Applying Knowledge Model To Agent Based Systems

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Abstract— Nowadays, multi-agent system is become promising means for the development of distributed systems, however its disadvantage is that it lacks the interconnection with semantic web such as Ontology Web Language (OWL). In this article, we aim to present a semantic knowledge model of an agent suitable for discrete environments as well as implementation and a use of such model using different softwares (JENA, JADE, JESS and Protégé) in order to allows interconnection of Agent and Semantic Web technologies which can be used in an agent based application where such interconnection is needed.

Keywords— Multi Agent System ; Web Ontology Language (OWL); Java Expert System Shell (JESS); SPARQL1.1.

I. INTRODUCTION

Multi-Agent System (MAS) is a powerful paradigm in nowadays and is become promising means for the development of distributed systems [1, 2, 3]. In Multi-Agent System the interoperability allows agents to communicate and cooperate in order to attain their own objectives and sometimes to solve a common problem. As part of the open multi-agent system, heterogeneous agents, is designed by different organizations and in different languages and can dynamically join or leave the system. This implies a dynamic environment changing functionality, which makes the problem of interoperability of heterogeneous agents very complex.

Among the proposed solutions, FIPA [4] proposes specifications that ensure interoperability at different levels. In FIPA-ACL communication protocol already offers the use of ontologies for describing the content of messages. Unfortunately, ontologies are most often used simply to write the format of messages exchanged forgetting the semantic part.

The Semantic Web [5, 6] is an extension of the current web. According to the World Wide Web Consortium (W3C), "The Semantic Web provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries"[7]. The main goal of the Semantic Web is to enable users to find their applications more efficiently by allowing the machine to understand and respond to human request according to their meaning. For that to happen, Web resources must be described using a set of W3C standards and technologies to enable its processing. Among these standards are Resource Description Framework (RDF), RDF Schema and the Web Ontology Language (OWL) [8], all of which aim to provide a formal description of concepts, terms and relationships within a given knowledge domain.

Java Agent Development Framework (JADE) is a software framework for the development of multi agent applications in compliance with The Foundation for Intelligent Physical Agents (FIPA) specifications [9]. Many approaches to build knowledge model for JADE agent can be found. The most promising approach is using ontology based knowledge representation which is one of the main standards for the Semantic Web proposed by World Wide Web Consortium (W3C), and it is based on Description Logic (DL). Representing knowledge based on ontology provides many advantages over other representations. The traditional approach used conventional rule engine. Java Expert System Shell [10] (JESS) is a familiar rule engine written entirely in Sun’s java language, provides a powerful tool for developing systems with intelligent reasoning abilities. The Jess gives the possibility for building Knowledge in the form of declarative rules and facts, and reason about it.

The aim of this article is to build an agent knowledge model that takes advantages of description logics expressivity used in semantic web technologies OWL. A behavioral architecture is implemented to build an intelligent agent in JADE platform with knowledge models based on OWL ontology which is implemented in Protégé. Moreover, Jess language was used to enrich the ontology with logic and functionality. Then, we used The Jena Semantic Web [11] Toolkit which is a Java Application Programming Interface (API) and software toolkit for manipulating RDF, RDFs, OWL and SPARQL which can be used to query data that is structured in hierarchies.
This paper is structured as follows. In section 2, we give an overview of the multi-agent systems and the different agent architecture. Section 3 introduces the benefits of introducing ontology and semantic web into these systems. Section 4 introduces the Ontology web Languages which is based on Description Logic and explains how to build knowledge model in JADE platform. Section 5 illustrates how steps to build successfully the Semantic Web application; finally, we draw conclusions in section 6.

II. RELATED WORK

At the beginning of the decade, the publishing of the agent technology roadmap [12] pointed out the lack of interconnection between multi-agent systems and semantic web technologies. Since then, several applications and frameworks have been developed to bridge this gap:

B.Schiemann et al. [13] proposed Owl-dl as a FIPA ACL content language in order to facilitate the building of simple interaction protocols that are based on information dialogues and to separate of speech act semantics from content semantic. One limitation of this approach is that they only use propositions or referential expressions in the content field of speech acts (Inform and Query-ref).

M. Laclavík et al. [14] presented a semantic knowledge model of an agent suitable for discrete environments as well as implementation and a use of such model using the Jena semantic web library, the JADE agent system and model it in the Protégé ontology editor.

M.Babík et al. [15] described how semantic web technologies can be applied in multi-agent system and an agent knowledge model was created to allow the possibility to model the agent environment, agent context and its results. The agent knowledge model was developed and extends the JADE agent system, which is the most popular MAS toolkit.

A.M.Zarafin et al. [16] proposed a semantic description of multi-agent systems, showing the advantages regarding integration with Web semantic technologies.

M.Obitko et al. [17] presented how semantics and ontologies can be employed in industrial systems, considering particularly distributed, agent-based solutions and demonstrated the integration of new manufacturing ontology with an agent-based simulation and control system MAST.

N.B.Aldabagh et al. [18] developed a comparative study between the implementation of an intelligent agent in JADE platform with two different knowledge models. The first one is based on OWL ontology, the second is by integrating the agent with the Jess.

III. MULTI AGENT SYSTEM

An agent is defined as “person who’s acting on behalf of other people” [19]. In the context of computer science, mobile agent is considered as an entity that moves from one machine to another in the network to perform certain tasks on behalf of the user [20]. Mobile agents have the following properties which distinguish them from other programs: Adaptability, Autonomy, Communication, Mobility and Persistence [21].

Many agent architectures are developed to support intelligent agent:

- Reactive architectures implement decision-making as a direct mapping of situation to action and are based on a stimulus–response mechanism.
- Belief Desire Intention (BDI): Are the most popular agent architectures and can reason about their actions.
- Behavioral architecture: An agent has many behaviors and it can be executed in sequence or in parallel depending on the task to effect. This architecture is more suitable for used in real applications and our implementations will based on it.

A. JADE

The Java Agent Development Framework (JADE) is a flexible agent platform that provides a middleware layer for the development of distributed multi-agent systems in compliance with FIPA specifications [9]. It provides the following mandatory components for agent’s management:

- AMS (Agent Management System), which besides to provide white page services as specified by FIPA and to play the role of authority in the platform.
- DF (Directory Facilitator), which provides yellow pages services to other agents.
- ACC (Agent Communication Channel), which is responsible for sending and receiving messages on an agent platform.

Among the advantages of JADE is the ability to integrate with others java implementation tools, like Jena .This tool can be used to build knowledge model within an agent and reason over it.

B. Building Knowledge Model in JADE

Knowledge of the agents is stored in the Web Ontology Language (OWL). It rests primarily on two existing and linked APIs from JENA and Protégé. The JENA framework is an open-source Semantic Web framework for Java that provides
APIs to build semantic Web applications managing the RDF and OWL languages. It also provides methods to write and read in RDF/XML, along with a SPARQL (Query Language for RDF) query engine. The Protégé-OWL plugin is described as an extension of Protégé that supports OWL. Protégé is a free, open source ontology editor and knowledge-base framework. The Protégé-OWL API provides methods to load and save OWL and RDF ontologies, and to edit these ontologies in a powerful way.

IV. ONTOLOGY AND SEMANTIC WEB

Ontology is a term which has been used to name the general discipline of metaphysics, in the traditional first philosophy of Aristotle. It is, many times, faced as a complement to the idea of epistemology (science of knowledge) [24]. Ontology based knowledge representation allow the developers to share knowledge between different entities, also to reuse it over well defined Web ontologies. Thus such knowledge model will improve interoperability between different agents in different platforms.

The utilization of ontologies is mainly related to the Semantic Web (SW). SW (Figure1) aims to provide a common framework in order to allow data to be effectively shared and reused. It is envisioned as an extension of the World Wide Web that brings the semantic description of content so that it can be found, processed and integrated by software agents more effectively [25]. The core semantic web technologies are Resource Description Framework (RDF) and Web Ontology Language (OWL).

V. WEB ONTOLOGY LANGUAGE

Web Ontology Language (OWL) it’s a language recommended by the W3C for expressing ontologies in the Semantic Web [3]. OWL comes in three increasingly expressive sublanguages. OWL-DL is one of sublanguages which provides the maximum expressiveness with complete and decidable reasoned. Such languages are based on Description Logic [24].

A. Description Logics

Description Logics (DL) are a family of knowledge representation formalisms used to represent ontology based knowledge. The basic syntactic building blocks are concepts which correspond to classes, roles which represent relationships between two concepts or concept and a data type and individuals which represent classes instances. In DL the knowledge base consists of a:

- TBox(terminological box): which contains definitions and assertions about classes and properties.
- ABox(assertion box): which contains the facts about the instances (individuals) in terms of basic classes, properties and classes.

VI. EXAMPLES

We create a simple ontology using protégé (Figure2).

- First step:

The next step is to enrich the ontology. This is managed using the JessTab plugin of Protégé which allows writing code in Jess in the protégé environment.

- Second step:
For example if we want to add an individual F7 to the class Ford (Figure 3) with three datatype: title, price (prix) and state (etat). The code writing in Jess is as follow:

(make-instance F7 of Ford (title "Ford cayen") (prix 200000) (etat "excellent"))

For a total of 1 facts.

- **Third step:**

We develop two agents:
- AskAgent
- Answeragent

The answer and ask agents use the same ontology, but with different individuals. In Figure 4 you can see the model of the AnswerAgent. For example, the model contains five brands: Ford, Renault, Volswagen, Peugeot and Mercedes. The brands ford contain 7 individuals: F1, F2, F3, F4, F5, F6, and F7.

- **Forth step**

A user selects a type of resource for which the AskAgent search. The type of the resource is passed to an agent by the XML-RPC method call. One of the AskAgent behaviors is activated and the AskAgent produces the SPARQL query and passes the ACL QUERY message to the AnswerAgent.

```
PREFIX ont: <http://fsts.ac.ma/agents.owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
SELECT ?x ?y WHERE { ?x  ont:prix ?y.FILTER (?y>94000)}
```

The AskAgent asks the AnswerAgent to return to it all cars it has in the memory with the condition the price is superior of 94000. The AnswerAgent receives an ACL QUERY message and performs an SPARQL query on its memory. The result is passed as various ACL INFORM messages consisting of the RDF description of requested resource.

```
<RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
 xmlns:owl="http://www.w3.org/2002/07/owl#"
 xmlns="http://fsts.ac.ma/agents.owl#"
 xmlns:dct="http://purl.org/dc/terms/"
 xmlns:dct="http://purl.org/dc/terms/">
```

Figure 3: The execution of the code

Figure 4: The model of AnswerAgent
This paper presents how semantic web technologies as Ontology Web Language (OWL) can be applied to build an intelligent JADE agent. So, an agent knowledge model was created using protégé and using JESS language to enrich the ontology. Then, using Jena which provides methods to write and read in RDF/XML. Last but not least the use of Sparql1.1 like Filter which restricts solutions to those for which the filter expression evaluates to true.

REFERENCES


VII. CONCLUSION

Multi-Agent System (MAS) is a powerful paradigm in nowadays and is become promising means for the development of distributed systems. However its disadvantage is that it lacks the interconnection with semantic web standards such as Ontology Web Language (OWL).


