Ontology Enrichment in Multi Agent Systems Through Semantic Negotiation

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Abstract. Ontologies play a key role in the development of Multi-Agent Systems (MASs) for the Semantic Web, providing conceptual description of the agents' world. However, especially in open MASs, agents use different ontologies and this often leads to communication failures. Semantic negotiation is a recent framework which provides an effective solution to such a problem, but it is a too heavy framework to be implemented in large agent communities. In this paper, we deal with the inefficiency in semantic negotiations, and we show how a possible solution is to build a common representation of the different terms used by the agents. We argue that a reasonable compromise to use a common ontology consists of combining it with semantic negotiation and we propose an algorithm which implements this idea in the recent HISENE semantic negotiation framework. Moreover, the semantic negotiation is exploited, in our proposal, to dynamically enrich the global ontology.

1 Introduction

Nowadays, we can observe a growing use of MASs in different applications on the Semantic Web, since software information agents make possible the widespread acquisition of machine understandable data, opening myriad opportunities for automated information processing. In this context, the notion of *ontology* plays a prominent role. On one hand, ontologies drastically enhance the possibility to make the Web being really "semantic". On the other hand, in order to make both effective and efficient the use of ontologies, two main problems, strongly related to the intrinsical heterogeneity of the Semantic Web, arise.

Problem A: Heterogeneity between agents. Ontologies are often advocated as a complete solution for knowledge sharing between agents, giving the possibility to assign a *meaning* to terms contained in the exchanged messages. However, such a possibility exists only in the case each agent of the system knows the ontology of other agents; on the contrary, an agent that receives a message from another one that uses a different ontology is not able to understand the content of the message. A solution to such a problem is represented by the use of a common ontology [4,6], shared by all the agents. However, this is a solution

R. Meersman and Z. Tari et al. (Eds.): OTM 2007, Part I, LNCS 4803, pp. 391–398, 2007.

that appears unlikely in open MASs, since it would imply all the agents agree to adopt a standard ontology, about which it is necessary to reach consensus.

Problem B: Necessity of a unique representative ontology. An agent has the necessity to know the content of the other ontologies, in order to choose the most suitable terms for a correct communication. In other words, the agent would desire to have a "global ontology" which allows him to interact with the community. Moreover, such a global ontology would be also very useful for the new agents that join with the community. However, for the same reason, it is worth to point out that the global ontology cannot be "a priori" fixed and static, since it must reflect the possible introduction of new terms and the possibility of use of new meanings of the same term.

Recently, a new framework suitable to face the problem of semantic heterogeneity has been developed, which seems promising to solve the problem A. This framework, called *semantic negotiation* [3,5,6], is a process by which the agents of a MAS try to reach mutually acceptable definitions (i.e., mutually acceptable agreements on terms). In this context, in [1] we have introduced the idea that two agents involved in a communication can require the help of other agents in order to solve possible understanding problems. On the basis of this idea, we have proposed the *HIerarchical SEmantic NEgotiation* (HISENE), that is suitable to be applied for implementing such a semantic negotiation in the standard Java Agent DEvelopment Framework (JADE) [2]. HISENE gives a solution to the problem A since its semantic negotiation protocol provides a framework to allow the agents of a MAS to understand each other, without constraining the agents to adopt a unique, fixed ontology. However, if a new agent joins with the system, he cannot access to a global view of the existing terms, but he needs to activate a semantic negotiation to gradually learn the personal "language" of each other agent. This obviously leads to significant inefficiencies in the communication process of the entire system. The present work gives a contribution to the problem B. In particular, we propose an algorithm, called *Hisene Ontology Enrichment* (HOE), to derive a global ontology from the personal ontologies of different agents. The global ontology generated by our algorithm contains all the terms used by each agent and, for each term, the set of all the different meanings exploited for that term. Moreover, the global ontology so derived can be continuously enriched during the evolution of the system, giving the possibility to add new terms and new meanings of the same term. Using HOE in combination with HISENE, each agent of a MAS can autonomously enrich his own ontology by using the semantic negotiation protocol and, at the same time, access to the global ontology to have a synoptical view of the terms used by all the other agents. Each term of the global ontology is associated with a set of meanings, and each meaning is associated, in its turn, with the agents that have used it in the past. This allows an agent, that desires to send a message to another agent, to choose the most suitable term with the most appropriate meaning from the global ontology. Only in the case the agent does not find in the global ontology the necessary term, he will use a new, personal term that is not contained in the global ontology and that probably will lead to a semantic negotiation process.