Seamless Semantic Framework for Interoperability of Virtual Group using Ontology-based Gateway

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ABSTRACT: *Collaboration* among enterprises in a dynamic environment makes the actors to concentrate on their respective core competences and allow provision and sharing of expertise, resources, and skills for taking advantages and better respond to business opportunities. The coming together of such organizations, usually enhanced by computer network, is referred to as virtual enterprise (VE) or task group. This partnership is only possible if the systems in the various associated organizations can process the data in one another. A major challenge in the enterprise collaborative system that has attracted many research efforts in the recent past is semantic interoperability. This collaborative-based market place requires among others common conceptualization and meaningful data exchange. Effective collaboration among VE members is a major key to the accomplishment of this noble objective. For this interoperability to be effective, we propose in this paper an ontology-based middleware framework 'Ontology Gateway' used by players in such situation to exchange information needed to carry out the process. The middleware not only assists in the formation of VE by interested members, but also facilitates semantic interpretability among task groups.

I. INTRODUCTION:

One of the greatest challenges to enterprise systems developed for open environments is interoperability among distributed heterogeneous services i.e. semantic web services, semantic grid services and agent's services. These three type of services have differences in their structure as well as semantics, which need to be resolved. Service- oriented Computing (SOC) has been considered as technology trend that provides mechanisms for bringing interoperability among heterogeneous semantic services [1]. SOC involves collection of services which provides higher level for organization business process and resulted in bringing interoperation by exposing their interface to outer world [2]. Semantic Grid is an extension of current grid where grid services are semantically described in forms of ontologies which helps in discovery as well as joining of resources automatically and ultimately achieve creation of dynamic virtual organizations.

Web services are isolated, independent computational entities which allow construction and deployment of distributed components. Web services have been used by grid community for definition of Web Services Resource Framework (WSRF) [3] to bring state fullness in web services and also they are being enhanced to semantic web services by W3C Semantic web service collation group [4]. Agents are encapsulated computer system that is situated in some environment and is capable of flexible and autonomous action in an environment in order to meet its design objectives [3]. The importance of agent technology has been realized as one of the key technologies to successfully support activities like e-business which require autonomous entities to handle dynamism of communication and results in conceptual simplicity and enhance scalability [8]. W3C working group for web services architecture stated that "software agents are the running programs that drive web services - both to implement them and to access them as computational resources that act on behalf of a person or organization" [4]. Agents play important roles in the Semantic Grid based on their capabilities to realize virtual organizations and virtual services [5]. Ontologies are core for semantic descriptions of these technologies. It defines formal and explicit specification of certain domain. Use of ontologies in these technologies is aimed at facilitating automatic processing of huge amount of data available on grid without human interventions.

Ontologies are core of semantics as they allow semantic representation of services which play a vital role for bringing interoperability among heterogeneous semantic services and enables software agents to discover, invoke and execute semantic services automatically [14]. While OWL is semantic language provided by W3C for semantic description of web contents [6], FIPA SL is semantic language for agent's community. Both differ in underlying support for terms, syntax and semantics. Three types of integration approaches or patterns have been reported in [7] for establishing the communication between agents and web services. These are 1) Adapting one technology to other; 2) Middleware based integration; and 3) Minimal changes integration. Web Services Integration Gateway Service (WSIGS) [9] is example of minimal changes integration architecture and is related to Gateway model produced by AgentCities.Net web services working group. We aim at providing agents mediated semantic interoperability in heterogeneous distributed environment where technologies like agents can automatically and transparently access web and grid services and vice versa without changing standards and specifications.

We present in this work our ontology-based framework that serves as a middleware for the various organs willing to form a temporary alliance coming together and identify their various potentials and needs in order to pool together resources and take advantage of business opportumt1es. The proposed system describes how agents communicate with OWL-based Web Services including understanding these services. Likewise, it also illustrates how OWL Web Services communicate with agents to obtain services required to accomplish a task. Since both OWL and FIPA SL have different principles in terms of syntax, semantics and implementation, devising transformations for such a system is the main focus of this paper. In doing this, the work sought to keep existing specification and implementations of the two technologies. Secondly, the framework addresses task group formation as requested by an enterprise seeking to form an alliance in taking advantage of a business opportunity. Lastly, we illustrate our implementation strategy using a sample scenario.

II. IL AGENTS AND VE FORMATION

In meeting and even exceeding customers' demands, an organization often needs to cooperate and collaborate with its counterparts. Apart from time constraints in fulfilling these requests from clients, availability of both human and material resources of individual enterprise sometimes makes this cooperation very inevitable. These enterprises may virtually come together to better respond and take advantage of any business opportunity. This cooperation varies along product/service development phase, in marketing and sales activities and sharing of their business processes, resources, core competencies, skills and know-how [12). The coming together of some business organizations to collaboratively respond and take advantages of business opportunities through sharing of skills and resources in a computer network forms a VE. Unlike the virtual organization (VO) that is not profit oriented, VE are meant to generate revenues for the participating enterprises.

Identification of willing partners and VE formation is keen to the success of achieving any specific goal as intended by the initiator. One important characteristics of this task group formation is limitation in lifeline - they are meant to collaborate for certain duration in achieving an objective. Another important feature of this collaboration is that promptness is often imperative in meeting the deadlines of the goals. Each potential participant has its own goals and targets. Thus, these have to be taken into consideration in this group association. There is need for a reasoning mechanism which will facilitates the communication, coordination, and negotiation expected. This knowledge-based system should be autonomous, fault- tolerant, proactive, and responsive. Software agents are most suitable to be saddled with these important responsibilities. Agent-based approaches to business modeling take advantages of the nature of loosely coupled entities called agents for better operations. These characteristics include flexibility, adaptive, communicative and intelligence ability. A community of agents coming together to solve a problem which is too complex to be tackled by a single agent in a system is referred as a multi- agent system(MAS).

In VE formation, the three basic steps are required as identified in [13). These are:

- Alignment of the goals of the Interested Partners with the goals of the initiator
- Matching the Interested Partners to the requirements of the roles - including skills and capacities, availability and cost requirements
- Verification of the information provided in the bids

As illustrated in Fig. I, a task group initiator sends a request to the agent-based facilitator specifying it needs and timeframe. Subsequently, the agent contacts the web where other enterprises had registered their services. For those who have indicated interest and could satisfy the requirement, links are established and subsequently, requests are forwarded to them. In the process, a VE is formed. The tick lines and broken lines depict direct and virtual communication respectively between the partners.

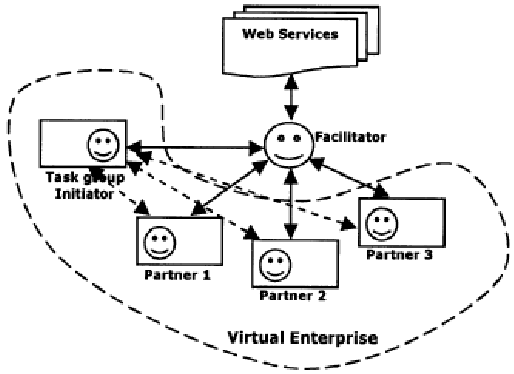

Fig. I. VE formation with the aid of an agent facilitator

Our focus in this paper is on the first two steps of goals alignment and relationship formation. The BDI (belief, desire, intention) feature of agents could be ultimately utilized in facilitating goals alignment and interest matching of wiling partners in the VE.

III. RELATED WORK

Considering the noble aspiration of interoperability between agents and web services technologies in the semantic web research community, we have conducted study of the capabilities of OWL-S and the potential of semantic web services [14,15]. With OWL-S markup of services, the information necessary for WS discovery could be specified as computer-interpretable semantic markup at the service Web sites, and a service registry or ontology- enhanced search engine could be used to locate the services automatically [15].

Execution of a Web service can be thought of as a collection of remote procedure calls. OWL-S markup of WS provides a declarative, computer-interpretable API that enables automated WS execution [20, 19). Given a high- level description of the task by the user, automated composition and interoperation of WS to perform the task is of particular interest to us. With OWL-S, the information necessary to select and compose services would be encoded at the service Web sites [21]. Software agents can be written to manipulate and interpret this markup, together with a specification of the task and thus can be bestowed with the ability to perform the task automatically [18, 19, 20). Solution in this literature is based on implementing a wrapper, which turns a current Web service into an agent like entity. The other alternative is to capture all the functionalities of a Web Service and imbed them into an existing software agent. In [16], an architectural model for enabling transparent, automatic connectivity between WS and agent services was proposed.

Previously we provided the semantic translations [6] between OWL to FIPA ontologies with minimum semantic loss. The system does not require any change in the standard specifications and implementation of the existing technologies. Open systems like Grid are still working on to hide the resource heterogeneity and making a scalable and robust infrastructure, while software agents acts as key entities of these systems to semantically interoperate and negotiate with each other

IV.PROPOSEDARCHITECTURE

The idea behind the proposed architecture of Ontology Gateway is how the software agents will communicate effectively with OWL-based Web Services and vice versa. Fig.2. provides the semantic interoperability in distributed environments where different enterprises are working together to achieve a particular task. As described in section 2, the initiator agent communication system contacts the controller agent who afterward uses our Agent Gateway [6,7] to contact the Web and establish willing task partners.

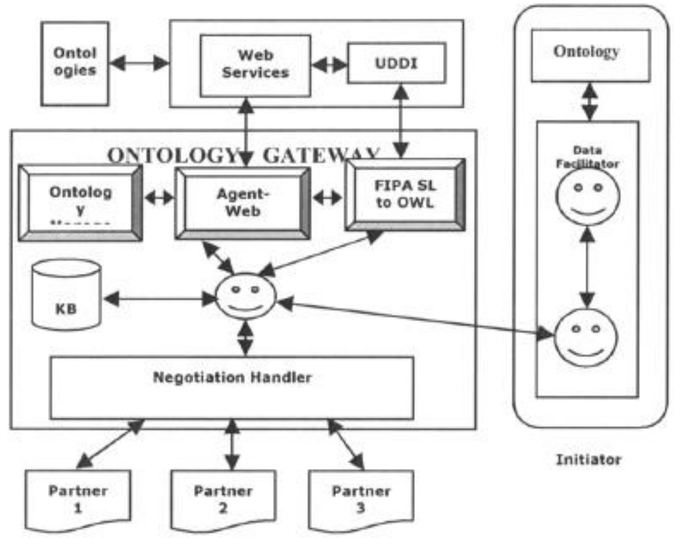

Fig. 2.Ontology Gateway for achieving semantic interoperability

We have utilized the Semantic Web capabilities in order to provide a conceptualization by which the distributed knowledge can 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.

V. SAMPLE SCENARIO AND PROTOTYPE IMPLEMENTATION

We are working on a prototype implementation of our framework. It involves an enterprise using agent-based supply chain management (SCM) for service delivery to customers. SCM is the process of planning, implementing, and controlling the operations of the supply chain to satisfy customer requirements in an efficient and cost effective manner. SCM spans all movement and storage of raw materials, work-in-process inventory, and finished goods from point-of-origin to point-of-consumption [22]. The supply chain consists of worldwide network of factories, suppliers, warehouses, distribution centres, and retailers through which materials are acquired, transformed, and delivered to customers. The functional capability of the Ontology Gateway is fully utilized. This is shown in Fig. 3. It demonstrates the interoperability between FIPA-compliant software agents and the OWL-based Web Services. Different agents communicate with each other and use information provided by the Web Services to plan and coordinate their actions and how they provide a transparent environment to multiple partners that cooperate together in order to achieve a business goal in a distributed environment.

Using Ontology gateway, these agents can acquire data that is not available in their default DF or remote platforms. We developed nontrivial agent-based supply-chain architectures which supports simple cooperative work and the management. This agent-based SCM system covers just the Business-to-Business (B2B) aspect of the supply chain. The main activities of buyer's agents in B2B are to avail the economical offer in the market, for that it has to communicate with various agents around and on remote platforms. In this application, the buyer agent is also able to find the lowest cost of products/service it wants to buy. The supplier's agents aim to attract a buyer agent and then sell its goods to it. For this purpose it interacts with various buyer agents and submits its rates. If the buyer's agent feels that this is the lowest bid, then the appropriate supplier agent is contacted.

In detail, the buyer agent checks the stocks of a company in a warehouse, and if it feels that the stock is below a certain level, then it decides to place an order for the required product. To place an order, it contacts various supplier agents and asks them to submit their bids. Web Services are also contacted through Ontology Gateway. They are sent a message in which they are asked to submit their bids. At the end of the day, all suppliers' agents and Web Services submit their bids. The agent or web service with the lowest price is requested to dispatch the product to its customer. Supplier agents, when receives a message concerning the issues of submitting the rates, they contact the sender agent and send them their rates and bids. At the end of the day all the bids are checked and the agent that has submitted the smallest bid will be contacted and the order will be placed.

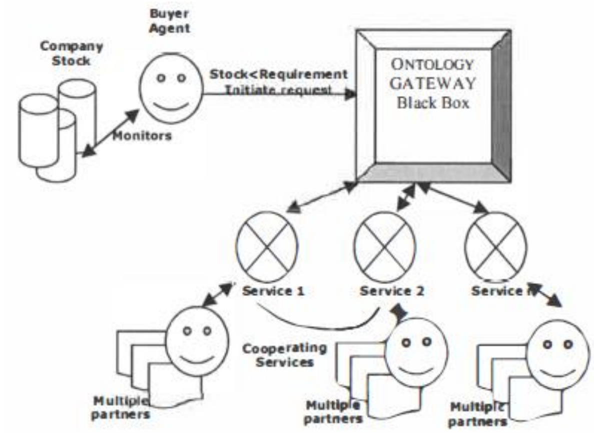

Fig. 3. Ontology Gateway based SCM

The OWL based web services are registered in UDDI and OWL-UDDI matchmaker works as wrapper to do semantic search on web services registered in UDDI. The buyer agent will contact Ontology gateway controller agent to search for OWL web services with lowest inventory price. Controller agent of Ontology gateway will translate the request to SOAP message with help of ACL2SOAP component [7] and forwards to OWL-UDDI-matchmaker. The search results are returned to Ontology gateway controller agent after translation from SOAP2ACL component. Controller agent accesses the OWL web service, translates the ontology from OWL to FIPA with help of OWL2FIP A SL component and then saves the translated ontology on local web server. Ontology gateway agent sends the reference of translated ontology to an agent generated the request. In this way ontologies are translated from OWL to FIPA and used with the same semantics in the FIPA compliant Agents as they are defined in OWL.

VI. CONCLUSIONS

In Ontology Gateway, we have devised architecture to provide a detailed illustration of how the agents and Web Services can effectively communicate with each other autonomously. The detail of semantic interoperability between FIP A agents and OWL-based web and grid services was also described. We gave an overall description of system architecture involving an enterprise that uses SCM techniques in meeting its customers' demands. The case study gave an insight into the system implementation. Ontology Gateway enables flexible and autonomous interaction between semantic web and agent services. In addition, we have explained the translation of OWL ontologies to FIP A SL and vice versa without semantic loss, and storage/registration of translated ontologies.

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