Regulating Complex Adaptive Systems: Towards a Computational Model for Simulating the Effects of Rules

Ameneh Deljoo[1], Tom van Engers[2], Leon Gommans[3] and Cees de Laat[1]

[1]Institute of Informatics, University of Amsterdam

[2]Leibniz Center for Law, University of Amsterdam

[3]Air France-KLM, Amsterdam-Schiphol

Ameneh Deljoo (Second year PhD Student): Institute of Informatics, University of Amsterdam

Prof. Tom van Engers: Leibniz Center for Law, University of Amsterdam

Dr. Leon Gommans: Air France-KLM, Amsterdam-Schiphol

Prof. Cees de Laat: Institute of Informatics, University of Amsterdam

The research presented here is from the **SARNET project**[1].

Understand the value of collaboration between alliance members in terms of **risk reduction,** increasing trust**, cost benefit and revenue impact.**

[1]http://delaat.net/sarnet/index.html

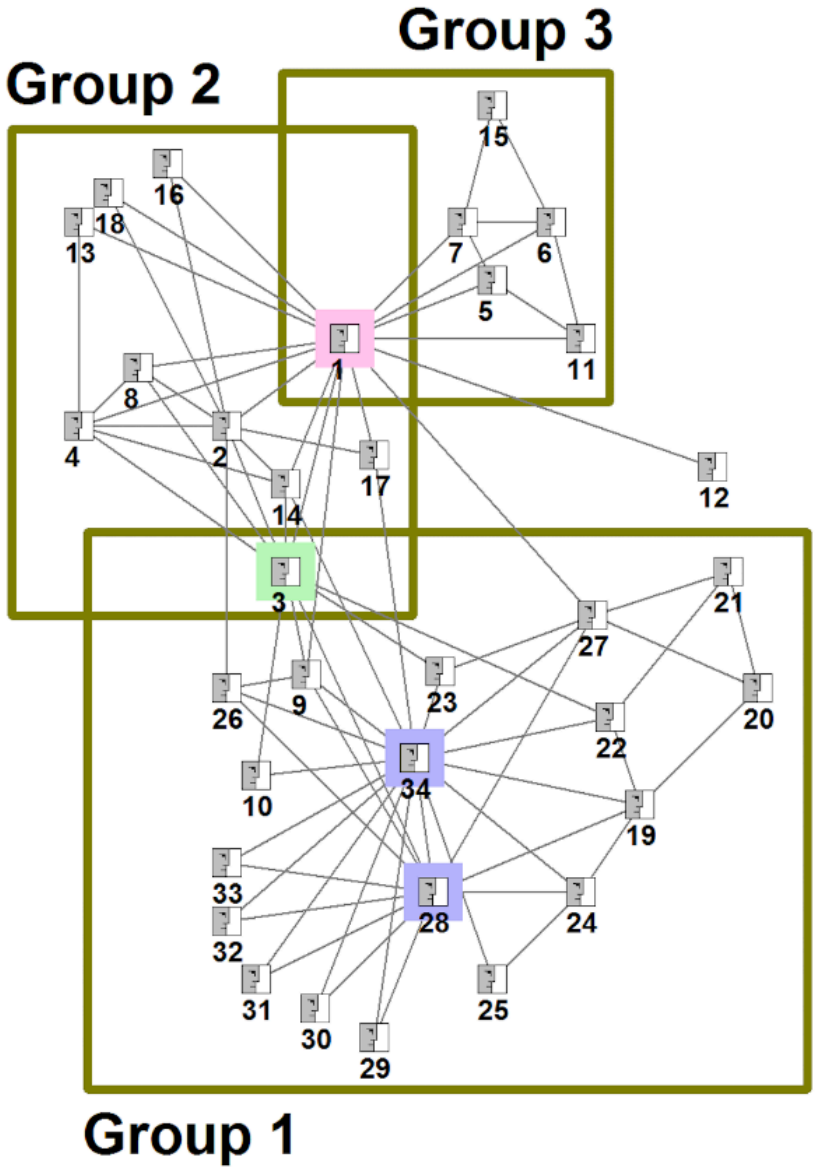
Motivation

- Organizations including our societies **cannot exist** without rules.
- These may be **legal rules**, contract **agreements**, social rules, **ethical rules** etc.
- This is a long tradition in Philosophy and Law on such rules.
- However **legal scholars** seem to be more interested in explaining (the highest) court decisions than in understanding **how** (legal) **norms impact society.**
- Recently legal **institutions** (e.g. tax administrations, immigration services, social benefits agencies) have realized that being able to understand how rule impact society is extremely important, amongst others to decide on **(non-)compliancy monitoring** and **enforcement** strategies and for building effective **eServices**.

Collaborative Network of Organizations

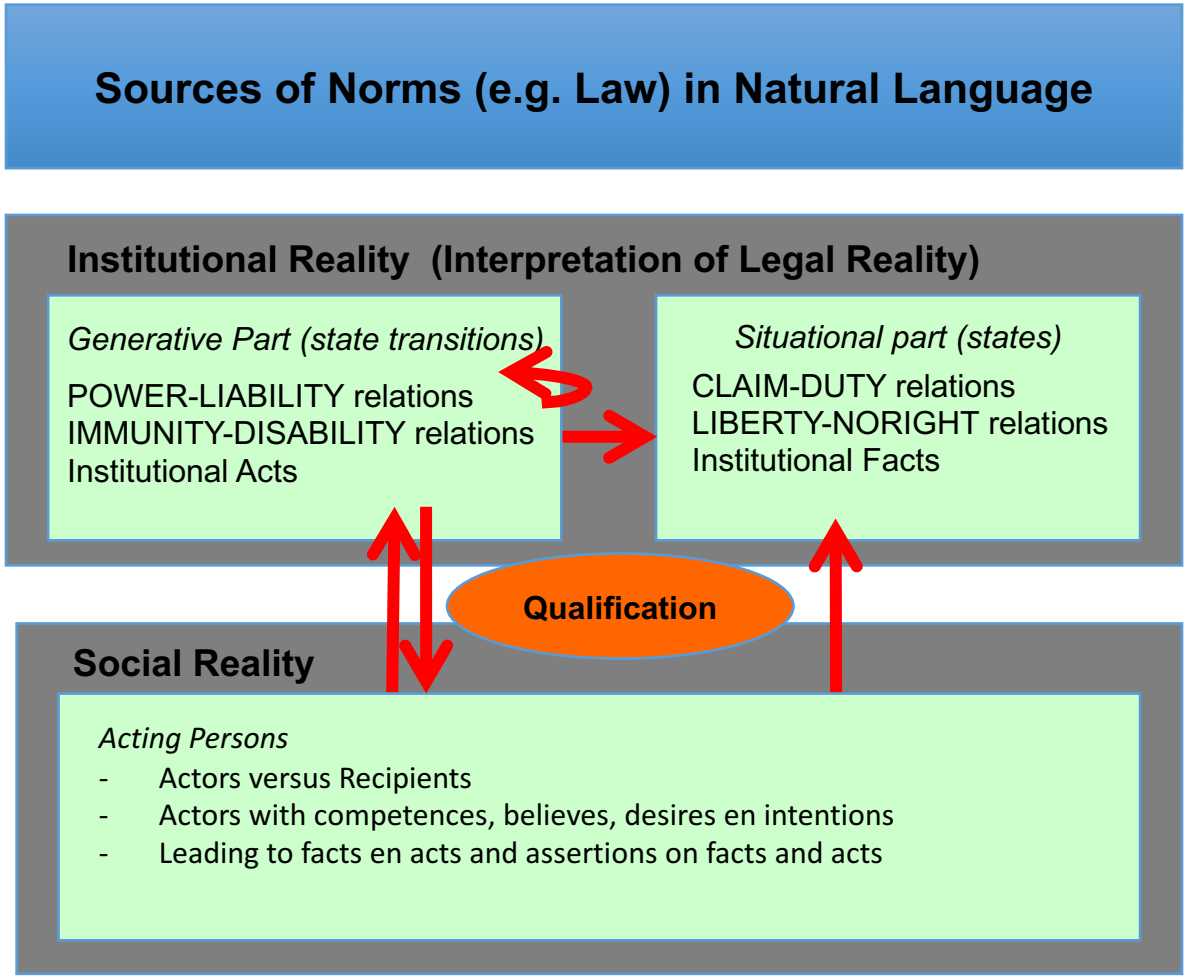
- Collaborative network of organizations are bounded by collaborative rules
  - Deliver a single service.
  - This service is only available if its members collaborate (e.g, Master Card).
  - The network is governed by a different set of rules.
  - These rules may not hold for various parties in this network.

- Complex relationships and dependencies
  - dependencies on goals, conflicts over resources
  - and various beliefs among the parties involved.



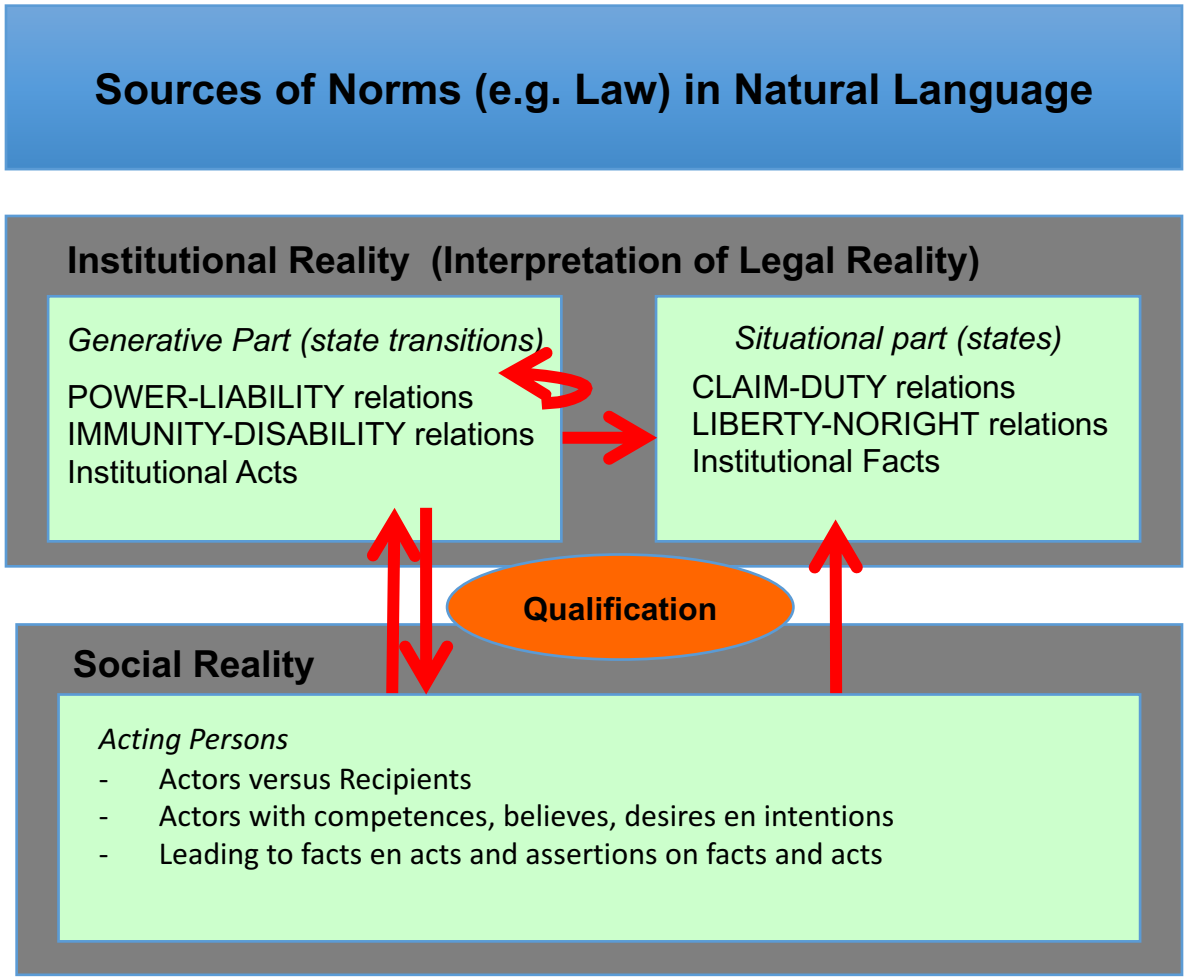
Levels of reality

- Derived from **Searle** adapted by Boer & Van Engers.
- **Distinct levels** for **institutional reality** and **social reality**.
- **Social reality** is interpreted into **institutional reality** (by qualification, i.e. some fact or act is qualified as **institutional** fact or act).
- **Institutional reality** is effecting **social reality** by **agents** that act accordingly.
- There may be alternative institutional interpretations (e.g. in conflicts) and one may disagree on the qualification.



Scenario based agent-role behavior and normative reasoning

- **Norms** and **normative** reasoning is based upon the work of Hohfeld.
- Our framework is based upon the two situational normative relations (**Duty-Claimright and Liberty-NoRight**) and two generative normative relations (**Power-Liability** and **Disability-Immunity**).
- The latter can **create** or **destroy** other normative relations if the acts that are part of the generative relations are executed. This leads to plausible world semantics, where every path is the result of some normative reasoning.



Scenario based agent-role behavior and normative reasoning (I)

- Basic assumptions:
  - **No central** coordination mechanisms.
  - Every agent makes **observation** and **acts** in a **interconnected** world.
  - Bounded rationality → no complete information on which action selection can operate, also the **effects** on society are uncertain as actions may fail and other agents also interact with the world.

- Agents represent **persons** (both natural as non-natural persons, e.g. **organizations**)
- Agents **adopt agent-roles** that **fit** the situation and that come with certain behavior, intentions, plans etc.

Scenario based agent-role behavior and normative reasoning (II)

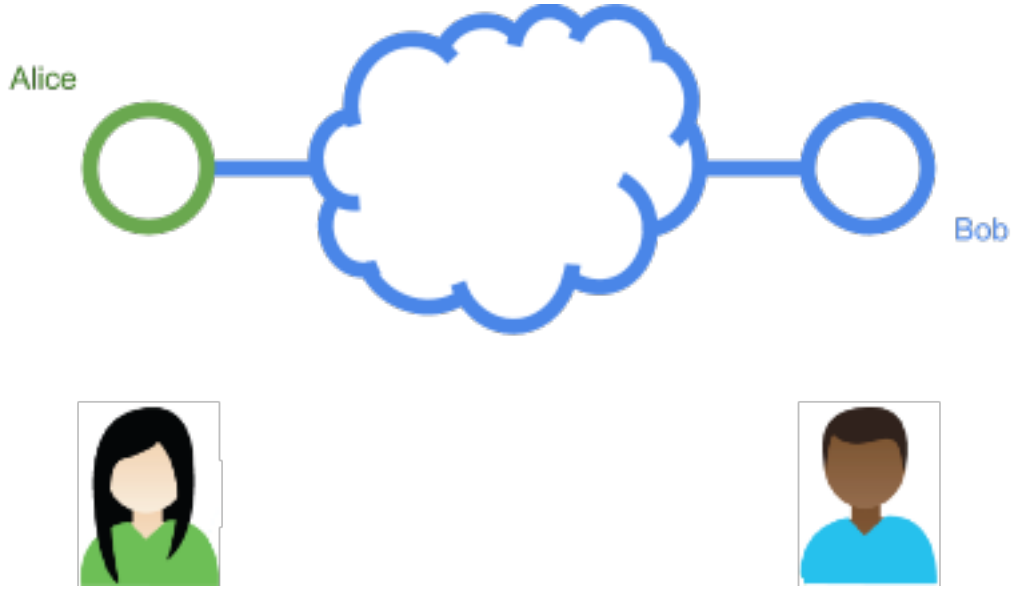
- We can model the **behavior** belonging to an **agent-role** by **describing** the scenario. The **scenarios** the agent recognizes are the starting point for understanding the **world** it is in.
- Besides **direct observations** by the agent's sensors the **main** source of information is through communication acts of other agents.
- That communication is the result of a deliberate (communication) act of another agent and is impacted by the **belief set** of that agent, its **intentions** etc.
- The receiving agent will reason about the **trustworthiness** of the information received. This requires a model of **(non-)compliance**, the social behavior of others etc.

Scenario based agent-role behavior and normative reasoning III

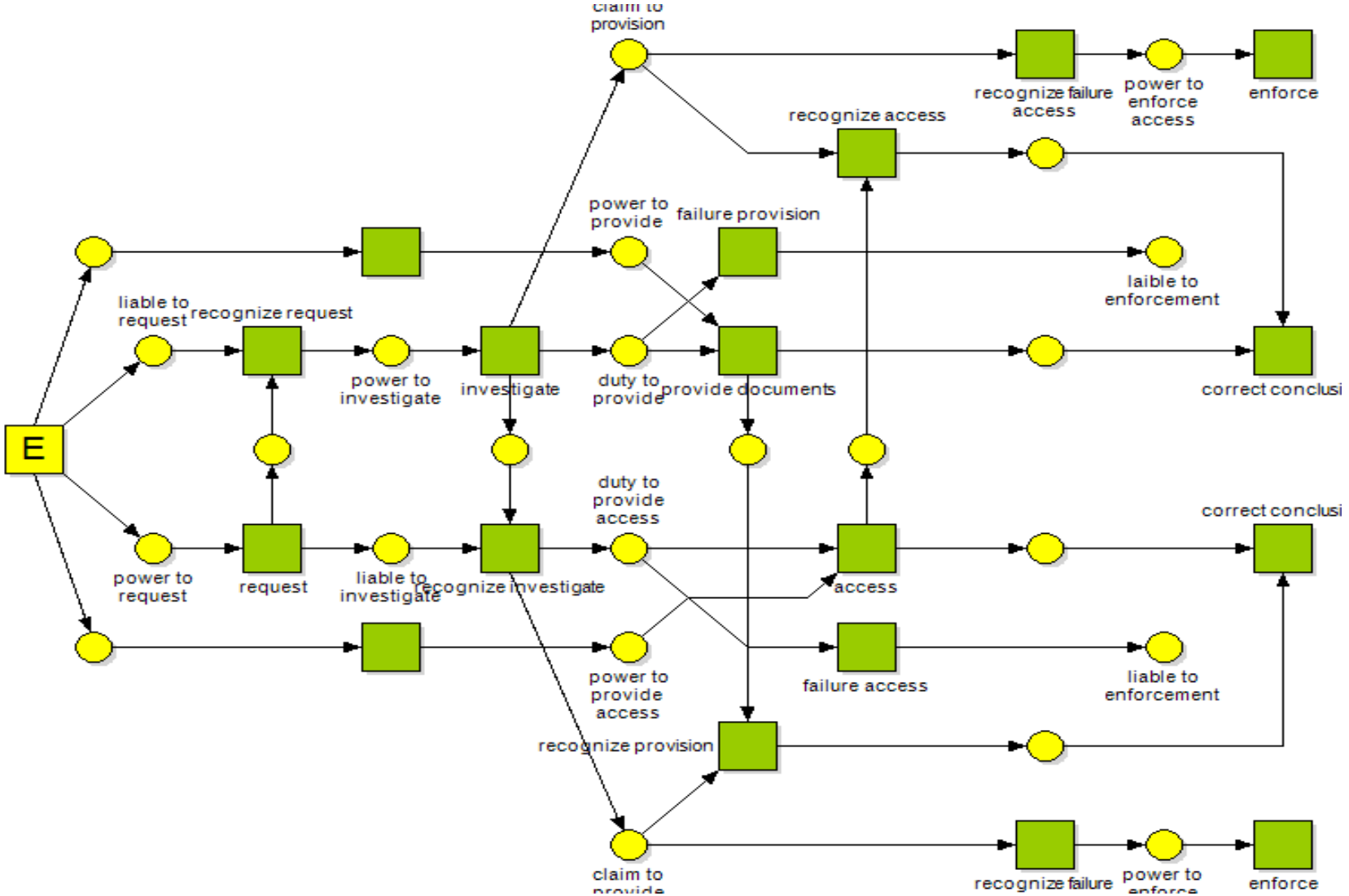
- The agent, based upon his **belief set** and **intentions** may have a **plan** available (one of the plans it can select in its current **agent-role**) or not (then the agent will have to look for an **alternative agent-role**).
- The most **appropriate action** will be selected upon its **contribution** to the agent's aims (**expected utility**) and costs (effort etc.).
- The **effects** on the agents environment (society) become part of the agent's **belief set** and allow the agent to **monitor** the **success** of the **action** and after **diagnosis** to select a **different** action.

An Example of Scenario based agent-role

- Bob is a security manager at company A. For the sake of his company, he is looking for a way to collaborate with Alice, who is a security manager at company B. To establish this collaboration, each agent needs to plan it choices to estimate risks, benefits and at the end minimize the risks.

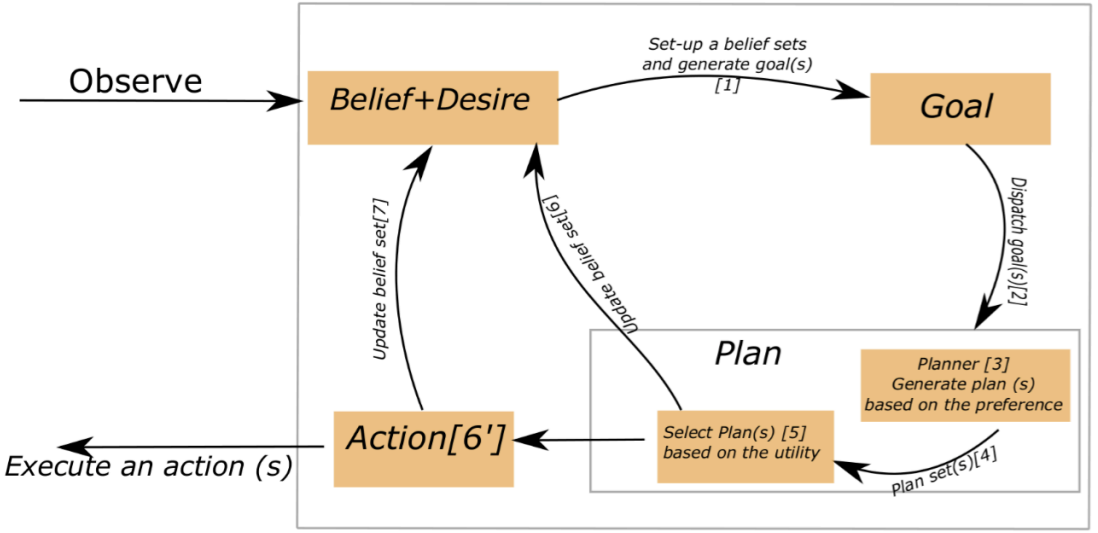


Combining the collaboration scenario with institutional reasoning



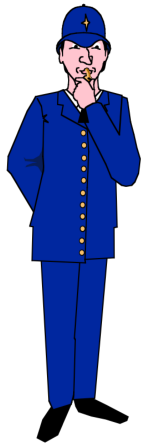
Implementing the model in an ABM environment

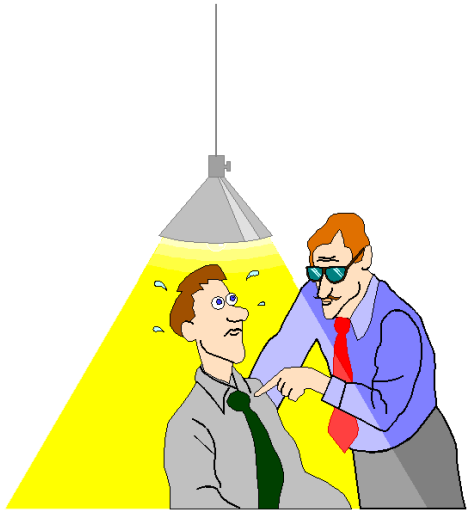
- Agent Architecture
- BDI Agents (Belief, Desire, Intentions)
- Evolutionary Prisoners' Dilemma game

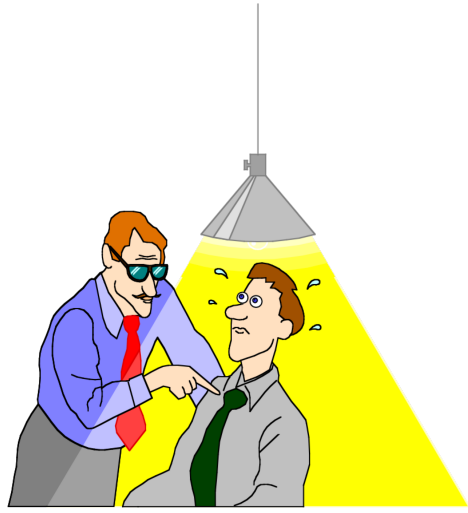


One example: the prisoners' dilemma (PD) as ABM (PD)

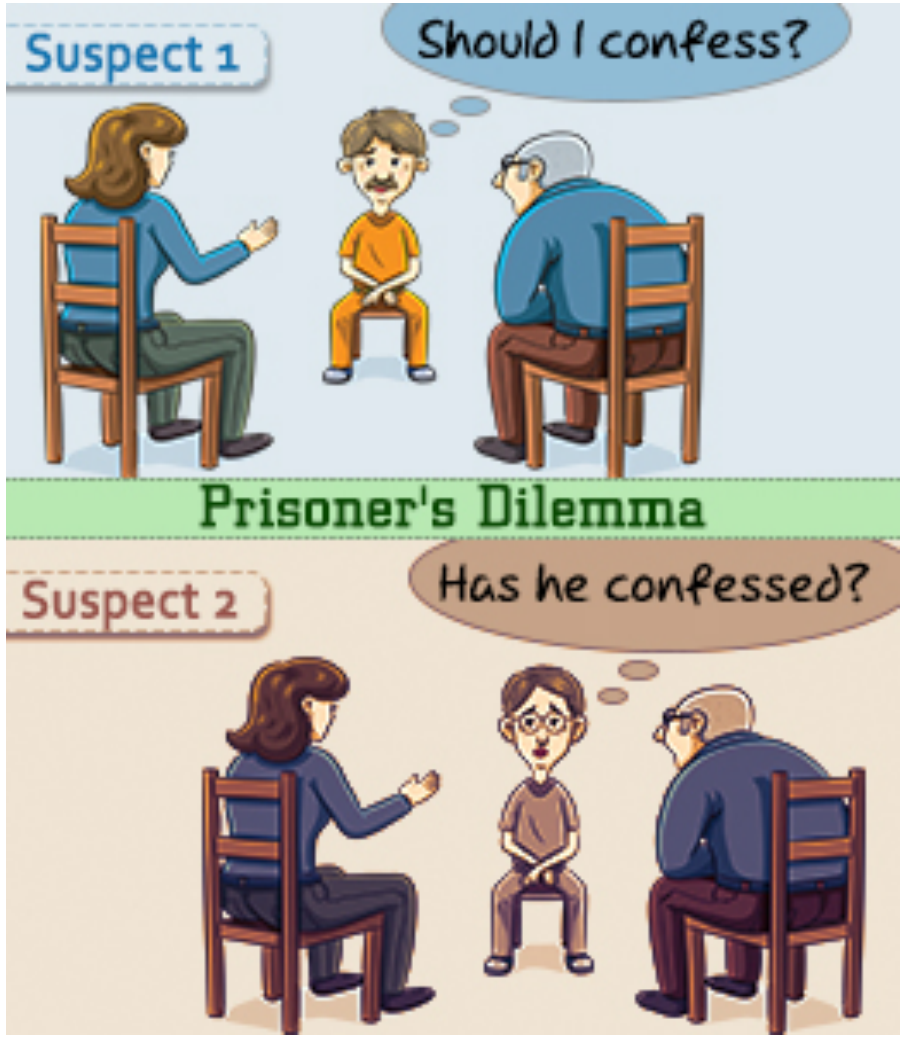
- **The Game:**
  - Two people have been arrested separately, and are held in separate cells. They are not allowed to communicate with each other at all.
- **Each prisoner is told the following:**
  - We have arrested you and another person for committing this crime together.







Evolutionary Prisoners' Dilemma (PD)



Partner B / Partner A	Cooperate	Defect
Cooperate	A: (R = 3) B: (R = 3)	A: (S = 0) B: (T = 5)
Defect	A: (T = 5) B: (S = 0)	A: (P = 1) B: (P = 1)

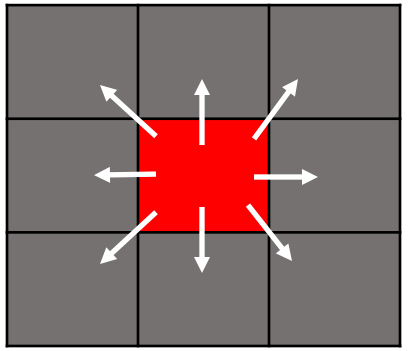
$$T > R > P > S$$

Evolutionary Prisoners' Dilemma (PD)

- Players may play with each other again.
- Players will develop strategies based on previous game interactions.
- A player's move now may affect how his/her opponent behaves in the future and future payoffs.
- The population is quite large.

Game Setup

- Every agent on the grid has eight immediate neighbors.
- Every agent records sixty-four possible histories.
- Uniformly distributed.
- Every agent randomly selects a strategy.
- Different strategies to chose from (e.g. Always Defect, TFT, Always Cooperate).

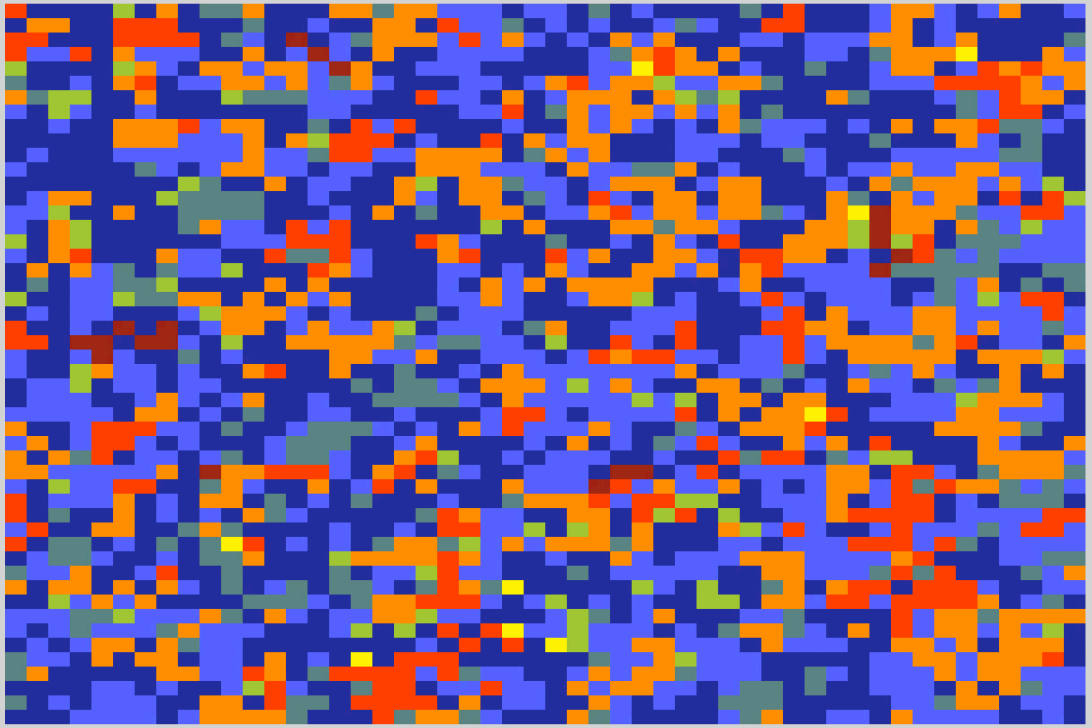


Spatial Interactions

Evolutionary Prisoner's Dilemma

Game Type Rules Strategies

Main Display



Player Type

Very 'Nice': 0.36 %
Mostly Cooperative: 2.88 %
Cooperative: 8.44 %
Balanced ('nice'): 27.16 %
Balanced ('nasty'): 34.88 %
Tendency to Defect: 17.8 %
Mostly Defects: 7.72 %
Very 'Nasty': 0.76 %

Population Fitness Stats

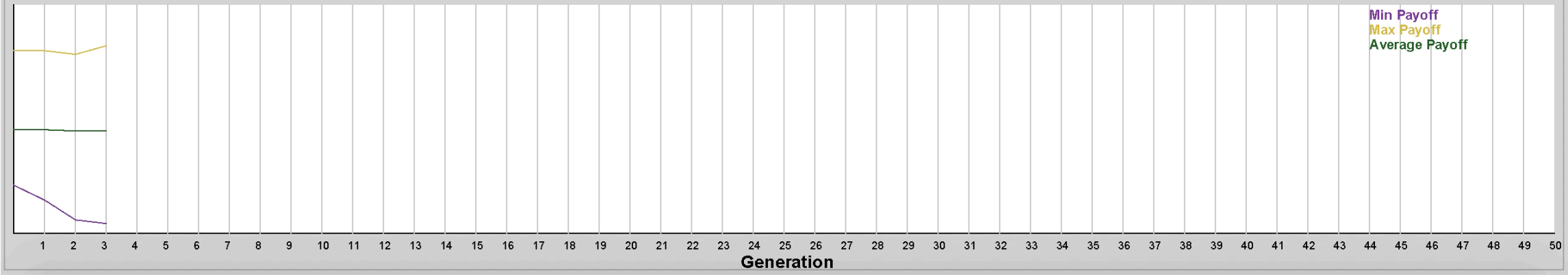
Minimum Payoff: 0.1925
Maximum Payoff: 4.105
Average Payoff: 2.24

Use an Evolutionary Algorithm
Use a Genetic Algorithm

Start | Stop

View Fittest Individual | View Weakest Individual

Graph



Discussion

- **Over time** the proportion of the population choosing the **strategy Cooperate** eventually becomes **extinct**.
- Many **behaviors involve** the interaction of **multiple players** in a population.
- ABM model to simulate the behavior of regulated societies.

Ameneh Deljoo: a.deljoo@uva.nl

Tom Van Engers: t.m.engers@uva.nl

Leon Gommans: leon.gommans@klm.com

Cess de Laat: delaat@uva.nl