Waste Management Using Request-Based Virtual Organizations

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Abstract. Waste management is on top of the political agenda globally as a high priority environmental issue, with billions spent on it each year. This paper proposes an approach for the disposal, transportation, recycling and reuse of waste. This approach incorporates the notion of Request Based Virtual Organizations (RBVOs) using a Service Oriented Architecture (SOA) and an ontology that serves the definition of waste management requirements. The populated ontology is utilized by a Multi-Agent System which performs negotiations and forms RBVOs. The proposed approach could be used by governments and companies searching for a means to perform such activities in an effective and efficient manner.

Keywords: Waste management, RBVO, SOA, Agents.

1 Introduction

According to The Economist's 2009 'Special Report on Waste', the average Westerner produces over 500kg of municipal waste a year. In addition, both developed and developing countries generate vast quantities of construction and demolition debris, industrial effluent, mine tailings, sewage residue and agricultural waste. Rich countries spend some $120 billion a year disposing of their municipal waste alone and another $150 billion on industrial waste, according to CyclOpe, a French research institute. The amount of waste that countries produce tends to grow in tandem with their economies, and especially with the rate of urbanization. So waste firms see a rich future in places such as China, India and Brazil, which at present spend only about $5 billion a year collecting and treating their municipal waste. Concern about global warming should also provide a boost for the waste business [1].

Waste is not just a substance that needs to be disposed. It is also a potential resource: it can be burned to generate energy; new technologies turn it into fertilizer, chemicals or fuel; paper, plastic, aluminum, etc can be recycled. Much waste can also be reused [1].

However, there is no centralized collaboration system supporting the management of waste. Companies and municipalities wishing to recycle or find other ways of disposing of their waste need to locate appropriate firms which can support them, i.e. from a simple transport company, which can take their waste to the appropriate place, to specialized recycling companies or firms that could reuse the waste.

In this paper we propose an approach based on which a system could be developed to be used by governments, companies and other organizations that are searching for a means to dispose of, transport, recycle, and reuse their waste in an efficient and cost effective manner. In order to do this they need to find and collaborate with appropriate combinations of firms.

In Section 2 we present an overview of the approach and its main concepts. Section 3 deals with the overall proposed system and its architecture, followed by a section which describes the potential use of such a system. Finally, there is a discussion which looks at the possible expansion and broader use of the system.

2 The Approach

From a functional point of view, our approach is designed bearing in mind the needs of a municipality, or a contracting company, in finding the appropriate combination of firms who can help dispose of its waste in an environmentally friendly and cost effective manner. The same approach holds for any business company that wants to recycle its waste. This is a difficult task, in general, because a variety of business actors are required to be involved and coordinated, each of which undertakes a specific and highly specialized task that needs to be performed in an accurate way and according to the general standards set. A participating actor performing his tasks in an ineffective and inefficient way could lead to a huge negative impact on the environment, the community and the reputation of the organization in charge.

As the green movement expands, the importance of finding appropriate partners for waste management becomes more acute. To provide a means for locating these partners, from a technological point of view, our approach is based on the concept of Request Based Virtual Organizations (RBVOs), a more sophisticated form of Virtual Organization (VO).

2.1 The concept of RBVOs

A VO is usually described as a network among organizations and/or individuals [2]. Therefore, it appears as a single unified organization. The benefits of VOs (cost, transaction, process and strategic) are well-documented in the literature [3-5]. However, the static nature of VOs fails to address the growing demands to locate products, services and business partners. In Government to Business (G2B) or

Business to Business (B2B) contexts the above problems are more profound, due to the large potential number of collaborative partners with diverse capabilities and the lack of standardization of service description [6]. Request Based Virtual Organizations (RBVOs) overcome this by enabling the discovery and matching of appropriate business partners.

RBVOs are short-living entities that are formed to respond to business opportunities offered by electronic commerce. An RBVO is comprised of a cluster of partnering organizations that have totally replaced their vertical integration into a virtual one [7].

According to Svriskas and Roberts, the key features of a RBVO as opposed to the "classic" VO are:

- A possibility for an enterprise to discover potential business partners upon demand and advertise itself in a standard way.
- Short-lived ad-hoc virtual formations of collaborating partners.
- Highly dynamic involvement of an enterprise in different e-business activities, serving different defined and advertised roles, at the same time, if needed.

In addition, RBVOs also inherit many of the features of a "classic" VO, i.e.

- A cluster of geographically dispersed organizations either within regions or inter regionally.
- A range of relationships from transactional to collaborative that vary dynamically over time in response to market opportunities.
- Lower transaction costs for geographically dispersed transactions [2].

Quotes from a large number of sellers can provide a good overview of price. However, overcoming ignorance of product quality and other supplier capabilities may be more difficult. RBVOs are coupled with the concept of sector specific Service Level Agreements (SLA) to address the issue. In its most basic form, a SLA is a contract or agreement that formalizes a business relationship, or part of the relationship, between two parties [2, 8].

Vokrinek et al. have designed an RBVO protocol which supports a flexible formation of RBVOs taking into account the use of SLAs with an emphasis on reflecting the conditions of real competitive environments. The protocol consists of three phases: (i) potential partner search, (ii) negotiation of SLAs and RBVO establishment and (iii) RBVO execution and dissolution [9].

Organizations participating in RBVO formations can reduce the costs of market search, and benefit from more effective monitoring schemes thus lowering transactional costs. Improved information flows can also facilitate improved planning and more coordinated actions to reduce uncertainty [7].

3 The Proposed System

There are many ways to implement RBVOs, but utilizing a community of Intelligent Agents (Multi-Agent System) has shown to be a most effective method [10]. In this way, the organization and functioning of the RBVO's activities are served by the

Multi-Agent system that is developed to orchestrate and automate procedures and operations of RBVOs.

For the proposed system, a Service Oriented Architecture (SOA) is used. The SOA paradigm enables the linking of business and computational resources - mainly organizations, applications and data on demand [11]. SOA is seen to be essential for delivering business agility and IT flexibility [12]. The advantages of SOA can be obtained for a conglomeration of companies coming together to exploit complementary skills and competencies synergistically. Although there is no shortage of platforms for firms to collaborate online within particular industries or across industries, the advantages of adopting a SOA approach for such platforms need to be taken into consideration. This is due to the adaptability and easy reconfigurability that SOA offers which matches heterogeneous RBVO's business requirements [10]. In addition, SOA has also been shown to interoperate with agent technologies [13-14], which are used in the architecture described below.

3.1 Architecture

Figure 1 presents the architecture of the proposed system.

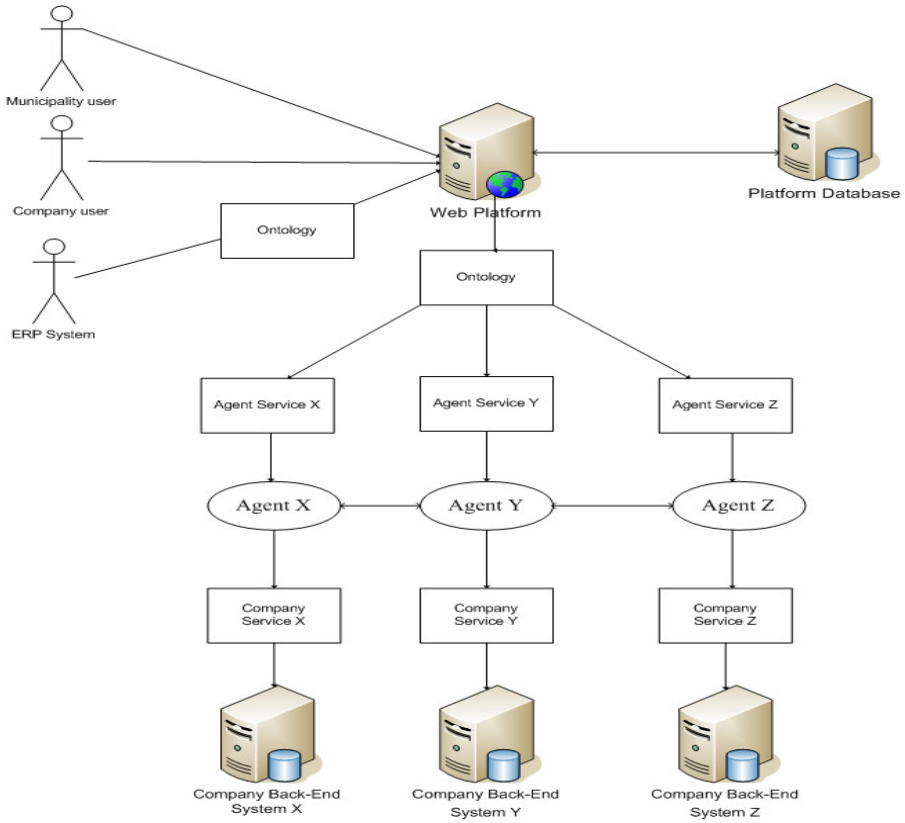

Fig. 1. System Architecture

The system is comprised of the following components:

- Web platform: A portal from which the user has access to the partner search functionality.
- Directory service: A data store with login information and user profiles which should be accessed via a web service.
- Ontology: A high level representation of waste related information which can be used to encapsulate the user's requirements regarding the types and amounts of substances that need to be disposed or recycled.
- Agent Services: A web service that enables the submission of a Collaboration Request to the Agent and the acquisition of the list of the proposed RBVOs.
- Agent: An independent distributed instance which interacts with other Agents and represents a potential collaborator.
- Company Services: A set of simple web services that enable the municipality's/company's Agent to access its Information/Enterprise Resource Planning (ERP) system or private repository, i.e. Company Back-End System.
- Company Back-End System: Contains private information of the company such as the municipality's/company's profile, requests for collaboration, contracts and recycling capacity it currently has available.

4 Usage of the System

4.1 A Usage Scenario

Let us assume that a municipality official wishes to find a new cost effective way to dispose of cardboard, used batteries, canteen food waste, plastic bottles, old computers and mixed rubble. To take advantage of the proposed system, the first step would be to register as a user and have an instance of an Agent set up to represent the municipality. This registration process would be required not only for municipalities and organizations who wish to find partners for waste management, but also for the companies offering these services in order for them to be represented in the system's network by their Agents.

After logging into the system, this new user needs to complete a web form in which the type of waste which requires management is defined. The waste is categorized as sorted or mixed. For each type of waste the corresponding amount (i.e. approximate weight/volume) should be provided. Also, the location, language in which the service is required, time constraints and any other specifications would be defined in this form.

Once completed, the form can be submitted as a request to find a combination of companies within the system's network which can complete the tasks. An ontology

would be populated with the information which has been provided and then would be forwarded to the Agent Service.

Should the user wish to complete the aforementioned form on a frequent basis, manual insertion of values might become tiresome. For this reason a custom script could be incorporated as a means of automatically populating the ontology from specified values in the municipality's information system. (In the case of a company, the ontology could be linked to its ERP system).

After the Agent Service has received the populated ontology, this information would be forwarded to the user's Agent. The Agent in turn would send the specifications to the other Agents registered in the system. Each Agent filters the incoming specifications to see if any of the required tasks are of interest to the firm it represents. A set of negotiations, based on each firm's private constraints and on offered prices, would be performed between the Agents, resulting in a list of suitable RBVOs. The list would finally be returned to the user who would be presented with all the possible combinations of appropriate organizations which could perform the defined tasks.

The user, in this case the municipality official, can now select the preferred combination of firms (RBVO), either based on price, time constraints or other criteria. Of course, once selected, contracts would need to be signed - possibly in the form of SLAs - in order for collaboration to begin.

The sequence of the above described scenario is presented in Fig. 2.

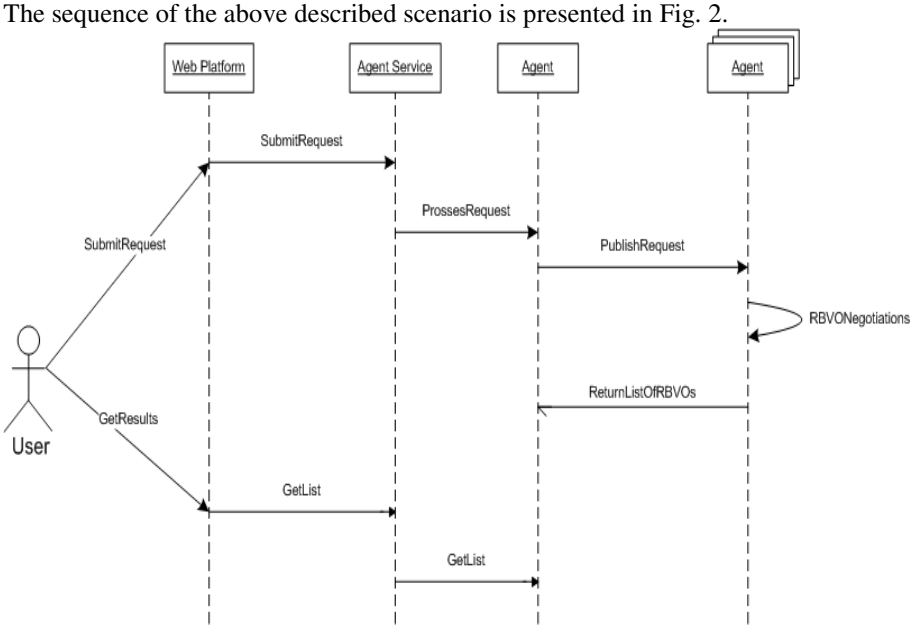

Fig. 2. Sequence of RBVO formation

4.2 Utilizing the Agents

The scope of Agent contribution can be formulated as Agent-based negotiation towards RBVO formation by using dynamic semi-private knowledge (i.e. Company

Back-End System). As stated in the PANDA project [10], the Agents represent individual actors participating in the RBVO formation processes taking into account individual private constraints, preferences that are hidden to other actors and minimizing the disclosure of such private information. In their negotiations, agents can be guided by user-defined business rules. Agents need to decide which of these rules are applicable in each type of negotiation. Flexibility is essential when adapting and prioritizing these rules as the negotiations progress. Such rules can be set by each user to guide his/her Agent, and can be implemented using a rules engine.

Indicative user-defined business rules for the negotiation between Agents could include:

- Tolerance on price -x% to +y%.
- Prepared to wait x days to get a better price.
- Prepared to pay more for the tasks to be finished sooner.
- Prepared to pay more for 'greener' outcomes.
- Wishes only to consider partners in the same region/country as the user.
- Do not want to participate in projects less than x Euros.

5 Discussion

To improve waste management, it is vital that companies are able to collaborate with each other in the widest way possible and this system could open doors to previously unforeseen collaboration potentials. Examples of waste management companies that could be sought through the system range from simple waste disposal firms to more complex ones specialized in transport and disposal systems for dangerous substances.

The system could be used to encourage start-up firms in the waste cycle process, enabling them to find companies with small waste loads and progressing to expanding their client base as their equipment and resources grow. Such start-ups might include innovative bio-fertilizer firms who could recycle human and animal waste. Such schemes are popular in modern China and using an RBVO system would promote their expansion.

The architecture of the system could be expanded to consider more eco-friendly ways of managing waste and other resources of the company. An 'Eco' score built into the system might spur firms to improve their style of waste disposal. The system could rate the RBVOs based on each firm's Eco considerations. For example, emissions of CO2 could be used as a basis for recommendations of the best ways of transporting the companies' waste to appropriate areas. This would require each waste management firm which registers in the system to complete its profile by providing eco-related details of its disposal methods. In cases of transport, distances would have to be calculated via a service such as Google Maps in order for emissions to be estimated.

The system could also be expanded to be a type of waste monitoring system because at present, nobody knows how much waste the world generates or what it does with this [1]. For this purpose active government support would be required.

6 Summary

This paper presents an approach and a brief outline of a proposed system for decision support on selecting a combination of firms to enable cost effective, ecologically sound and efficient waste management of a municipality's or a company's waste. A SOA based system which uses a Multi-Agent community to create RBVOs, enabling easy adaptability and reconfigurability, has been illustrated. Improving the options available online for assisting the management of waste is an essential step in minimizing global pollution.

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