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# Representation and Reuse of Organizational Knowledge

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**Abstract:** In this paper we define agencies as organizations and propose a formalism to represent Organizational Intelligence. A distinguishing point is attributing the organizational knowledge to at least a pair of agents. The private knowledge of an agent is modeled by a symbol structure (SS) and agents can share their knowledge using join, simplification, specialization and generalization rules. We give a coherent view of agent interaction, i.e., cooperation, coordination and competition.

## 1 Organizational Knowledge

Organizations, of various forms, physical, cognitive, temporal and institutional have been studied in operation research, management and computer sciences. The game theoretic approach to study organization focuses on modeling and suggesting computational algorithms for certain aspects of the coalitions, such as social welfare [4], individual rationality, voting consensus, etc. The computational approach focuses on identifying general principles of organization and their exceptions.

The already proposed organizational models for multiagent systems have certain drawbacks. First, they cannot explain the organizational knowledge in terms of its comprising agents without reference to any other intermediary concepts. Second, they cannot provide frameworks for comparing and evaluating different organizations. Third, the organizational knowledge base cannot be updated dynamically, accounting for different configuration of the participant agents. Finally, they cannot explain the need for services of a certain agent in an organization. All of these factors are necessary in organization design and are addressed in our research.

## 2 Assumptions

**a) Intelligence of Pair (IoP)**
All of the proposed theories and formalisms have implicitly assumed that Organizational Intelligence (OI) exists and implemented using a meta-agent (e.g., directory and ontology service agents) (such as [1]). However there are certain difficulties in both logical formulation and actual implementation of such theories. This is mainly due to ignoring the dynamic interactions among the agents when devising the components of OI.

A point in our research is that in a purposeful (i.e., not random) organization, OI is a property of interaction among agents and can only be ascribed to at least a pair of agents. We call this '*Intelligence of Pair (IoP)*' assumption.

**b) History of Patterns (HoP)**
In biological coalitions, participants may have a kind of *role* or function (during interaction with the other participants), if they show some persistence in their profile of actions over time. The same could be devised for artificial coalitions. As a matter of fact, it is not difficult to find organizations that display non-random persistent and repeated patterns of actions [1].

Agents act and perform in a physical world. Their past experiences can be recorded and explained in terms of their *histories*, that is, their *profile* of actions and *states* that they go through.

Intuitively, histories can display certain patterns. A basic feature of state representation is that it assigns a certain characteristic to its reference agent. Therefore it is possible to define OI patterns with reference to agents' history.

Another point is that OI patterns emerge from discovering a persisted state or an ordered pattern in the agent's profile of actions. We call this '*History of Patterns (HoP)*' assumption.

IoP and HoP assumptions account for dynamic interactions and a computation method based on this assumption is proposed in Sect. 6.

## 3 Modeling

Symbol structure (SS) is used to model individual agent's knowledge structure. SS is a finite connected multi-layer bipartite graph. There are two kinds of nodes in each layer of SS: *concepts (c)* and *relations (r)*. One source of difficulty when processing concepts,

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is distinguishing a concept at various levels of abstraction, as well as differentiating between generic concepts and their instances. Function *type* is defined to ease such differentiation. The function *type* maps concepts and relations onto a set $T$. The elements of $T$ are called type labels. Type hierarchy provides a means of evaluating a concept at various levels. The type hierarchy is a partial ordering defined over the set of type labels, $T$. Flexibility, extendibility and interoperability are three main advantages of knowledge representation and reasoning with SS.

# 4 Reasoning

**Join rule:** Join rule merges identical concepts. If a concept $c$ in $u$ is identical to a concept $d$ in $v$, then let $w$ be the symbol structure obtained by deleting $d$ and linking to $c$ all arcs of relations that had been linked to $d$.

**Simplification rule:** Redundant relations of the same type linked to the same concept in the same order can be reduced by deletion all but one. If the relations $r$ and $s$ in the symbol structure $u$ are duplicates, then one of them may be deleted from $u$ together with all its arcs.

**Generalization / Specialization rule** : For two arbitrary levels $u$ and $v$ of any SS, if $u$ is identical to $v$ except that some type labels of the nodes of $v$ are restricted to subtypes of the same nodes in $u$, then $u$ is called a specialization of $v$, and $v$ is called a generalization of $u$.

# 5 Interaction Among Agents

Now we have a framework for representing and reasoning with the knowledge on an individual agent basis. Knowledge sharing by moving from one agent to another and on an organizational basis requires defining the basic agent interactions, i.e., *cooperation*, *coordination* and *competition*. For a pair of agents to interact, each should maintain a model of the other agent, as well as a model of future interactions [3].

**Cooperation:** Cooperation is revealing an agent's *goal* and the knowledge behind it, i.e., its symbol structure to the other party. In cooperation both agents have a common goals.

**Coordination:** Coordination is revealing an agent's *goals* and the knowledge behind it, i.e., its symbol structure to the other party. In coordination, agents have separate goals.

**Loose Competition:** Loose competition is revealing only an agent's *goals* but encapsulating the knowledge behind it to the other party.

**Strict Competition:** Strict competition is neither revealing an agent's *goals* nor the knowledge behind it to the other party.

Therefore, knowledge sharing is equivalent to merging two or more symbol structures using join, simplification, generalization and specialization rules.

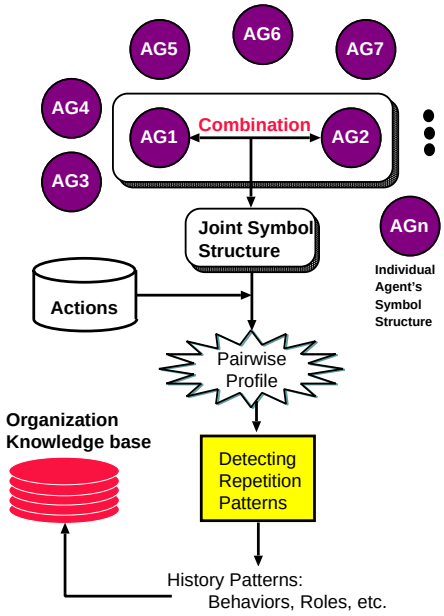


Figure 1: Organization Intelligence concept

# 6 Computational OI

We propose a computation method for generating OI concepts based on the IoP and HoP assumptions (see Sect. 1). Fig. 1 depicts the idea. In this method, first, a pair of agents are selected and by using reasoning rules (see Sect. 4) their pairwise profile is produced (see Sect. 5). Then by using a simple pattern detection algorithm, possible repetition and persistence patterns are derived and added to the knowledge base of the organization.

Applications using the framework and techniques described in this paper, such as a multiagent system for electronic commerce [2] are under investigation and development.

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