

Dynamics of Contracts-Based Organizations*

A Formal Approach Based on Institutions

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ABSTRACT

An organization comprises a group of collaborating agents (individual agents or nested organizations) that exhibit complex behaviors. Of particular interest are dynamic organizations that form and dissolve as their members' needs change. Such organizations are important in many applications, including scientific and business computing. Contracts among autonomous agents have long been used to facilitate their collaboration. This paper provides a contracts-based approach for managing organizations. The proposed approach places organizations within *institutions*, themselves modeled as specialized organizations. Commitments form the basis of contracts and this paper establishes some important dynamic aspects by providing a commitment life cycle analysis. This approach has been applied in a prototype tool to manage organizations.

Categories and Subject Descriptors

I.2.11[Artificial Intelligence]: Distributed Artificial Intelligence – *multi-agent systems*.

General Terms

Management, Design.

Keywords

Contracts, organizations, institutions, commitments.

1. INTRODUCTION

An organization comprises a dynamic collection of entities such as individuals, enterprises, and their resources collaborating on some computational activity. The key properties of autonomy, heterogeneity, dynamism (membership and structural) distinguish organizations from traditional

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IT architectures. Thus agents can best model organizations and their members.

An *institution* is an organization with an identity of its own and whose life time exceeds that of its members. The US Supreme Court and universities are examples of institutions. Markets such as eBay are institutions. An institution can be modeled as an agent, and defines one or more *roles*, each of which might be played by zero or more agents. For example, eBay supports creating an indefinite number of auctions; each auction must have exactly one (registered) seller and as many (registered) buyers as happen to participate in the auction. Each auction corresponds to a dynamic organization, which exists temporarily within the eBay institution, and is subject to eBay's requirements.

Our main contribution is in the form of a dynamic conceptual model for contracts-based organizations formed within institutions. It demonstrates how organizations are created within institutions and provides a life cycle analysis of commitments, which form the basis for the enactment of contracts. The proposed approach has been implemented in a prototype tool to manage organizations.

2. CONCEPTUAL FRAMEWORK

This section introduces our static conceptual model, which builds on our previous research [4]. This model forms the basis for our contracts-based model for organizations. This paper extends our previous work with institutions. It introduces several dynamic aspects of organizations that have not been formalized before.

Organizations. An organization is an agent that comprises other agents, in particular, other organizations. That is, an agent may be either an individual (representing a person, business partner, or a resource), or an organization. Note that an organization in this sense is a computational entity and may not necessarily correspond to a real-life organization. We can create as many organizations as needed.

Commitments. Commitments form the key abstraction for expressing organizational interactions among agents [3]. Commitments capture the essence of obligations in a three-party manner, involving a *debtor*, a *creditor*, and an organization serving as the *context* for the commitment. Commitments are directed obligations from a debtor agent to a creditor agent, but within the scope of a parent organization, which forms the context. Commitments can be manipulated through several operations. In our framework, we consider seven operations on commitments namely, *create*, *discharge*, *cancel*, *release*, *delegate*, *assign*, and *escalate*

[4]. The above operations are ways of manipulating commitments and hence form the key components of the agent interactions. Such commitments provide a natural basis for contracts. Also, the context of a commitment provides the means to handle exceptions and opportunities by delimiting the scope of a commitment to its context organization. Thus the context provides an organizational basis for revoking or otherwise manipulating commitments.

Contracts. A contract among two or more agents encapsulates a related set of commitments. A contract is formed within the same context organization as its constituent commitments. If such an organization doesn't already exist, the act of contracting creates it. The operations on a contract can have ramifications on the commitments formed within this contract, and vice versa. A contract is *created* when a set of agents collaborate by forming a related set of commitments within a specified context. A contract can be *completed* by the context organization if all the commitments specified in the contract are successfully discharged. A contract can be *released* by the context organization, which essentially eliminates all the commitments. A context organization can also release the commitments of an individual contracting agent, in effect releasing it from the contract. A contract is *canceled* by the context organization if the commitments fail to discharge or if they cause violations.

Institutions. An institution is a kind of an organization that provides a means of describing the social environment within which organizations (managing various contracts) are hosted, i.e., come into being. Each such organization might itself be an institution, and thus host additional organizations to solve more specific problems for their members. An institution encapsulates a set of roles, a nonempty set of agents, policies, and a set of commitments. The policies include entry and exit policies for agents to join and exit the institution, policies regarding the life time of the organizations hosted, their functioning, penalties, rewards, and so on. eBay's membership policies are good examples.

An institution encloses *abstract* and *instantiated* organizations. An *abstract* organization is a conceptual model of an organization, with a set of member *roles* and commitments that are associated with a role. An *instantiated* organization is formed when an abstract organization and its roles are instantiated by agents who form a contract under the context of this instantiated organization.

3. DYNAMIC CONCEPTUAL MODEL

We demonstrate how organizations are created within institutions and describe the life cycle of commitments, which form the basis of the contracts.

Creation of Organizations within Institutions. Figure 1 illustrates the current scenario. An institution T already exists that includes a repository of abstract organizations, and a repository for instantiated organizations. Here, agents A_1 – A_6 attempt to enter the institution T (by registering with T). A_1 – A_5 qualify as members, while A_6 fails to get registered in T (Steps 1 and 2). A_1 and A_2 wish to contract with each other, and choose an existing abstract organization (O^i), instantiate the roles defined in it, and create an instantiated organization: O_1^i . Similarly, A_4 and A_5 create O_2^i . If O_1^i is open to new members, A_3 may enter it, provided A_3 is already a member of T , and meets the entry requirements of O_1^i (Step 3). A_3 becomes a member

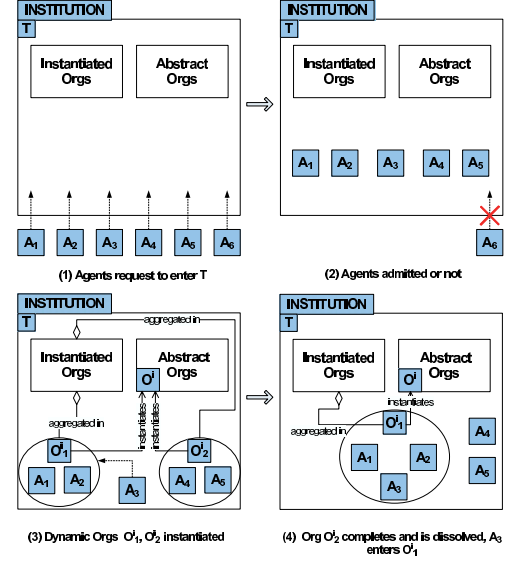


Figure 1: The creation of organizations

of O_1^i due to an operation such as a delegation of a commitment by A_1 or A_2 , and is situated below the delegator agent in the organizational hierarchy (not shown in the Figure). The organization O_2^i is dissolved when the contract is either enacted successfully, or canceled (Step 4).

In simple terms, this means agents must find their way into an institution. Once there they have the credentials and capabilities needed to enter into contracts with their peers. The institution thus provides critical functions (as needed) such as helping agents find one another, credentialing, and nonrepudiation of contracts.

An Example Scenario. Consider a scenario where universities $Univ_1$ and $Univ_2$ form a contract (Cm_1) to provide the *InterLibrary Loan (ILL)* services to each other. $Univ_1$ commits to providing the service of lending a book to any request from $Univ_2$, and vice versa. An organization (Org_1) is created for this contract and it forms the context for the contract and its associated commitments. Each university delegates and assigns the two commitments to its library.

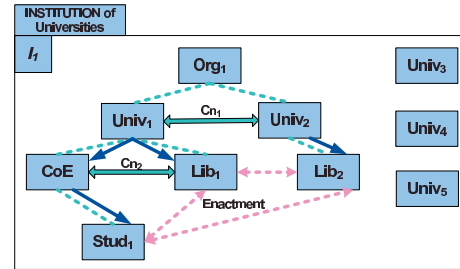


Figure 2: An example of contract enactment

Figure 2 illustrates this scenario. $Univ_1$ contains Lib_1 and a College of Engineering (CoE), which contains the student $Stud_1$. Likewise, $Univ_2$ contains Lib_2 . The dashed edges

