

Preconditions

OC terminology, architectures

Objectives

Extension from single agents to groups of agents

Content

- Social mechanisms
- Trust Communities for Open Grid Computing
- Ostrom's Enduring Institutions and norms
- Holonic agents

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Interwoven systems

Social agents

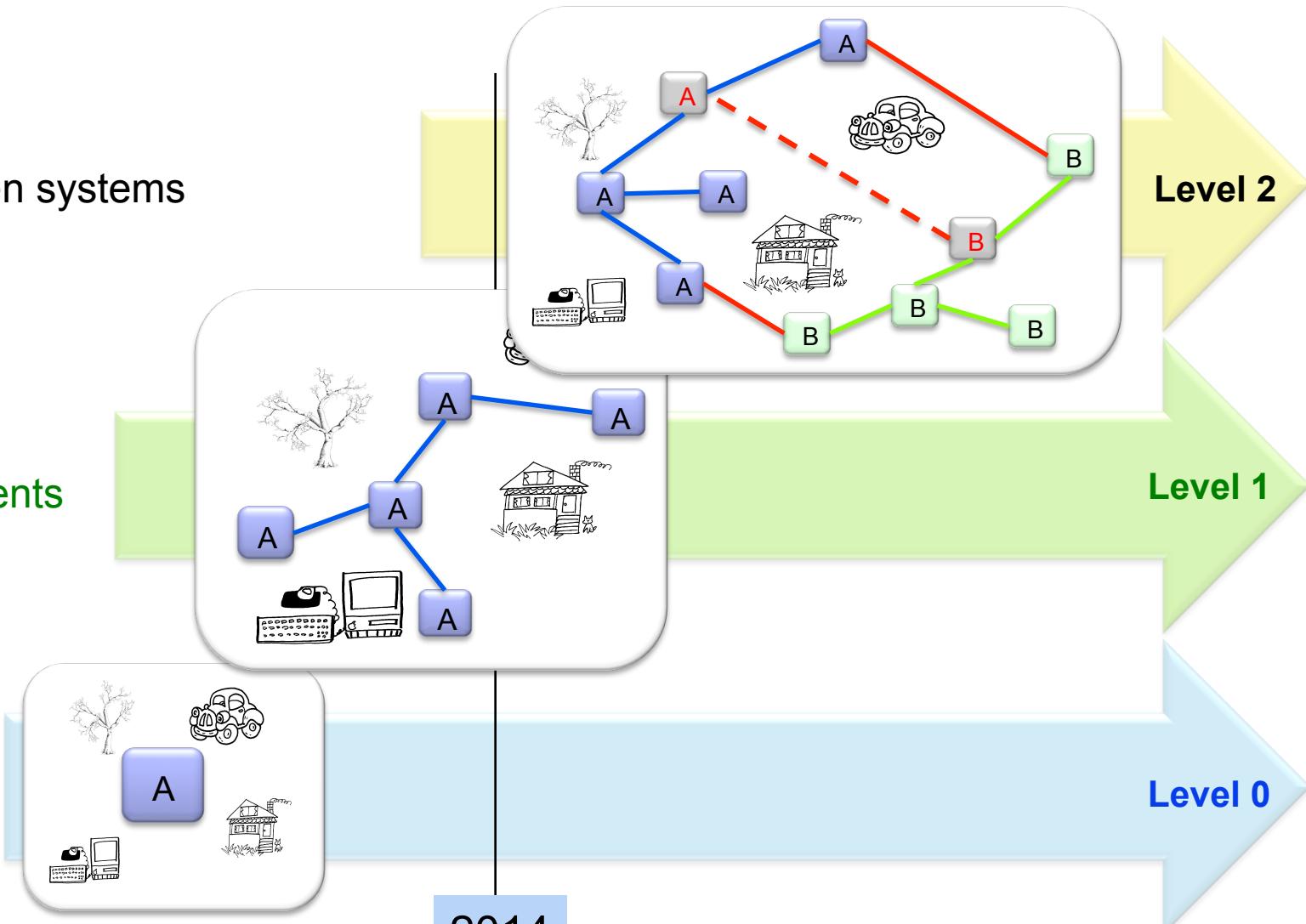
Context-aware agent

2014

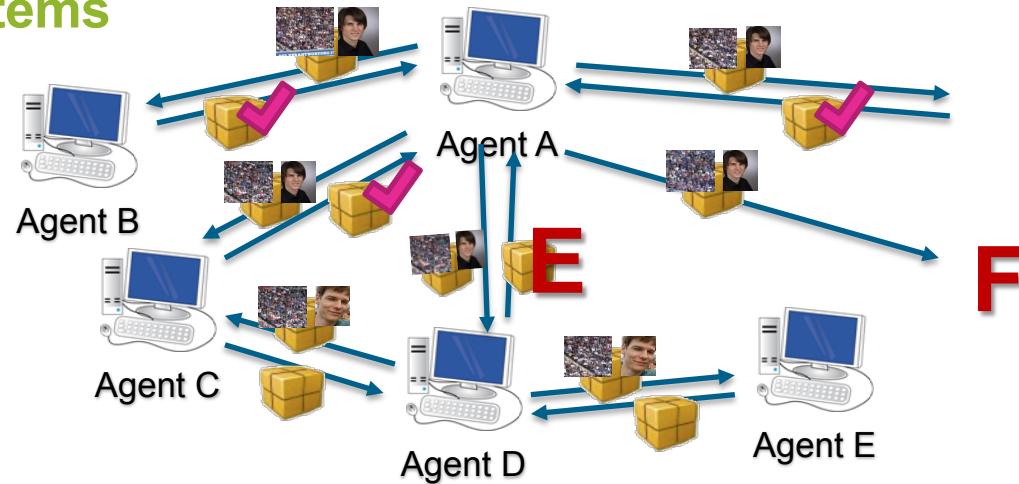
Level 2

Level 1

Level 0



□ The glue of social systems



- Two members of a criminal gang are imprisoned.
- Each prisoner is in solitary confinement with no means of communicating.
- If both confess (CC) they will be sentenced both to **two years** in prison.
- Simultaneously, the police offer each prisoner a bargain:
 - If he testifies against his partner (DC), he will go free (**zero**) while the partner will get **five** years in prison.
 - If *both* prisoners testify against each other (DD), both will be sentenced to **three** years in prison.



	D	C
C = Confess	D	3-3 0-5
D = Defect (deny)	C	5-0 2-2

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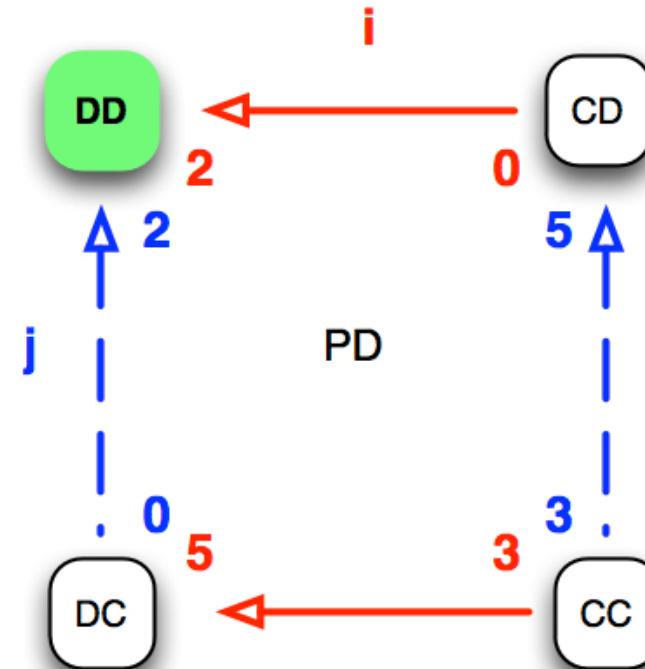
□ Rational Agents

- Agent i: $DC \geq CC \geq DD \geq CD$
- Agent j: $CD \geq CC \geq DD \geq DC$

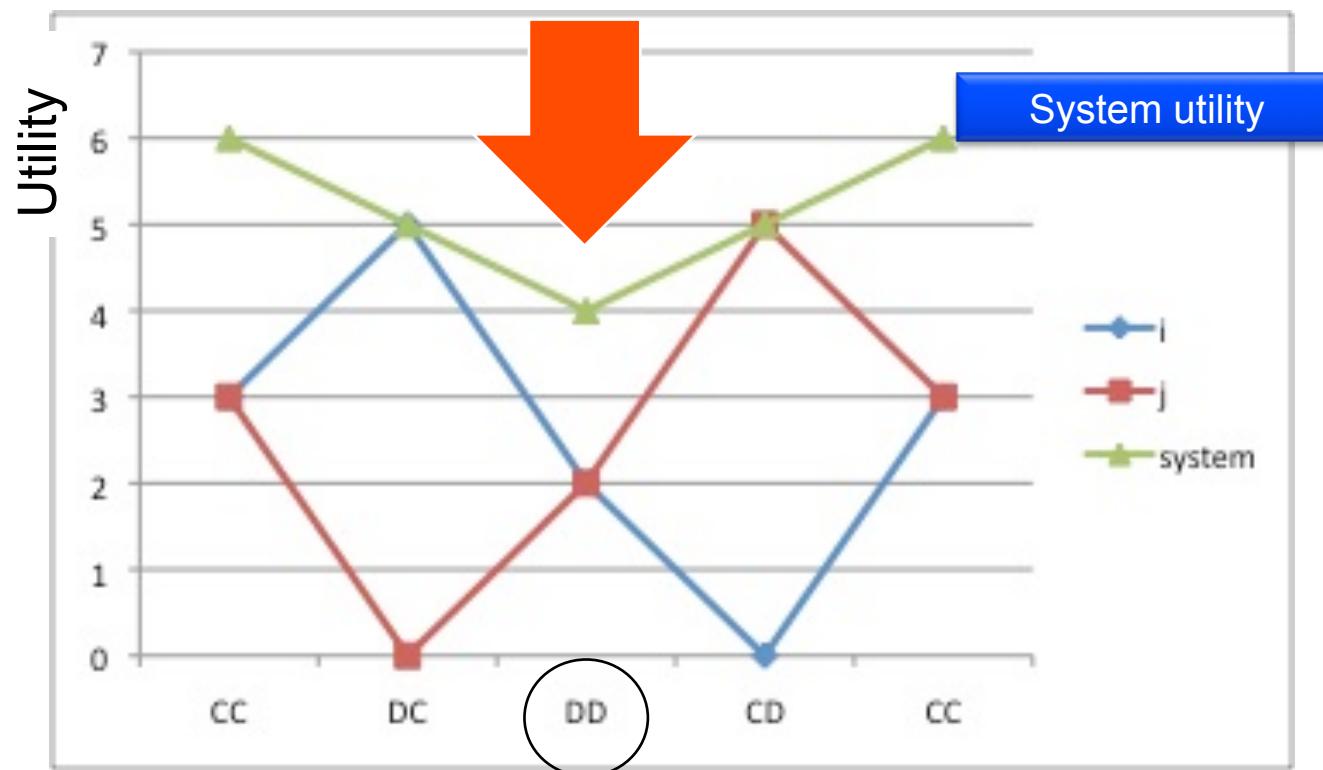
□ Nash equilibrium at DD: Neither agent has an incentive to deviate from a Nash equilibrium.

Utility matrix:

Utility = 5 - "years in prison"



- The “rational” choice can lead to a sub-optimal system utility.



□ Tragedy of the commons

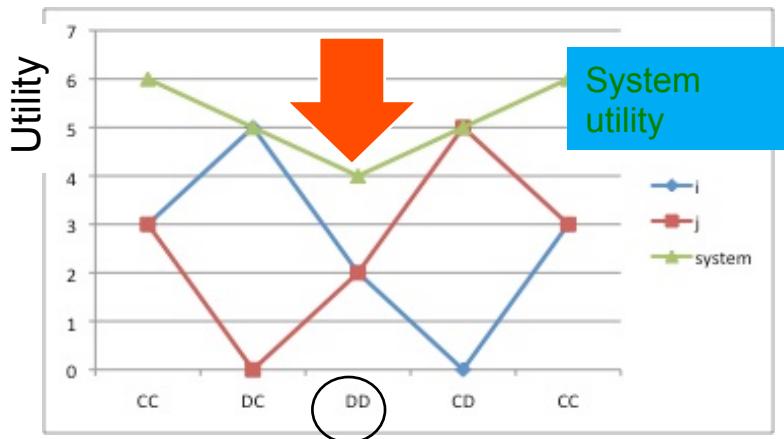
- Example: Herders share a common parcel of land → overgrazing
- Multiple individuals, acting independently and rationally in their own **self-interest**, deplete a **shared limited resource**.
- Problem: Short-term profit vs. long-term interest



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Garret Hardin (ecologist): "The Tragedy of the Commons". *Science* **162** (3859): 1243–1248. 1968.

Hardin, G. (1994). "The Tragedy of the Unmanaged Commons". *Trends in Ecology & Evolution* **9** (5): 199.



- How can we optimize the system utility and the individual utility?

- The “Rational Agent” is not really rational.
- Short-term interest dominates.
- Long-term and social awareness are missing.
- Therefore
 1. Extend the reasoning process to include the system utility.
 2. Enable the agents to negotiate state transition sequences.
 3. Introduce binding commitments → **TRUST**

Preconditions

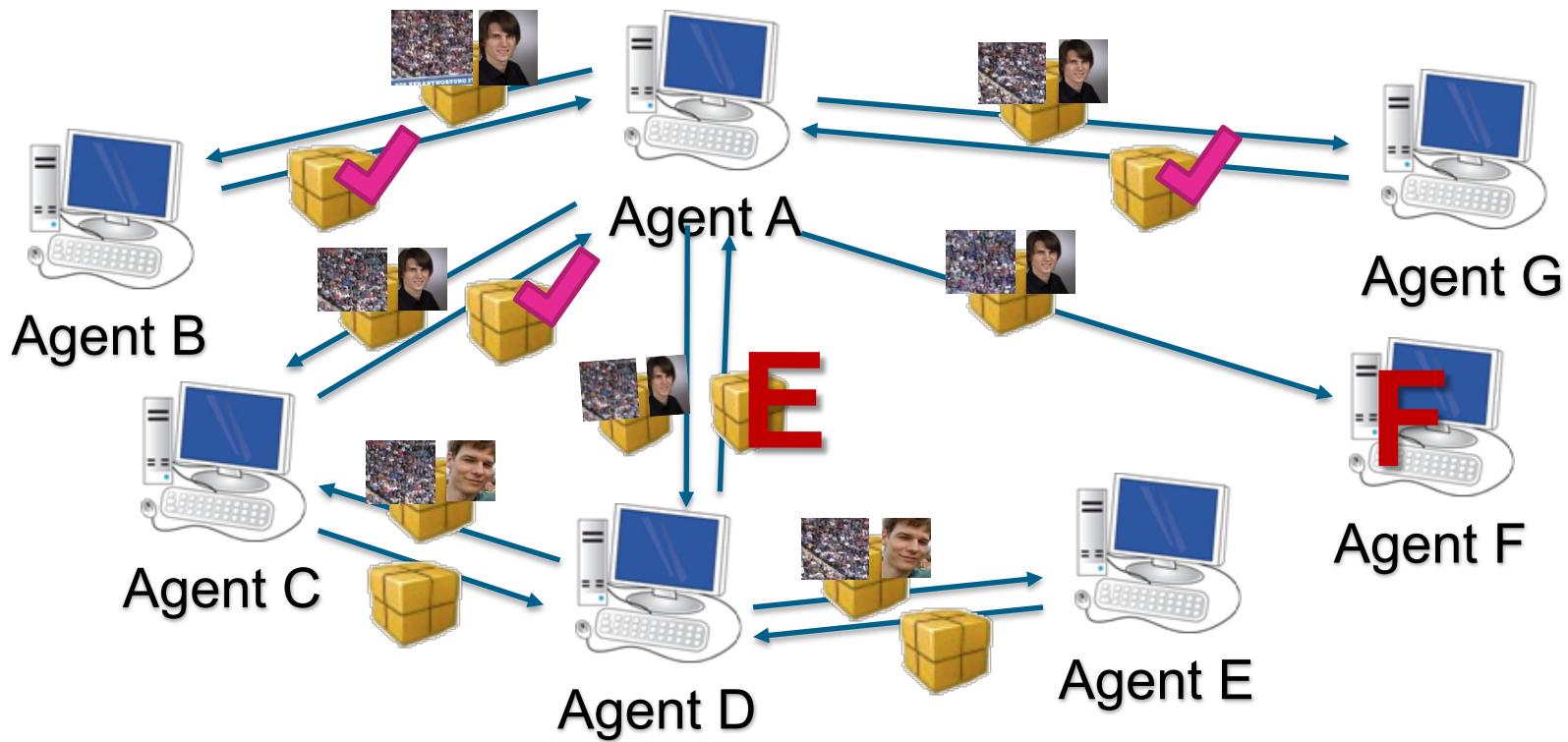
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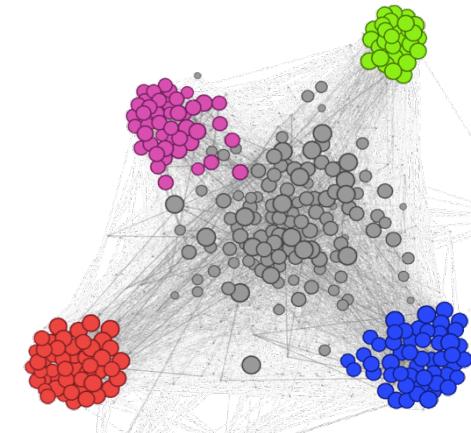
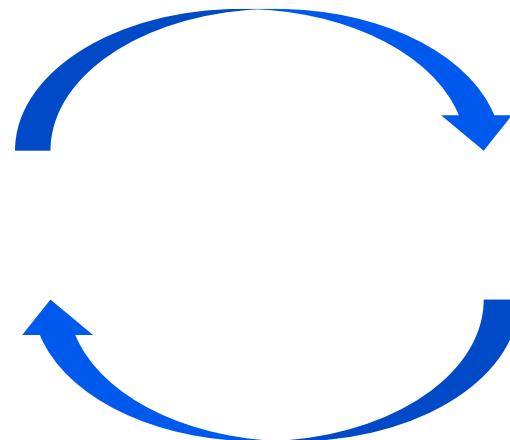
Content

- Social mechanisms
- Trust Communities for Open Grid Computing
- Ostrom's Enduring Institutions and norms
- Holonic agents



- Computation on computers from different domains: Open system
 - **Free-riders** refuse to accept work units.
 - **Egoists** return wrong/incomplete results.
- Requires job replication and result checking -> **waste, inefficient**

- The Trust Community concept uses *metaphors* from human social life.
 - Technical utilization of social concepts
 - Utility, not truth!
- Multi-agent systems can *model* social systems.
 - Imitation of social mechanisms



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□ Hypothesis

- Trust is a social mechanism, which allows more efficient and effective cooperation between individuals.
- This mechanism can be transferred into technical systems. → Trust Community

□ System-to-system trust!

- **BUT:** Trust mechanisms introduce overhead. It has to be shown that the benefit is greater than the cost.

- ❑ Trust = expectation value
 - Probability that a certain event will happen in the future
- ❑ Reputation: The collective rating of an agent's behavior.
- ❑ How can we measure trust?
 - Trust from direct experience
 - Trust from indirect experience (reputation)
 - Trust from reliability metrics
- ❑ How can we use trust?
 - **Outgoing:** My own behavior towards another agent depends on my trust in him.
 - **Incoming:** Trust of others in me influences my own behavior.
- ❑ What we need:
 - Trust-aware and adaptive agents
 - Trust infrastructure

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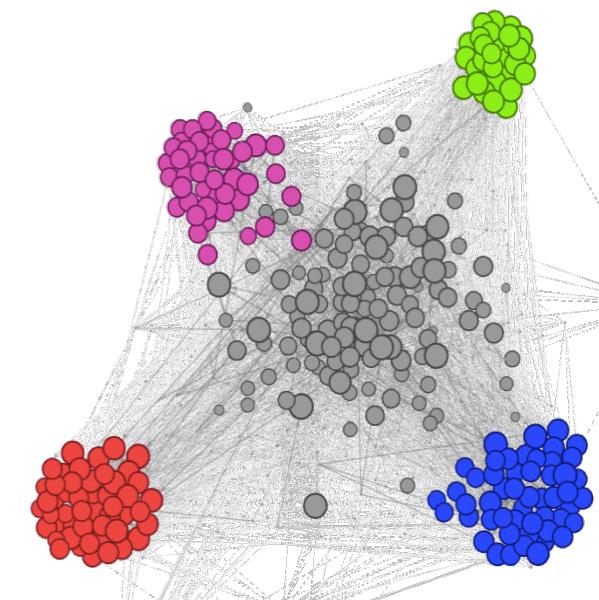
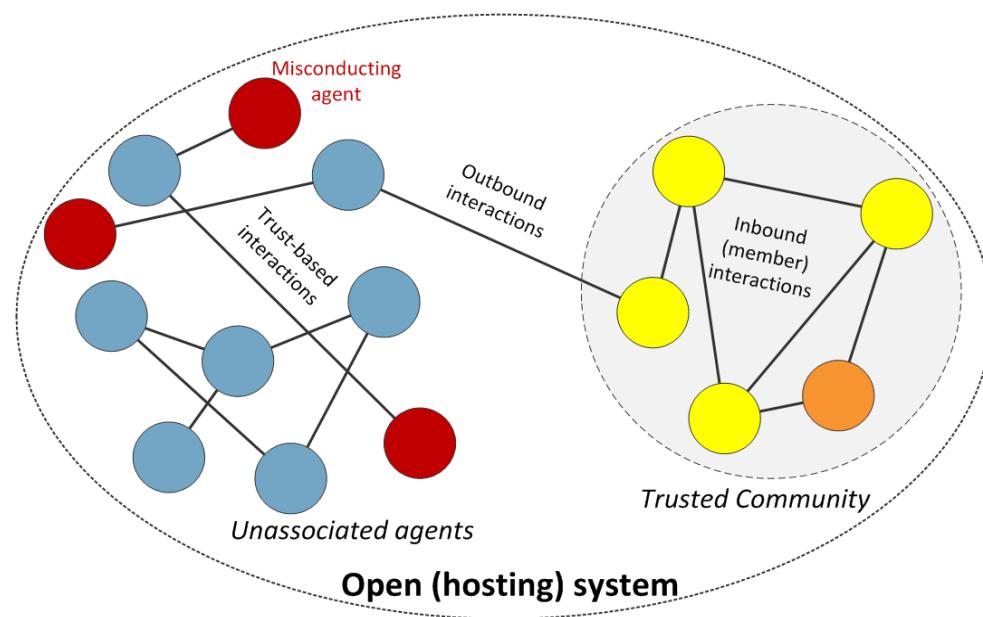
□ Open system, high fluctuation

- Autonomous unknown agents
- Assumption of benevolence is in general unjustified
- Behavioural patterns (agent roles)
 - Socially-ignorant
 - Selfish/egoistic
 - Malicious
 - Strategic/tactical



□ Trust Community

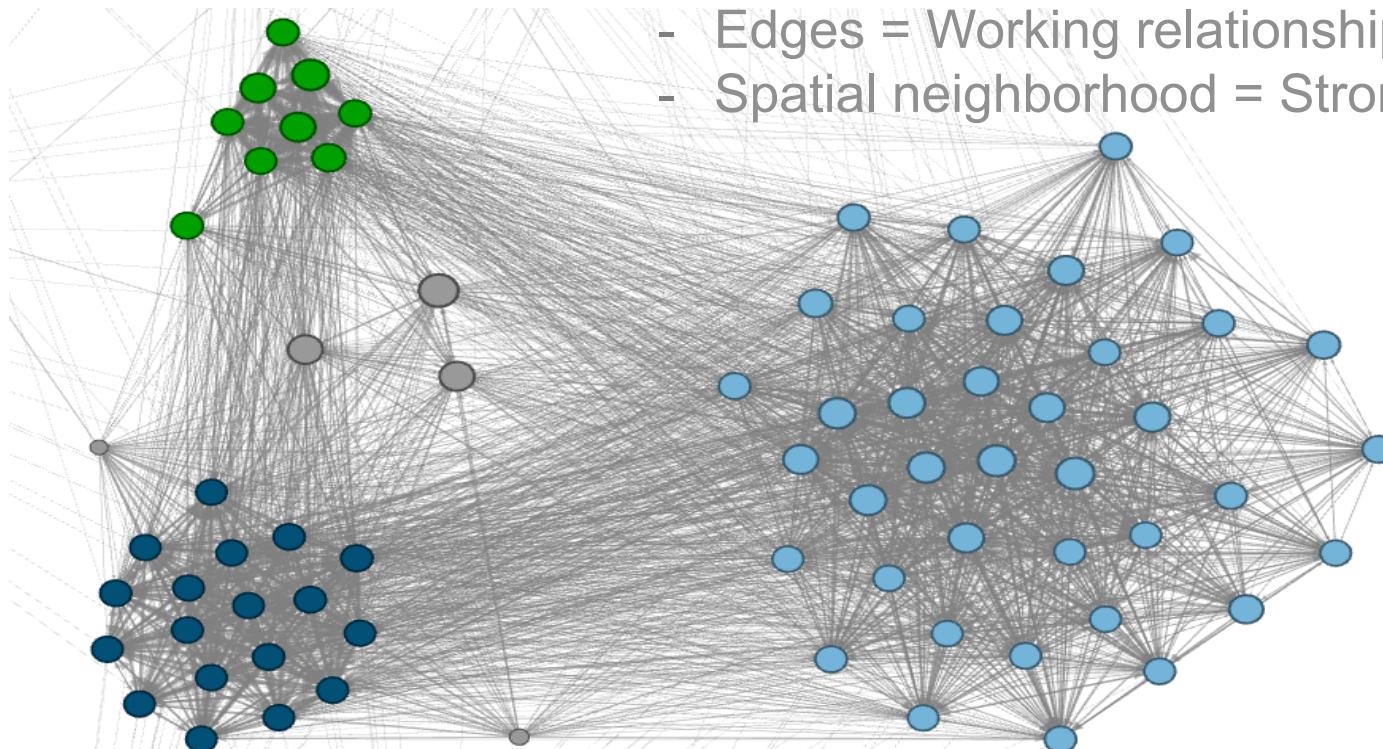
- Institutional architecture
 - Self-organized community building
 - Social information infrastructure: Reputation system



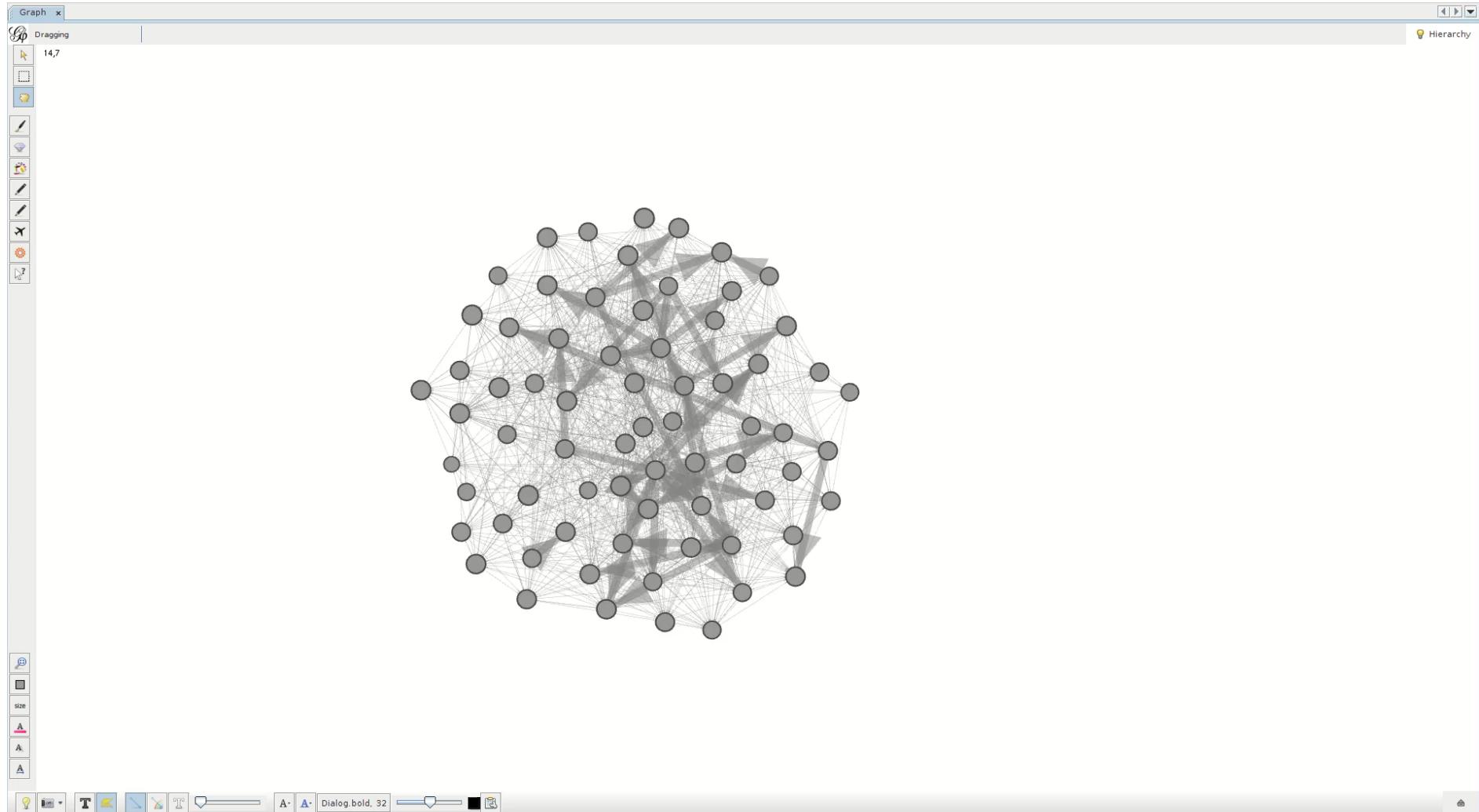
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- Formation of multi eTCs
- Self-scaling for large agent populations

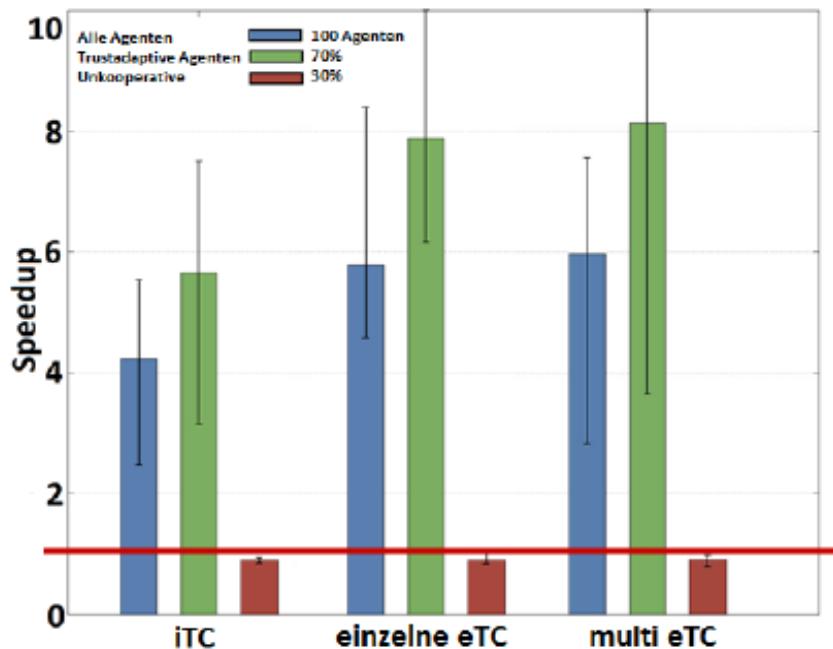
- Color = TC association
- Size = global reputation
- Edges = Working relationships/trust
- Spatial neighborhood = Strong working relation



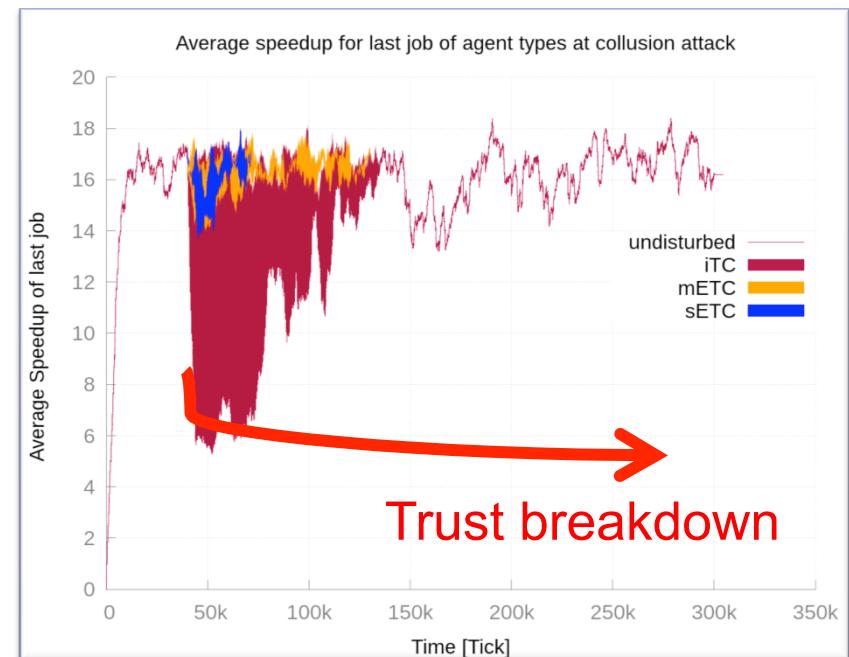




□ Speed-up x8



□ Robustness



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	Excludable	Non-excludable
Non-rivalrous		
Rivalrous		

	Excludable	Non-excludable
Non-rivalrous	Club goods cinemas, private parks	Public goods free-to-air TV, air
Rivalrous	Private goods food, clothing, cars	

	Excludable	Non-excludable
Non-rivalrous	Club goods cinemas, private parks	Public goods free-to-air TV, air
Rivalrous	Private goods food, clothing, cars	Common Pool Resources fish stock, timber, coal

e.g. Prisoners' Dilemma

□ Common Pool Resources

- Resource owned by no one: open access
- Risk of destruction: Overuse due to collective action (tragedy of the commons)

□ Solution

- Governance by common property regimes (E. Ostrom): Self-management in **Enduring Institutions**



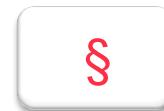
Elinor Ostrom: Nobel Prize in Economic Sciences 2009

Ostrom, E. (1990): Governing the commons: The evolution of institutions for collective action. Cambridge University Press

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□ An Enduring Institution is defined by 8 principles

1. Boundaries; ✓
2. Rules balancing demand and supply; !!
3. Monitoring; ✓
4. Sanctions for rule violations; !!
5. Conflict resolution mechanisms; X
6. Rule modification by democratic mechanisms; X
7. Self-control (no external interference); and ✓
8. Systems of systems ✓



Rules – Norms - Laws

§

$v \leq 50 \text{ km/h}$

$P = 80 \text{ €}$

□ Social norms ...

- are group-held beliefs about how members should behave in a given context:

Rules

- Examples

- Permission, allowance: You may donate money.
 - Order: Pay your taxes!
 - Interdiction: Do not tap telephone lines!

□ Sanctions ...

- are means of enforcement or incentives for obedience with the law.

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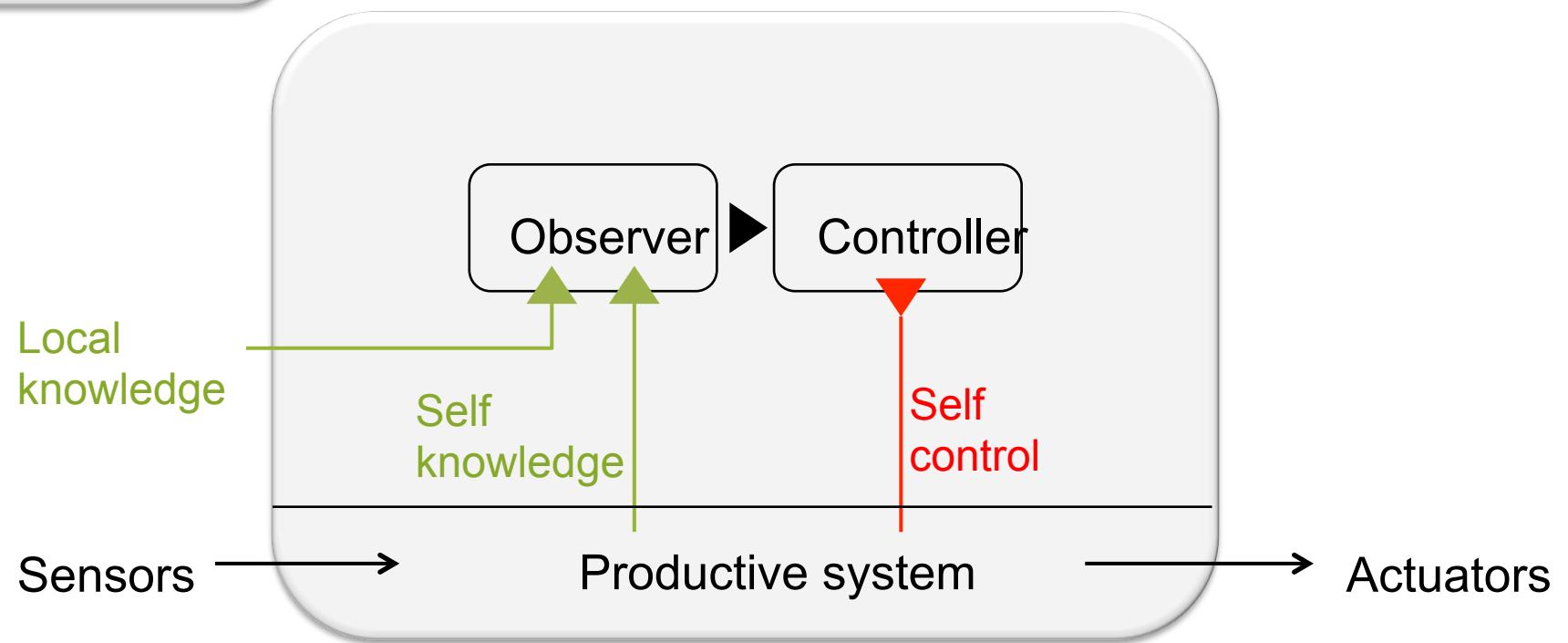
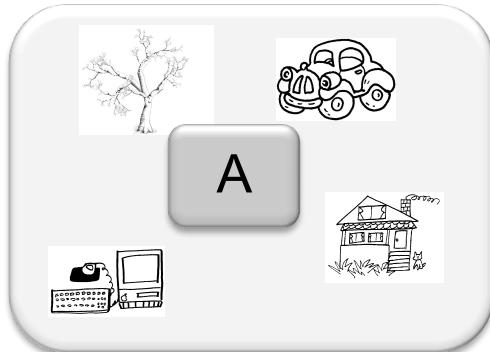
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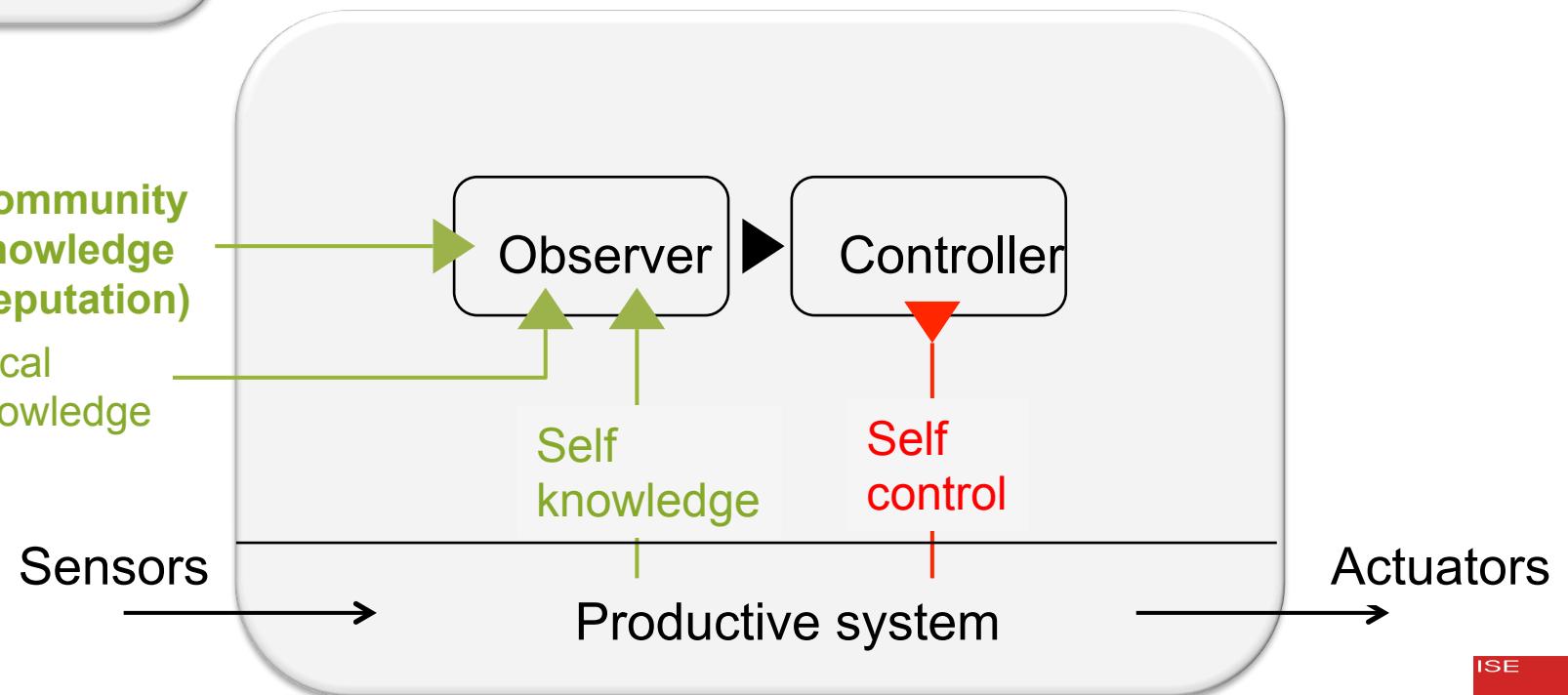
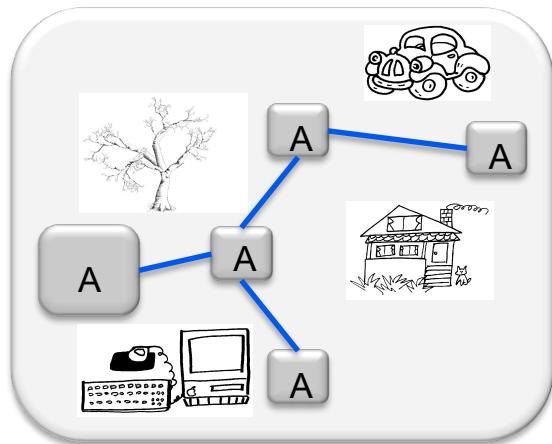
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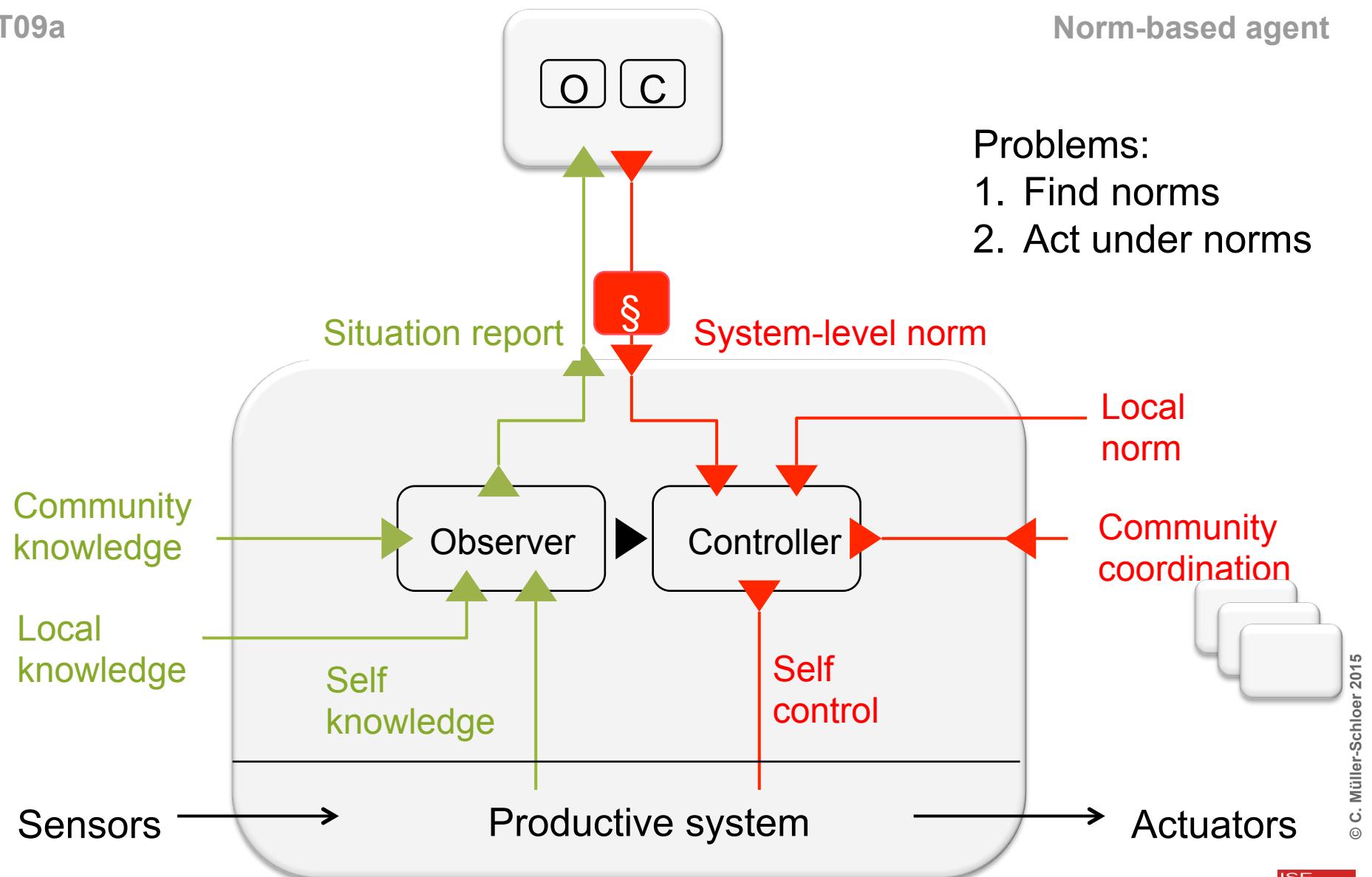
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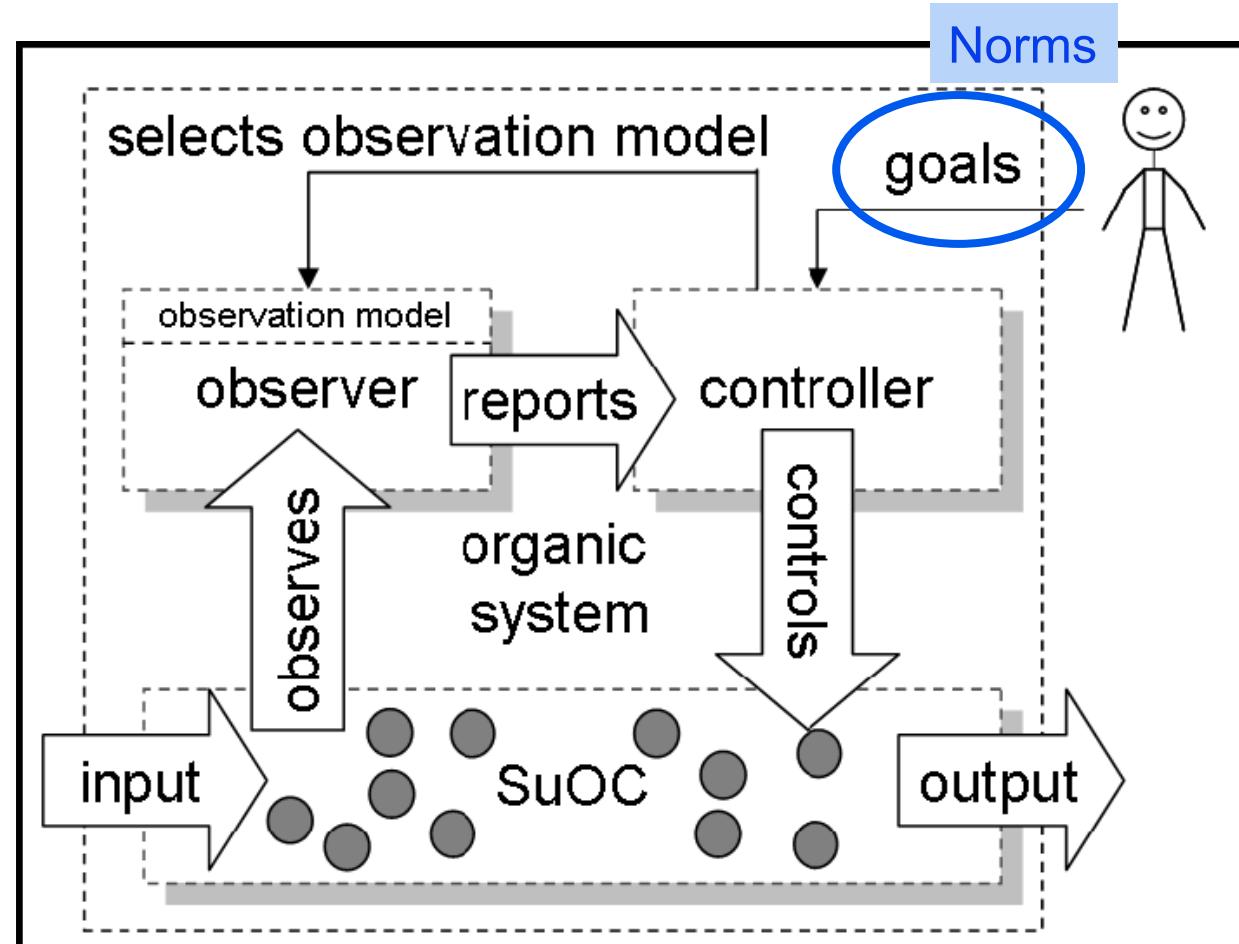
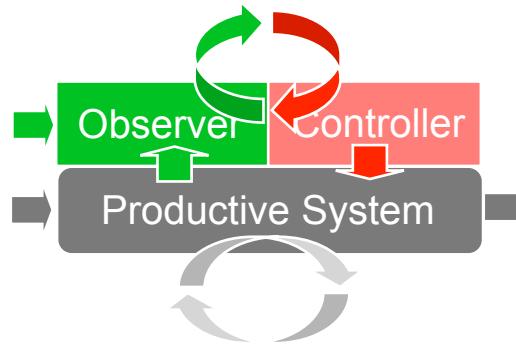
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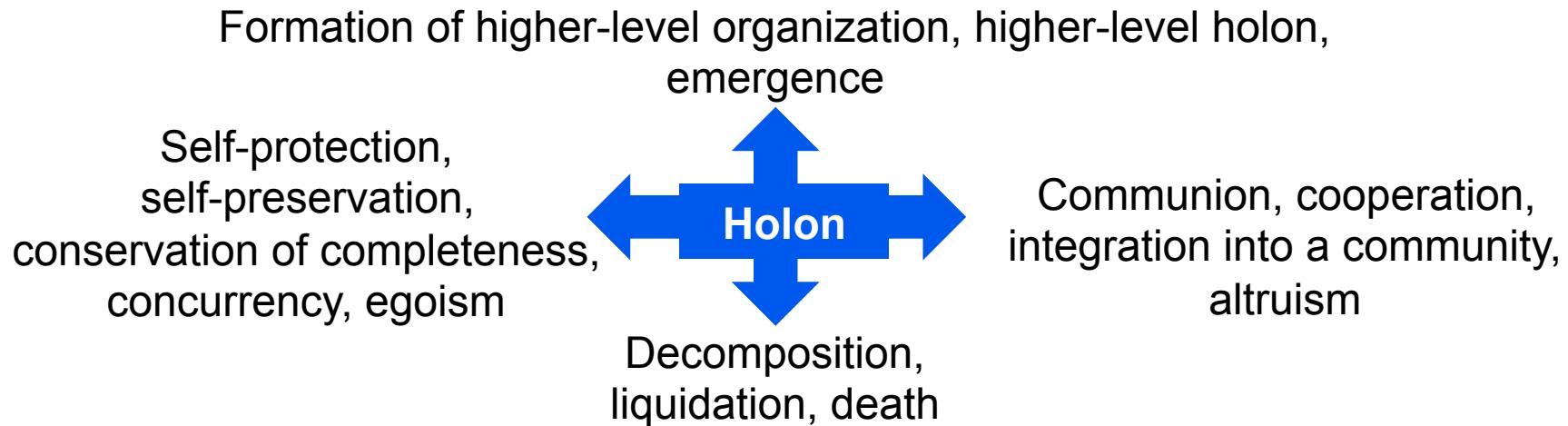


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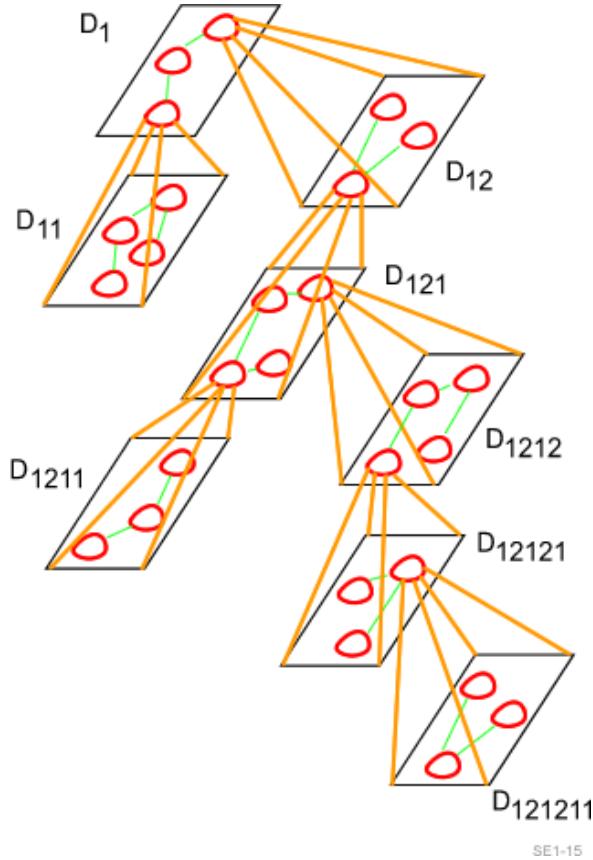
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- Technical subsystems (here modeled as agents) become more autonomous and cooperative.
 - **Autonomy means they have their own goals.**
 - **Cooperation means to demand services or behaviors from other agents and being subject to such demands from the outside.**
- This form of cooperation goes **beyond a rigid command** (i.e. call/return) relationship because in a world of uncertainty the default case is the non-fulfillment or the partial fulfillment of a demand.
- Agents with this kind of behavior are “**semi-autonomous**”, i.e. they try to follow their own goals while also trying to comply with external demands.
- We propose a generic mechanism to organize the cooperation between semi-autonomous agents in complex communities based on goals.



- Holons are characterized by a horizontal and a vertical axis of behaviors.
 - **Vertical:** A holon is a **nested structure**: Holons consist of holons which consist of holons... They can integrate into or des-integrate from these structures.
 - **Horizontal:** A holon must balance its behavior between its own interest (egoism, intrinsic dimension) and the interests of the environment (social / extrinsic dimension). This entails **reconciliation** of opposing interests.

OC-T09a



Koestler's holarchy



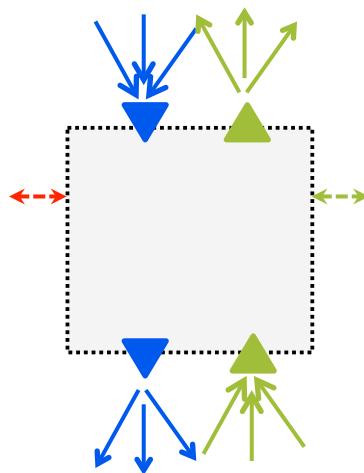
Janus

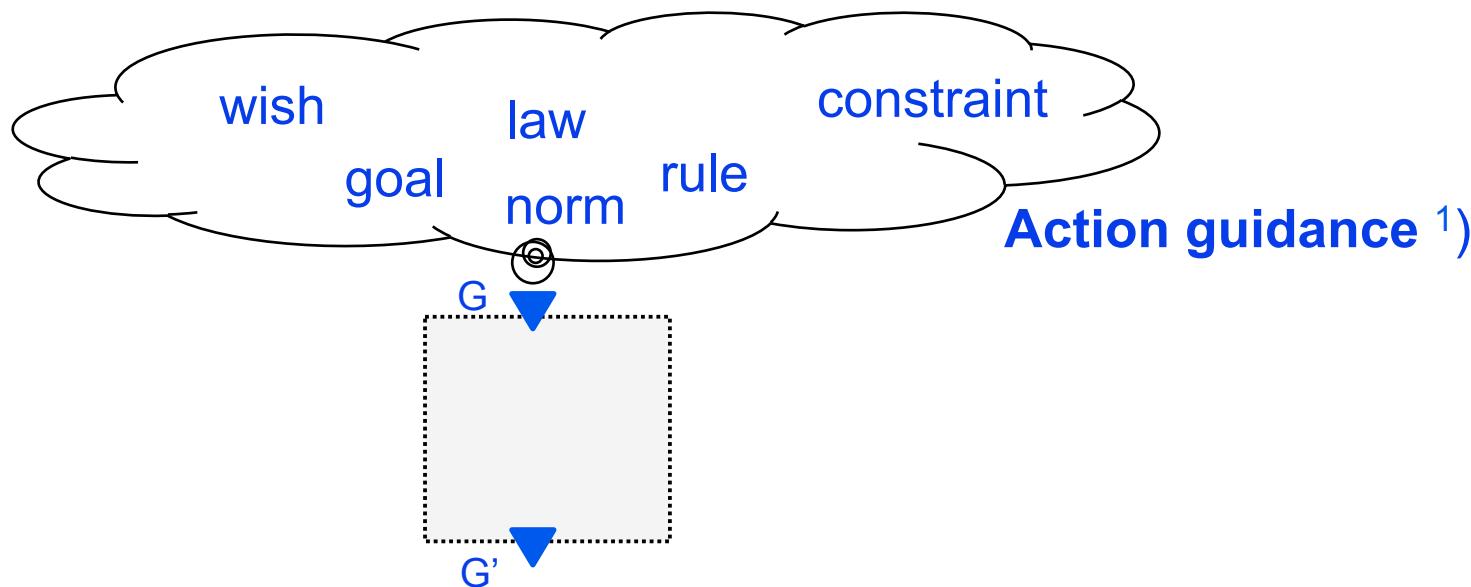
Every agent is at the same time

- a whole and
- a part.

□ A holonic agent needs

- ▼ ▪ a reconciliation mechanism for goal conflict resolution,
- ▼ ▪ a recursive nesting architecture to organize holonic sub-agents,
- ▲ ▪ an escalation mechanism in case of non-compliance, and
- a *formalization* of the expression of demands *from* the outside (goals ▼) and the reporting of (non-)compliance to the outside (replies ▲).

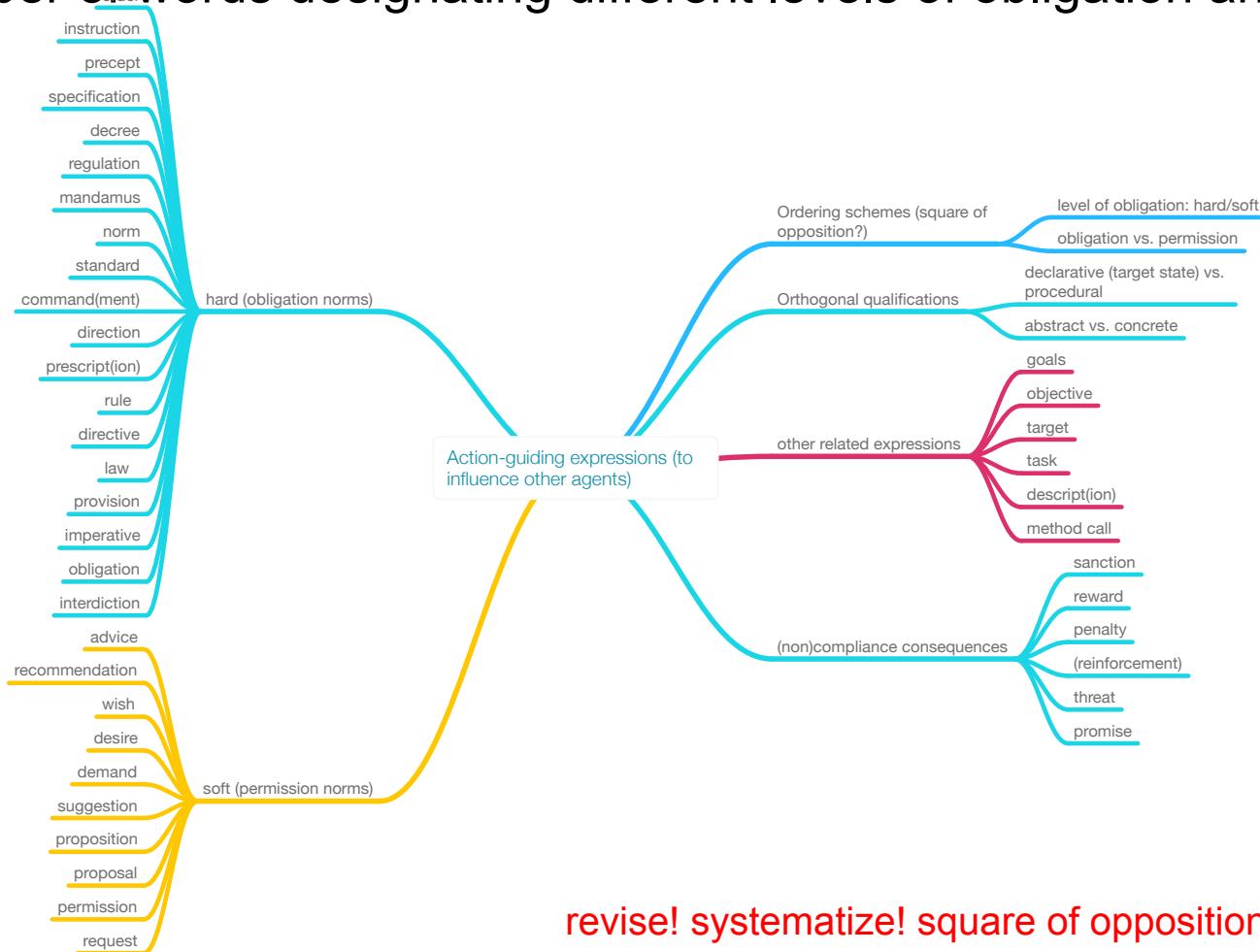




- Every agent is subject to various forms of **action guidance** from many different sources with a range of obligation levels and different flavors (affirmative/positive, permissive, prohibitive/negative).
- Norms** are a *special case* of action guidance.

¹⁾ Action guidance = Handlungsbeeinflussung. Erving Goffman (US-amerikanischer Soziologe) definiert Interaktion als eine „wechselseitige Handlungsbeeinflussung, die Individuen aufeinander ausüben, wenn sie füreinander anwesend sind.“ Niklas Luhmann übernimmt diesen Begriff...

Action guidance is an everyday aspect of social life. Therefore, we use a large number of words designating different levels of obligation and variants:



- The holonic agent has
 - an upward/outside interface
 - input: goal (prescript) **G**
 - output: reply (descript) **R**
 - a downward/inside interface
 - output: sub-goal (sub-prescript) **G'**
 - input: sub-reply (sub-descript) **R'**
 - a body for
 1. goal transformation, and
 2. reply escalation.

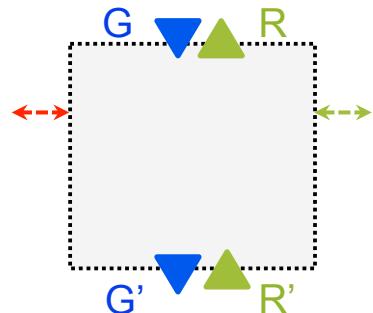
The upward/outside interface corresponds to the holon's member role as a goal receiver.
The downward/inside interface corresponds to the holon's role as a goal issuer.

The agent's own goals can be expressed explicitly in terms of self-prescripts as well.

A prescript is more than a goal. It comprises

1. a goal
2. an achievement policy
3. an activation context

see below



G: Top-down input: goal

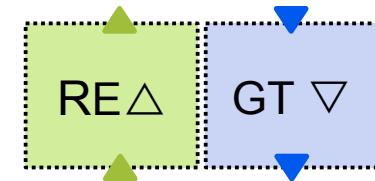
R: Bottom-up output: reply (report, affirmation, disaffirmation)

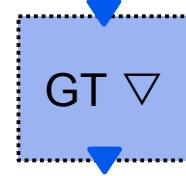
G': Top-down output: action, sub-goal

R': Bottom-up input: reply (report, affirmation, disaffirmation)

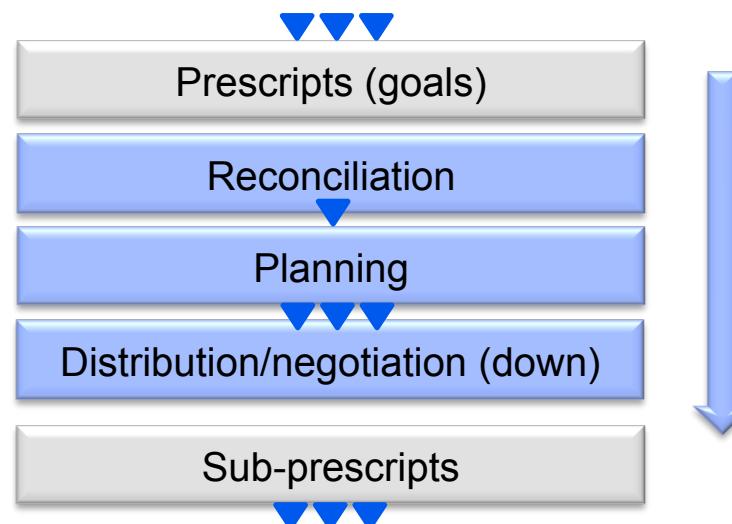
There might exist more than 1 goal/reply relationship.

- We break up the O/C cycle into a top-down part (goal transformation GT) and a bottom-up part for non-compliance and escalation handling (reply escalation RE).
- **Goal transformation (GT ∇)**
 - *Input:* goals (prescripts)
 - *Output:* control signals / sub-goals (sub-prescripts)
- **Reply escalation (RE Δ)**
 - *Input:* raw data / sub-descripts: (non-)compliance observations
 - *Output:* descripts: (non-)compliance observations

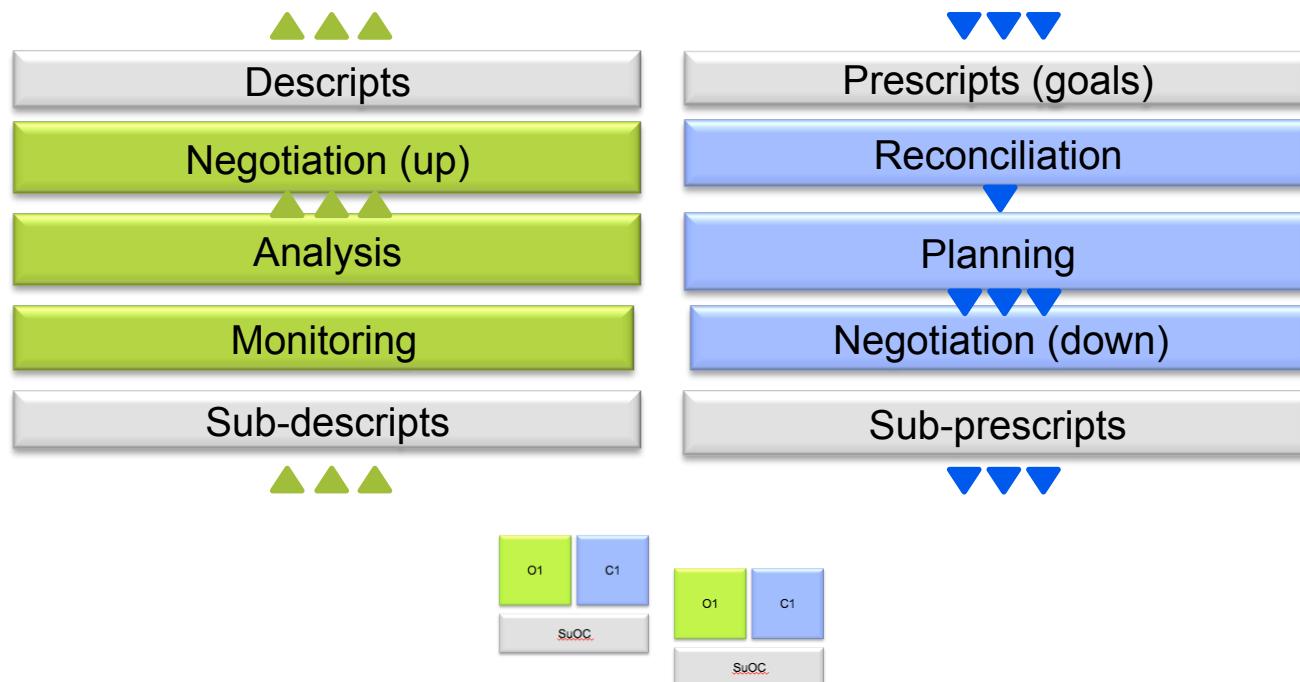
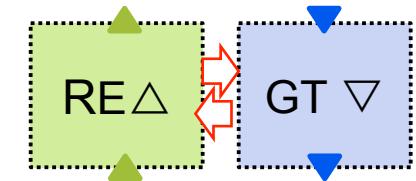




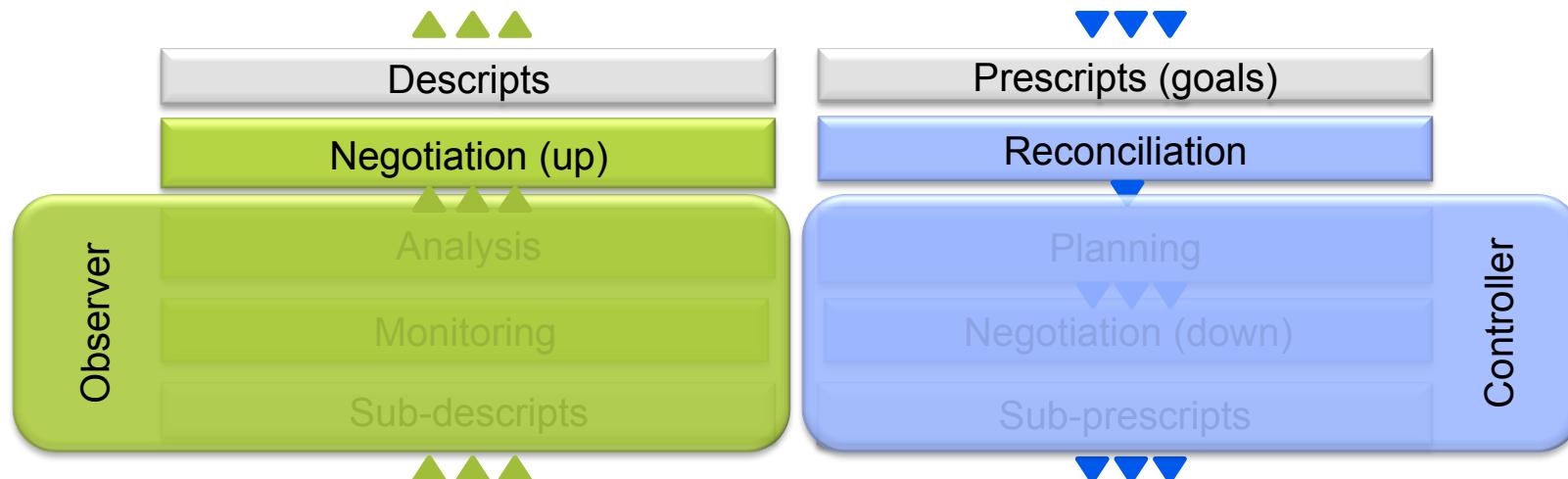
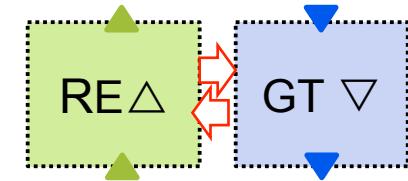
- **Goal transformation** consists of
 - **Goal reconciliation**: Find a solution for the combination of multiple possibly conflicting goals. This results in a single goal (the intended goal).
 - **Planning**: Define sub-goals (sub-prescripts).
 - **Distribution/negotiation**: Downward distribution of prescripts with negotiation



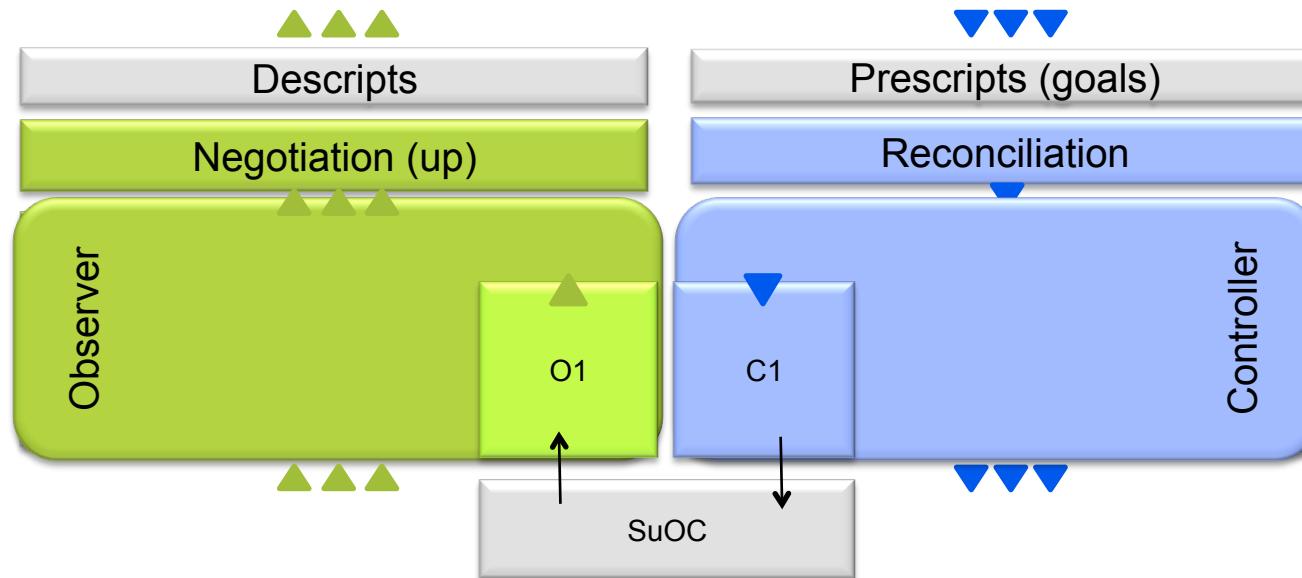
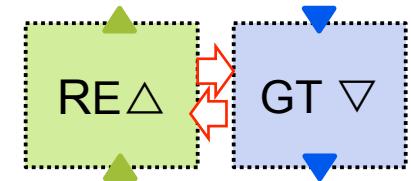
- **Reply escalation RE** consists of
 - **Monitoring**: monitors the replies (success of the goal execution),
 - **Analysis**: Evaluation, situation recognition, prediction
 - **Negotiation (up)**: Upward distribution of descripts with negotiation

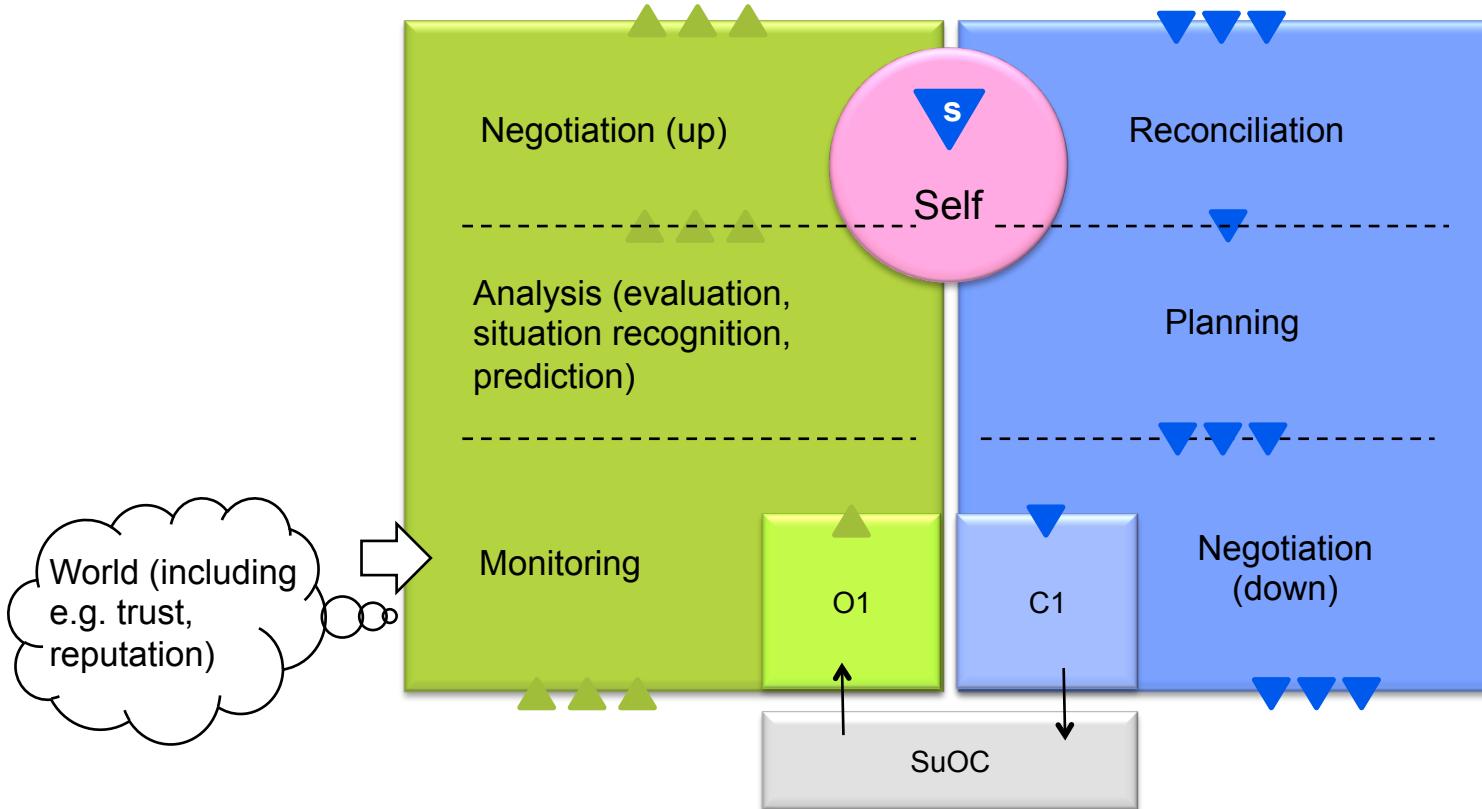


- **O/C architecture**
 - We have a classical observer/controller (MAPE) architecture for goal and reply handling...
 - plus two new upward oriented steps.
 - So far missing: Our agent can act itself, too.



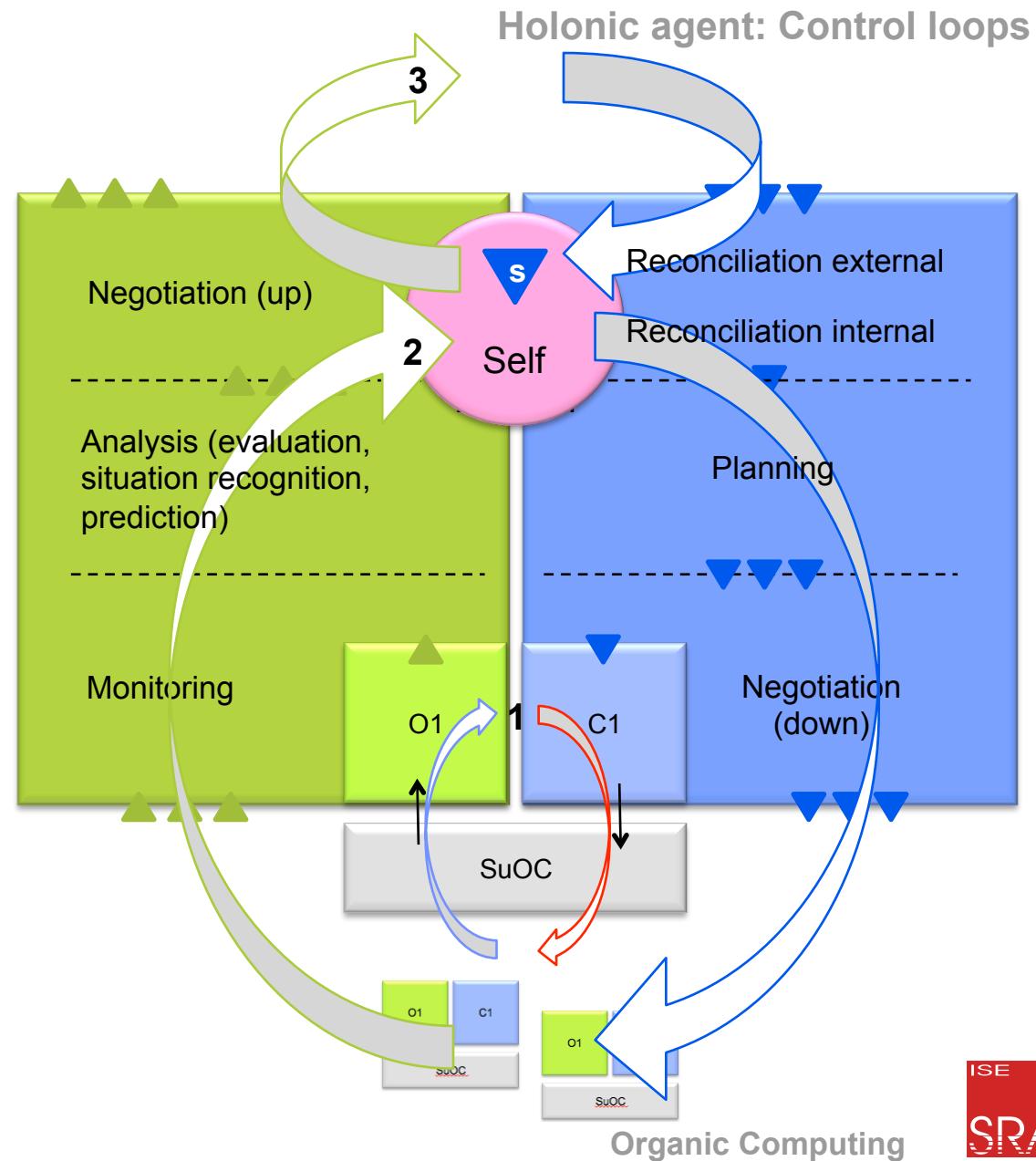
- Combination of goal/reply handling with local action by O1/C1.



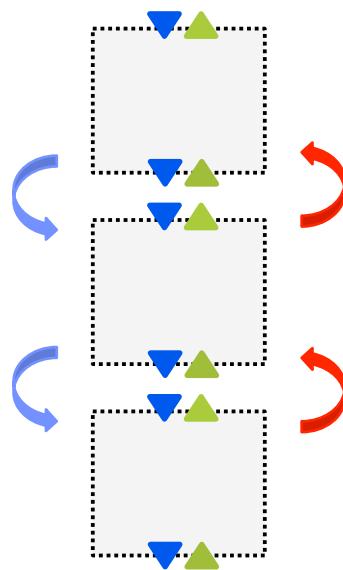


OC-T09a

- **Loop 1**
 - Goal is preserved; re-execution, re-planning
- **Loop 2**
 - Local goal (self goal) is modified.
- **Level 3**
 - Escalation to higher level (to issuer of the goal)

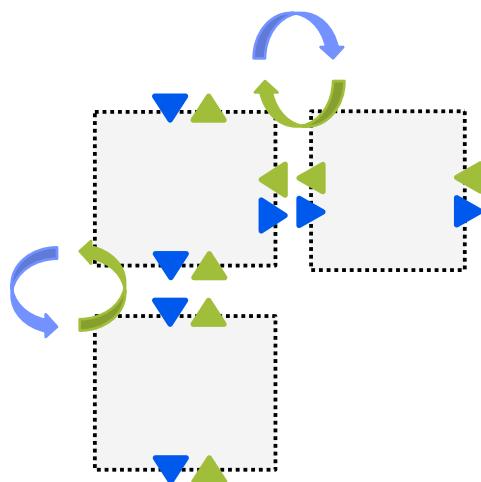


- If several **hierarchical** levels of agents are involved, the two-partner negotiation (escalation level 3) might lead to a further escalation extending upwards. This corresponds to an on-line version of the traditional off-line **yoyo design** process.



The relation of the agents is not necessarily hierarchical. Any network structure is possible. The specific form of cooperation is determined by the “obligation level*” of the goals.

- In a P2P organization all agents have the same obligation level.
- In a hierarchy, the higher-level agent has more “strength” than the lower level agent.



Open question: Is there a generic “strength” value of an agent which in turn determines/limits its ability to impose sanctions?

*) The obligation level can be expressed in terms of sanctions, see below.

1 Prescript formalization

- A **prescript** is a formalization of a *demand* for an agent to do something (an action guidance) expressed by an external issuer or by the agent itself.
- A prescript has an originating agent (*issuer*, in some cases the authority) and a destination agent (*target*, also called the subject).
- Prescripts are modeled as a triple
 - **prescript := <goal/action; policy if (not) achieved; activation context>**
- A **Goal/action** specifies **what** has to be achieved.
- A **Policy** specifies the action envisaged by the issuer of the prescript as a consequence of compliance/non-compliance.
- Prescripts might be active only in a certain **context** (scope, time...).

- A **Goal/action** specifies **what** has to be achieved:
- This can assume the form of a procedure (low-level: a single action, a list of actions), or a desired end state (abstract, high-level: a goal, an objective).
 - Goals are **declarative** specifications of the desired result (what).
 - Actions are **procedural** specifications (how).
- A clear distinction between goal and action is not always possible.

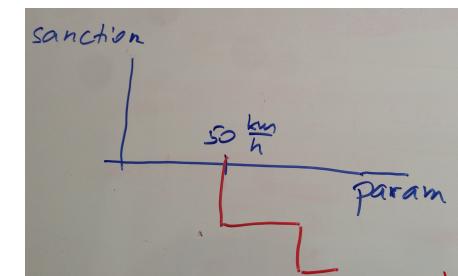
Therefore **we subsume the action under the term goal**.

- The demand for a robot to “Go from A to B” might be an atomic action from the issuer point of view. For the robot, it might involve a series of single actions.
- In this sense, even a procedure call might be understood as a goal.
- We might say: For the issuer, everything is an action, for the target, everything is a goal.
- Pragmatically, there will always be a final lowest level, which will be executed without being first translated.

A **policy** specifies envisaged consequences to be imposed in case the demand is (not) fulfilled.

- policy := <execution option; consequence (i.e. sanction); probability>
- sanction can be positive (reward) or negative (penalty)
- A probability is usually assigned/learned/estimated by the target agent.
- The execution option specifies the possible forms of compliance:
 - do not: non-compliance
 - do: compliance
 - modify-do (param): range of compliance possibilities over a parameter *param*, where the sanction depends on *param*.

execution option	consequence	probability
do not	sanction	p.dn
do	sanction	p.d
modify-do (param)	sanction = f(param)	



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2 Descript formalization

- A **descript** is a formalization of a reply....
 - link to the prescript (specifies the prescript which has triggered this reply)
 - chosen execution option
 - degree of achievement (Grad der Zielerreichung)
- The execution option specifies the form of actual compliance:
 - do: compliance
 - do not: non-compliance
 - modify-do (param): range of compliance possibilities over a parameter *param*, where the sanction depends on *param*.

ToDos

- In order to implement such systems we need:
 1. Formalisms
 1. to express action guidance by **prescripts**
 2. to express replies by **descripts** → tbd
 2. a Holonic **system architecture** → see Ada's paper "Towards a generic goal-oriented architecture for autonomic computing"
 3. a **goal reconciliation method** (inside the agent) → multi-criteria optimization (tbd)
 1. local
 2. multi-party
 4. a **planning** mechanism: translation goal → sub-goal (prescript → sub-prescript) tbd
 5. an **example** (tbd): e.g. rendering on TDG