HoloJade: A Role Based Holonic Extension for JADE

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ABSTRACT

Holonic Multi-Agent Systems (HMAS) provide a convenient and relevant way to analyze, model, and simulate complex systems in which a large number of entities are interacting at different levels of abstraction. Many models have been proposed for the implementation of these systems; however, most are not general enough to cover applications other than the ones for which they are applied. In this paper, the authors introduce HoloJade, an extension to JADE platform, as a generic solution for the development of HMASs in which Holons and their assigned roles are presented as first level entities available at runtime. This includes a detailed description of the extension, in terms of its meta-model, the needed protocols for the possible interactions, and facilities for the reorganization of the holons. In this paper, the authors also present a hypothetical library example to demonstrate the steps for designing a holonic structure using this extension.

Keywords: HMAS, HoloJade, Holon, JADE, Multi-Agent Systems

INTRODUCTION

During recent decades there has been an immense growth in size and complexity of Multi-Agent Systems (MASs) (Odell et al., 2005). Although MASs are considered today to be well suited to analyze, model and simulate complex systems, in cases where there is a great number of entities interacting at different levels of abstraction, it seems improbable that MAS will be able to faithfully represent complex systems without multiple granularities. To deal with this problem, holonic systems have attracted the attention of researchers. And today many of its contributions to many application ranging from Manufacturing Systems (Maturana et al., 1999), Transports (Burkert et al., 1998), cooperative work (Adam et al., 2000) or yet radio mobile mesh dimensioning (Rodriguez et al., 2003) are apparent.

Holonic structures like organizational ones in multi-agent systems are beneficiary of many desirable and simplifying features such as simplification in representation, further encapsulation, and modularization. In these structures, interactions are specified in two different scopes, within and outside of the holon, and as a result interoperability problems are reduced by a considerable degree. Additionally, by means of role concept and evaluation of the holons or organizations and their members using this concept, we can reduce the possibility that unfit members can be grouped together toward
a specified aim and on the other hand, enable them comply with these requirements. In spite of over-mentioned useful features, these kinds of structures are not always supported explicitly and generically by agent platforms and most of the proposed solutions or platforms are application based, i.e., they have been developed for a specific domain of applications.

Considering these remarkable features of holonic systems in solving and modeling of complex problems, it is not surprising to find numerous methodologies and frameworks for the development of these systems. Most of the works proposed in implementation and development of these systems, as stated above, are strongly related to the domain of applications, mostly in manufacturing domain, they were applied for. In other words, an agent or holonic architecture to that specific application is presented at first and then that architecture is implemented using current agent platforms as desired. Therefore these solutions are applicable merely to very similar cases. For instance, Van Brussel et al. (1998) introduced a holonic system architecture, called PROSA that includes three types of basic holons: order holons, product holons and resource holons; Langer proposed a methodology and architecture for holonic multi-cell control system (Langer, 1999); Liu et al. (2000) presented the architecture and coordination of a holonic automated guided vehicle system, and Glanzer et al. (2001) implemented a machine-holon using ZEUS (Nwana et al., 1999) agent framework.

In addition to the over-mentioned examples, some of other works try to propose a generic framework that is applicable in various domains. Among these works, we can mention the platform developed by Rodriguez et al. (2005). In their work, the authors have used MADKIT (Gutknecht & Ferber, 2000a; Gutknecht & Ferber, 2000b) agent platform which is built upon the AGR (Agent / Group / Role) organizational model (Ferber et al., 2004; Gutknecht, 2001) and extended it to support holonic structures by considering Parunak and Odell’s modification to AGR model. Another generic framework which is worth noting is JANUS (Gaud et al., 2008). This platform has been developed from scratch to support holonic multi-agent systems based on an organizational approach and its key focus is that it supports the implementation of the concepts of role and organization as first-class entities.

In this paper we present HoloJade, a holonic extension for JADE platform (Bellifemine et al., 1999; JADE, 2001). JADE platform is a FIPA (2002) compliant software framework for multi-agent systems in Java that allows the coordination of multiple agents and the use of directories and the standard FIPA-ACL communication language in both SL and XML. The agent platform can be distributed across machines (even with different OS) and its configuration can be changed at run-time by moving agents from one machine to another whenever it is required. JADE supports the implementation of ontology for the content of messages and knowledge of agents and since it provides a library of behaviours for performing FIPA interaction protocols, is also one of the preferred platforms to implement conversation protocols among agents either from scratch or by combining the existing protocols. In spite of addressing the problem of composition of agent groups, it does not provide explicit features for groups apart of the emergent behaviour obtained by manifesting the behaviours of each agent. It is also does not support the role concept. In this paper we try to add the concepts of holon ad roles as first class entities to this popular platform by the HoloJade extension.

In the rest of this paper, in section two an introduction to holonic systems is given. In section three, our HoloJade extension is presented by its detailed meta-model and required protocols. In section four, we will show how this example can be used for the modeling of a hypothetical holonic library example. Finally in section five conclusion and remarks for future works are presented.

Holonic Multi-Agent Systems

The concept of holon is central to this paper and therefore a definition of it seems to be
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