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A Framework for Organization-Aware Agents

(JAAMAS Extended Abstract)

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ABSTRACT

This short paper introduces and summarizes the AORTA reasoning framework that can be integrated into BDI-agents to enable organizational decision-making. This work has recently been published in the Journal of Autonomous Agents and Multi-Agent Systems (JAAMAS), as [3].

Keywords

Autonomous Agents; Multi-Agent Systems; Organizations; Operational Semantics

1. INTRODUCTION

Open systems are characterized by the presence of a diversity of heterogeneous and autonomous agents that act according to private goals. Organizations, such as those existing in the real-world to structure human activities, can also be used to describe and regulate the agents' behavior space. The success of an agent's participation in an open system depends on its ability to understand and reason about the system organization (roles, rules and ontologies). Assuming an environment where agents are developed independently of the organizational structures, it is necessary to endow those agents with information and functionalities that enables them to reason about the organization so that they can deliberate about their own actions, act within the expected boundaries, and work towards the objectives of the organization. AORTA provides "organization-ignorant" agents with capabilities that allow them to perform organizational reasoning, such that they understand the organizational model of a system, can reason about participation and are able to choose whether or not to comply with the expectations that stem from the role(s) they enact. Such agents are *organization-aware*.

The main contributions of [3], which we highlight in the remainder of this short paper, are:

1. The operational semantics, based on temporal logic, that enable agents to make organizational decisions in order to coordinate and cooperate without explicit coordination mechanisms within the agents.
2. The organizational metamodel that enables to handle organizational models developed with different frameworks. The AORTA metamodel supports the notions of roles and role enactment, objectives and objective dependencies, capabilities, and conditional obligations.

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2. THE AORTA FRAMEWORK

Organizational models describe expectations and requirements or goals of an organization. In itself, an organizational model is just a structural description, and provides no central control over the agents and no specific mechanisms to ensure the fulfilment of the expectations. Moreover, agents joining the organization may be designed by distinct designers, which leads to uncertainty about the agents' motives and actions. Organizational reasoning concerns the capabilities that enable agents to decide about entering and exiting an organization, reasoning about which roles to enact, whether to comply or violate certain norms and how to coordinate tasks with other members of the organization. Agents that are able to perform organizational reasoning are called *organization-aware* agents [4]. In the following, we define what we mean by organizational reasoning and compare our approach to related work on organizational reasoning. Considering the three dimensions of organizational reasoning presented in [4], our work can be positioned as follows: (i) AORTA takes a top-down approach, assuming an existing model and providing agents with the means to reason about this model. (ii) AORTA provides agents with the possibility to understand organizational specifications, and assumes that agents understand the domain ontology used in the organizational model. (iii) AORTA provides reasoning rules that allow agents to successfully move through the phases of participation: entering the organization, playing roles in the organization and leaving the organization.

The focus of AORTA is on the second dimension: to provide agents with the possibility to understand organizational specifications. This understanding, combined with organizational reasoning rules, allows agents to successfully move through the phases of participation: entering the organization, playing roles in the organization and leaving the organization.

AORTA assumes a pre-existing organization, is independent from the agent, and focuses on reasoning rules that specify how the agent reasons about the organization. The organization is completely separated from the agent, meaning that the architecture of the agent is independent from the organizational model, and the agent is free to decide

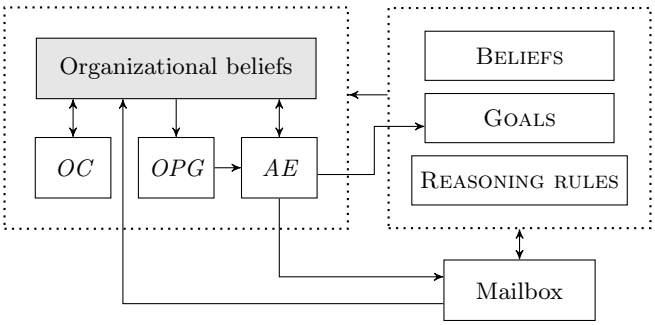

Figure 1: The AORTA component.

on how to use AORTA in its reasoning. The separation is possible because AORTA is based on an organizational metamodel, to which other organizational models can be translated. Figure 1 shows the AORTA component and the flow of information. Organizational reasoning in AORTA divided into three phases: *obligation check* (OC), *option generation* (OPG) and *action execution* (AE). The OPG-phase uses the organizational state to generate possible organizational options. The OC-phase uses the agent's mental state and organizational state to determine if obligations are activated, satisfied or violated, and updates the organizational state accordingly. The agent considers these options in the AE-phase using reasoning rules, which can alter the organizational state, the agent's intentions or send messages to other agents.

Each individual agent will use its own AORTA component. This means that agents can decide by themselves how to use the component, making AORTA suitable for many different kinds of agents. It may, however, also lead to agents holding different views about the organization, leading to inconsistency among them. However, this is not different from what happens in real-life, where actors in an environment may very well have different views about the world state, and contributes therefore to the realism of the approach.

3. AORTA METAMODEL

The AORTA metamodel supports the notions of roles and role enactment, objectives and objective dependencies, and conditional obligations and is defined by the following predicates:

- role(*Role*, *Objs*), where *Role* is the role name, and *Objs* is a set of objectives, where each *Obj* is a partial state description.
- obj(*Obj*, *SubObjs*), where *Obj* is the name of an objective, and *SubObjs* is a set of sub-objectives.
- dep($Role_1$, $Role_2$, *Obj*), where role $Role_1$ depends on role $Role_2$ for completion of objective *Obj*.
- rea(*Ag*, *Role*), where agent *Ag* enacts role *Role*.
- cond(*Role*, *Obj*, *Deadline*, *Cond*), where there is a conditional obligation for role *Role* to complete *Obj* before *Deadline* when *Cond* holds.
- obl(*Ag*, *Role*, *Obj*, *Deadline*), where there is an obligation for agent *Ag* playing role *Role* to complete *Obj* before *Deadline*.
- viol(*Ag*, *Role*, *Obj*), where agent *Ag* playing role *Role* has violated the obligation to complete *Obj*.

4. AORTA SEMANTICS

The framework is founded in formal operational semantics that precisely define how the agent can reason about an organization. Firstly, using temporal logic, we have formalized the intended behavior of organization-aware agents. Secondly, we defined the operational semantics of executing agents in the AORTA framework using a transition system, which consists of a set of transition rules that define the transformation from one configuration to another. The semantics of the deontic aspects of the domain are based on LAO [1] extended with the ability to deal with obligations, which also enables us to capture the fact that the agents and the organization reside in an environment, which none of them fully control. For details and proofs on the AORTA semantics, we refer the reader to [3]. Note that there is currently no formal connection between these semantic models, and future work is needed in order to establish the correctness of the operational semantics with respect to the semantics of obligations.

Using transition rules, the component can activate obligations, detect violations and suggest role enactment or objective commitments, all based on the agent's current state. The agents act upon this using organizational actions, allowing to following the suggestions – enact roles or commit to objectives – or to coordinate their actions with other agents in the system.

5. CONCLUSIONS

AORTA can be seen as an add-on component to cognitive agents, providing them with organizational reasoning capabilities. [3] provides an initial evaluation of the framework using a tender process scenario, demonstrating that, given agents with the capabilities to fulfil the roles in such a scenario, AORTA made it possible for them to coordinate their tasks and detect and act upon violations of the obligations imposed upon the agents. The framework has been partially implemented in Java and integrated in the *Jason* platform [2]. We plan to extend that work with the complete and updated operational semantics presented in the paper [3]. This would make it possible to execute and evaluate larger scenarios, and to, e.g., test how agents are able to recover from violations of obligations.

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