AORTA: Adding Organizational Reasoning to Agents

Andreas Schmidt Jensen

Technical University of Denmark, Kgs. Lyngby, Denmark
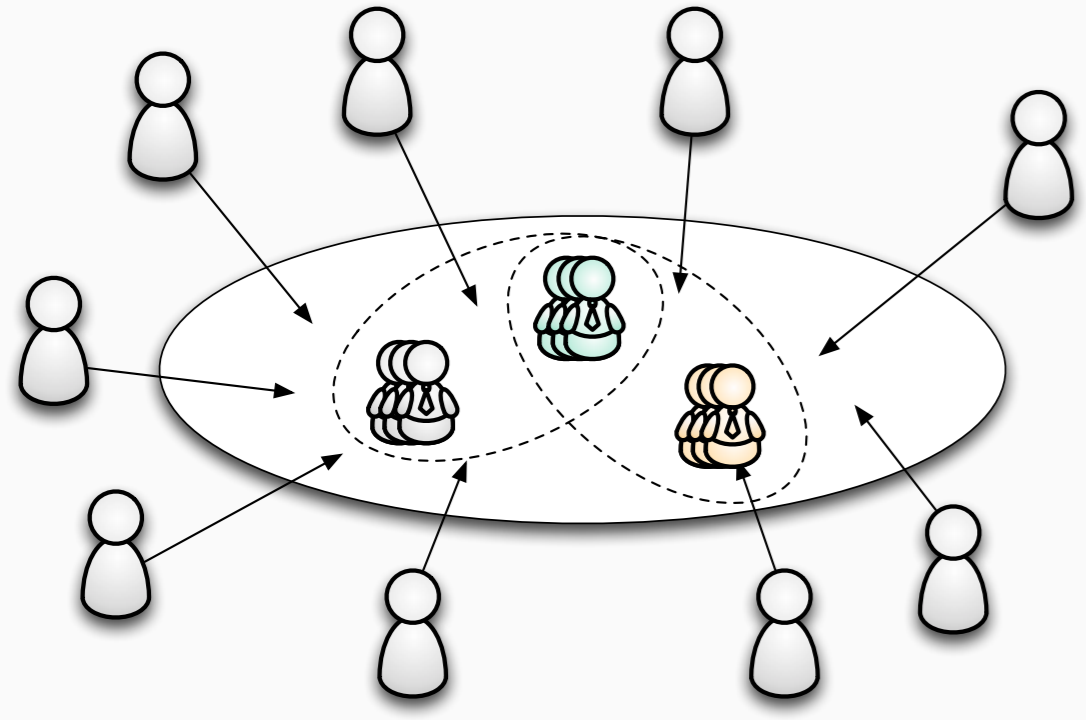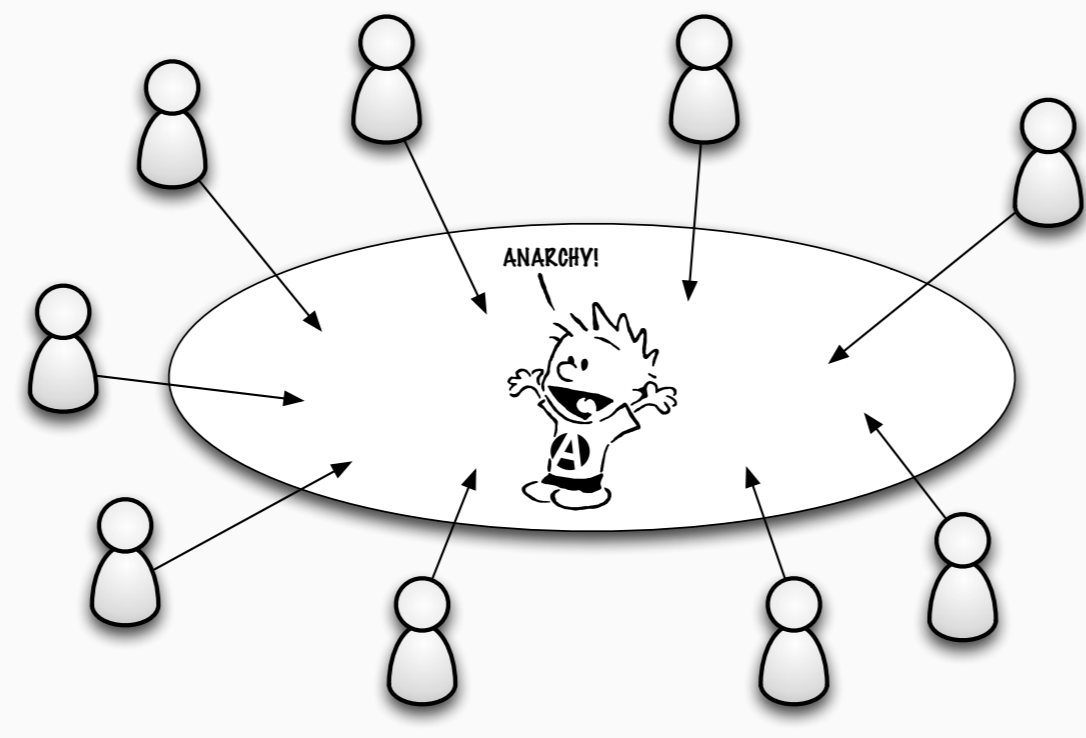
Virginia Dignum

Delft University of Technology, Delft, The Netherlands

1. Motivation

We consider *agents* in *open societies*

- Limited control of the agents in the society.
- Makes it difficult to
  - → assume any kind of agent behavior.
  - → ensure completion of global objectives.

Using organizations as regulation

- Organizations regulate agents entering a society.
- An abstract description of the expectations of agents in the society.
- Contains predefined boundaries that should not be violated.

We propose AORTA as a way to make agents **organization-aware** [4]. The AORTA system
- → integrates organizational reasoning into existing agent platforms, and
- → works with different organizational models.

Reasoning in AORTA is based on an organizational metamodel

- An **organizational model** is an explicit representation of an organization.
- Often based on **roles** and **objectives**
  - → Roles abstract implementation details away from expectation.
  - → Objectives define the desired outcome.
  - → Roles **depend** on each other for objective completion.
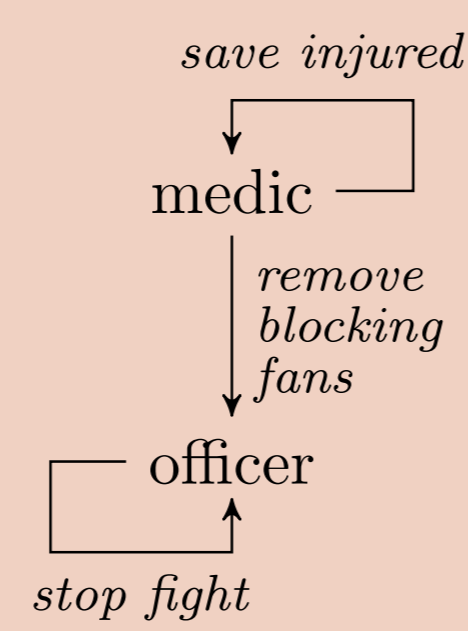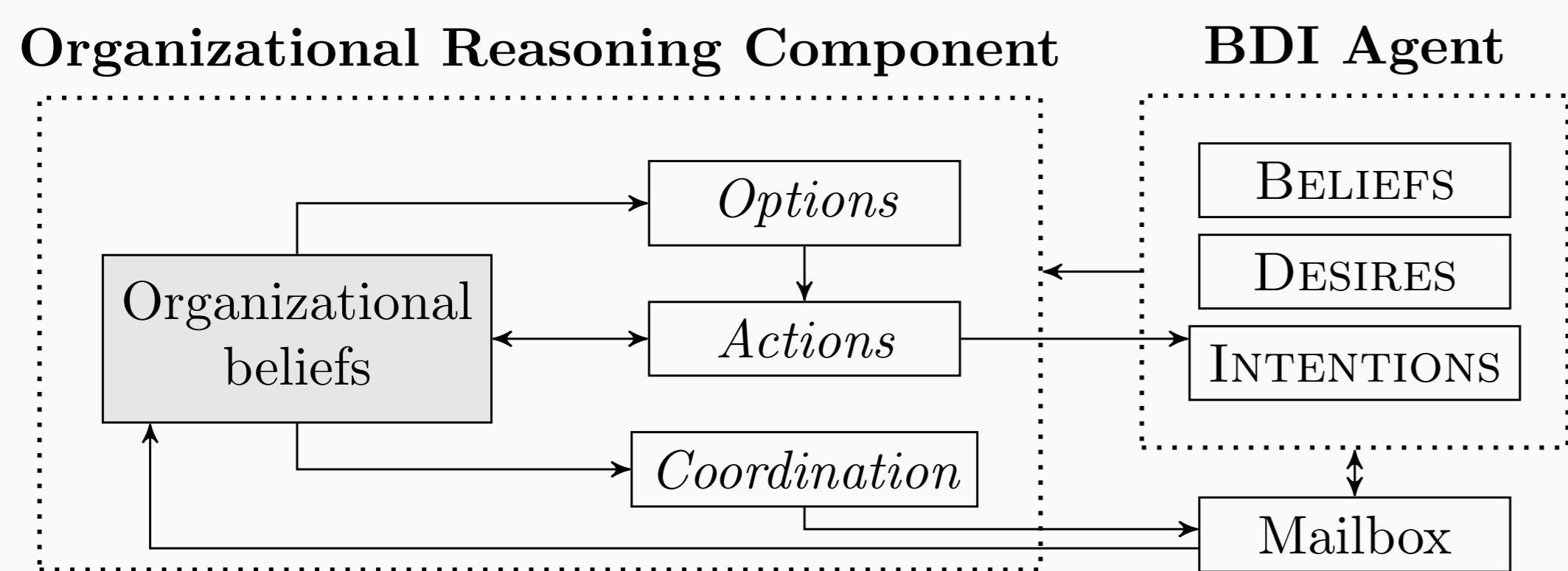- AORTA supports different organizational models (e.g. OperA, MOISE^+).

Fig. 2: Roles, objectives and role dependency.

2. Adding Organizational Reasoning to Agents

- AORTA provides organizational reasoning capabilities to agents.
- AORTA-agents are enriched with an **organizational reasoning component** (ORC).
- The ORC divides organizational reasoning into
  - → *organizational option generation* (I **can** enact the role),
  - → *organizational action deliberation* (I **enact** the role), and
  - → *organizational coordination* (I **inform** others about my role).

Organizational Reasoning Component — **BDI Agent**

Bob believes he can rescue people – $\Sigma_a \models can\_rescue$.

$$\text{bel}(can\_rescue) \implies \text{consider}(\text{rea}(bob, medic))$$

Bob now considers the role enactment an option; he can enact the role:

$$\text{opt}(\text{rea}(bob, medic)) \land \text{bel}(no\_medics < 2) \implies \text{enact}(medic)$$

3. Operational Semantics

- AORTA is formalized using structural operational semantics [3].
- Reasoning formulas **query** the mental state.
- Actions **alter** the mental state.
- **Reasoning rules** – $\rho \implies a$ – execute actions.
  - → Applicable when $MS \models \rho$
  - → Transition function: $\mathcal{T}(a, MS) = MS'$

Reasoning Formulas ρ	Mental state MS	Actions a
$\text{org}(\phi)$	Organization Σ_o	$\text{enact}(role)$
$\text{opt}(\phi)$	Options Γ_o	$\text{consider}(org\_fml)$
$\text{bel}(\phi)$	Beliefs Σ_a	
$\text{goal}(\phi)$	Goals Γ_a	$\text{commit}(objective)$

Scenario: Crisis Response

After a match between Manchester United and Manchester City, the fans are fighting and some of them are badly hurt. The authorities have been contacted, and a number of medics and police officers (the first-responders) have arrived. The medics are supposed to help the injured, while the police officers are supposed to break up the fight. However, fans of one group will not allow medics to help the injured from the other group.

4. Evaluation

- Scenario implemented in Blocks World for Teams [2].
- Evaluated using **Jason**+AORTA [1].
- Using a simple, linear strategy
  1. Check for incoming organizational messages (CHK)
  2. Check for external events (EXT)
  3. Consider options (OPT)
  4. Execute actions (ACT)
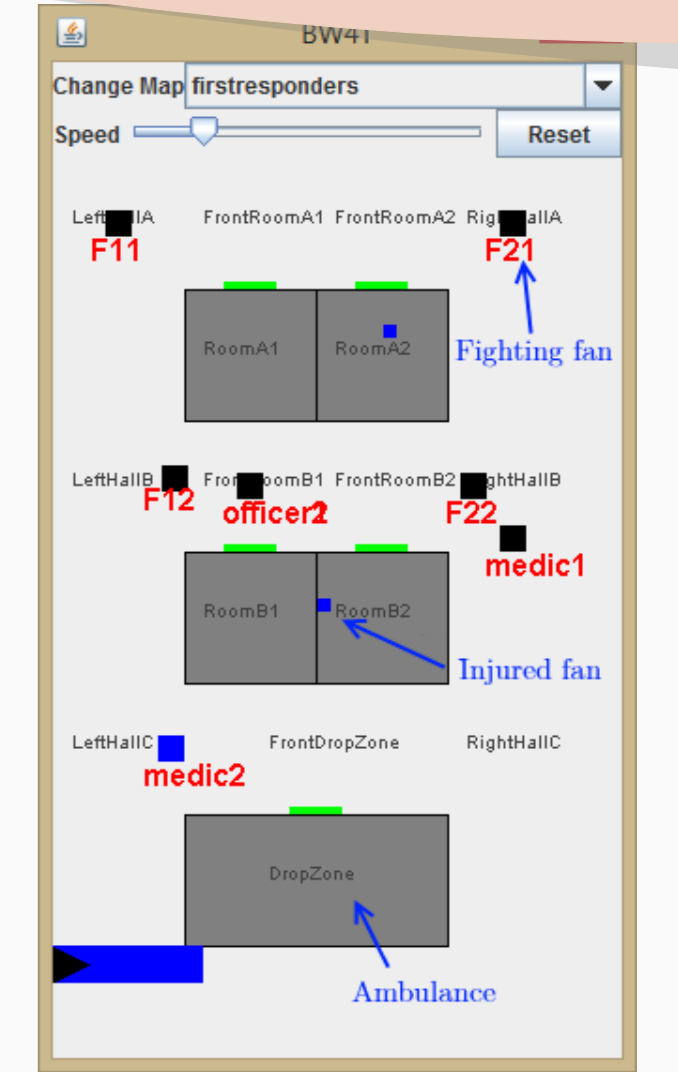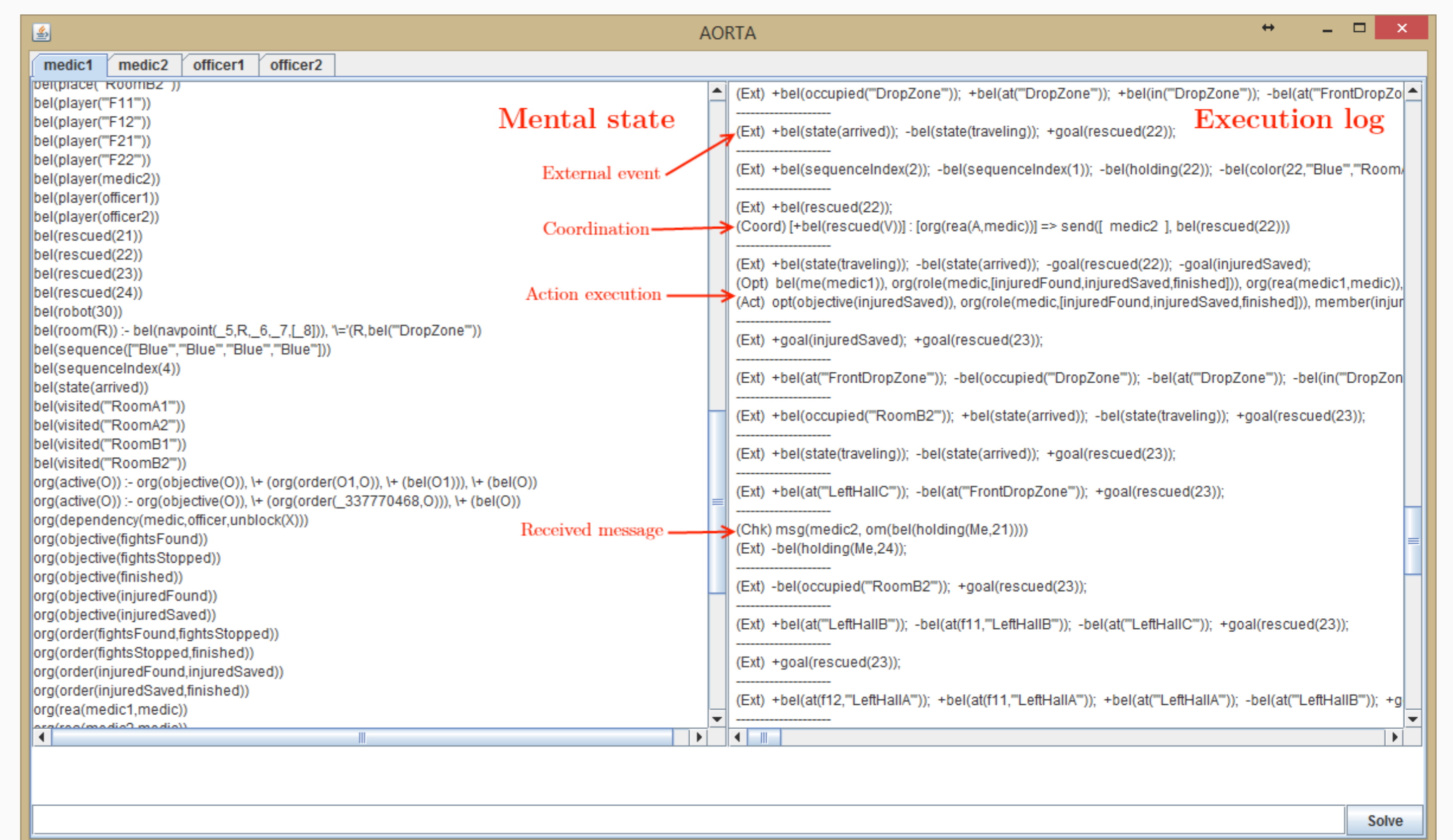 5. Perform organizational coordination (COORD)

Fig. 3: Blocks World for Teams

Fig. 4: The **Jason**+AORTA interface.

1. Alice enacts the medic role and informs Bob.

$$\text{enact}(medic) \quad (\text{ACT})$$
$$\text{msg}(\{bob\}, \text{org}(\text{rea}(alice, medic))) \quad (\text{COORD})$$

2. She finds an injured fan in one of the rooms, commits to rescuing him and informs Bob.

$$\text{bel}(injured(fan1, room1)) \quad (\text{EXT})$$
$$\text{commit}(rescue(fan1)) \quad (\text{ACT})$$
$$\text{msg}(\{bob\}, \text{bel}(injured(fan1, room1))) \quad (\text{MSG})$$

3. Bob informs that the fan is saved and Alice drops her commitment.

$$\text{msg}(bob, \text{bel}(rescued(fan1))) \quad (\text{CHK})$$
$$\text{drop}(rescue(fan1)) \quad (\text{ACT})$$

5. Conclusion

Now

- AORTA provides agents with organizational reasoning capabilities.
  - → Integrates with BDI agents.
  - → Independent from the organization.
- Integrated into the **Jason** agent platform.
- Organization is decentralized.
  - + Removes need for "gatekeepers".
  - − Needs synchronization of organizational beliefs.
  - − Can prove hard to regulate.

Future

- Integration with other agent platforms.
- Model checking organization-aware agents.
- Support for norms and normative multi-agent systems.
- Centralization of certain aspects
  - → Extract organization into a shared component; an AORTA-organization.
  - → Using artifacts or a middleware.

References

[1] A. S. Jensen, V. Dignum, and J. Villadsen. The AORTA architecture: Integrating organizational reasoning in *Jason*. In *Pre-proceedings of EMAS 2014*, pages 112–128, 2014.

[2] M. Johnson, C. Jonker, M. B. van Riemsdijk, P. J. Feltovich, and J. M. Bradshaw. Joint activity testbed: Blocks world for teams (BW4T). In *Engineering Societies in the Agents World X*, pages 254–256, 2009.

[3] G. D. Plotkin. A structural approach to operational semantics. Technical report, University of Aarhus, 1981.

[4] M. B. Riemsdijk, K. Hindriks, and C. Jonker. Programming organization-aware agents. In *Proc. of 10th Int. Workshop on Engineering Societies in the Agents World*, ESAW '09. Springer, 2009.

Technical University of Denmark

TUDelft