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COORDINATION AND REORGANIZATION IN MULTI-AGENTS SYSTEMS, II

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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. These two models have been presented in Part I.

In this part a new multi-agent system model is proposed. In this proposed model we reconsider the MOCA and MOISE+ notion of role. Our aim is to overcome the main drawbacks of these models. Moreover, the notion of behaviorist role in MOCA is enlarged through several features of roles from the MOISE+ model. We propose some strategies for system's dynamics and coordination that can assure the system adaptation.

Additional keywords: Multiagent Systems Reorganization, Role Endorsement Mechanism

1. Introduction

The goal of the new proposed model is to overcome the main drawbacks of MOCA and MOISE+ models. The aim is two-folded. On the one hand, we suggest a way to achieve the MAS adaptation at environment changes. For this purpose we state some reorganization rules in the management group (endowed with the organizational dynamic, this group idea exists in MOCA) following MOISE+ model of missions. On the other hand, we propose a role endorsement mechanism associated with MOCA-organizational structure and roles, by using the global planning mechanism of MOISE+. This is realized through the integration of the notions of role in MOCA and MOISE+.

2. MAS Adaptation at Environment changes

MAS adaptation is needed because, generally, the system designer cannot predict all the situations the system has to face or because there are some unknown

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parameters that define some situations. In unpredictable situations the system must manage in order to achieve its global goal. In what follows we suggest some research directions that would lead to an acceptable system behavior in such unpredictable situations.

The first proposal is related to adaptation in the management group. The second proposal refers to system reorganization coordinated by the agents in the management group.

2.1. **Management group adaptation.** The notion of management group appears also within MOCA platform. The purpose of this group is to manage the organization dynamics meaning group formation, assigning agents to roles, agents entering and leaving a group (Amiguet, 2003). The management group has one agent playing the Yellow Pages role, other agents playing the manager role and agents that wish to enter an organization play the demander role.

The role of Yellow Pages agent is to keep track of what groups are created and to provide this information to agents requiring it. When an agent wants to enter a given group and this group is not created yet, the group will be created and the agent will be assigned the role of manager of this group. From now on any agent that wants to enter or leave the group must communicate with the manager agent.

This group of management could be the entry point of system failures, in case some manager agent fails. In order to find out when a problematic situation has appeared, the agents in the management group have an image about all the others, image that is changed when the agents send messages about their status (Kumar, Cohen, Levesque, 2000).

Following the model of goals and missions from MOISE+ model, the designer of the MAS should specify some rules that would make the agents from the management group to deal with situations in which one or more agents from this group have become unavailable. When some manager agent cannot properly work, the other agents must commit to some specified missions. These missions should impose to available manager agents to take and accomplish the tasks of the agent that became unavailable. They also have to restore somehow the agents with problems. Indeed the whole system performance would decrease but the system failure situation is avoided as long as at least one manager agent is still available.

The proposed solution can only increase system robustness and adaptation in critical situations.

2.2. **System reorganization.** The designer of MAS can imagine some special situations when system reorganization is needed in order to achieve system's global goal. System reorganization means a new organization structure in terms of positions and agents occupying these positions.

A *position* represents *potential roles assignment* within a structure. A position may or may not have an agent assigned to it. At a given moment in time, only one agent can be associated with a given position.

A situation can be identified by some critical parameters. We can tell that a situation is the expected one if some predicates representing that situation are true (of course with some error degree). For some special situations the system designer might know the most appropriate structure for system's best performances.

We saw that MOISE+ model offered the possibility of specifying the minimum and maximum number of positions that can be taken in a group, the minimum and maximum number of subgroups a group can have and also other system parameters. This was a way of defining very flexible organizations. But in some situations it can be known *a priori* which is the best structure that should be used. For example in the soccer game: in a critical situation the system would be more efficient if more agents are in defensive positions.

For such predictable situations the system designer could provide some agent diagrams (Mellouli, Mineau and Pascot, 2002) telling which agents should be put in which positions.

When detecting such situations the management group must start the reorganization operation. In other situations, when it is obvious that the current structure is not the best one but no agent diagram is provided, the management group could decide by itself how reorganization is made.

After the reorganization action, no matter if it was a priori planned or the management group decided it, the taken solution must be given a weight representing its success rate or its current weight must be updated.

This approach of giving feedback for each reorganization action that is made would help the agents next times to adopt a solution that has the greatest success chances.

3. Role Endorsement Mechanism

A strong constraint that is imposed by MOCA platform is that relations between agents in different groups are allowed only if the same agent plays roles in both groups and there are relations between these roles. This constraint is also meet in the proposed model.

First of all we must state two major changes that are made to MOISE+ model:

- relations between agents follow the constraint described above;
- an organization cannot exist without the management group.

The role endorsement mechanism will be exemplified by the following example.

3.1. **An Example for the Structural Dimension in MOISE+ and MOCA.**

Let us consider a MOISE+ organization of soccer players, with its three dimensions: structural, functional and deontic. The structural dimension corresponds to the organizational structure and is presented in Figure 1:

It is obvious that in such a structure, three points of view may be identified: coaching, attack and defense. MOCA allows for the possibility to separate them into three distinct organizational structures: a coaching organization, an attack

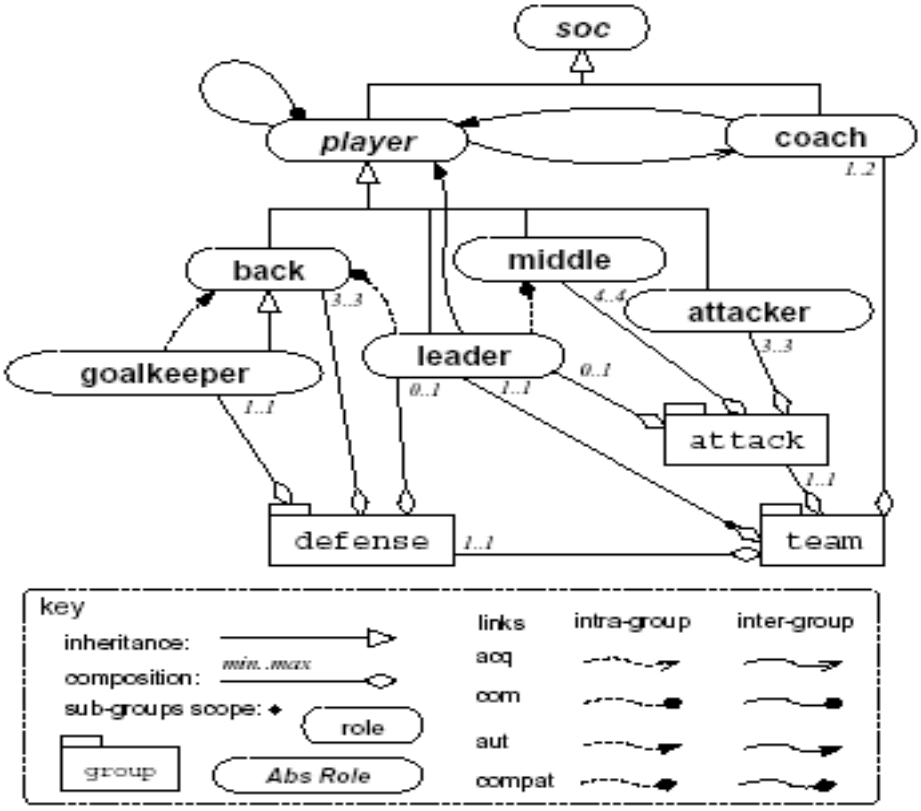

FIGURE 1. Structure of a soccer team

organization and a defense organization depicted in Figure 2. Each adverse team will have to follow such a structure.

The multi-agent system, that is the instantiation of the organizational structure, is initially composed of two instantiations of the Coaching organization (one for each team, with the correct cardinalities for each role) and from an Environment organization, composed from the soccer ground, the ball, the agents in expectation (the reserves) and the coach agent.

The advantage of a multi-view point approach (one view for attack, one for coaching, containing coaches' behavior and basic players' behavior, etc.) on the 'soccer team' is that there is no further need to define any sub-role. Every agent is able to take one or several roles in any organization, according to instantiation rules which need to be specified. No distinction is needed between abstract roles

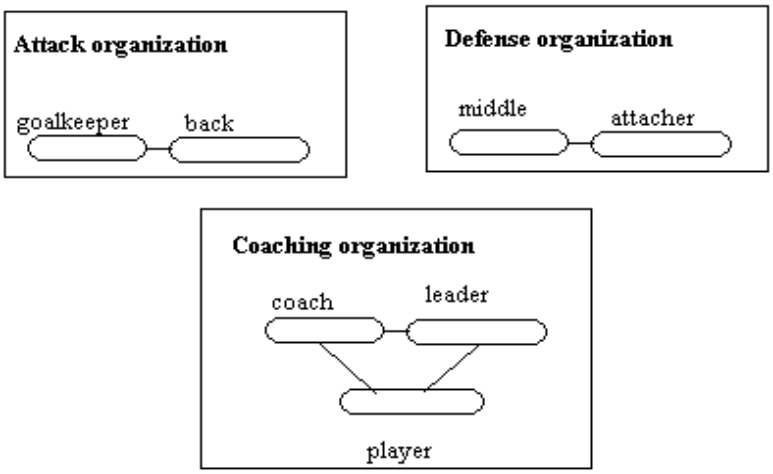

FIGURE 2. Soccer team organizations

and roles, as in MOISE+. Agents will simply be able to take two or several roles in the same time, as 'player' and 'middle' or 'goalkeeper', 'leader' and 'player'. Each of these organizations will be instantiated in one or more groups, which will interact through their shared agents.

MOCA furnishes to any agent a very basic set of skills, related to its ability to communicate, endorse and leave an organization (endorse and leave competences). Acquaintance relations between roles, minimum and maximum cardinalities for roles instantiations are specified, as well as the relations between roles, but a finer cardinality, which might be 'situation-dependent', is desirable. We propose to do this by introducing the notion of *position* of an agent and through MOISE+ like (deontic) predicates.

3.2. **An Example of Behaviorist Role.** There are only a few examples of MOCA organizations. We will exemplify the way MOCA roles are given content. The behavior of every role is fixed, and thus roles represent norms on agents' behavior.

Let us define a *player* role description through a state chart (Amiguet, 2003) as in Figure 3.

The three default states B, D and F concern the knowledge about the players and ball locations and the ability to receive indications from teammates or coach. A1 and A2 are *or-states*, while A and F are *and-states*, which are executed in parallel. The state H allows propagating indication to other roles (ex. 'middle', 'goalkeeper') endorsed by the same agent.

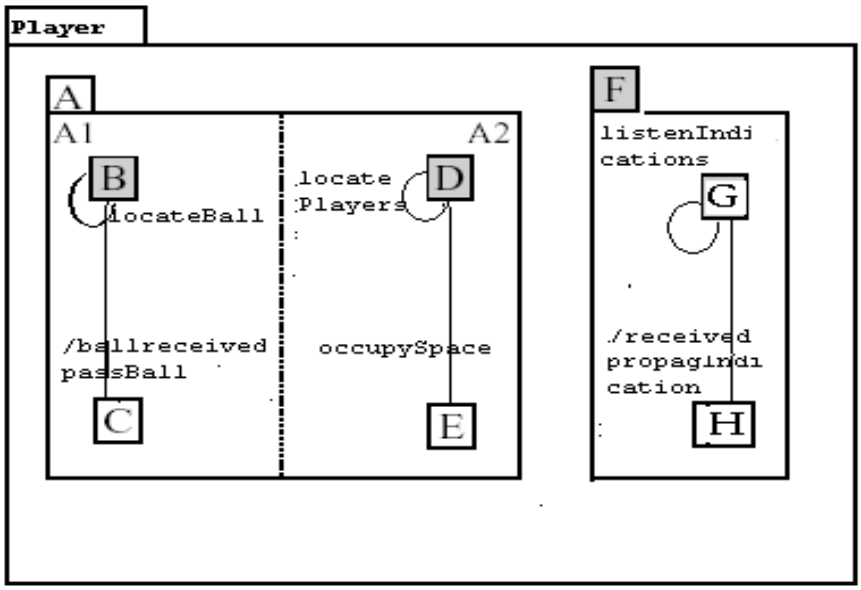

FIGURE 3. Player role

3.3. **Agent Position.** Assume every individual agent in the team (excepting the coaches) has endorsed a player role. We are now able to use the individual goals graph built through MOISE+ goal decomposition.

We will first define the *status* (social status) of an agent. This (sociology inspired) notion defines *the set of roles an agent endorses at a given moment.*

The notion of *position,* defined before can, then, be given a more precise meaning. The position is the *potential status of an agent.* It represents *all the roles and competences an agent might have in a given moment.* The position will be computed from agent's competences, the roles it already endorses, the relations between roles, organizational constraints regarding the roles compatibilities and agent's individual goals.

The *position* of every team member will be equally composed by a set of basic competences like - for the example of soccer agents - being able to *move* within the ground, to *perceive* the locations of other players, to *receive* indications from them and from the coach. Some of these skills are provided by the **player** role exemplified above. Further skills will be provided by the other roles. Individual positions of the soccer player agents are then defined by the roles already endorsed

and other conditions expressed through deontic predicates. For example, an agent who is already a coach may be middle if he is not retired from the team; an agent who is a goalkeeper cannot take the role of attacker.

3.4. **Goal Driven Mechanism for Role Endorsement.** Once the positions of any agent are computed, the functional dimension of MOISE+ expressed through goal description and potential missions (that is succession of goals) can be used.

The MOISE+ functional decomposition is exemplified bellow in Figure 4.

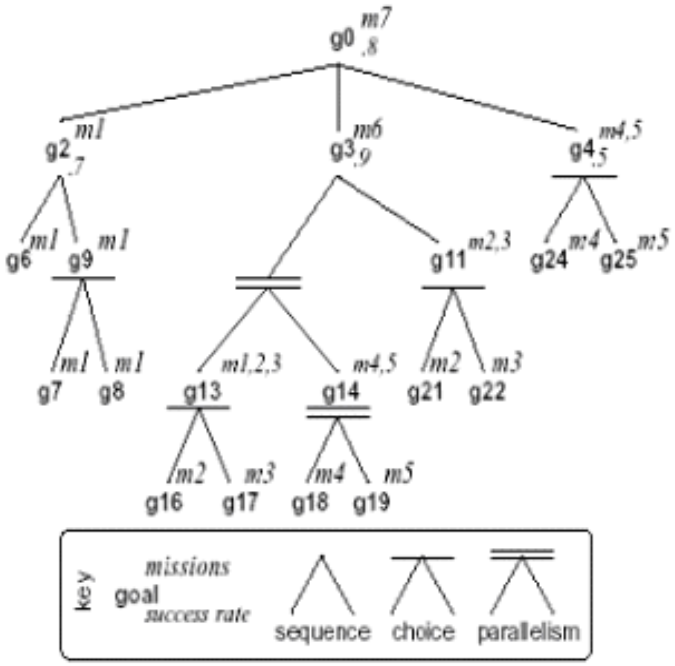

FIGURE 4. Soccer team social scheme to score a goal

We are now able to show how role allocation (endorsement and leaving) can be driven by individual goals. We consider two situations when role allocation is driven by agent individual goal:

(i) Suppose that g24 was already reached. In most of these cases, according to the ball's position (considered as input from the environment) and to an established defense strategy (not exemplified here) ***left attacker*** agent might wish to take a role in the defense organization;

(ii) Suppose now that the ball is in the middle field and a ***middle*** agent may choose the mission composed of the goals {g2, g9, g13, g18, g25}. Then, it will have to endorse the role of ***attacker*** for this individual action.

Goal	Goal description
g0	score a soccer-goal
g1	the ball is in the middle field
g2	the ball is in the attack field
g3	the ball was kicked to the opponent's goal
g4	a teammate has the ball in the defense field
g6	the ball was passed to a left middle
g7	the ball was passed to a right middle
g9	the ball was passed to a middle
g11	a middle passed the ball to an attacker
g13	a middle has the ball
g14	the attacker is in good position
g16	a left middle has the ball
g17	a right middle has the ball
g18	a left attacker is in good position
g19	a right attacker is in good position
g21	a left middle passed the ball to a left attacker
g22	a right middle passed the ball to a right attacker
g24	a left attacker kicked the ball to the opponent's goal
g25	a right attacker kicked the ball to the opponent's goal

TABLE 1. Semantics for notations from Figure 4

MOCA allows a dynamic role allocation, but the mechanism is entirely left to the designer. We have seen now that the allocation may be done thanks to dynamical individual goals agents may have. The identification of individual goals to goals from a given strategy might be done in several ways: through the individual reasoning about a situation, through indications received from the leader or the coach, or through the past experience agent has recalled.

Thus, we have shown how the purpose of using a MOISE+ like functional decomposition to drive the MOCA role allocation can be reached. The formalism behind this example will be described in a further paper.

4. Group dynamics

It is difficult and often infeasible to specify Multi-Agent-Systems completely in advance, because there are frequently unforeseen situations that agents may encounter.

The MOCA platform enhances agents with the capability of entering and leaving a group. These operations are managed by the manager agent who is the first agent that required entering the group before the group has been created. After the group creation all agents that want to enter or leave the group must ask this to the.

In this context we can see the role having a double interpretation: it reflects the competencies that an agent has and that the agent should provide to the other agents.

The manager agent should be endowed with a reasoning capacity in order to allow an agent to enter the group or not. The acceptance of an agent by a group depends on the fact that the utility of the group increases. The manager agent disposes a mechanism of punishment and favoring to make agents agree on roles. On the other hand, an agent joins only a group if its own utility increases, too.

We consider a group as being formed from agents having common interests. An interest can be the desire or need to share resources and competencies. Within an organization agents have different roles reflecting the competencies necessary for accomplishing the common goal. This competence based approach comprises deliberative agents which are aware of the roles they are playing and of those they want to play.

So we can define a group as the set of roles which identify the positions which individual agents can play. As defined in MOCA the role is defined by the competences associated to it. Each individual agent is able to play different roles in a society depending on its individual competencies.

An agent has a set of desired roles that he wants to play. Instead the group has a set of expected roles that agents entering the group should play. We define the committed role as the role the agent has committed to play within the group.

When an agent enters a group something like a convention is created between the agent and the entered group. In fact, a convention is something like a social norm which allows agents to increase the utility of an organization and also their own one. In fact a convention describes the structure of the group that has been statically defined by the system designer (the maximum and minimum number of agent playing a certain role) or a new convention could have been created in a system reorganization phase (see System reorganization).

How do agents now agree on a convention to form an organization? We need something to express the motivation of a group to accept/refuse an agent and the motivation of an agent to accept/refuse a role. A very useful mean is the definition of utility functions.

The utility function for an agent depends on the roles it wants, the roles it has already committed to. Also the organization has a utility function. This function depends mostly on its convention. Examples of utility function definitions can be found in (Glasser and Morignot, 1997).

This dynamic behavior of an organization permits the group evolution over time. Autonomous agents are required to be able to modify their local knowledge in such a way that they can agree with other agents to build a group.

Thus when a candidate agent having reactive, cognitive, cooperative and social competencies applies for a group membership, the group manager will favor the agent's desired roles that augment the organization utility function.

This management of group dynamic makes it possible the organization to draw benefits from its new members and to be able to answer the environmental changes.

5. Conclusions

This paper represents a starting point in combining the two organization centered models, namely MOCA and MOISE+. The notion of *status* of an agent and the notion of *position* are defined. The notion of position is combined with the decomposition of global goals in *goal schema* and *missions*, in order to direct the MOCA-role assignment strategies and role endorsement through a dynamic choice of individual goals.

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