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COORDINATION AND REORGANIZATION IN MULTI-AGENTS SYSTEMS, I

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Abstract. A method of considering coordination and reorganization as keys in achieving (organizational) multi-agent system adaptation in unknown situations is proposed. Within a not totally predictable environment multi-agent systems are prone to failures. In such unpredicted situations the system must be able to adapt in order to accomplish its purpose.

The proposed system architecture is a combination of MOISE+ and MOCA concepts. The main inconvenient of MOCA platform is that the mechanism of dynamic role allocation is entirely left to the designer. The inconvenient of MOISE+ platform is that agents' behavior is not considered.

MOCA gives a structural vision on multi-agents systems based on individual and collective patterns of behavior. MOISE+ model describes how agents endorse roles in order to achieve their individual and collective goals.

In Part I the main concepts of MOCA and MOISE+ models are presented.

Keywords: Additional Key Words: Multiagent Systems Reorganization, Role Endorsement Mechanism

1. Introduction

The term agent is difficult to define. The main point about agents is they are autonomous: capable of acting independently, exhibiting control over their internal state. Thus: an agent is a computer system capable of autonomous action in some environment. An intelligent agent is a computer system capable of flexible autonomous action in some environment. By flexible, we mean (Wooldridge and Jennings, 1995) *autonomy, reactivity, pro-activeness* and *social ability.*

1.1. **Multi Agent Systems.** A Multi Agent System (MAS) is a network of autonomous entities (agents) that work together in order to achieve a global goal, the system goal. Data in the system is decentralized and there is no agent that can accomplish by himself the system's goal, meaning that agents need each other to

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achieve the system goal. A MAS has two main properties, which seems controversial: the global purpose that must be achieved and the autonomous agents. While the autonomy of the agents is essential for the MAS, it may also cause the looseness of the global coherence. In these conditions MAS organization is used to solve this conflict, constraining agent's behavior towards the system global purpose.

1.2. **Mainstream researches in MAS.** Mainstream researches in MAS correspond to the MAS central concepts: namely that of *agent* and *group*. The agent-centered approaches are concerned on how to represent agent 'internal' knowledge (such as *Believes, Intentions* and *Desires*, in a so-called *mentalist* approach) or internal behavior, as well as their local interactions and environment (Nagy, 2002).

In the framework of organizational systems, three dimensions are used to describe the MAS:

- the structure expressed through roles and groups,
- the functioning (global plans and tasks) and
- deontic relations or other norms (agents' obligations, norms, responsibilities, permissions etc.).

Agent and organization based approaches share the same goals: explain what a multi-agent system is, how it works and how it can be used. The main difference is the set of basic concepts. While both of them allow for a sociological dimension - local interactions for the agent-centered approach – the organization-centered approach has a real social dimension.

When describing an organization, one of the encountered problems is to define these aspects in such a way that they can be assembled in a single coherent specification. The existent models of MAS concentrate mainly on a single dimension. Such is the MOCA platform (Amiguet, Müller, Báez, and Nagy, 2002) and the Agent-Group-Role (AGR) models or others concentrated on the deontic aspect of the system (Barbuceanu and Lo, 2000).

Our research is located in the field of organization-centered systems where agents are able to represent the organization they evolve in. The proposed model combines the existent concepts in two models: MOCA model and MOISE+ model.

2. MOCA platform

There are mainly two types of approaches of organizational multi-agent systems in literature: some systems allow for dynamic social organization but social structures do not impose anything on agent's behavior; other models do consider social structures as recurrent patterns of interaction, but then the social structures are usually static.

The contribution of MOCA (Model of Organization Centered on Agents) platform is to combine these two approaches by allowing the designer to describe the organizations with their roles, relationships and dynamics (protocols), but simultaneously allowing any agent to dynamically create a group instantiating an organization, to enter and to leave such a group.

MOCA is the first realized platform that gives both the theoretical background and an operational semantics for the notion of (*behavioral) role* and *organization.* In what follows, we will distinguish MOCA's concepts of role and organization by mentioning the platform *MOCA-role*, *MOCA-organizational structure*, etc.

While the deontic and other specifications of multi-agent systems in terms of agents' obligations, norms, responsibilities, permissions, etc. can be classified as *mentalist* (Parunak and Odell, 2001) approaches to organizational design, the specification of MOCA organization belongs to the class of *behaviorist* approaches (see Nagy, 2003).

A MOCA-organization is a recurrent pattern of interaction, representing a global, but specific (meaning several view-points on a system can co-exist and interact) view on a system. Such an organization is represented by a graph where the vertices are MOCA-role descriptions and the edges are inter-role relations, which specify – among other properties – the types of perturbations a role can generate and receive.

A *MOCA-role* is an individual recurrent pattern of behavior, within an organization. MOCA-roles are specified through the mechanism of state-charts, which identify the sequences of state-transition and actions firing, according to internal conditions and perturbations received by the agent endorsing a role.

MOCA leaves a high autonomy to agents, which can endorse and leave a role according to their individual goals (this part is left for a further work and it is here that our model enriches MOCA). However, the role endorsement is driven by agent competences.

A MOCA-role specifies what competences an agent should have in order to endorse it. Also some competences can be provided to the agent through the roles the agent endorses. The agent's competences are expressed as components of the role, and implemented, on the MOCA platform, as java interfaces.

MOCA notions are structured on two axes: a two levels structure and an internal-external distinction (see Figure 1).

The distinction between the executive level and the descriptive level is the same as the distinction between the class and the object in the object oriented programming. We can tell that the executive level is the instantiation of the descriptive level.

The internal - external distinction related to the agent shows the role position in this model: the role realizes the link between the internal state of the agent and the system he evolves in.

The main inconvenient of MOCA is that it leaves the system designer without any tool for assigning roles to agents. Another shortcoming can be the management group. This group is responsible for group's dynamic (agents entering and leaving

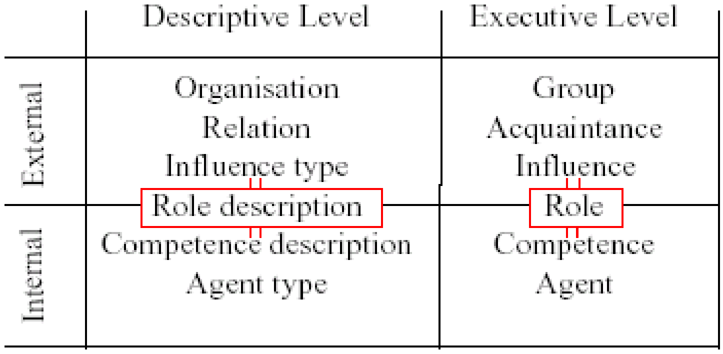

Figure 1. The main concepts of MOCA

groups). This can be a bottleneck point in the system and its failure could lead to system failure.

3. MOISE+ Model

A new direction in MAS is to join the organizational "roles" with global and individual plans. In MOISE model three levels were identified:

- *individual level* - representing the behaviors that an agent is responsible for when it adopts a role,
- *social level* - describing interconnections between roles and
- *collective level* - that represents the roles aggregation in large structures.

The organization-centered models usually concern only one direction of the two: the system functioning, meaning system's global plans or the system structure. Although MOISE tries to concern about these two aspects, its main shortcomings (for reorganization) are the lack of the concept of an explicit global plan and the strong dependence among the structure and the functioning.

MOISE+ is a model conceived to assemble the three levels of the system in a coherent MAS organizational description, suitable for the reorganization process. This was accomplished by specifying the first two dimensions almost independently of each other and after properly linking them by the deontic dimension (Hübner, Sichman, Boissier, 2002).

Figure 2 shows how system global purpose can be achieved by constraining agents' behavior by organization's structure but also providing them some tested plans for goal achievement through organization functional specification. In this way agents have some tested plans to follow, they have the choice of reasoning for a plan to work together when there is no plan to be followed and this must not be done each time they want to work together, because experience is stored in system knowledge base.

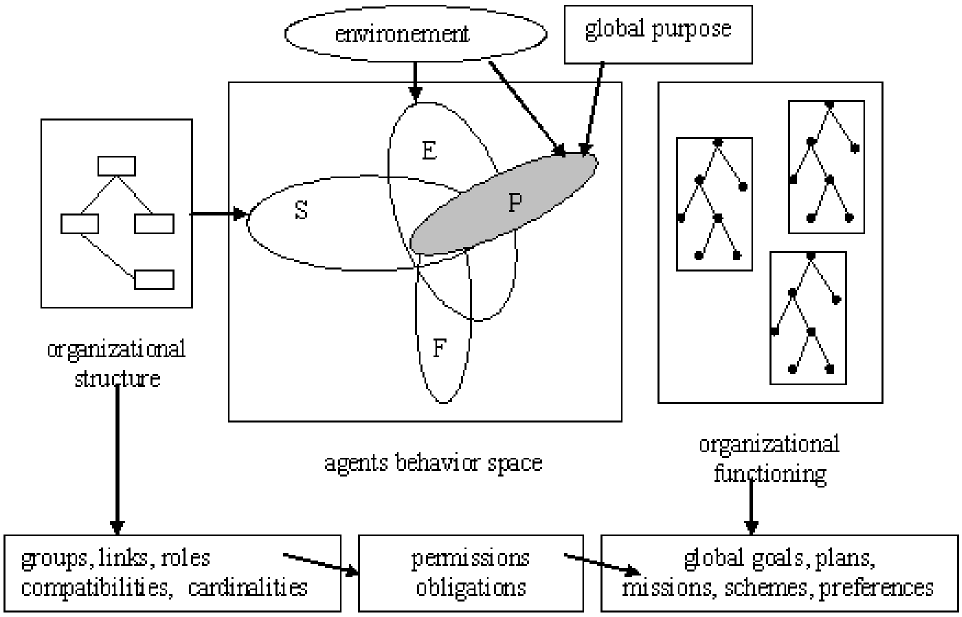

FIGURE 2. The organization effects on MAS

Within MOISE+ platform three dimensions can de distinguished:

- structural dimension,
- functional dimension,
- deontic dimension.

3.1. **Structural dimension.** Within MOISE + three main concepts - roles, role relations and groups - are used to build the individual, social, and collective structural levels of an organization.

The *individual level* is formed by the roles of the organization. A *role* means a set of constraints that an agent ought to follow when it accepts to enter a group playing that role. The constraints imposed by the role are defined in relation to other roles (in the collective structural level) and in relation to global plans.

The *social level* is used to specify relations between roles, relations that directly constraint the agents. The relations between roles are called *links* and are represented like predicates: link(s, d, t) where s is the link source, d is the link destination and t is the link type that can be authority, communication or acquaintance.

These links are used to constrain agents after they have accepted to play a role.

The *collective level* imposes some constraints regarding the roles an agent can play at the same time. The roles can be played only in a group already created. A *group* is an instantiation of a group specification.

When specifying a group the following elements must be stated:

- roles that may be played in the group;
- sub groups the group has;
- links between the roles in the group;
- links that can exist between agents playing a role in the group and agents playing different roles in other groups;
- compatibilities between the roles played by the same agent in the same group and also in other groups;
- for each role- the maximum and minimum number of agents that can play a role in the group in order it to be well formed;
- for each group - the minimum and the maximum number of subgroups that can be created.

3.2. **Functional dimension.** The functional dimension describes how the global goals are decomposed by plans and distributed to the agents by missions**.** At the collective level, this means that there is a global plan decomposed in *schema* and at the individual level there are *missions* that an agent may be committed to.

Each goal can be decomposed in sub-goals through plans, which may use three operators: sequence (the sub-goals must be achieved one after the other), choice (only one of sub-goals must be achieved) and parallelism (the sub-goals can be achieved in parallel). At this level there is also an order for missions telling in a given situation the success rate of each mission. Using this order the agents may choose the mission that looks to be the most promising for the global goal achievement.

3.3. **Deontic dimension.** *Deontic dimension* relates the structure and the functioning dimensions describing the permissions and obligations from roles to missions at specified moments in time. The deontic dimension is thus a set of obligations and permissions for the agents playing different roles on schema decomposed in missions.

A MOCA organizational system may allow for agents without any internal content other than the ability to send and receive messages, to enter organization (an agent enters an organization by endorsing a role in that given organization). In MOISE+ nothing is said about the internal abilities or competences of agents and the present architecture in not self-consistent.

Furthermore, it is beyond the scope of the quoted papers on MOISE+ to describe the instantiation process, and particularly the correspondences between the competences of agents and the behaviors specified by the MOISE+ roles. This correspondence between role competences and agents arises naturally within MOCA.

Therefor we consider that MOCA and MOISE+ could be seen as complementary approaches. MOCA gives a good operational semantics to the notions of organizational structure, organization and role, together with a fully operational platform. Notion of competence required from an agent to endorse a role is clearly defined and the conditions where an agent is eligible to endorse a role are put.

MOISE+ describes the constraints for the role endorsement by agents, as well as constraints about the cardinality of the final multi-agent system in order to achieve the global goal of the organization. Another advantage is that conditions for role compatibility within the same agent can be given because MOISE+ allows specifying for every role, if it can be endorsed or not by an agent having other given roles.

4. Conclusions

This paper presented the models MOCA and MOISE+ which are the basis for a new multi-agent system model. This new model will be introduced in Part II.

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