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A cooperative approach for QoS-aware Web services' Selection

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Abstract

As Web services are becoming omnipresent on the Web, quality of Web services (QoWS) support and management is becoming a hot research topic. Several frameworks for Web service selection have been proposed to support clients in selecting suitable Web services. They are very often based on a middle-tier component to make the selection decision. These solutions suffer very often from scalability problems. To deal with this issue, we propose in this paper a new architecture for Web service selection based on a federation of cooperative brokers. Each broker of the federation manages the Web services within its domain and cooperates with its peers by exchanging information about Web services, such as reputation and QoS, to better serve client requests. We have developed a prototype of the architecture and we have conducted experiments using three broker selection policies mainly "random", "round-robin", and "cooperative brokers" to evaluate the degree of fulfillment of clients' requests. Preliminary results show that the best results are obtained by using the cooperative brokers' policy.

I. INTRODUCTION

Web services are a new emerging paradigm that drives the Internet for a better support of business-to-business interactions.

A Web service can be defined as an application that exposes its functionality through an interface description and makes it available for use by other programs. A composite Web service can further be created by aggregating a set of Web services to produce a more complex Web service with a wide range of functionalities.

The management of Quality of Web services (QoWS), as an integral part of the Web service management will play an important role for the success of this paradigm. Providers of Web services need to remain competitive by satisfying different client's requirements. Clients also will have the possibility to look for appropriate Web services that suits their QoWS preferences.

Several initiatives have been proposed to tackle the issue of QoWS management ([2][3][4][5]). These solutions are mainly based on a third party to mediate between clients and providers of Web services by providing a set of QoWS management operations such as: QoWS based Web service selection, and QoWS monitoring. However, these models suffered from substantial limitations considering the scalability of the model to process an increasing number of client's requests with different QoWS requirements. Besides, a single mediator may not be able to manage several QoWS properties. Thus, to overcome these issues, a federation of third parties (e.g. brokers) needs to be considered.

This paper aims to extend our previous works ([2] [3][4][5]) to support federation of distributed and independent QoWS brokers from different domains. These QoWS brokers cooperate in order to deliver QoWS management for both providers and clients of Web services. The work essentially focuses on the specification and the development of a multi-broker architecture and their components as well as the definition of the interactions between the brokers.

The remaining sections of this paper are organized as follows: the next section discusses related work concerning the management of QoWS. Section 3 describes our proposed multi-broker architecture for Web service selection and QoS management. Section 4 details the prototype implementation and describes the experiments we have conducted. Section 5 concludes the paper and describes future work.

II. RELATED WORK

Web services are a novel approach for business-to-business interactions. Their management, especially QoWS management, is becoming more and more crucial for their success. The approaches that have been proposed so far for QoWS management may be classified into two categories:

1. Approaches that extend the existing Web service protocols (e.g. SOAP, and WSDL) to support QoWS management operations. The approach described in [6] recommends extending the SOAP header with QoWS information. The WSDL extension approach augments the WSDL document with QoWS annotations [5]. The UDDI extension approach consists of extending the current UDDI data structure with QoWS information [8]. These extensions are relatively simple and not standardized.

2. Approaches that utilize an independent entity that is mandated to support QoWS management operations. These operations include mainly: QoWS discovery and selection, and QoWS monitoring. Related work from this category includes the work of Ran et al. in [9], the work of Sravanthi et al. in [10], Maximilien et al. in [11], and Chen et al. in [12], and our work in ([2][3][4][5]). All these works proposed architectures to support some QoWS management operations provided by one single entity that mediates between clients and providers of Web services.

The above solutions for QoWS management present some drawbacks, which are related to one or more of the following issues:

- A single third party may not satisfy all the needs of clients/providers regarding QoWS management operations. Furthermore, a single broker may not support the management of a wide range of QoWS properties.

- As the proposed architectures are centralized around one entity, they present the same weaknesses of centralized architecture with no alternative backup solution in case the broker falls down.

- Providing many instances of the same Web services with different QoWS description has not been considered in most of the proposed solutions.

We foresee that a multi-broker architecture is in a position to extend the previous architectures by considering the above weaknesses.

To our knowledge, no previous work used a multi-broker model for Web services selection. However, this model had been used in other contexts different from the context of Web services. The work proposed by Varalakshmi et al. in [13] focuses on the development of a multi-broker framework for trust management of resource selection in Grid environment. The work proposed by Mohamed-Salem in [14] uses a multi-broker architecture for scaling the server selection in the context of Web servers.

III. MULTI-BROKER MODEL

A. Description

Figure 1 illustrates an example of a federation of brokers that may be composed of two or more cooperative brokers. These brokers may be invoked by clients and/or providers that are interested by the QoWS management operations. Brokers may manage the same set of Web services but with different QoWS. They communicate and cooperate in order to efficiently guide the process of Web services' selection and QoWS management. They exchange summary reports on their status and share load in periods of high demand.
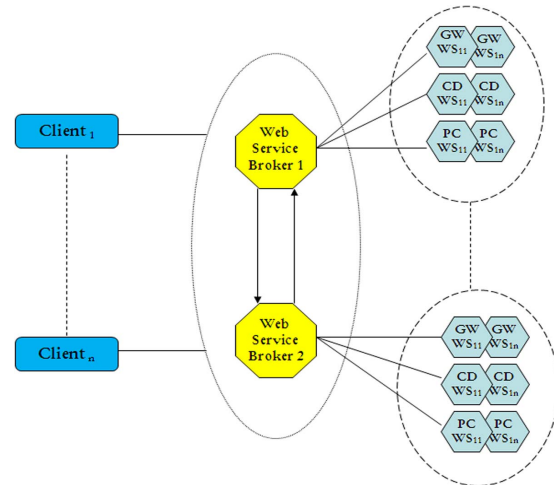

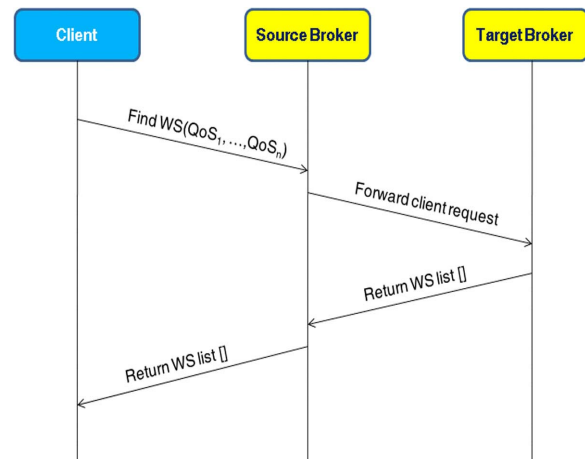**Figure 1. Multi-Broker architecture**

Figure 2. Example of Broker-Broker interaction scenario

B. Broker-Broker Interaction

A Broker within the federation may cooperate with its peers by either requesting QoWS information of a given Web service or delegating Web services selection to another broker within the federation. Figure 2 describes an example of sequence diagram of broker-broker interaction.

IV.   IMPLEMENTATION AND EXPERIMENTS

A.   Web services

To test our proposed architecture we have used a set of QoS-aware Web services: (1) Global Weather (GW) that provides the current weather and weather conditions for major cities around the world, (2) Country Details (CD) that provides for each country its currency, currency code, international dialing code, ISO country code for all countries, and (3) Picture catalog (PC) Web service that provides a set of pictures classified by category, size, rate, and type.

QoWS information of each of the above Web services is described in their WSDL documents.

B.   Test-Bed Configuration

To evaluate our proposed model, we are considering the selection of the above QoWS -aware Web services using some scenarios where providers, clients, and brokers are involved. We have used a clients' generator to generate a large number of requests that are sent to the brokers of the federation. Figure 3 depicts our test-bed configuration.
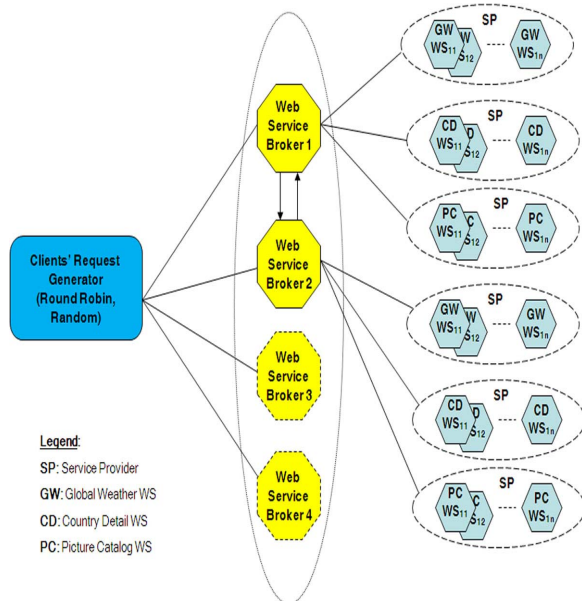

Figure 3.   Federation of Brokers: Test-Bed configuration

C.   Experiments

We have conducted a set of experiments using two scenarios:

Scenario 1. In this scenario, we generated a series of requests that are sent to the federation using three policies for the broker selection (1) Random, (2) Round Robin, and (3) 'Cooperative brokers". For the Random and the Round Robin policies, requests are handled by selected brokers without cooperating with peer brokers of the federation. For the "Cooperative Brokers" policy, the initial selected broker may cooperate with its peers in order to find out the most suitable Web service that can process the client request. Each request specifies the values of required QoWS parameters such as response time, availability, and processing time. The aim of this experiment is to evaluate the multi-brokers selection using the above policies in terms of the average response time and processing time of requests.
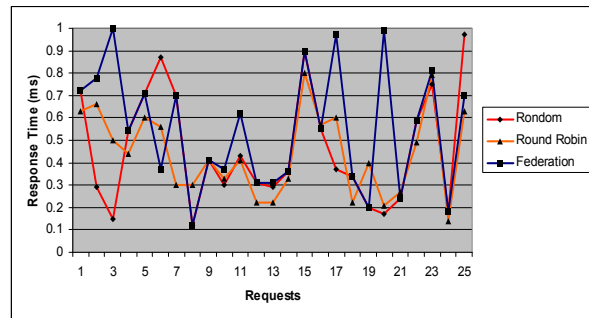

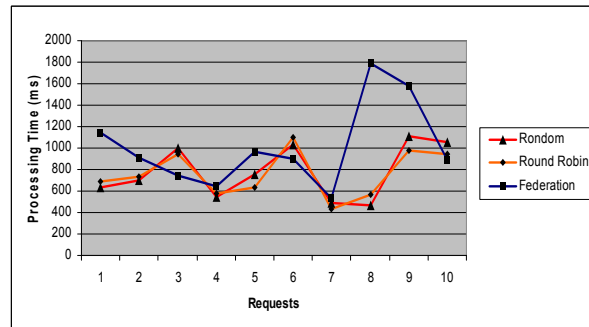**Figure 4.   Requests Response time using the three selection policies**

Figure 5.   Requests Processing time using the three selection policies

Scenario 2. In this scenario, we generate the same series of requests as in scenario 1 using the three selection policies, and we calculate the best match Web service which satisfies the requested QoWS. Our main

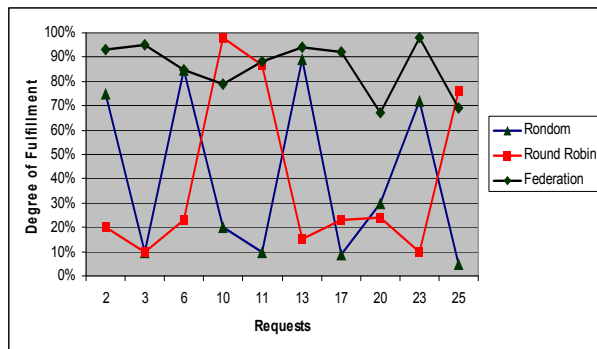goal here is to evaluate the three selection policies regarding the satisfaction of requested QoWS.

Figure 6. Degree of request fulfillment of requested QoWS using the three selection policies

D. Results Interpretation

Figure 4, 5, and 6 illustrate the distribution of Response Time (RT) and Processing Time (PT) of each request by using the three selection policies respectively: random, round robin, and cooperative brokers. With random and round robin policies, the RT, and PT are very close to each other (see figure 4 and 5). However, for the cooperative brokers' policy, there is a noticeable difference between RT and PT. This may be explained by the fact that some requests require that the initial selected broker cooperates with its peers to find out the most suitable Web service that might process the request according to its required QoWS. The RT fluctuates from one request to another as they may require different QoWS and due to other factors such as the performance of the server on which the broker and/or the selected Web service is deployed, the location of Web services, etc.

Figure 6 depicts the degree of fulfillment of each request send to the federation using the above selection policies. These values are computed based on the QoWS requirements of each request. Using the cooperative brokers' policy, clients requests are better served because it provides the highest degree of fulfillment which exceed 90% for most of requests. This may be explained by the fact that the aggregation of brokers together served several requests with various QoWS requirements. In addition, each broker within the federation can cooperate with its peers for efficient selection of target Web service based on QoWS requirements. For the requests generated using random and round robin policies, only 50% of the requests have been fulfilled (satisfies completely the requested QoWS). This is due to the fact that some requests might be sent to a broker that can not satisfy their QoWS requirements.

Therefore, according to our experiments, we can state that cooperative brokers' policy is the best selection policy as it allows having better degree of fulfillment of requests with respect to their QoWS requirements.

V. CONCLUSION

Web services selection has been recognized as being indispensable for Web services providers seeking to achieve a higher degree of competitiveness. Our main objective in this research is to support a client in selecting Web services based on the QoS they provide. To attain this goal, we have proposed a model for Web services' selection, which is capable of handling an increasing number of clients with different QoWS requirements. The model is developed around a federation of brokers. These brokers cooperate and share QoWS information to optimize Web services' selection.

The conducted experiments showed that the Cooperative Brokers' policy outperforms the random and round robin policies, and allows Web service satisfying a large number of requests with various QoWS requirements.

As a future research work, we intend to enhance the federation model by providing support to other QoWS management operations such as QoWS monitoring.

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