Chapter 14
Towards a Hybrid MAS Organizational Model: Combining the ACMAS and OCMAS Viewpoints

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ABSTRACT

The organizational aspects are currently getting a great attention within the multi-agent systems (MAS) community. The motivation towards this trend is finding a way to handle the increasing complexity and distribution of modern agent-based applications using higher order abstractions such as agent organizations. It is a transition from concerning the micro level (individual agents) to concerning the macro level (the whole system) to handle complexity. A large number of MAS organizational models can be found in MAS literature. Some of them adopt the ACMAS (Agent-Centered MAS) viewpoint and others adopt the OCMAS (Organizational-Centered MAS) viewpoint. Each of the ACMAS and OCMAS viewpoints has its advantages and disadvantages; therefore, combining them into a hybrid model is expected to give us the chance to take benefit of their advantages and avoid their disadvantages. This chapter presents our recent work towards the conceptual design of a hybrid MAS organizational model that combines both of the ACMAS and OCMAS viewpoints.

INTRODUCTION

Multi-Agent Systems (MAS) are currently widely adopted for modeling, designing, and developing a diversity of real-world application domains. The design concepts behind agents are vital in the globalization context as globalization refers to an inherently distributed world both from geographical and information processing perspectives. What distinguishes the agent-based approach from traditional

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approaches is its unique ability to handle simultaneously many challenges of future and even present real-world applications especially those applications which are highly distributed and their working environments are highly dynamic and uncertain. MAS are considered as a promising engineering (i.e., architectural) style for developing adaptive software systems able to handle the continuous increase in their complexity as a result of their open, heterogeneous, and continuous evolution nature. They model the system as distributed autonomous agents cooperate together to achieve system goals. There are two viewpoints of MAS engineering, the first one is the agent-centered MAS (ACMAS) in which the focus is given to individual agents. With this viewpoint, the designer concerns the local behaviors of agents and also their interactions without concerning the global structure of the system. The global required function of the system is supposed to emerge as a result of the lower level individual agent interactions in a bottom-up way. The key problems of the ACMAS viewpoint are mainly related to the unpredictability and uncertainty of agents' behaviors and interactions. Because the whole is more than the sum of its parts (Upton et al., 2014), this approach can lead to undesirable emergent behaviors that may impact system performance, as a result, this approach might be not suitable to design and engineer complex multi-agent systems.

The second viewpoint of MAS engineering is what is called organization-centered MAS (OCMAS) in which the structure of the system is given a bigger attention through the explicit abstraction of agent organization. With that approach, the designer designs the entire organization and coordination patterns on the one hand, and the agents' local behaviors on the other hand. It is considered as a top-down approach because the organization abstraction imposes some rules or norms used by agents to coordinate their local behaviors and interactions with other agents.

Although the MAS paradigm is successfully adopted for the development of many applications either industrial or any other real-life domains, but their adoption for developing large-scale applications that contain a very large number of agents is currently facing many challenges. The reason is that the current practice of MAS in industrial environments tends to be limited to individual agents and static small face-to-face groups of agents that operate as closed systems, which comprise a small number of agents' types and a small number of agents in general (Odell, 2003). This approach is not adequate for modeling and designing complex, open, heterogeneous, and highly distributed systems, where agents must be able to reorganize towards the most appropriate organizations to adapt unpredictable environment changes within MAS. Types of reorganization can be seen from two different levels. The individual agents level (the micro level) where an agent changes its behaviors and interactions with other agents to adapt the dynamic changes of its environment. And the organizational level (the macro-level) where the whole system changes its structure by adding or removing agents. Abbas et al. (Abbas, 2015a; Abbas, 2015b) provided a comprehensive overview about MAS organization including its motivations, paradigms, models, and other related concepts such as self-organization and emergence. The key conclusion of the authors' overview is that in MAS literature there are a large number of organizational models proposed to enable dynamic reorganization within MAS. The large number of present MAS organizational models indicates that concerning the organizational aspects within MAS is currently a very active and interesting research area. Also, it indicates that till now there is no a fit-to-all organizational model that can be used for engineering all possible application domains. To our best knowledge there is not any proposed model for enabling dynamic reorganization within large-scale and ultra-large-scale MAS. Although some of them are claimed to be adequate for developing open MAS but their proof-of-concept case studies are small-scale applications. We are convinced that still there is a need for a new MAS organizational