Agent Description Ontology *

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1 Introduction

We propose “Agent Description Ontology” as a response to FIPA’s Fifth Call for Proposal [4].

This document proposes an ontology for describing agents’ aspects such as agents’ knowledge, capability, and attributes. The ontology will include the terms and their semantics for such descriptions. This ontology should make it possible for agents to communicate their identity to each other.

This proposal can be taken as an informative application specification for FIPA98 Ontology Service Specification [3]. When the proposal is accepted, we are going to build a specific ontology for agent description. This experience will provide important feedback on Ontology Service Specification.

The proposal somewhat addresses section 4.3.4.2 “Base model for agent management” of the 5th FIPA Call for Proposal, but this proposal is much broader in the perspective since the proposal also addresses the ontology for describing the content such as the knowledge agents have.

We believe that “Agent Description Ontology” should be discussed and adopted as a standard for the following reasons.

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Realization of efficient communication between agents When we scrutinize the case of human communication, it is very difficult for two persons to talk with each other without the knowledge of the counterpart even if they speak the same language.

If agents are deprived of the capability to communicate what they are and what they can do, agents need to go through a very inefficient process of building the models of other agents from indirect evidences.

Agent Description Ontology should make it possible for agents to communicate their attributes and capabilities. Agents can build models of other agents rapidly through the direct messaging, and then efficient communication between them can then be established.

Realization of agent services In order to realize the agent services such as brokerage/recruitment/recommendation, agents need to have accurate models of other agents.

KQML specification [1] defines advertise messages. KQML specifies that an advertise message has the KQML message as its content. Therefore an advertise message can only communicate the message-handling capability of the sender agent by a matching pattern. If we restrict the agents to the advertise messages as the ways to convey their capabilities, this would greatly restrict the possibilities of agent services. It should be very difficult to realize content-based brokerage for example. [1] We need predicates, of which semantics are defined in the ontology, to provide a variety of such agent services.

Human benefits When "Agent Description Ontology" is prepared, a particular agent will be described using this ontology. We believe that this would benefit the people, especially the developers and users of agent systems in the current situation where the definitions of agents are just abundant.

The ontology does not give a unique definition of what an agent is, but does give dimensions to measure agents. This makes it possible to position agents in those dimensions and to compare them. Developers and users of agent systems can then decide much easily which agent system to adopt.

2 SAGE (Smart AGent Environment)

This section introduces the SAGE (Smart AGent Environment) project and describes our agent system architecture, where an agent description ontology plays an essential role. The toolkit to build agent systems of SAGE architecture will be available as a software product very soon.

R & D of intelligent agents at Fujitsu Laboratories Ltd. are being done under the SAGE (Smart AGent Environment) project with emphasis on seamless integration of heterogeneous information distributed over networks. The main topics of the SAGE

[1] We have realized content-based brokerage service which is explained in section 2.

project are facilitators and ontologies. Those and other research areas for the SAGE project include:

- Agentification of users and legacy applications
- Facilitation of interoperation between agents by facilitators
- Ontologies used in agent systems
- Message formats and transactions
- Libraries and tools for the above
- Real-world applications

The project utilizes software agent technology, especially of those conversational agents that communicate by ACL (Agent Communication Language) [6]. Currently we use KQML (Knowledge Query and Manipulation Language) [1] for the message format and KIF (Knowledge Interchange Format) [5] for content language in our agent system, but use of FIPA-ACL is under consideration.

A facilitator is an agent that realizes content-based brokerage services. Since facilitators depend on contents of messages to provide their services, ontologies are of crucial importance. We will give more details on R & D efforts on facilitators in the rest of this chapter.

The architecture of SAGE has a 3-tier structure where facilitators are placed between user agents and database agents. User agents represent users as agents to SAGE and database agents represent databases and other information sources as agents to SAGE. Facilitators stand between them to provide brokerage, translation, merge and other services to help those agents interoperate.

The system works as follows.

1. When a database agent starts, it advertises categories, message formats and ontology it can handle to a facilitator.
2. When a user makes a query through the user interface, the user agent turns the query from the user into an ACL message and sends it to the facilitator.
3. The facilitator chooses the appropriate database agents based on advertise/unadvertise messages from the database agent and translates it for each database agent if necessary. [2]
4. The facilitator sends out the messages to the chosen database agents and wait for the reply messages.
5. The database agent changes the ACL message from the facilitator into a SQL query and consults the database.
6. The result from the database is composed into an ACL message and the ACL message is sent back to the facilitator.

[2] We allow database agents to have different ontologies for KIF terms in KIF content of the messages.

7. The facilitator merges the messages from the database agents into one and sends back to the user agent.

8. The user agent displays the result.

The facilitator works as a content-based broker in the scenario above. What the facilitators do are summarized as follows: [3]

- Selects appropriate database agents for the query message based on the stored advertise messages.
- Forwards the query message to the selected database agents.
- Translates messages from one ontology to another using translation knowledge if necessary.
- Merges the reply messages from the database agents and sends the merged (and sorted) results to the user agent.

In realizing the above content-based brokerage, an "Agent Description Ontology" plays an essential role. The contents of the advertise messages sent from database agents are written in KIF using an "Agent Description Ontology." With this ontology, database agents can communicate their knowledge, capability, and attributes to the facilitator. Only then, the facilitator can decide which agent can deal with the original query and what is the appropriate way to put the query to the agent.

We have applied our agent system to many real-world applications such as inter-company EC, online database integration, knowledge management, etc. The function of ontology translation was not used in some of the applications. But the advertise mechanism that is based on an "Agent Description Ontology" is used in every one of them and this is essential to our agent system. With this mechanism and the ontology, database agents can communicate their knowledge, capability, and attributes dynamically and the facilitator can provide useful brokerage services.

3 Agent Description Ontology

We believe "Agent Description Ontology" should include, but not limited to, the followings.

We list possible normative topics first.

Name of the ontology We need to give the name of the ontology that should appear as the value for the :ontology parameter of the ACL message. If the terms are appropriately categorized, we need to give names for ontologies corresponding to those categories.

Framework to express the ontology We need the framework to express the ontology. This may be a meta-ontology in one of first order logic languages. In order to

[3] This is not an exhaustive list of facilitator's functions.

make the standard language-independent, we can take such an approach for example to provide models in graphs and serializations of the models into SL, KIF, XML [9], etc. This is a similar approach to that of RDF (Resource Description Framework) [8].

Content of the ontology We need to standardize the content of the ontology, which is the essential part of this proposal. We need the terms for the predicates to describe the agents and possibly the values or the formats of the values for those predicates. Here we list the categorized list for the possible terms. These categories may not be exhaustive and may be reorganized during the discussion.

- Terms for describing agent's knowledge
  - Range of agent's VKB (Virtual Knowledge Base)
    - Syntactical range of VKB
    - Semantic range of VKB
- Terms for describing agent's capability
  - Inference capability
  - Protocols the agent can handle
  - Communicative acts the agent can handle
  - Languages the agent can handle
  - Mobility related capability
  - Access methods (email address, URL)
- Terms for describing agent's attributes
  - Groups the agent belongs to
  - Specialty of the agent
  - History of the agent
  - Access restrictions of the agent

Here follows the list of possible informative topics.

- Example descriptions of agent using the ontology
- Example of agent services (such as content-based brokerage) realized by using the ontology

4 Conclusion

As we stated above, ontologies for describing agents are of critical importance to building efficient agent systems. It is also essential for developers and users to understand the positions of agent systems they are going to use.

We also outlined our agent system, SAGE (Smart AGent Environment) which will be available as a software product very soon. This agent system depends on such an ontology for its central functionality.

We believe “Agent Description Ontology” is ready for being discussed and adopted as a standard within the FIPA initiative.

Currently we use a proprietary ontology for that purpose, but we would like to adopt the standard when the standard is produced.

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