A communication protocol for semantic heterogeneity with incomplete ontology alignment

(Extended Abstract)

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ABSTRACT

Recent work shows that, in an open loosely coupled MAS, it is difficult to deal with semantic heterogeneity between agents in a static way. In this paper, we present an interaction protocol for the request interpretation which permits to manage the semantic heterogeneity when the ontology alignment is incomplete. We first briefly describe the messages translation mechanism, based upon the presence of an ontology alignment service. We then present the answer strategy of our agents, which relies on several specific performatives. We propose an experimental evaluation.

Categories and Subject Descriptors

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

General Terms

Algorithms, Experimentation.

Keywords

Multiagent systems, interaction, communication & protocol, semantic heterogeneity, ontologies.

1. INTRODUCTION

Multi-Agent Systems (MAS) strongly rely on communication for the coordination of agents. However, in open loosely coupled MAS, each agent can have its own representation of the domain and communication becomes hazardous when agents do not use the same set of terms in message contents. This problem is know as semantic heterogeneity [4].

Recent work [1, 5] only considers systems where each agent has its own ontology. In these systems, the preliminary step of any communication is to compute an alignment between the ontologies of the two agents. Using their cognitive abilities coupled with semantic negotiation protocols, the agents can compute an alignment between terms of the two ontologies [1, 5]. However, in a loosely open MAS, the ontology alignment will balance between two opposite situations: either the alignment is not optimal and incorporates mistakes, or the alignment is optimal and is not complete. These two situations represent the starting hypothesis of our work: in many case, resolving the alignment is not sufficient to solve the interoperability problem between two agents.

In this paper, we propose to interpret requests which lack of concepts because of the alignment problem. We rely upon an ontology alignment service which can provide an initial alignment between terms of the two agents ontologies [1]. This allows us to partially translate the request from the initiator agent using the terms of the receiver agent. Then, the receiver agent uses a matching algorithm between the partial request and agent actions to decide the best answer. To this purpose, we introduce five new performatives.

2. COMMUNICATION STRATEGY

When an agent A sends a request to an agent B, he uses concepts from its own ontology $\mathcal{O}^A$. Since the agent B uses its own ontology $\mathcal{O}^B$ too, he has to translate the request into its own terms before trying to interpret it. We chose to consider (as [1]), that the MAS has an access to an ontology alignment service. Let S_A be the request content sending by A to B (which use concepts from $\mathcal{O}^A$). The translation S_B of S_A in $\mathcal{O}^B$ is then defined as a set of concept of $\mathcal{O}^B$ such that an alignment (found with the alignment service) linked to a concept of S_A exists. This formula simply assigns all the terms from the initial request of A to new terms defined in the ontology $\mathcal{O}^B$, but could use complex algorithm from literature [1, 5]. However, some concepts could be undefined in one of the two ontologies and the alignment will be incomplete, which is our starting hypothesis.

Our agents are programmed using the *View Design Language* (VDL)[1]. This model allows agents to access *at runtime* the description of their actions. This introspection capability allows us to generate the list of all *abilities* of the agent at the current time [2]. An ability is a set of parameters for a given action of the agent, which allows him to produce an effect on his environment or to make a modification of its internal state. We previously describe, in [2], how to compute a matching score between a set of organized concepts as S_B and each ability, using a semantic measure based on the agent ontology [3]. This algorithm allows us to consider two scores: 1) the score $p_{\mathcal{E}}$ which corresponds to the best matching score between a directly processable ability; 2) the score

[1] `http://www-poleia.lip6.fr/~sabouret/demos`

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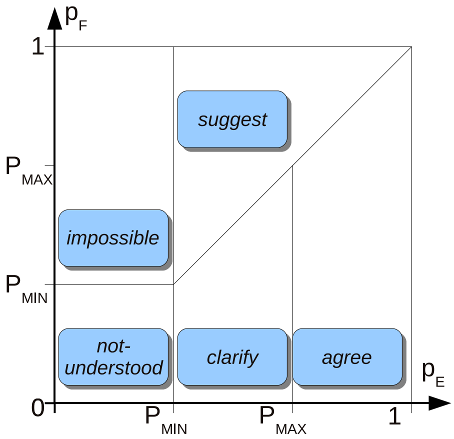

Figure 1: Performative choice regarding to $p_{\mathcal{E}}$, $p_{\mathcal{F}}$, p_{min} and p_{max}.

$p_{\mathcal{F}}$ which corresponds to the best matching score between an ability which is not currently directly possible. Currently, we only use these scores for ease of human-machine natural language interaction. This article propose a way to extends these score for agent/agent interaction.

In an agent/agent situation, the agent which considers the message S_B chooses the performative to be sent using the position of $p_{\mathcal{E}}$ and $p_{\mathcal{F}}$ regarding to two thresholds. The threshold p_{min} is the minimal value for a request to be considered equivalent to an ability, but with uncertainty. The threshold p_{max} is the minimal value for a request to be considered as totally understood and analogue to an ability.[2] The performative right choice regarding of the relative position of $p_{\mathcal{E}}$ and $p_{\mathcal{F}}$ with p_{min} and p_{max} is given in figure 1.

The initiator agent A receives one of the five new performatives from B. If the performative is *agree*, *impossible* or *error*, then the interaction is finished. If the performative is *clarify* or *suggest,* then the agent receives the set S' of B associated to his initial request S. This set corresponds to two different meanings: 1) with a *clarify*, the agent knows that its request S is considered by the agent B to be possible and S' correspond to a set of concept which was not understood ; 2) with a *suggest*, the agent knows that its request S is considered by the agent B to be impossible, and S' correspond to a set of close possible requests.

Here, A can decide to renounce to the interaction. If it decides to continue, the agent has to send a new request which allow B to clarify or to confirm a suggestion.

3. EVALUATION

We use two automatically generated hierarchy of concepts for the two agents ontologies. We have considered five parameters to control this generation (T, S, N_{ab}, P_{inter} and P_{match}). The T parameter corresponds to the number of node of depth one whereas the S parameter corresponds to the number of node of depth two.[3] The P_{inter} parameter corresponds to the intersection ratio between the ontology $\mathcal{O}_A$ and the ontology $\mathcal{O}_B$ (*i.e.* if $P_{inter} = 1$, the ontologies are equals, if $P_{inter} = 0$, the ontologies are totally disjoint). The N_{ab} parameter is the number of possible abilities for agent B at the current state. The P_{math} parameter defines the mean ratio of common concepts between two abilities (with the idea that if two abilities share a lot of concepts, it will be more difficult to disambiguate them).

Results may be measured using three ratios. The ratio R_{direct} corresponds to requests which are directly understood (*i.e.* our system was not useful). The ratio $R_{clarify}$ corresponds to requests which have been solved using our system. The ratio $R_{impossible}$, which correspond to requests which (from god's point of view) are impossible to solve.

Our approach is especially efficient when the ontologies shares little information (*i.e.* P_{inter} is low) and when the abilities are less similar (*i.e.* P_{match} is low). For instance, when $P_{inter} = 0.1$ and $P_{match} = 0.2$, our system allows to solve 80% of requests (*i.e.* $R_{clarify} = 80$) whereas only 2% of request are directly processed (*i.e.* $R_{direct} = 2$). In addition, when the P_{match} ratio increase, the $R_{clarify}$ ratio decreases, but only because the $R_{impossible}$ ratio increases (the R_{direct} ratio remains stable). On the contrary, our system is less useful if, for instance, the request contains a lot of concepts (depends on N_{ab} value).

4. CONCLUSION

This paper proposes an interaction protocol (with a set of new performatives) to allow heterogeneous agents to disambiguate requests when alignments are incomplete. The main idea of our work is that the disambiguation of different interpretations for a given request is enhanced using the generated abilities of the agent and a matching algorithm.

Current work has especially focused on the alignment problem to solve the semantic heterogeneity in MAS communication. We think that our approach is complementary, since our protocol relies upon a preliminary alignment. Furthermore, the communication combined with our system becomes more robust to semantic gaps caused by partial or incomplete alignment.

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[2] We empirically used $p_{min} = 0.3$ and $p_{max} = 0.8$.
[3] Since it is a preliminary evaluation, we do not consider hierarchy with more than a depth of two.