A Model for the Structural, Functional, and Deontic Specification of Organizations in Multiagent Systems

Jomi Fred Hübner[1] *, Jaime Simão Sichman[1] **, and Olivier Boissier[2]

[1] LTI / EP / USP
Av. Prof. Luciano Gualberto, 158, trav. 3
05508-900 São Paulo, SP
{jomi.hubner,jaime.sichman}@poli.usp.br
[2] SMA / SIMMO / ENSM.SE
158 Cours Fauriel
42023 Saint-Etienne Cedex, France
Olivier.Boissier@emse.fr

Abstract. A Multiagent System (MAS) that explicitly represents its organization normally focuses either on the functioning or the structure of this organization. However, addressing both aspects is a prolific approach when one wants to design or describe a MAS organization. The problem is to define these aspects in such a way that they can be both assembled in a single coherent specification. The $\mathcal{M}$OISE$^+$ model – described here through a soccer team example – intends to be a step in this direction since the organization is seen under three points of view: structural, functional, and deontic.

1 Introduction

The organizational specification of a Multiagent System (MAS) is useful to improve the efficiency of the system since the organization constrains the agents behaviors towards those that are socially intended: their global common purpose [8,7]. Without some degree of organization, the agents' autonomy may lead the system to lose global congruence.

The models used to describe or project an organization are classically divided in two points of view: *agent* centered or *organization* centered [10]. While the former takes the agents as the engine for the organization formation, the latter sees the opposite direction: the organization exists *a priori* (defined by the designer or by the agents themselves) and the agents ought to follow it. In addition to this classification, we propose to group these organizational models in (*i*) those that stress the society's *global plans* (or tasks) [12,11,13] and (*ii*) those that have their focus on the society's *roles* [5,6,9]. The first group concern is the *functioning* of the organization, for instance, the specification of global plans, policies to allocate tasks to agents, the coordination to execute a plan, and the quality (time consumption, resources usage, . . .) of a plan. In this group, the global

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purposes are better achieved because the MAS has a kind of organizational memory where the best plans to achieve a global goal are stored. On the other hand, the second group deals with the specification of a more static aspect of the organization: its *structure*, i.e., the roles, the relations among them (e.g.: communication, authority), roles obligations and permissions, group of roles, etc. In these latter models, the global purpose is accomplished while the agents have to follow the obligations and permissions their roles entitle them. Thus we should state that organization models usually take into account either the functional (the first group) or structural (second group) dimension of the organization. However, in both groups the system may or may not have an explicit description of its organization that allows the organizational centered point of view.

The Fig. 1 briefly shows how an organization could explain or constrain the agents behavior in case we consider an organization as having both structural and functional dimensions. In this figure, it is supposed that a MAS has the purpose of maintaining its behavior in the set P, where P represents all behaviors which draw the MAS's global purposes. In the same figure, the set E represents all possible behaviors in the current environment. The organizational structure is formed, for example, by roles, groups, and links that constrain the agents behavior to those inside the set S, i.e., the set of possible behaviors ($E \cap S$) becomes closer to P. It is a matter of the agents, and not of the organization, to conduct their behaviors from a point in $((E \cap S) - P)$ to a point in P. In order to help the agents in this task, the functional dimension contains a set of global plans that has been proved efficient ways of turning the P behaviors active. For example, in a soccer team one can specify both the structure (defense group, attack group, each group with some roles) and the functioning of the team (e.g.: rehearsed plays, as a kind of predefined plans that was already validated).

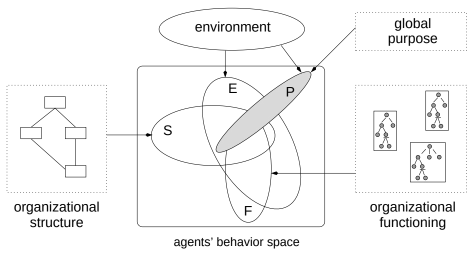

Fig. 1. The organization effects on a MAS

If only the functional dimension is specified, the organization has nothing to "tell" to the agents when no plan can be performed (the set of possible behavior is outside the set F of the Fig. 1). Otherwise, if only the organizational structure is specified, the agents have to reason for a global plan every time they want to play together. Even with a smaller search space of possible plans, since the structure constrains the agents options, this may be a hard problem. Furthermore, the plans developed for a problem are lost, since there is no organizational memory to store these plans. Thus, in the context of some application domains, we hypothesize that if the organization model specifies both dimensions while maintaining a suitable independence among them, then the MAS that follows such a model can be more effective in leading the group behavior to its purpose (Fig. 1). Another advantage of having both specifications is that the agents can reason about the others and their organization regarding these two dimensions in order to better interact with them (in the case, for example, of social reasoning).

A first attempt to join roles with plans is the MOISE (Model of Organization for multI-agent SystEms). The MOISE is structured along three levels: (*i*) the behaviors that an agent is responsible for when it adopts a role (*individual* level), (*ii*) the interconnections between roles (*social* level), and (*iii*) the aggregation of roles in large structures (*collective* level)[9]. The main shortcoming of MOISE, which motivates its extension, is the lack of the concept of an explicit global plan in the model and the strong dependence among the structure and the functioning.

This article sets out a proposal for an organizational model, called $\mathcal{M}$OISE$^+$, that considers the structure, the functioning, and the deontic relation among them to explain how a MAS organization collaborates for its purpose. The objective is an *organization centered model* where the first two dimensions can be specified almost *independently* of each other and after properly linked by the deontic dimension.

The organizational models that follow the organizational centered point of view (e.g., AALAADIN [5], MOISE [9]) usually are composed by two core notions: an Organizational Specification (OS) and an Organizational Entity (OE). An OE is a population of agents functioning under an OS. We can see an OE as an instance of an OS, i.e., agents playing roles defined in the OS (role instance), aggregated in groups instantiated from the OS groups, and behaving as normalized in the OS. Following this trend, a set of agents builds an OE by *adopting* an appropriate OS to easily achieve its purpose. An $\mathcal{M}$OISE$^+$ OS is formed by a Structural Specification (SS), a Functional Specification (FS), and a Deontic Specification (DS). Each of these specifications will be presented in the sequel.

2 Structural Specification

In $\mathcal{M}$OISE$^+$, as in MOISE, three main concepts, *roles*, role *relations*, and *groups*, are be used to build, respectively, the individual, social, and collective structural levels of an organization. Furthermore, the MOISE original structural dimension is enriched with concepts such as inheritance, compatibility, cardinality, and sub-groups.

Individual level. 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. Following [2], these constraints are defined in two ways: in relation to other roles (in the collective structural level) and in a deontic relation to global plans (in the functional dimension).

In order to simplify the specification[1], like in object oriented (OO) terms, there is an *inheritance relation* among roles [6]. If a role ρ' inherits a role ρ (denoted by $\rho \sqsubset \rho'$), with $\rho \neq \rho'$, ρ' receives some properties from ρ, and ρ' is a sub-role, or specialization, of ρ. In the definition of the role properties presented in the sequence, it will be precisely stated what one specialized role inherits from another role. For example, in the soccer domain, the attacker role has many properties of the player role ($\rho_{player} \sqsubset \rho_{attacker}$). It is also possible to state that a role specializes more than one role, i.e., a role can receive properties from more than one role. The set of all roles are denoted by $\mathcal{R}_{ss}$.

[1] Although we will use the term "specification" in the sequence, the $\mathcal{M}$OISE$^+$ could also be used to "describe" an organization.

Following this OO inspiration, we can define an *abstract role* as a role that can not be played by any agent. It has just a specification purpose. The set of all abstract roles is denotated by $\mathcal{R}_{abs}$ ($\mathcal{R}_{abs} \subset \mathcal{R}_{ss}$). There is also a special abstract role ρ_{soc} where $\forall_{(\rho \in \mathcal{R}_{ss})}\ \rho_{soc} \sqsubset \rho$, trough the transitivity of $\sqsubset$, all other roles are specializations of it.

Social level. While the inheritance relation does not have a direct effect on the agents behavior, there are other kinds of relations among roles that directly constrain the agents. Those relations are called *links* [9] and are represented by the predicate $link(\rho_s, \rho_d, t)$ where ρ_s is the link source, ρ_d is the link destination, and $t \in \{acq, com, aut\}$ is the link type. In case the link type is acq (acquaintance), the agents playing the source role ρ_s are allowed to have a representation of the agents playing the destination role ρ_d (ρ_d agents, in short). In a communication link ($t = com$), the ρ_s agents are allowed to communicate with ρ_d agents. In a authority link ($t = aut$), the ρ_s agents are allowed to have authority on ρ_d agents, i.e., to control them. An authority link implies the existence of a communication link that implies the existence of an acquaintance link:

$$link(\rho_s, \rho_d, aut) \Rightarrow link(\rho_s, \rho_d, com) \tag{1}$$

$$link(\rho_s, \rho_d, com) \Rightarrow link(\rho_s, \rho_d, acq) \tag{2}$$

Regarding the inheritance relation, the links follow the rules:

$$(link(\rho_s, \rho_d, t) \wedge \rho_s \sqsubset \rho'_s) \Rightarrow link(\rho'_s, \rho_d, t) \tag{3}$$

$$(link(\rho_s, \rho_d, t) \wedge \rho_d \sqsubset \rho'_d) \Rightarrow link(\rho_s, \rho'_d, t) \tag{4}$$

For example, if the coach role has authority on the player role $link(\rho_{coach}, \rho_{player}, aut)$ and player has a sub-role ($\rho_{player} \sqsubset \rho_{attacker}$), by Eq. 4, a coach has also authority on attackers. Moreover, a coach is allowed to communicate with players (by Eq. 1) and it is allowed to represent the players (by Eq. 2).

Collective level. The links constrain the agents *after* they have accepted to play a role. However we should constrain the roles that an agent is allowed to play depending on the roles this agent is currently playing. This *compatibility* constraint $\rho_a \bowtie \rho_b$ states that the agents playing the role ρ_a are also allowed to play the role ρ_b (it is a reflexive and transitive relation). As an example, the team leader role is compatible with the back player role ($\rho_{leader} \bowtie \rho_{back}$). If it is not specified that two roles are compatible, by default they are not. Regarding the inheritance, this relation follows the rule

$$(\rho_a \bowtie \rho_b \wedge \rho_a \neq \rho_b \wedge \rho_a \sqsubset \rho') \Rightarrow (\rho' \bowtie \rho_b) \tag{5}$$

Roles can only be played in the collective level, i.e., in a group already created in an OE. We will use the term "group" to mean the instantiated group in an OE and the term "group specification" to mean the group specified in an OS. Thus, a group must be created from a *group specification* represented by the tuple

$$gt =_{\text{def}} \langle \mathcal{R}, \mathcal{SG}, \mathcal{L}^{intra}, \mathcal{L}^{inter}, \mathcal{C}^{intra}, \mathcal{C}^{inter}, np, ng \rangle \tag{6}$$

where $\mathcal{R}$ is the set of not abstract roles that may be played in groups created from gt. Once there can be many group specifications, we write the identification of the group specification as subscript (e.g. $\mathcal{R}_{gt}$). The set of possible sub-groups of a group is denoted by $\mathcal{SG}$. If a group specification does not belong to any group specification $\mathcal{SG}$, it is a root group specification.

A group can have intra-group links $\mathcal{L}^{intra}$ and inter-group links $\mathcal{L}^{inter}$. The intra-group links state that an agent playing the link source role in a group *gr* is linked to all agents playing the destination role in the *same* group *gr* or in a *gr* sub-group. The inter-group links state that an agent playing the source role is linked to all agents playing the destination role despite the groups these agents belong to. For example, if there is a link $link(\rho_{student}, \rho_{teacher}, com) \in \mathcal{L}^{inter}$, then an agent α playing the role $\rho_{student}$ is allowed to communicate with the teacher(s) of the groups where it is a student and also with the teachers of any other group, even if α does not belong to these groups.

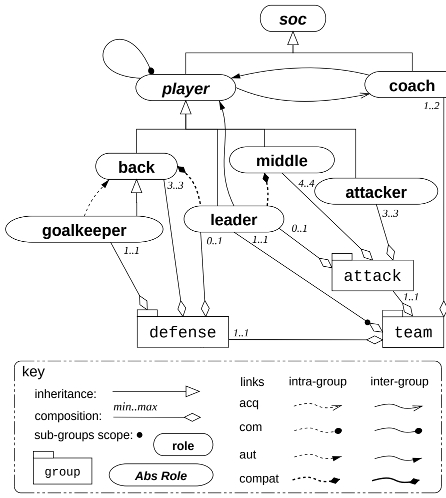

Fig. 2. Structure of a soccer team

The roles compatibilities also have a scope. The intra-group compatibilities $\rho_a \bowtie \rho_b \in \mathcal{C}^{intra}$ state that an agent playing the role ρ_a in a group *gr* is allowed to also play the role ρ_b in the *same* group *gr* or in a *gr* sub-group. Otherwise, the inter-group compatibilities $\rho_a \bowtie \rho_b \in \mathcal{C}^{inter}$ state that an agent playing ρ_a in the group gr_1 is also allowed to play ρ_b in other group gr_2 ($gr_1 \neq gr_2$). For instance, an agent can be a teacher in a group and a student in another, but it can not be both in the same group, so it is an inter-group compatibility.

Along with the compatibility, we state that a group is well formed if it respects both the role and sub-groups *cardinality*. The partial function $np_{gt} : \mathcal{R}_{gt} \nrightarrow \mathbb{N} \times \mathbb{N}$ specifies the number (minimum, maximum) of roles that have to be played in the group, e.g., $np_{gt}(\rho_{coach}) = (1, 2)$ means that *gt* groups need at least one and no more than two coaches to be well formed. Analogously, the partial function $ng : \mathcal{SG}_{gt} \nrightarrow \mathbb{N} \times \mathbb{N}$ specifies the sub-groups cardinality. By default, cardinality pairs are $(0, \infty)$.

For example, the defense soccer team group can be defined as

$$\begin{aligned} def = \langle &\{\rho_{goalkeeper}, \rho_{back}, \rho_{leader}\}, \{\}, \{link(\rho_{goalkeeper}, \rho_{back}, aut)\}, \{\}, \{\rho_{leader} \bowtie \rho_{back}\}, \\ &\{\}, \{\rho_{goalkeeper} \mapsto (1,1), \rho_{back} \mapsto (3,3), \rho_{leader} \mapsto (0,1)\}, \{\}\rangle \end{aligned}$$

In this group specification (see Fig. 2), three roles are allowed and any defense group will be well formed if there is one, and only one, agent playing the role goalkeeper, exactly three agents playing backs, and, optionally, one agent playing the leader role. The goalkeeper has authority on the backs and the leader is allowed to be either a back or the goalkeeper, since $\rho_{back} \sqsubset \rho_{goalkeeper}$.

Using the recursive definition of group specification, we can specify a team as

$$
\begin{aligned}
team = \langle &\{\rho_{coach}\}, \{def, att\}, \{\}, \{link(\rho_{player}, \rho_{player}), com),\\
&link(\rho_{leader}, \rho_{player}), aut), link(\rho_{player}, \rho_{coach}), acq), link(\rho_{coach}, \rho_{player}), aut)\},\\
&\{\}, \{\}, \{\rho_{leader} \mapsto (1,1), \rho_{coach} \mapsto (1,2)\}, \{def \mapsto (1,1), att \mapsto (1,1)\}\rangle
\end{aligned}
$$

A *team* is well formed if it has one defense group, one attack group, one or two agents playing the coach role, one agent playing the leader role, and the two sub-groups are also well formed. The group *att* is specified only by the graphical notation presented in the Fig. 2. In this structure, the coach has authority on all players by an inter-group authority link. The players, in any group, can communicate with each other and are allowed to represent the coach. There must be a leader either in the defense or attack group. In the defense group, the leader can also be a back and in the attack group it can be a middle. The leader has authority on all players on all groups, since it has an inter-group authority link on the player role. In this group, an agent ought to belong to just one group because there is no inter-group compatibilities. However, notice that a role may belong to several group specifications (e.g., the leader).

Based on those definitions, the SS of a MAS organization is formed by a set of roles ($\mathcal{R}_{ss}$), a set of root group specifications (which may have their sub-groups, e.g. the group specification *team*), and the inheritance relation ($\sqsubset$) on $\mathcal{R}_{ss}$.

3 Functional Specification

The FS in $\mathcal{M}$OISE$^+$ is based on the concepts of missions (a set of global goals[2]) and global plans (the goals in a structure). These two concepts are assembled in a Social Scheme (SCH) which is essentially a goal decomposition tree where the root is the SCH goal and where the responsibilities for the sub-goals are distributed in missions (see Fig. 3 and Tab. 3 for an example). Each goal may be decomposed in sub-goals through plans which may use three operators:

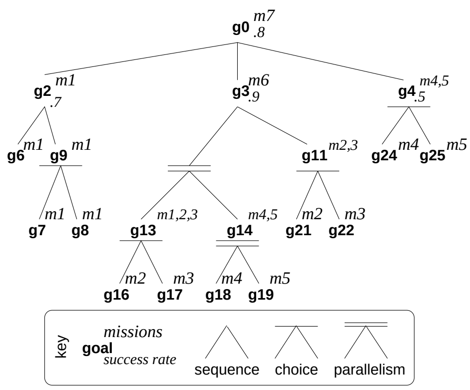

Fig. 3. An example of Social Scheme to score a soccer goal

- sequence ",": the plan "$g_2 = g_6, g_9$" means that the goal g_2 will be achieved if the goal g_6 is achieved and after that also the goal g_9 is achieved;
- choice "|": the plan "$g_9 = g_7 \mid g_8$" means that the goal g_9 will be achieved if one, and only one, of the goals g_7 or g_8 is achieved; and
- parallelism "‖": the plan "$g_{10} = g_{13} \parallel g_{14}$" means that the goal g_{10} will be achieved if both g_{13} and g_{14} are achieved, but they can be achieved in parallel.

[2] Regarding the terminology proposed in [3], these goals are collective goals and not social goals. Since we have taken an organizational centered approach, it is not possible to concept the social goal which depends on the agents internal mental state.

It is also useful to add a certainty success degree in a plan. For example, considering the plan "$g_2 = g_6, (g_7 \mid g_8)$", there may be a environment where the achievement of g_6 followed by the achievement of g_7 or g_8 does not imply the achievement of g_2. Usually the achievement of the plan right side implies the achievement of the plan goal g_2, but in some contexts this may not happen. Thus, the plan has a success degree that is continually updated from its performance success. This value is denoted by a subscript on the $=$. For example, the plan "$g_2 =_{0.85} g_6, (g_7 \mid g_8)$" achieves g_2 with 85% of certainty.

Table 1. Goal descriptions of the Fig. 3.

goal	*description*
g_0	score a soccer-goal
g_2	the ball is in the middle field
g_3	the ball is in the attack field
g_4	the ball was kicked to the opponent's goal
g_6	a teammate has the ball in the defense field
g_7	the ball was passed to a left middle
g_8	the ball was passed to a right middle
g_9	the ball was passed to a middle
g_{11}	a middle passed the ball to an attacker
g_{13}	a middle has the ball
g_{14}	the attacker is in good position
g_{16}	a left middle has the ball
g_{17}	a right middle has the ball
g_{18}	a left attacker is in a good position
g_{19}	a right attacker is in a good position
g_{21}	a left middle passed the ball to a left attacker
g_{22}	a right middle passed the ball to a right attacker
g_{24}	a left attacker kicked the ball to the opponent's goal
g_{25}	a right attacker kicked the ball to the opponent's goal

In a SCH, a *mission* is a set of coherent goals that an agent can commit to. For instance, in the SCH of the Fig. 3, the mission m_2 has two goals $\{g_{16}, g_{21}\}$, thus, the agent that accepts m_2 is committed to the goals g_{16} **and** g_{21}. More precisely, if an agent α accepts a mission m_i, it commits to all goals of m_i ($g_j \in m_i$) and α will try to achieve a g_j goal only when the precondition goal for g_j is already achieved. This precondition goal is inferred from the sequence operator (e.g.: the goal g_{16} of the Fig. 3 can be tried only after g_2 is already achieved; g_{21} can be tried only after g_{10} is achieved).

A *Social Scheme* is represented by a tuple $\langle \mathcal{G}, \mathcal{M}, \mathcal{P}, mo, nm \rangle$ where $\mathcal{G}$ is the set of global goal; $\mathcal{M}$ is the set of mission labels; $\mathcal{P}$ is the set of plans that builds the tree structure; $mo : \mathcal{M} \to \mathbb{P}(\mathcal{G})$ is a function that specifies the mission set of goals; and $nm : \mathcal{M} \nrightarrow \mathbb{N} \times \mathbb{N}$ specifies the number (minimum, maximum) of agents that have to commit to each mission in order to say the SCH is well formed, by default, this pair is $(1, \infty)$, i.e., one or more agents can commit to the mission.

For example, a SCH to score a soccer-goal (*sg*) could be (see Fig. 3):

$$
\begin{aligned}
sg = \langle & \{g_0, \ldots, g_{25}\}, \{m_1, \ldots, m_7\}, \{\text{“}g_0 =_{.8} g_2, g_3, g_4\text{”}, \text{“}g_2 =_{.7} g_6, g_9)\text{”}, \ldots\}, \\
& \{m_1 \mapsto \{g_2, g_6, g_7, g_8, g_{13}\}, m_2 \mapsto \{g_{13}, g_{16}, g_{11}, g_{24}\}, \ldots, m_7 \mapsto \{g_0\}\}, \\
& \{m_1 \mapsto (1,4), m_2 \mapsto (1,1), m_3 \mapsto (1,1), \ldots\} \rangle
\end{aligned}
$$

This SCH is well formed if from one to four agents have committed to m_1 and one, and at most one, agent has committed to the other missions. The agent that will commit to the mission m_7 is the very agent that has the permission to create this SCH and to start its execution, since the m_7 is the *sg* root goal.

It is also possible to define a *preference order* among the missions. If the FS includes $m_1 \prec m_2$, then the mission m_1 has a social preference on the mission m_2. If there is a moment when an agent is permitted to m_1 and also m_2, it has to prioritize the execution of m_1. Since m_1 and m_2 could belong to different SCHs, one can use this operator to specify the preferences among SCHs. For example, if m_1 is the root mission of the SCH for an attack through one side of the field (*sg*) and m_2 is the root of other SCH for the substitution of a player, then $m_1 \prec m_2$ means that the *sg* must be prioritized.

To sum up, the FS is a set of several SCHs and mission preferences which describes how a MAS usually achieves its global goals, i.e., how these goals are decomposed by plans and distributed to the agents by missions. The FS evolve either by the MAS designer who specifies its expertise in a SCH form or by the agents themselves that store their (best) past solutions (as an enterprise does through its "procedures manual").

4 Deontic Specification

The FS and SS of a MAS, as described in Sec. 2 and Sec. 3, can be defined independently. However, our view of the organization effects on a MAS suggests a kind of relation among them (Fig. 1). So in $\mathcal{M}$OISE$^+$ this relation is specified in the individual level as permissions and obligations of a role on a mission.

A permission $per(\rho, m, tc)$ states that an agent playing the role ρ is allowed to commit to the mission m, and tc is a time constraint on the permission, i.e., it specifies a set of periods during which this permission is valid, e.g.: every day/all hours, for Sundays/from 14h to 16h, for the first month day/all hours. In order to save space, the language for specifying the tc is not described here (it is based on the definitions presented in [1]). *Any* is a tc set that means "every day/all hours". Furthermore, an obligation $obl(\rho, m, tc)$ states that an agent playing ρ ought to commit to m in the periods listed in tc. These two predicates have the following properties: if an agent is obligated to a mission it is also permitted to this mission; and deontic relations are inherited:

$$obl(\rho, m, tc) \Rightarrow per(\rho, m, tc) \tag{7}$$

$$obl(\rho, m, tc) \wedge \rho \sqsubset \rho' \Rightarrow obl(\rho', m, tc) \tag{8}$$

$$per(\rho, m, tc) \wedge \rho \sqsubset \rho' \Rightarrow per(\rho', m, tc) \tag{9}$$

For example, a team deontic specification could be:

$$\{per(\rho_{goalkeeper}, m_7, Any)\}, \{obl(\rho_{goalkeeper}, m_1, Any),$$
$$obl(\rho_{back}, m_1, Any), obl(\rho_{leader}, m_6, Any), obl(\rho_{middle}, m_2, Any),$$
$$obl(\rho_{middle}, m_3, Any), obl(\rho_{attacker}, m_4, Any), obl(\rho_{attacker}, m_5, Any)\}\rangle$$

In our example, the goalkeeper can decide that the SCH *sg* will be performed. The goalkeeper has this right due its permission for the *sg* mission root (Fig. 3). Once the SCH is created, other agents (playing $\rho_{back}, \rho_{leader}, \ldots$) are obligated to participate in this SCH. These other agents ought to pursue their *sg* goals just in the moment allowed by this SCH. For instance, the middle agent α that accepts the mission m_2 will try to get the ball (g_{16}) only after the ball is in the middle field (g_2 was achieved).

The DS is thus a set of obligations and permissions for the agents, through roles, on SCH, through missions. In the context of the Fig. 1, the DS delimits the set $S \cap F$. Among the allowed behaviors (S), an agent would prefer a $S \cap F$ behavior because, for instance, this latter set gives it a kind of social power. If an agent starts a SCH (i.e., a place in $S \cap F$) it can force, by the DS, other agents to commit to this SCH missions. Notice that the set of all goal for an agent are not defined by the DS, only the relation of its roles to *global* goals are defined. The agents may also have their local, eventually social, goals, although this is not covered by the $\mathcal{M}$OISE$^+$.

Having an OS, a set of agents will instantiate it in order to form an OE which achieves their purpose. Once created, the OE history starts and runs by events like agent entrance or leaving, group creation, role adoption, SCH starting or finishing, mission commitment, etc. Despite the similarities with the object oriented area, there is not a "new Role()" command to create an agent for a role. In our point of view, the agents of a MAS are autonomous and decide to "follow" the rules stated by the OS. They are not created by/from the organization specification, they just accept to belong to groups playing roles. However, this paper does not cover how an agent will (or won't) follow the organizational norms.

5 Conclusions

In this paper, we have presented a model for specifying a MAS organization along the structural and functional dimension, which are usually expressed separately in MAS organization models as we have stressed in the introduction. The main contribution of this model is the *independence* design of each one of these dimensions. Furthermore, it makes explicit the deontic relation which exists between them. We have used the $\mathcal{M}$OISE$^+$ model to properly specify the three dimensions of a MAS organization in both a soccer domain, used as an example here, and in a B2B (business to business) domain, not presented here.

Comparing this proposal with the MOISE model [9], on which this work is based, the contributions in the structural dimension aim, on one hand, to facilitate the specification with the inclusion of an inheritance relation on the roles, and on the other hand, to verify if the structure is well formed, with the inclusion of the compatibility among roles and of a cardinality for roles and groups. Regarding the functional dimension, the main contributions are: the changes in the mission specification in order to express the relation among goals and their distribution through the inclusion of SCHs in the model; the inclusion of the preference among missions; and the inclusion of time in the deontic relations. Its functional specification is represented in a high abstraction level. Nevertheless, this specification could be specialized in a more detailed functional description already developed in the MAS area. For instance, a SCH could be detailed in a TÆMS task description [4] without redefining the structural specification.

Even if an organization is useful for the achievement of a global purpose, as mentioned in the introduction, it can also make the MAS stiffer. Thus the system may loose one important property of the MAS approach, its flexibility. For example, if the environment changes, the current set of allowed organizational behaviors may not fit the global purpose anymore. In order to solve this problem, a reorganization process is mandatory.

The $\mathcal{M}$OISE$^+$ independence property was developed aiming to facilitate this process since we can change, for instance, the functioning dimension without changing the structure, only the deontic dimension needs to be adjusted. This trend will be part of our future work.

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