AORTA: Adding Organizational Reasoning to Agents (Extended Abstract)

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ABSTRACT

Open systems are characterized by a diversity of heterogeneous and autonomous agents that act according to private goals, and with a behavior that is hard to predict. They can be regulated through organizations similar to human organizations, which regulate the agents' behavior space and describe the expected behavior of the agents. Agents need to be able to reason about the regulations, so that they can act within the expected boundaries and work towards the objectives of the organization.

This extended abstract introduces AORTA, a component that can be integrated into agents' reasoning mechanism, allowing them to reason about (and act upon) regulations specified by an organizational model using simple reasoning rules. The added value is that the organizational model is independent of that of the agents, and that the approach is not tied to a specific organizational model.

Categories and Subject Descriptors

I.2.11 [**Artifical Intelligence**]: Distributed Artificial Intelligence—*Coherence and coordination, Intelligent agents, Languages and structures, Multiagent systems*

Keywords

Multiagent Systems; Organizations; Operational Semantics

1. INTRODUCTION

In open systems, agents can enter and exit freely, thus these systems will often contain many heterogeneous agents. Since it is hard to predict and control the agents' behavior, such systems need to be regulated, for example, by restricting the agents' behavior space or by introducing norms that specify how the agents are supposed to behave [1]. Regulations are useful, if the agents being regulated are able to reason about the regulations. If agents take regulations as constraints, they always behave well, but are not able to act flexibly. Regulations are often specified as organizational models, usually using roles that abstract away from specific agent implementations such that any agent will be able to enact a given role.

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Agents that are able to reason about organizations are *organization-aware* [3]. Such reasoning includes (but is not limited to) understanding the organizational specification, acting using organizational primitives, and cooperating with other agents in the organization to complete personal or organizational objectives. From the agent's perspective, there are two sides to organizational reasoning. First, how can the agent contribute to the objectives of the organization, and second, how can the agent take advantage of the organization, once it is a part of it.

In this extended abstract, we present AORTA[1], an organizational reasoning component that can be integrated into the agent's reasoning mechanism, allowing it to reason about (and act upon) regulations specified by an organizational model using simple reasoning rules. That is, assuming the organization to be preexisting and independent from the agent, the component is agent-centered, focusing on reasoning rules that specify how the agent reasons about the specification. By completely separating the organization from the agent [4], the architecture of the agent is independent from the organizational model, and the agent is free to decide on how to use AORTA in its reasoning. The separation is achieved by basing the component on reasoning rules using the organizational ontology, which differs depending on the organizational model being used. We show how the component can be used to extend BDI-agents and we provide operational semantics for organizational reasoning.

2. ORGANIZATIONAL REASONING

Organizational reasoning as a concept covers many aspects: reasoning about entering and exiting an organization, reasoning about which roles to enact, whether to comply or violate certain norms and how to coordinate with other members of the organization in order to complete certain organizational objectives. This suggests certain capabilities are required for agents that want to reason about organizational concepts.

Classical BDI agents are represented by sets of beliefs, desires and intentions, where desires are possible states of affairs that the agent might want to realize, and intentions are those states of affairs that the agent has committed to (attempt to) realize. A similar approach can be taken for organizational reasoning: the agent holds beliefs about the organization and can use that for reasoning about objectives that should be achieved, roles that can be enacted, norms that are enforced, and so on. In AORTA the mental state, *MS*, is queried using *reasoning formulas*.

[1] **A**dding **O**rganizational **R**easoning **t**o **A**gents.

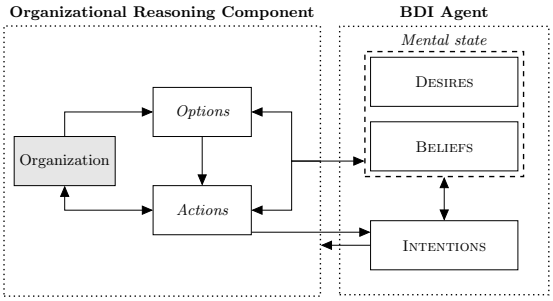

Figure 1: The Organizational Reasoning Component of AORTA.

Reasoning formulas, $\mathcal{L}_R$, with typical element ρ, are based on organizational formulas, option formulas, belief formulas and goal formulas:

$$\rho ::= \top \mid \mathsf{org}(\phi) \mid \mathsf{opt}(\phi) \mid \mathsf{bel}(\phi) \mid \mathsf{goal}(\phi) \mid \neg\rho \mid \rho_1 \wedge \rho_2,$$

where ϕ is a propositional formula. The reasoning formulas query the organizational, option, belief and goal bases, respectively.

2.1 Operational semantics

Organizational reasoning in AORTA is divided into two main parts: *organizational option generation* and *organizational action deliberation*. An organizational option is something that the agent should consider, such as an organizational objective or a role. An organizational action is the execution of an organizational option: enacting a role or committing to an organizational objective. This creates the expectation (for the organization) that the agent should somehow believe it is able to achieve it (by itself or by cooperation). Deceitful agents might know that they cannot achieve an organizational objective, but will commit to it anyway to disturb the organization, or to achieve their private goals.

AORTA-agents have organization-specific actions, such as considering certain options (what happens by enacting a certain role, pursuing an objective), or performing organizational actions (enacting a role, committing to an objective).

Definition 1. (Organization-specific actions) The set of options with typical element a_O is denoted Opt and the set of actions with typical element a_A is denoted Act.

$$\begin{array}{lcl} a_O & ::= & \mathsf{consider}(\phi) \mid \mathsf{disregard}(\phi) \\ a_A & ::= & \mathsf{enact}(\rho) \mid \mathsf{deact}(\rho) \mid \mathsf{commit}(\phi) \mid \mathsf{drop}(\phi) \end{array}$$

The *organizational reasoning component* of AORTA is depicted in figure 1. Based on the agent's mental state AORTA can determine which organizational options to choose, and the organizational actions might change the mental state. In order to consider the available organizational options, AORTA uses the agent's capabilities and intentions. AORTA furthermore lets agents commit to objectives: an organizational action leads to change in the agent's intentions, corresponding to the fact that the agent commits to the objective. Reasoning rules are used to decide which actions to execute.

Definition 2. (Reasoning rules) The sets of option rules, $\mathcal{R}_O$ and action rules, $\mathcal{R}_A$ are defined as follows.

$$\begin{array}{lcl} \mathcal{R}_O & = & \{\rho \implies a_O \mid \rho \in \mathcal{L}_R, a_O \in \mathsf{Opt}\} \\ \mathcal{R}_A & = & \{\rho \implies a_A \mid \rho \in \mathcal{L}_R, a_A \in \mathsf{Act}\} \end{array}$$

Actions are executed using transition functions, $\mathcal{T}_O$ for organizational options and $\mathcal{T}_A$ for organizational actions. Each action is only applicable in certain states. $\mathsf{consider}(\phi)$ can only be applied if ϕ is a proposition in the organizational knowledge base, and the effect is that ϕ is added to the options base. Role enactment, $\mathsf{enact}(\rho)$, is applicable only when ρ is the name of a role, the agent does not currently enact that role, and it does not enact a role that is in conflict with ρ. Commitment, $\mathsf{commit}(\phi)$, is possible only if ϕ is an organizational objective, and ϕ is not already a belief or a goal. $\mathsf{disregard}(\phi)$, $\mathsf{deact}(\rho)$ and $\mathsf{drop}(\phi)$ simply remove the respective formula from the appropriate knowledge base.

The action execution transition rule is shown below. The corresponding rule for option execution is similar and has been omitted.

Definition 3. (Action execution)

$$\frac{\rho \implies a_A \in AR \quad MS \models_{\mathcal{L}_R} \rho \quad \mathcal{T}_A(a_A, MS) = MS'}{MS \longrightarrow MS'}$$

For example, given an agent, α, which has the option of enacting role r_1 ($\mathit{rea}(\alpha, r_1)$) and believes it is capable of enacting it ($\mathit{capable}(r_1)$). The following rule will, when executed, result in a new state, where the agent enacts r_1.

$$\mathsf{opt}(\mathit{rea}(\alpha, r_1)) \wedge \mathsf{bel}(\mathit{capable}(r_1)) \implies \mathsf{enact}(r_1)$$

That is, $\mathit{rea}(\alpha, r_1)$ is now entailed by the organizational knowledge base.

3. CONCLUSION & FUTURE WORK

In this extended abstract we have introduced AORTA, which is a component integrated into agents, allowing them to reason about organizational models. That is, AORTA-agents are *organization-aware* and are able to decide whether or not to act according to regulations put forward by the organization. Our approach is agent-centered, and independent from the organization, allowing agents to join open systems which are regulated by arbitrary organizations. We achieve this by basing the component on reasoning rules that uses the ontology of the organizational model.

We are currently working on integrating AORTA into the agent platform *Jason* [2]. This will allow us to simulate more complex scenarios with more agents, and furthermore, by dropping the assumption that agents are cooperative, investigate what happens when organization-aware self-interested agents enter open multi-agent systems.

4. REFERENCES

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