by more nodes, higher if more neighbours with garbage

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- Changing network:
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  - Dying:
    - Some garbage is "vital", neighbour can eat you, depending on your and his fitness
    - The lower fitness, the more chance to die

The end

Thank you!