Task and Social Coordination in Agent Organizations

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ABSTRACT

Support for new forms of organization and social interaction requires understanding the influence of structure on behavior. In this paper, we will investigate what is the exact nature of this relationship between roles in an organization and what are the consequences of different structure forms.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*multi-agent systems*; D.2.10 [**Software Engineering**]: Design—*methodologies*

General Terms

Design, Languages, Theory

Keywords

Coordination, Roles, Dependencies

1. INTRODUCTION

One of the main issues in agent organizations is the specification of coordination mechanisms between agents playing roles in a regulated social environment. Coordination can be defined as the process of managing dependencies between activities In this sense, which is the most commonly used in Multi-Agent Systems (MAS) research, coordination refers to the allocations of tasks to agents, such that common goals are achieved. Coming forth from Organizational Theory, another way to manage dependencies, considers the supervision and collaboration relations between actors. In this sense, coordination refers to the specification of power and authority relations between agents. Although the two perspectives are interrelated, they are based on different concepts and views on organizations, and their differences are not explicitly accounted for in most MAS models.

In this paper, we discuss the implications of the coordination type to the dependencies between roles. Given that one role depends on another to achieve a goal, the realization of that goal will depend on the social relationship between the roles, that is, whether the role has power over the other role. We distinguish between hierarchical, network and market social relationships between roles. Although role hierarchies can be thought of in terms of hierarchical organizations, we argue that the reason to call an organization hierarchical is not just because the roles are structured in some kind of a hierarchy (or tree), but has more bearing on the type of coordination used between roles that are related. A tree shaped organization usually also indicates that the roles coordinate in a hierarchical way (through commands), but this is not necessarily so. Even in such an organization, each role might offer a task to its "subordinates" instead of delegating it.

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2. SOCIAL STRUCTURE

Behavior and structure are interleaved; people go through a socialization process and become dependent of the existing social structures, but at the same time structures are modified by their activities. This instantiation of practical activity is not based on a even distribution of power and resources, but asymmetry and domination are, in fact, part of the natural order. Different power relations between actors and the utilization of different resources are at the basis of the development of particular structural principles. It is useful to consider groups and organizations from a structuration perspective because doing so: (a) helps one understand the relative balance of deterministic influences and willful choices that characterize groups; (b) suggests possibilities for how members may be able to exercise more influence than they otherwise think themselves capable of.

In organizational science and economics, relationships between and within organizations are developed for the exchange of goods, resources, information and so on. Transaction costs are considered determinant for the organizational model When transaction costs are high, societies tend to choose a hierarchical model in order to control the transaction process. If transaction costs are low, that is, are straightforward, non- repetitive and require no transaction-specific investments, then the market is the optimal choice. Networks are another possible coordination model that stress the interdependence between different organizational actors and pay a lot of attention to the development and maintenance of (communicative) relationships, and the definition of rules and norms of conduct within the network. At the same time, actors are independent, have their own interests, and can be allied to different networks.

3. ROLES AND DEPENDENCIES

Coordination in MAS, is mainly taken care of by using standard interaction mechanisms, task allocation and planning. The idea of Agent Societies is that interactions occur not just by accident but aim at achieving some desired global goals. Global goals are external to each individual participant (or agent) but can only be reached by the interaction of those participants. The design of agent organizations must capture on the one hand, the structure and requirements of the society owners, and on the other hand, must assume that participating agents must be available that are able and interested in enacting society roles. The OperA Model for agent societies [2] separates the description of the structure and global behavior of the domain from the specification of the individual entities that populate the domain. Agents are actors that perform role(s) described by the society design. The agent's own capabilities and aims determine the specific way an agent enacts its role(s).

Roles identify the activities and services necessary to achieve social objectives and enable to abstract from the specific individuals that will eventually perform them. From a society design perspective, roles provide the building blocks for agent systems that can perform the role, and from the agent design perspective, roles specify the expectations of the society with respect to the agent's activity in the society. Roles also define normative behavioral repertoires for agents [4]. In OperA, roles are described in terms of *objectives* and *sub-objectives* (that is, what is an actor of the role expected to achieve) and *norms* (that is, how is an actor expected to behave). Furthermore, role descriptions also specify the *rights* associated with the role. **Role objectives** are states of affairs expected to be achieved in the environment. Formally, a role objective is a predicate describing an ideal state (or set of states) for the role. Once a society model is animated, the objectives of a role are expected to be executed by the agent(s) enacting that role. The actual semantics of objectives depend on the way objectives are treated and assumed by the agent acting the role and on the semantics of agent goals in the agent model.

The notion of role is closely related to those of cooperation and coordination. Different application contexts exhibit different needs with respect to coordination, and the choice of a coordination model will have great impact on the design of the agent society. In this paper, we distinguish between three coordination types: hierarchies, markets and networks, which result in different frameworks for agent societies. The way objectives are allocated to roles determines the **dependencies** between them, which describe how enacting agents enacting interact and contribute to the realization of the objectives of each other. The dependency relation between roles r_1 and r_2 for objective γ of r_1, represented by $r_1 \succeq_\rho r_2$, indicates that objective ρ can be passed to r_2, that is, that r_2 can realize objective ρ for r_1.

DEFINITION 1 (ROLE DEPENDENCY). *A dependency relation $r_1 \succeq_\rho r_2$ describes the fact that role r_1 depends on role r_2 to realize (sub)objective ρ. The relation $\succeq_\rho \in R \times R$ is reflexive and transitive. That is, for all $r_1, r_2, r_3 \in R$, (1) $r_1 \succeq_\rho r_1$, and, (2) $r_1 \succeq_\rho r_2$ and $r_2 \succeq_\rho r_3$ implies $r_1 \succeq_\rho r_3$.*

Dependency relations in OperA are not inheritance relations, but define the links through which objectives can be delegated to other roles. In general, one can identify three different reasons for an agent to commit itself to a request from another agent [1]: **Power**: $power(i, j, \varphi)$, j accepts a request from i because of some domination relationship between i and j. This type of relation is standard in hierarchical societies. **Authorization**: $auth(i, j, \varphi)$, when j has committed itself to i for a certain service, a request from i leads to an obligation when the conditions are met. This relation is established by mutual agreement. **Charity**: j will answer a request from i without being obliged to do so. The different semantics of dependencies relations relative to the coordination structures, are defined over power and authorization relations between roles.

The way the objective ρ in a dependency relation $r_1 \succeq_\rho r_2$ is actually passed between r_1 and r_2 depends on the coordination type of the society: in hierarchies, $r_1 \succeq^H_\rho r_2$, the parent role demands the realization of its sub-objectives from its children, that is r_1 has power over r_2 for ρ. In markets, $r_1 \succeq^M_\rho r_2$, a child role can request the assignment of objectives from the parent role, which defines an authorization relations. In a network, $r_1 \succeq^N_\rho r_2$, an objective can either be delegated by the parent role or requested by the child role, which defines an equivalence relation between related roles in a network.

All interaction is realized through communication, which can be described in terms of speech acts. We argue that speech acts have different effects, depending on the type of social dependency between the agents. For example, a request to agent x has another force whether it is done by an agent with power over x, than by any other agent. The formal definition of the intended effects of communicative acts is as follows. These axioms describe how obligations can arise for an agent: by means of a request based on a power or authorization relation, or by committing itself. The full paper contains all formal definitions, which are left out here due to space restrictions [3].

4. CONCLUSION

In this paper we have argued that organizational structures are important for MAS. Structures need to exist outside the individual agents in order to ensure the achievement of objectives of the organization that rise above the individual agent level, over a longer period of time. We concentrated on the role dependencies that arise from the dependencies between the objectives of those roles. The coordination type of the organization also influences the type of facilitation roles that are needed in that organization, such as a matchmaker for a market and a gate keeper for a network organization.

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