A Cost-Based Transition Approach for Multiagent Systems Reorganization

(Extended Abstract)

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ABSTRACT

In this paper we present an organization transition model that is based on costs along with an associated organization transition mechanism. This mechanism calculates how a current instance of an organization can evolve to a future instance and how costly this evolution is.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Multiagent systems

General Terms

Design,Algorithms,Experimentation

Keywords

Reorganization,Transitions,Organizations

1. INTRODUCTION

Reorganization in MAS defines a process that changes an organization into a new one [3]. These changes are regarding to the organization specification such as roles, goals, services, and the agent population as well as changes in the relationships among these components.

Most existing approaches for reorganization in MAS define adaptation processes due to organizational changes. These approaches propose solutions for reorganization when changes prevent the organization from satisfying current goals (such as when an agent leaves the organization) or for achieving better utility. However, they are not focused on proposing mechanisms for achieving specific future instances of the organization and computing the associated costs.

This paper explores the area of reorganization in MAS and focuses particularly on a novel work based on achieving future instances of an organization at minimal cost. With this objective in mind, we have designed a cost-aware organization transition model to allow a reorganization by means of organization transitions. By using this organization transition model, we provide an organization transition mechanism that allows a specific instance of an organization to evolve into another instance of the organization at the minimal transition cost. It also provides the sequence of steps that must be carried out to achieve the future instance by taking into account the restrictions that must be fullfiled during the transition.

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2. ORGANIZATION TRANSITION MODEL

The organization transition model is composed by three parts: the definition of organization; the organization transition; and the computation of the cost related to the organization transition.

2.1 Organization

In this work we use an adaptation of the organization definition proposed by Argente et al. in [2].

Definition 1 (Organization). An organization in a specific moment ω is defined as a tuple $O^{\omega} = \langle OS^{\omega}, OE^{\omega}, \phi^{\omega} \rangle$.

The Organizational Specification OS details the set of elements of the organization by means of two dimensions: $OS = \langle SD, FD \rangle$. The Structural Dimension SD describes the set of roles R contained in the organization in a specific moment. The Functional Dimension $FD = \langle S, provider \rangle$ describes the set of services S that the organization is offering in a specific moment and $provider : S \rightarrow 2^R$ relates a service with the set of roles that offer it.

The Organizational Entity OE describes the population of agents A in a specific moment.

The Organizational Dynamics $\phi = \langle plays, provides \rangle$ represents the relationships among the elements of the OS and the elements of the OE, where:
$plays : A \rightarrow 2^R$, relates an agent with the set of roles that it is playing in a specific moment.
$provides : A \rightarrow 2^S$, relates an agent with the set of services that it is providing in a specific moment.

2.2 Organization transition

An *organization transition* [1] allows us to relate two different instances of the same organization in different moments ini and fin. This mechanism changes the current OS^{ini},OE^{ini}, and ϕ^{ini} into a new OS^{fin}, OE^{fin}, and ϕ^{fin}, respectively.

Definition 2 (Events). An *event* (ε) defines each individual change that can be applied to an element during the organization transition, in terms of addition or deletion. Given two organizations, O^{ini} and O^{fin}, a transition func-

tion defines a set of events $\tau = \{\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_n\}$ that when applied to O^{ini}, allows a transition to O^{fin}.

Definition 3 (Dependency of events). An event ε is *dependent* of another event ε' if, in order for ε to be applied, ε' must first be applied. A set of events τ must be split into subsets of events which group independent events. Thus, a set of events τ can be represented as a sequence of subsets of events $\tau_1, \tau_2, \ldots, \tau_n$ ordered by a dependency order.

Definition 4 (Transition path). If a sequence of subsets $\tau_1, \tau_2, \ldots, \tau_n$ is applied to transition from O^{ini} to O^{fin}, the application of each $\tau_i \subset \tau$ causes a transition to an intermediate organization. The sequence of organizations that is reached in the transition between O^{ini} and O^{fin} represents a *transition path* between both organizations.

2.2.1 Transition Path of the minimal cost

Each event ε has an associated cost $c(\varepsilon)$ to be applied. For any set of events τ that allow a transition from O^{ini} to O^{fin}, we define the cost of the organization transition as the cost of applying all the required events: $C_{trans} = \sum_{\varepsilon \in \tau} c(\varepsilon)$.

The Organizational Dynamics ϕ^{fin} represent relationships between OS^{fin} and OE^{fin}. These relationships define which services offers each agent and which roles the agent plays in a specific moment. Therefore, according to the Organizational Specification OS^{fin} and the Organizational Entity OE^{fin}, some agents could require to be reallocated to other roles that they were not playing in O^{ini}. Each one of these possible reallocations defines a different ϕ^{fin} that fulfills OS^{fin} and OE^{fin} and has associated a set of events τ_ϕ related to the Organizational Dynamics transition with a cost of C_ϕ.

Let Θ denotes the set of all the possible τ_ϕ that defines an Organizational Dynamics transition from ϕ^{ini} and fulfills OS^{fin} and OE^{fin}, our major challenge is to find the specific set of events that minimizes the Organizational Dynamics transition cost: $\tau_{\phi_{min}} = argmin\{\sum_{\varepsilon \in \tau_\phi} c(\varepsilon) \mid \tau_\phi \in \Theta\}$.

The transition path of the minimal cost defines a transition from O^{ini} to O^{fin} in which the Organizational Dynamics transition from ϕ^{ini} to ϕ^{fin} has the associated set of events of the minimal cost $C_\phi = c(\tau_{min})$.

2.3 Organizational Dynamics cost computation

The cost related to the Organizational Dynamics transition defines how costly it is for agents to acquire the services to play a specific role, to start playing this role, to stop playing a role that is currently being played by an agent, and to stop providing the services required for this last role. We define the cost of an agent a for playing a role r as:

$$C_{ACQUIRE}(a, r) = C_{SERVICES}(a, r) + C(add(plays(a, r)))$$

where $C_{SERVICES}(a, r)$ defines the cost of aquiring the services offered by r that are not already provided by the agent a, and $C(add(plays(a, r)))$ defines the cost for a to play r once it provides the services required. On the other hand, the cost of agent a to stop playing a role r is defined as:

$$C_{LEAVE}(a, r) = C(delete(plays(a, r))) + C_{SERVICES}(a, r)$$

where $C(delete(plays(a, r)))$ represent the cost of agent a to stop playing the role r, and $C_{SERVICES}(a, r)$ defines the cost to stop providing the services required to play r that are no longer required by a for playing other roles.

Therefore, we define the cost of role reallocation for agent a from role r_{old} to role r_{new} as:

$$C_{Realloc.}(a, r_{old}, r_{new}) = C_{ACQUIRE}(a, r_{new}) + C_{LEAVE}(a, r_{old})$$

The cost related to the Organizational Dynamics ϕ^{fin} is computed as the aggregated cost of each role reallocation:

$$C_\phi = \sum_{a \in A} C_{Realloc.}(a, r_{old}, r_{new})$$

3. ORGANIZATION TRANSITION MECHANISM

The organization transition mechanism calculates how an organization can evolve to a future organization and how costly this evolution is. It is composed by three steps:
Calculating the Organizational Dynamics: This step uses an initial organization O^{ini}, the Organizational Specification OS^{fin}, and the Organizational Entity OE^{fin}, and calculates the Organizational Dynamics ϕ^{fin} which minimizes the organizational transition cost $C_\phi = c(\tau_{\phi_{min}})$.
Calculating the set of events: This step takes ϕ^{fin} and finds the τ that allows a transition from O^{ini} to O^{fin}.
Calculating the transition path: This step takes τ and calculates the dependency of events. Dependent events are splitted into different subsets, providing a sequence that must be applied in by order of dependence by defining the transition path between O^{ini} and O^{fin}.

4. CONCLUSION

Previous works in reorganization in MAS have usually approached reorganization as a requirement that appears at a given point in the life-span of an organization. This requirement usually appears when the performance of the organization must be improved. The most remarkable difference among previous approaches and this work is the fact that the future organization cannot be specified and is subject to the changes that guide the reorganization. Therefore, the cost associated for achieving future specific organizations cannot be computed.

The organization transition mechanism proposed in this paper allows an organization transition from an initial organization to another one by computing the cost of transition and the sequence of steps required to carry out the organization transition.

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