A MULTI-AGENT-BASED SEMANTIC WEB SERVICE SYSTEM

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ABSTRACT

The Semantic Web is the next generation of current Web. It enables computers to cooperate with people well. Web Services become more prevalent now. It lifts the Web function from the collection of information to an upper level of processing information. In order to fulfill the evolution from the services of current Web into the Semantic Web to benefit the full potential of the Web, in this paper we present our preliminary ideas of building Semantic Web service system based on a multi-agent system. Our system consists of three main aspects: multi-agent system, Web service management and Semantic Web contents. In order to demonstrate the effectiveness of our mechanisms, we build a semantic community Web portal service system for Semantic Web community.

1. INTRODUCTION

The Semantic Web is an extension of current Web, in which information is given well-defined meaning, better enabling computers and people to work in cooperation [1]. In the Semantic Web, people can do what they want by only pressing a button and the agent will help them to do all the other details. However, since the current Web is mainly used by human users rather than machine agents, in order to fulfill the evolution from the services of current Web into the Semantic Web to benefit the full potential of the Web, we need machine-readable Web contents, a new framework and mechanisms for enhancing the capability of the Web. Many researches on the Semantic Web services have been carried out recently [2]. However, in this area there are still many open research problems to be exploited such as the mediation service enabling anybody to speak with everybody in a scalable manner which need a mediator that translates user queries into sub-queries on the different information sources and integrates the sub-answers [3]. Agents can perform the mediator function to cope with the heterogeneity of the information and knowledge system and release users from complex processes.

In this paper we present our preliminary ideas of building Semantic Web service system based on a multi-agent system. Our system consists of three main aspects: multi-agent system, Web service management and Semantic Web contents. In order to demonstrate the effectiveness of our mechanisms, we build a semantic community Web portal service system for Semantic Web community. The main feature of our system is that it builds the Semantic Web services based on a multi-agent system called KODAMA [4] that has been developed at Kyushu University.

The rest of the paper is organized as follows. Section 2 gives a brief introduction about the basic technologies used in our system. Section 3 presents the overview of the system structure. Section 4 describes the implementation of our system. The conclusion and future work are given in section 5.

2. BASIC TECHNOLOGIES USED IN THE SYSTEM

In order to enable agents to cooperate with people so as to benefit from Web capability, it is necessary to generate Web materials in a machine-readable form. RDF (Resource Description Framework) [5], is a metadata (meaningful data) modeling language recommended by W3C (World Wide Web Consortium). Just as people need a common language to communicate with each other, machines also need it in order to share knowledge and to communicate with each other. Ontology is viewed as a dictionary that can answer this requirement. RDFS (RDF Schema) [6] is an ontology language which can formally describe the meaning of terminology used in semantic material, define the relationships and properties of them. In order to describe more complicated data relationships and perform useful reasoning tasks, OWL (Web Ontology Language) [7] was designed by W3C. These emerging foundation technologies of the Semantic Web like RDF(S)

and OWL have been accepted gradually and tools for validation, annotation, authoring and editing have also been developed to help people to construct the Semantic Web material. The ontology of certain domains has been developed too.

The standard protocols for Web service discovery, description and invocation such as Universal Description, Discovery, and Integration (UDDI) [8], Web Services Description Language (WSDL) [9], Simple Object Access Protocol (SOAP) [10] have been developed and widely used by current Web service systems. In order to satisfy the needs of Semantic Web services, DAML-S (DAML Ontology of Services) [11] deploys Semantic Web technology to facilitate the automation of Web service discovery, invocation, composition and interoperation, and execution monitoring.

The main purpose of the Semantic Web is to enable machine to cooperate with people to release people from the burden of complex processing details to do mission critical tasks. Under these circumstances, the agent is expected to play a vital role in the Semantic Web. In other words, the Semantic Web will not be so exciting without agent. The main feature of the Web is every body can speak everything from every where. The Web information is not centralized but distributed and to be changed dynamically. These open, dynamic and distributing features of the Web needs open, scalable, distributed agent system to satisfy its requirements. KODAMA is a distributed scalable multi-agent system designed and implemented by our laboratory. It was demonstrated fits well for the demands of distributed applications such as Web applications.

3. SYSTEM STRUCTURE

Our Semantic Web service system concerns about three main aspects: multi-agent system, Web service management, and Semantic Web contents.

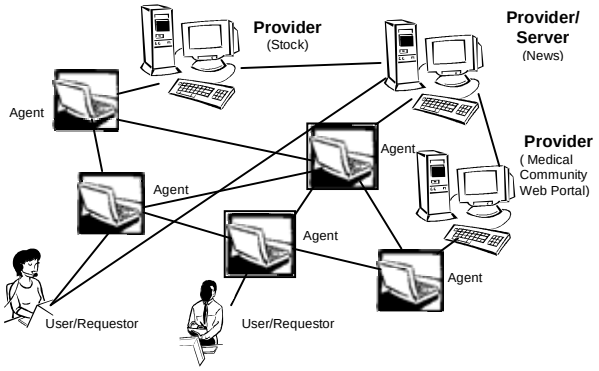

Figure 1: A Multi-Agent-Based Semantic Web Service System

In the multi-agent system, every agent is autonomous to be able to make decisions and act proactively. Agents can communicate, exchange knowledge, collaborate or negotiate with one another, to efficiently achieve the common goal. They process users' requirements, make use of user's preference, perform mediator functions of services. They break down or composite services if necessary, discover, select and interact with appropriate services automatically and give users the optimal result.

The Web service management component defines services, monitors requests, discovers associated services and accesses the service contents to gain necessary data and interacts with user agent to give satisfactory responds. It concerns Service description, publishing, discovering and accessing aspects.

The Semantic Web contents are the meaningful data which can be directly accessed by agents or people through Web, or be invoked as services.

4. IMPLEMENTATION

Our research purpose is to develop a new framework and mechanisms of the Semantic Web services based on a multi-agent system.

In order to demonstrate the effectiveness of our framework and mechanisms, we develop a prototype of the Semantic community Web portal services for the Semantic Web community based on multi-agent system KODAMA.

Because the Semantic Web is an emerging technology under its beginning stage, there aren't many Web sites whose metadata can be used as Web resources. Only the members of Semantic Web community who are promoting and doing research work on Semantic Web foundation and applications have constructed some Semantic data for the purpose of preliminary test or as the result of their researches. So we choose the portal of the Semantic Web community which has adequate semantic data at current to demonstrate the potential benefits of the future Semantic Web. The mechanisms used for building Semantic community Web portal services for Semantic Web community can be used for the other community and can also be generalized to the other services.

4.1 Multi-agent system KODAMA

KODAMA is a high quality, large-scale multi-agent system which can operate in open environments. It is a global distributed computing architecture based on agent-oriented programming and was demonstrated suitable for network-aware applications.

In our system we use KODAMA multi-agent system to realize the mediation of Web services and implement automatic maintenance functions of Web portal contents. All the agents in KODAMA system are constructed by

community based layered architecture. They form a logical world which is completely separated from the physical world consisting of agent host machines which means they needn't to be network-aware.

There are one or two agents to serve for each community member. They give friendly user interface to release people from complex processing details, process user's requests to change them into appropriate query, break down or composite services as necessary, cooperate with the other agents and Web portal agent to invoke services, and give satisfied response to the user.

As for the maintenance, community Web portal agent can collect up to date information with the help of agents of community members, the agents of community members can also detect and report the updates of information to the community Web portal agent.

4.2 Web service management

After the agent preprocessed the requests from the user, broke down or composed the services, and translated the requests into service queries, it will invoke the appropriate services on the Web.

Juan Minguel Gomez et al. have analyzed the current Web service infrastructure and presented the Web Services Modeling Framework (WSMF) to provide a new framework with the appropriate conceptual model for developing and describing Web services and their composition [3]. We follow this line of research and use DAML-S to describe semantic Web services and accomplish the services with the help of existing protocols used by current Web services such as SOAP, WSDL and UDDI.

The security and quality control aspects along with the whole service processes should also be considered.

4.3 Building semantic community Web portal contents

In order to fulfill the Semantic Web services, the service contents should be constructed. Here we describe our ideas about constructing Semantic community Web portal of Semantic Web community with a little detail.

A community consists of users who have the same interest in a certain domain. A community web portal is a portal for the information on the Web needed by the community.

There are many community Web portals existing now. But generally they have following problems. First, beginners of a certain community maybe don't know where the community Web portal is or even don't be aware of its existence. The users have to search with keywords and select from a bunch of answers. Second, generally the Web portals are designed for human using and not suitable for machine processing. People need to be navigated along with the link to get the information what they really want. Third, the existing Semantic community Web portals generally are built based on adding metadata by annotating the human-language contents currently on the Web, so people need to build duplicated contents used for human and machine and it's error prone for inconsistency between these two kinds of material.

Our community Web portal aims at solving these problems mentioned the above.

We provide the Web portal services that can be discovered and accessed automatically by machines or agents, and let people get answers by query directly rather than navigating along with the link.

We use ontology to represent common knowledge and interests within the community. The knowledge can be shared at a conceptually concise and elaborate level in the community so the users can get quick and accurate responses.

We unify the Web contents used for human beings and agents in order to avoid the duplicate work of constructing Web contents and the problem of inconsistency between Web contents. The Web portal contents are built with metadata based on ontology. They can be understood and accessed by agents easily, and it can be automatically rendered from metadata into browsing data by a proxy like agent when people browse the material.

Figure 2 illustrates the structure of our community Web portal.

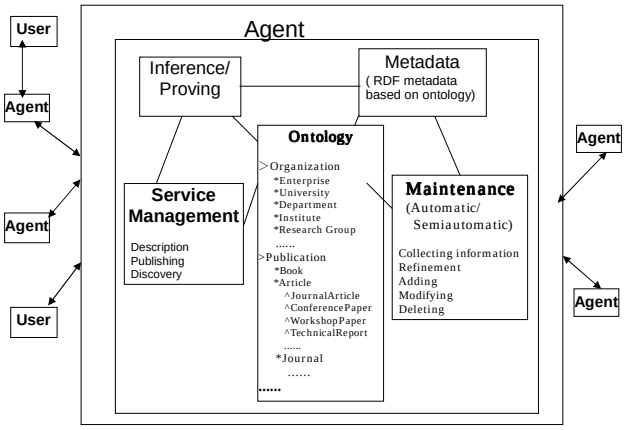

Figure 2: Structure of Semantic community Web portal

The community Web portal services can be invoked by agents or users through the Web portal Agent.

The Web portal agent processes all the requests from the other agents or people, and then invokes the appropriate subcomponents in the Web portal so as to give the proper response to the requestor.

Just as people need a common language to communicate with each other, machines also need it in order to share knowledge and to communicate with each other. Ontology

can provide a shared and common understanding of knowledge and interests within a community that can be communicated between people and machines. So it is a key technology that allows knowledge sharing at a conceptually concise and elaborate level within the community concerns all the aspects of the portal functions.

We treat ontology subcomponent as the backbone of the Web portal. It defines all the terminologies used within the community and the relationships and properties of them. It is used for the whole processes concern the Web portal functions including information providing, accessing, inference, and maintenance.

Instead of constructing a new ontology totally, we make use of the ontology made by S.Staab et al. used in KA2 community Web portal [12] because we use most of the same terminologies and properties as them. We may refine it and even extend it as necessary. The items of the ontology can be added, deleted and changed. We use the RDFS and OWL ontology language to define the ontology of Semantic Web community.

In order to response the request of services from agents and users, we need service management subcomponent to define services and realize these services by accessing the other subcomponents when is invoked. The services can be discovered and accessed automatically by agents.

One of the merits of using knowledge is that we can derive implied or indirect knowledge from the current one. The Inference subcomponent can infer new facts from the existing knowledge defined in the ontology to help agents to reach the optimal decision.

The Semantic Web metadata is built with RDF data model based on the ontology of the Semantic Web community domain with the help of appropriate existing tools [12].

After being constructed, the Web portal requires maintenance. The maintenance subcomponent deals with maintenances such as the aggregation of ontology, to add, delete or refine ontology items, refresh its data with up to date information after constructed. It discovers and gathers information from the members of community and refines the service material automatically or semi-automatically with the help of distributed multi-agents.

5. CONCLUSION AND FUTURE WORK

In this paper we presented our preliminary ideas of building Semantic Web service system based on a multi-agent system. Our system consists of three main aspects: multi-agent system, Web service management and Semantic Web contents. We also discussed some issues on how to build a semantic community Web portal service system for Semantic Web community. The main feature of our system is that it builds the Semantic Web services based on a multi-agent system called KODAMA that has been developed at Kyushu University.

As for the future work, we need to explore reasonable technologies and methods to build the semantic community Web portal for Semantic Web community, enable the portal services, and implement the automatic or semi-automatic maintenance functions of Web portal. We also need to evaluate our system from the users' point of view.

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