Chapter 88
Towards a New Approach for Controlling the Reorganization Process of Multi-Agent Systems

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ABSTRACT

Reorganization in Multi-Agent Systems plays a crucial role in the dynamic adaptation of the structure and the behaviour of organizations. In order to ensure consistency of the resulting organization, the reorganization process has to be controlled. This paper proposes a novel approach for controlling the reorganization process of Multi-Agent Systems, which are specified and implemented using the Framework OMACS (Organizational Model for Adaptive Computational Systems). The proposed control process is accomplished using the Framework MOP (Monitoring Oriented Programming) for supporting the verification of some reorganizational properties. The proposed approach, supported by a software tool that we developed, is illustrated using a concrete case study.

INTRODUCTION

Over the last decade, MAS (Multi-Agent Systems) have been more and more used to solve a wide variety of problems in a range of applications such as distributed sensing, information retrieval, workflow and business process management, air traffic control and spacecraft control (Kamboj & Decker, 2008). Each of these systems has to be flexible, reliable and capable of operating in open dynamic and unpredictable environments (Bernon, Gleizes, Peyruqueou, & Picard, 2003; Luck, McBurney, Shehory, & Willmott, 2005), where unplanned and unspecified changes may occur at run time (system objective can change,

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operational behaviour can evolve), agents are heterogeneous (don't have the same architecture, don't share necessary the same purposes), and they can migrate (enter or leave the system dynamically) (Penserini, Dignum, Staikopoulos, Aldewereld, & Dignum, 2009). In order to master these difficulties, MAS have evolved by integrating new dimensions such as: organizational, social, normative and institutional (M. V. Dignum, 2004; Ferber, Gutknecht, & Michel, 2004; Vázquez-Salceda, Aldewereld, & Dignum, 2004).

Nowadays, a new point of view has emerged; the organization-centred multi-agent systems. It consists in separating between agent and organization (a complex entity which has its own objectives), where the organization is independent of agents. According to this point of view, the global behaviour of MAS is dependent on their organizational structure, not on agents' individual behaviours (Ferber et al., 2004). This allows increasing the openness, heterogeneity and the adaptability of MAS.

In order to deal with unexpected events and changes of its environment, a MAS often has to reorganize itself, of course, according to an organizational model. However, the reorganization process must undergo some constraints and satisfy some safety and/or liveness properties. So that it can remain effective and continue to survive (V. Dignum, Dignum, & Sonenberg, 2004).

In the literature, several organizational models have been proposed. We can cite among others, AGR (Ferber et al., 2004), MOISE+ (Hübner, Sichman, & Boissier, 2002), OMNI (V. Dignum, Vázquez-Salceda, & Dignum, 2005), OperA (M. V. Dignum, 2004). However, none of these models have been designed to express the dynamism of the organization to provide the system with mechanisms for its reorganization; so that it can be ready for changes in its environment.

A more recent organizational model called OMACS (Organizational Model for Adaptive Computational Systems) has been proposed (Deloach, Oyenan, & Matson, 2008; S. DeLoach, 2009). It allows capturing and providing the system with information about its structure and its capacity; so that it can reorganize itself dynamically, respond to changes in the environment and/or to the capacity of agents.

In this paper, we propose a novel approach to on-the-fly control of MAS organizations, which are specified and implemented using the Framework OMACS (S. DeLoach, 2009). The proposed control process is accomplished using the Framework JavaMOP (Monitoring Oriented Programming) (Meredith, Jin, Griffith, Chen, & Roşu, 2012) through the verification of certain reorganizational properties.

The remainder of this paper is organized as follows. In Section 2, we give a brief overview of major related work. We present a background of the proposed approach in Section 3. Section 4 illustrates the approach we propose. We present the environment supporting our approach in section 5. Section 6 gives some conclusions and future work directions.

RELATED WORK

Reorganization for adaptation represents an important area for researchers interested in MAS. In the last few years, some works have emerged in the literature in order to deal with controlling the adaptation process of MAS at the micro level as well as at the macro level.

There are two main categories of approaches. The first category, on-the-fly approaches based on monitoring the system trace (dynamically), which rely on events and aim at observing and analysing in order to control the behaviour of the system. These approaches usually observe the execution of the multi-agent system to define its current behavioural model. Then, this model is analysed and checked to detect or anticipate the undesirable behaviours (Horling, Benyo, & Lesser, 2001; Kaminka, Pynadath, & Tambe, 2002). (Guessoum, Ziane, & Faci, 2004) have used a graph of independence to cuter and monitor