

Middleware between OWL and FIPA Ontologies in the Semantic Grid Environment

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***Abstract** – Ontologies are an essential element of the semantic web and they can act as a foundation for semantic interoperability among the various distributed systems as to achieve the service-oriented architectures. Ontologies provide a shared and universal knowledge of a domain that can be exchanged between communities and applications OWL (Web Ontology Language) is currently the W3C standard for providing specifying the ontologies and explicit semantics to the web services whereas the FIPA Ontologies and FIPA Semantic Language is the core of agent platforms due to its high expressive power. The key objective of this paper is the development of a middleware for above-mentioned content languages in such a way that the agents can communicate with the web services in an efficient manner. The challenging domain where our work can be applied is the messages that can be exchanged between FIPA compliant Multi Agent systems and the web services, thus enabling the agents based applications to interact with the web services. Our goal for these initial mappings/translations is to show that how the existing standards of FIPA Semantic Language could be mapped into representations, which could be readily used in a Web Services, based environment.*

Keywords: Semantic Grid, Ontologies, Multi Agents Systems, Web Ontology Language.

1. Introduction

Multi-Agent systems are one of the emerging technologies that provide collaborative environment for a community of social agents for the provision of continuous and dynamic services. A fundamental characteristic of multi agent systems is that individual agents communicate and interact. In general, communication is the intentional exchange of information brought about by the production and perception of signs drawn from a shared system of conventional signs. To

share information and knowledge humans need a formal communication language to communicate in an effective manner, similarly agents also require a formal language to carry out effective and meaningful communication as agent are mostly engaged in employing some knowledge on behalf of user's goals or desires.

Semantic Web [1] on the other hand has provided the foundations for the autonomous interoperation between the entities on the Internet. This interoperability can be achieved through annotation of the contents at arbitrary locations on the Web with machine processable data. When such annotations are associated with the ontologies, then computers can attain a certain degree of understanding of the data. Ontologies [4] are formal and explicit specifications of certain areas and are collective between large groups of stakeholders and are core of the Semantic Web. These properties make ontologies ideal for machine processing and facilitating interoperation and thus enhancing the interoperability and machine understandability. In fact, ontologies form the core of Semantic Web and are the key to enable automated interoperation and cooperation. Ontology is a combination of classes, their relation or properties, instances and axioms, expressed in some formal language.

The evolution of semantic web will give rise to structure the meaningful contents of WebPages and it will be an extension of the existing web in which the information processed is given a well-defined meaning and better-enabled computers [1]. To efficiently discover and utilize the resources on the web, the semantics would act as epoxy resin for autonomy. To bracket together the explicit semantic representations in the web services several ontologies and ontological web languages have been anticipated, which not only have deficiencies but also impose an overhead .The W3C has proposed two ontology languages for use on the Semantic Web. The first is RDFS [6], based on XML [9] and logic programming, which is a

lightweight ontology language. Whereas OWL [7] is another language by W3C with more expressive ontology language based on Description Logics [5] [2].

On the other hand (MAS) Multi Agent System is a promising field of distributed artificial intelligence, where an agent is a computer system capable of flexible autonomous action in a dynamic unpredictable and open environment [8].

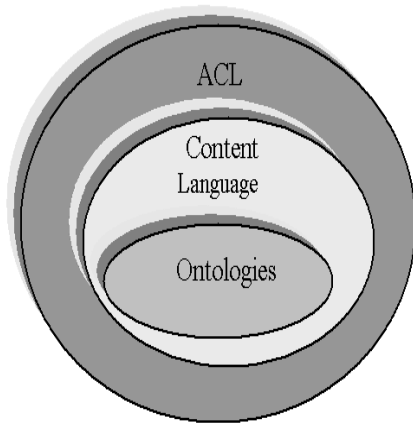


Fig. 1. Essentials of Agent communication Language

Agent communication is referred as interaction in which the dynamic relationship between agents is expressed through the intermediary of signals that once interpreted, will affect these agents [3]. Agents require a formal language to carry out effective and meaningful conversation as most of

them are engaged in employing some knowledge on behalf of user objective and desires.

2. Proposed System Architecture

Our devised model provides the semantic interoperability in distributed environments where technologies like agent applications and grid systems are combined and reused to achieve the autonomous semantic grid and thus providing a service oriented framework. The Semantic Web provides a conceptualization by which the distributed knowledge and be represented and viewed, in terms of formation, utilization, propagation and management. The concepts can be defined within extensible, open ontologies, which are published using the standard protocols with occurrence and properties being asserted at arbitrary locations across the web.

As we are specifying that the OWL will be the W3C standard for specifying the services on the web and will act as a content language. The communication infrastructure specified by FIPA permit the agents to communicate using any mutually comprehensible content language as long as it fulfills a few minimal criteria as a FIPA compliant content language [FIPA, 2003].

In Figure 2 an abstract architecture of the proposed system is shown. The key idea is to show that how the software agents can communicate with the OWL based web services in bringing the semantic operability, negotiation etc. Another important aspect of the proposed system is that it is not reshaping the existing standards of the FIPA

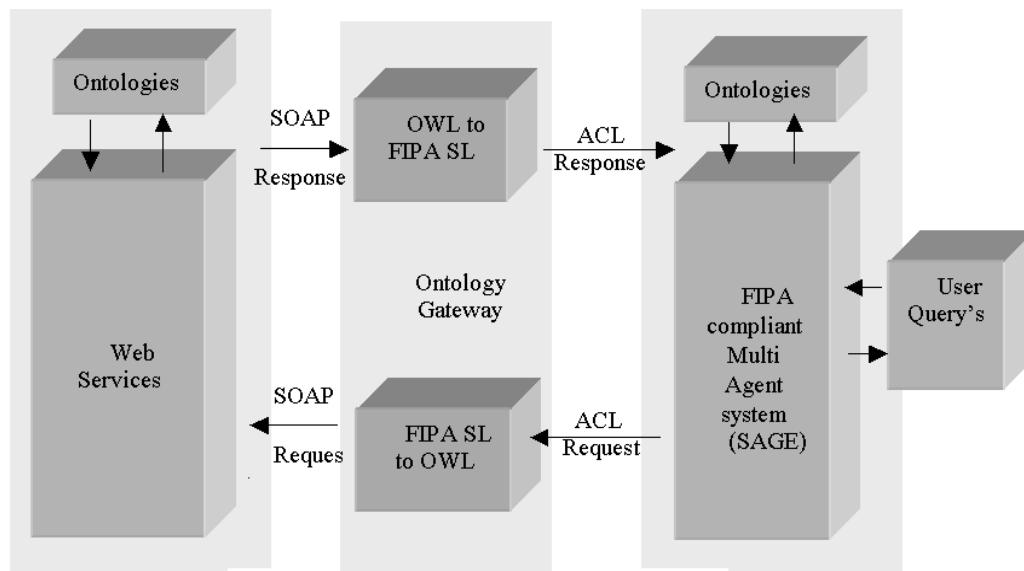


Fig. 2. Proposed System Architecture

Semantic Language and Web Ontology Language. Our focus is the interoperability of the two languages so that the autonomous software agents can communicate with the web services or they can be used to build their knowledgebase. The middleware act as a converter, which by taking input data (from the ACL message) converts it into mappings/translations described in OWL and vice versa.

2.1 Issues in Proposed System

Major issues in realizing the proposed system were:

- FIPA SL and OWL have different underlying support for the terms, syntax, semantics and implementation constraints.
- The two languages are based on different standards one by FIPA and the other by W3C.

Devising mappings/translations for such a system is quite demanding and challenging, as both languages vary tremendously. Comparison to both the languages is provided in terms of representations and possible mappings in Section 3, which shows that the difference between the two languages made these mappings/translations very challenging.

3. Comparative Analysis of OWL & FIPA SL

OWL ontology	FIPA ontology
Super Class	Concept
Sub Class (rdfs: subClassOf)	Concept
Object property	Slot
Restriction (has some values)	Predicate
Individual	Individual
disjointWith	NOT-SAME-VALUES
unionOf	BinaryLogicalOp = "and"
intersectionOf	BinaryLogicalOp = "or"
cardinality	CARDINALITY
minCardinality	MINIMUM-CARDINALITY
maxCardinality	MAXIMUM-CARDINALITY
rdfs:domain:	DOMAIN
someValuesFrom	SUBSET-OF-VALUES
someValuesFrom	SOME-VALUES
InverseOf	SLOT-INVERSE

Table 1. Comparison of OWL and FIPA primitives

In this section our primary focus is to carry the in depth analysis of ontologies of OWL and FIPA SL .OWL is a standard by W3C, which describes the ontologies for explicitly specifying the semantics and the distributed services. Its goal is for developing applications that utilize the semantically rich data processing and invocation of services that are described in OWL. As the OWL is based on description so it is the most suitable language for defining concept hierarchies and their relations, and is built on the top of RDF, which provides additional vocabulary and formal semantics. In the OWL ontologies we can specify the classes, subclasses there attributes, object properties etc.

FIPA SL on the other hand provides human readable string encodings (i.e. the contents of the FIPA SL are treated as a string) and is probably the most diffused content language in scientific community dealing with the autonomous software agents. FIPA SL provides certain subsets for imposing profiles that is, statements for imposing statements of restriction over the full expressive power of FIPA SL.FIPA SL is capable of representing propositions, actions and representing objects including identifying expressions to describe the objects.

The use of our proposed mappings/translations between the two languages will make it possible to describe the logical nature and context of the information being exchanged, while allowing for maximum independence between communicating parties and can be used to flexibly map specific data representations to these languages for eliminating the need to explicitly convert applications to adopt a certain data standard. Different agent based application will be able to use these mappings/translations to transform data from ontology to the other or to perform federated queries from a single query statement.

Thus resulting in a greater transparency and more dynamic communication between information domains regardless of business logic, processes etc and this interoperation will provide the basis for better resolving differences in syntax, structure, and semantics, without having to change their current standards.

4. Detail Design

This section describes the detailed design of proposed system in which the most important

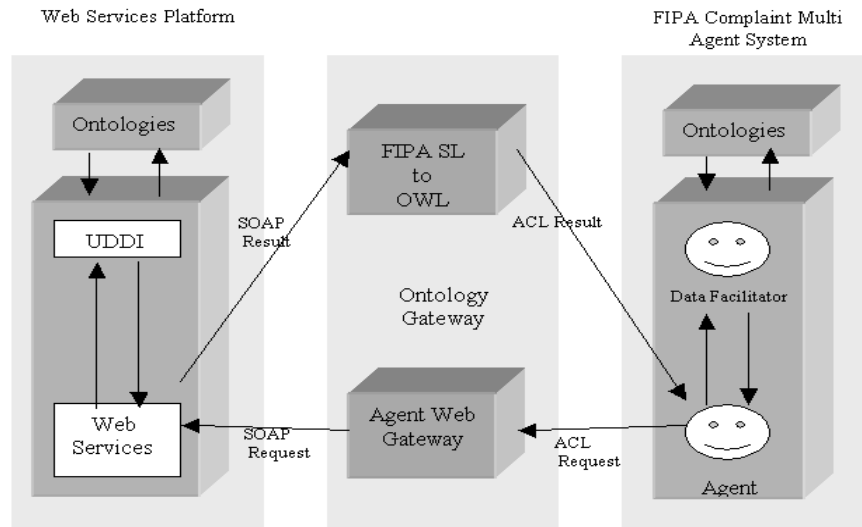


Fig. 3. Software Agents communicating with the OWL based Web Services

technical challenges are solved, i.e. without changing the specifications and standards of W3C OWL and FIPA SL, enabling the two-way communication and the content transformation entities including Grid services and Grid clients.

4.1 Software Agents communication with the OWL based Web Services

In this section, detailed design as shown in fig 3 that enables FIPA compliant Software Agents interact with W3C compliant OWL based Web Services.

A middleware is designed that makes services visible to Software Agents (see fig 3). Whenever an Agent needs to search for a service on the GRID environment the transformation of the ACL based search query into SOAP based UDDI search query and forwards to UDDI where the required service is expected is done using the Agent Web Gateway's component named ACL2SOAP converter [12] [13] [14]. Now the Software Agent has come to know about the existence and the address of the required service. The address for the Web Service file is now retrieved and the Software Agent extracts the required Web Service. Software Agent is needed to know about the Ontology, AgentAction Schema, Predicate Schema and

Concept Schema etc. so the Web Service is passed to Ontology Gateway that translates the Web service published in OWL into an equivalent FIPA compliant message.

4.2 Grid entities communication with the Software Agents

In this section, the shown detailed design enables W3C compliant SOAP based Grid computing environment entities including Grid services and Grid clients interact with FIPA compliant Software Agents by performing Service Discovery in DF, understanding services provided by a Software Agent and consuming services from Software Agents.

A middleware is designed that makes services visible to Grid Entities (see fig 4). Whenever a Grid Entity needs to search for a service on the GRID environment the SOAP based UDDI query is passed to a protocol converter of Agent Web Gateway named SOAP2ACL. The protocol converter extracts out the service name sends a valid ACL based DF search request message to the Agent Platform.

Directory Facilitator performs a search. If the required service is not found it is forwarded to a remote platform where the service is expected

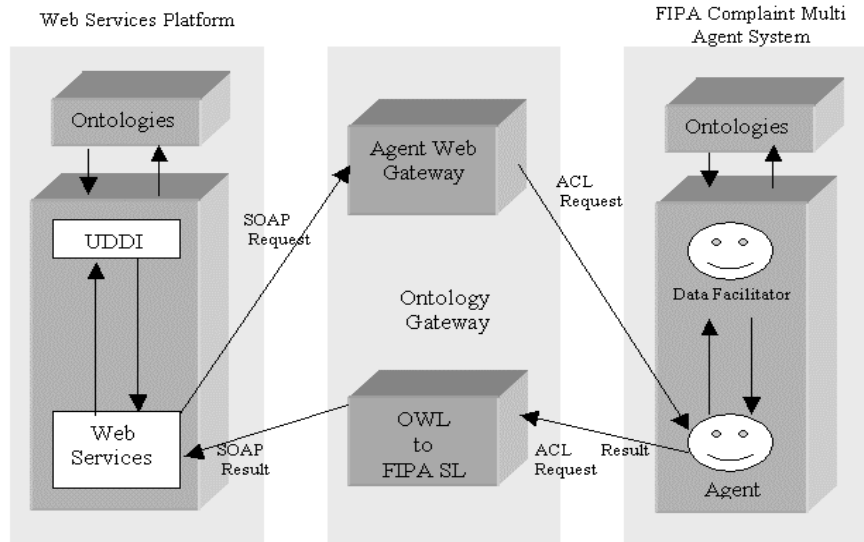


Fig. 4. Grid entities communication with the Software Agents

Directory Facilitator of the remote Agent Platform performs a search. If required service is found, the service is returned by the DF of that remote Agent Platform to the agent at our middleware, which converts the FIPA Ontology into its equivalent OWL Ontology. And the service that is retrieved is embedded into the original SOAP message with its name and certain other parameters, which are then forwarded to the Web Service Client that requested for the search. In this way, the Ontology Gateway helps the Web Service client to search for the services at an Agent Platform.

5. Conclusion

In this paper we have devised translation/mappings for the interoperability of FIPA Semantic Language with the Web Ontology Language in the context of achieving a semantic web and ultimately the semantic grid to achieve autonomous coordination in the messages that are exchanged between the FIPA compliant Multi agent systems and OWL based web services.

Our proposed system provides a robust infrastructure for semantic interoperability of messages between the two languages. We have done a detailed analysis of FIPA Semantic Language and the W3C OWL. The detailed design then explains the role of middleware that facilitates the two-way communication among the FIPA compliant software and W3C specified Web services without violating the existing standards.

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