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Service-Oriented Framework for Virtual Organizations

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Abstract— *This paper analyses the main issues that should be addressed in order to develop open multi-agent systems. Social concepts, such as norms, roles, etc. have been traditionally employed as a coordination mechanism in the design of this kind of systems. However, available tools rarely give support for these organizational abstractions and, consequently, they are not suitable for the development of real open multi-agent applications. The THOMAS multi-agent framework has been proposed in order to tackle with all these open issues. It provides a useful framework for the development of virtual organizations, on the basis of a service-based approach.*

Keywords: Service-Oriented Architecture, Open Multi-Agent Systems, Virtual Organizations.

1. Introduction

Virtual Organizations (VOs) are a set of individuals and institutions that need to coordinate resources and services across institutional boundaries [1], [2]. Thus, they are open systems formed by the grouping and collaboration of heterogeneous entities and there is a separation between form and function that requires defining how a behaviour will take place. The technology of multi-agent systems (MAS) and dynamic agent organizations is particularly well suited as a support for these open systems.

The main features of VOs are: (i) they are populated by heterogeneous agents which can enter or leave the system dynamically; and (ii) they are situated in dynamic environments. As a consequence of the heterogeneity feature, organizational concepts are needed for achieving the coordination in the system. In addition, system functionalities should be modelled as services in order to allow heterogeneous agents or other entities to interact in a standardized way. Moreover, the potential changes on the dynamic environment might require the adaptation of the structure and functionality of the organization. Furthermore, the likely adaptive needs of the system to be developed requires the application of knowledge discovering techniques and reasoning and planning mechanisms to resolve problems in an dynamic way.

The integration of MAS and Service Technologies has been proposed as the basis for these new and complex systems [3]. In this sense, both technologies can complement the strengths of each other: (i) service standards provide an infrastructure for the interaction among agents; (ii) MAS offer a more general and complex notion of *Service Oriented Architectures* (SOA); and (iii) intelligent and social capabilities of agents allow defining complex services.

Moreover, according to current approaches, it is necessary to improve the coordination methods in VOs by means of locating techniques and composition of services, both syntactic and semantic. The existence of adaptive mechanisms for creating organizational structures that allow optimizing the coordination in VOs, taking into account the heterogeneity of agents and services, is also an essential issue. Thus, it is necessary to employ basic mechanisms that, based on certain desirable criteria, would be able to find adequate services in VOs and, if necessary, to construct new services through service composition. Furthermore, VOs need the existence of regulatory mechanisms that guarantee a globally efficient coordination in open systems taking into account the impossibility of controlling (the majority of) the agents and services directly.

The present paper represents a step forward on these open issues, providing a service-oriented framework specifically designed for the execution of virtual organizations and based on the THOMAS architecture [4].

The paper is structured as follows: Section 2 makes a short review of related works. Section 3 describes the THOMAS architecture. Section 4 details the THOMAS framework, including an explanation of its implementation. An application example of the THOMAS framework is shown in Section 5. Finally, conclusions are presented in Section 6.

2. Related Work

Virtual Organization design and implementation. Recently, researchers have carried out several studies that offer new procedures and methodologies to enable designing open MAS, focused on the organizational aspects of the agent society. Some examples of these approaches are AGR [5], Tropos [6], Gaia2 [7]. Many of the recent works do not only focus on the employment of organizational structures during the design process, but also on the regulation of open MAS (standing out E-Institutions [8], Moise [9]). However, the abstractions and tools currently available are still not enough for many kinds of open MAS that deal with real world problems. Most of these works are, in a certain way, incomplete as they do not include all the phases and requirements for the entire development of systems of this

The new client agent (C1) requests the *SearchService* to the SF component so as to find services of its interest (message 3). The result of this service is shown in message 4. Then, C1 employs *InformService* in order to know inside which organizational unit this *SearchTravel* service is provided (messages 5 and 6). C1 must acquire the *Customer* role to demand this service (messages 7 and 8). Once C1 plays this customer role, it employs the *SearchProvider* service in order to know who the service providers are and how this service can be requested (messages 9 and 10). As shown in message 10, one implementation of the *SearchTravel* service has been previously registered. This implementation has two different providers (CH1 and CH2). C1 chooses to make a service petition to CH1 agent, so then according to this service process, C1 sends a message for requesting this *SearchTravel* service to CH1 agent (messages 11 and 12).

6. Conclusions

As explained in this paper, the available agent platforms seem to be not suitable for the development of large scale open multi-agent systems, as they are not capable of managing their complexity, uncertainty and dynamic features in an efficient way. Thus, a new service-oriented execution framework for supporting the development of real VOs, named THOMAS framework, has been proposed.

It extends the previous proposals taking as a reference the challenging development of open systems. Therefore, the main contributions of the THOMAS framework are:

- It gives support to *virtual organizations* as a social abstraction for coordinating the autonomous behaviours of agents.
- System functionalities are described and provided as *services* in order to make possible the interaction among heterogeneous entities in a standardised way.
- It provides *discovering* and *composition* services for allowing external agents, which have been designed independently of the THOMAS framework, to participate inside it.
- It provides mechanisms, i.e. services, for the adaptation and modification of both the structure and functionality of the organization in response to the environmental changes. In this sense, it allows agents to reorganize the system dynamically.

This paper contains a general overview of the THOMAS framework and a detailed description of its two main components: SF and OMS. A case study, which illustrates how an external agent is capable of discovering and employing functionalities in THOMAS, is also provided. All this work has been included in an available prototype of the THOMAS abstract architecture.

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