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Semantics Based Grid Services Publishing and Discovery

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Abstract: - A Grid service is an extended Web service that conforms to the Open Grid Service Infrastructure (OGSI) specification. The capability that existing Web service technology express is relatively weak. The publishing and discovery of Grid resource are crucial steps in Grid computing. In this paper, we propose a novel semantics based Grid Service framework which support publishing and discovery of Grid Service very well. The experimental result demonstrates that the framework has good performance.

Key-Words: - Grid, Web Service, Grid Service, OGSI

1 Introduction

Faced with decreasing time-to-market and increasing requirement volatility, software development processes are increasingly relying on reuse of existing software. Web services are modular and self-describing applications that can be mixed and matched with other web services to create new software components [1].

The web-services set of standards is aimed at facilitating and improving the quality of component-based applications on the web. It consists of a set of related specifications, defining how reusable components should be specified (through the Web-Service Description Language – WSDL [2]), how they should be advertised so that they can be discovered and reused (through the Universal Description, Discovery, and Integration API – UDDI [3]), and how they should be invoked at run time (through the Simple Object Access Protocol API – SOAP [4]).

The Open Grid Services Architecture (OGSA) represents an evolution towards a Grid system architecture based on Web services concepts and technologies. A Grid service is an extended Web service that conforms to the OGSI specification.

The lack of semantics in description creates inefficiencies in exploiting the Web Service discovery. Describing Web Service with semantics provides the ability for automatic Web Service discovery, invocation, composition and interoperation, and Web Service execution monitoring. Current standards focus on syntactic description of Web services. To overcome such limitations, the semantic web technology must be applied to Grid Service. Recently there is an important initiative in this respect, namely, DAML-S [5], which is OWL-S now, the newest version [6]. It is a comprehensive effort based on OWL [7] defining an upper ontology for Web Service description.

In this paper, we develop a framework for semantically Grid Service discovery where we incorporate the semantics and integrate it with UDDI registries. Our aim is to ground the discovery of Grid services on a semantic comparison between a client query and available Grid services. We first analyze the description requirements for Grid Service discovery and limitations for current standards in section 2. Section 3 gives the detail discussion of all the components of the framework.

The contribution of this paper lies in three fold. First, we conclude the limitations of WSDL and UDDI for automatic discovery. These standards concentrate on syntactic description for Grid service. Second, on the basis of analysis of semantics lack for current standards, we put forward the semantics based Grid Services discovery framework by extending UDDI framework. This architecture supports both service publishing and service discovery. Compared to previous work, the discovery process includes two steps. First is the direct discovery by exact matching. If this step is not successful, the composer looks for several services to compose for the request. Third, we present three kinds of semantic relationship between concepts. This is essential for matcher engine to inference. In the end, we implement a simple prototype to demonstrate our work.

2 Problem Description

Finding and matching of web services is fundamentally semantic in nature [8]. The current industry standards can describe the interface of services and how the services are deployed well (via SOAP and WSDL), but are limited in their ability to express what the capabilities of the services are. This lack of semantics is the result of the current syntax-oriented interface representations that cannot express the context in which the services operate and the relationships among various entities in that context.

2.1 Description Requirements for Grid Service Discovery

The description of Grid service capabilities is essential for classifying, discovering and using a service. It needs to be understandable by humans as well as by machines. This means that each service attribute must be described at both syntactic and semantic level. Syntactic information is concerned with the implementation aspects of a service and thus tailored towards the programmers' requirements. Semantic information is concerned with the conceptual aspects of a service aiming at facilitating end-users by shielding off the lower level technical details, as well as to facilitate developers to find services that best match their needs and to enable automatic service discovery [9].

Let us consider a stock quote service, which takes as input a string denoting the stock symbol and returns the stock quote as a number. The syntactic information denotes that the input parameter is a string and the output is a number, whereas semantic information conveys the real world meaning of the string and the number in the context of stock quote markets. Depending on whether the service requestor is an end-user, a developer or a machine, different kinds of service description are required. For the end-user, only semantic description is needed whereas developers or machines need both semantic and syntactic information.

2.2 Limitations for WSDL and UDDI

WSDL is an XML grammar for specifying properties of a Web Service such as what it does, where it is located and how it is invoked, i.e., it describes only the functional and syntactic aspects of a service. WSDL does not support non-functional information of services. For example, it is not possible to indicate the geographic region that a weather service is provided for or the charge associated with the service.

UDDI is an industry effort to provide directory services for Web Services offered by businesses. It allows businesses to publish their services in a directory and enable other business entities to locate partners and to form business relationships based on the web services they provide. UDDI provides a set of search facilities for finding businesses, and their services. Services can be searched by specifying business name, service name, service category or Tmodels. However, UDDI in its current form is limited in its search services by its inability to extend beyond the keyword-based matches .

First, UDDI does not capture the relationships between entities in its directory and therefore is not capable of making use of the semantic information to infer relationships during search. For example, a rental car service might advertise itself under 'Car Rental Services' in UNSPSC category but a request that is looking for car rental services under 'Passenger Transport' category would not find any matches although 'Car Rental Services' is a sub category under 'Road Transport', which in turn is a sub category of 'Passenger Transport'.

Second, UDDI supports search based only on the high-level information specified about businesses and services. It does not get to the specifics of the capabilities of services during matching. For example, UDDI can search for services that offer car rental services such as creating a reservation, updating a reservation, getting rental status etc. However, it cannot search for a service that can create a reservation by taking information such as user name, credit card information, rental pick up location, rental drop off location and drivers license and returning a reservation number.

Third, the search facilities in UDDI support only direct matches. In cases where no direct matches are available but a set of services can be composed to fulfill a request, UDDI fails to provide any search results because it does not look beyond direct matches.

3 Semantics Based Grid Services Discovery Framework

Current Web Service standards focus on technical conventions which allow parties to exchange information in a standardized manner. In this section, we put forward a discovery framework incorporating semantic description by extending current UDDI architecture. This architecture supports publishing and discovering of services. Fig. 1 shows a modular architecture of our semantically enhanced UDDI directory.

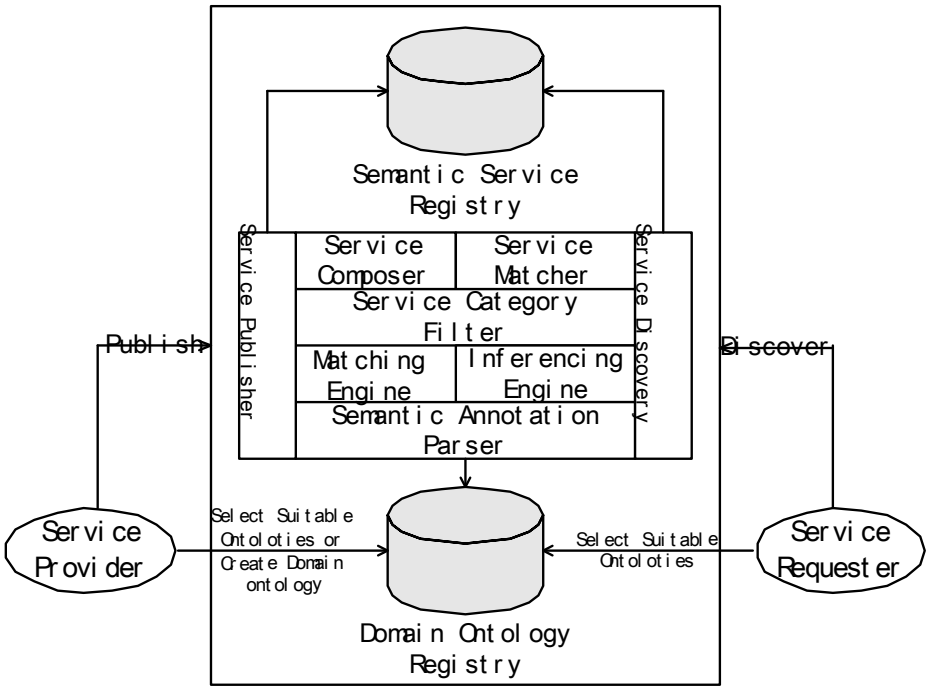

Figure 1: Semantics Based Grid Service Discovery Framework

We use domain ontology to provide an understanding of the static domain knowledge that facilitates knowledge sharing and reuse [10]. This is the basis for semantic description. For example, a travel ontology can codify the relationships such as a compact car 'is a' car which 'is a' vehicle.

3.1 Service Publishing

First, service providers describe the terms and concepts in their problem domain and their interrelationships to establish the ontology for describing the capabilities of their services. This is done by either creating an ontology document or selecting a suitable ontology from an existing ontology registry. This ontology is a document or a file that formally defines relations among terms. For example, if a rental car agency wants to publish its car rental services in UDDI registry, it would first describe the car rental domain in an ontology with domain classes such as reservation, pickup location, drop-off location, user, confirmation number, credit information, business affiliation, reservation start date, and duration. In the next section, we will give a detail discussion of the semantic relationship for service description.

Next, service providers annotate their services with semantic information. This contains information about the service provider, the functional attributes of a service (such as quality rating, quality guarantee, geographical radius, etc.), and the properties of the service namely the inputs, outputs, preconditions and effects. All of these together describe what a service is capable of doing. The properties of service semantics refer to the concepts defined in the domain ontology to express the context. After annotating services with semantics, a service provider publishes them in a UDDI registry. The publisher module uses this information to publish the given services under the specified UDDI taxonomy.

3.2 Two-steps Service Discovery

The service discovery module receives requests and executes the inquiry. First, the service category filter is applied to the service request. It performs a UDDI category-based search to retrieve all those services that fall under the specified set of categories in given taxonomies. This is performed using the standard UDDI find method. These filtered set of services are then passed into semantic matching engine. In essence, the matching engine matches the inputs, and outputs of a service request with those of a service. Two properties are considered a match if they either match exactly, or as defined by some relationship that can be inferenced from the ontology using an inferencing engine.

The matching engine first looks for any services that directly match the given request. This is the first step for discovery. A match is considered a direct match if a single service meets the requirements of a request exactly. If no direct matches can be found, our semantic matching engine automatically finds

ways in which two or more services could be composed to meet the original request. This is the second step using service composition techniques to meet the service requestor.

3.3 Grid Service Composition

A service is composed of several operations. The input/output of each operation tells us what type of document needs be provided in order to execute it, as well as the types of documents that will be returned upon successful and unsuccessful execution. It also gives us information on possible compositions of services. For example, if a particular service has an operation "buyBook", which takes as input an "isdnCode", and another operation "getISDN" (from a different service) outputs values of the same type, then we know that the latter operation is a composition of the former operation. This process can be implemented automatically. Sometimes a goal needs to be composed recursively. The detailed algorithm is as follows.

In order to express the service requestor' need, we use a set of output to express the goal, i.e. $S(O_1,O_2,\ldots O_n)$. The service requestor may provide some local information. For example, someone may want to query the temperature of Beijing in China, the location, i.e. Beijing, is an input for the objective Grid service. Thus we express this kind of local information as a set of input, i.e. $S(I_1,I_2,\ldots I_m)$. The algorithm executes as follows.

The algorithm takes $S(O_1,O_2,\ldots O_n)$ as the goal to be achieved and searches operations whose outputs are of sufficient similarity to the goal, inferencing from the domain ontology registry. The operation with the most similar output is selected first. If there are more than one operations (e.g. the same service is provided by two different companies), the algorithm will select one of them with the least number of inputs in $S(I_1,I_2,\ldots I_m)$.

If the total outputs can't be included in any operation, the operation with the maximum number of the total operations is selected and the left outputs are used as the goal for searching for operations with the same algorithm.

If $S(I_1,I_2,\ldots I_m)$ can satisfy these services found in the above procedure, i.e. their inputs are included in $S(I_1,I_2,\ldots I_m)$, the algorithm terminates and the goal is accomplished by the composition of these Grid services. Otherwise, the algorithm takes inputs or the left inputs excluded from $S(I_1,I_2,\ldots I_m)$ of these Grid as the goal to searches for operations and repeats the above procedure until $S(I_1,I_2,\ldots I_m)$ can satisfy these found services or a search limit is exceeded, i.e. the algorithm calls itself recursively. Then the request is composed by all these services.

4 Grid Service Semantic Annotation

Adding semantic information to syntactical Grid service definitions can help interpret the purpose and usage of Grid service. This is on the premise that a Grid service references to a proper ontology which provides a computer-interpretable description of the service. The ontology relates the domain concepts together for the whole semantics. A Grid service can be expressed as a set of operations. Each operation implements one functionality. An operation is specified by its name, its input and output message types, i.e. o: =<name, t_{in}, t_{out}>. Grid services discovery is in fact the matching of inputs/outputs of operations in Grid services. In this section, we discuss the semantic relationships between concepts for inference.

Going back to our car rental example. The car rental ontology describes the relationship among these classes such as a reservation will have a confirmation number, a start date, a duration, a pickup location, drop-off location etc. It also should capture information such as a pickup location 'is same as' a source location, a drop-off location 'is same as' a destination and that both pick and drop-off locations are 'sub-classes of' location etc. These relationships when represented in a well-defined language can be reasoned automatically enabling service capability and requirement matching.

In our approach, we identify the following three semantic relationships between concepts: Synonymy, Hypernymy/Hyponymy and Meronymy [11].

Synonymy. Concept T_1 is a synonym of Concept T_2, denoted by $S(T_1,T_2)$, if T_1 is in the synonym-set of T_2. For example, S(pickup location, source location).

Hypernymy/Hyponymy. Concept T_1 is a hypernymy of Concept T_2, denoted by $H(T_1,T_2)$, if T_1 is more generic than T_2. For example, H(location, drop-off location).

Add-on. Concept T_1 is associated with Concept T_2, denoted by Add-on(T_1,T_2) For example, a car is often associated with a driver, then Add-on(driver, car).

5 Implementation and Conclusions

In this section, we provide an initial prototype to illustrate the semantics based Grid service discovery we proposed. We use relational database to simulate ontology registry and Systinet WASP UDDI 4.6 as the UDDI server. The semantic relationship between

concepts is stored in the *ontology (Concept, relatedConcept, SemanticType)* table, where *SemanticType* is one of the above three semantic types.

Location of Grid services is inherently a semantic problem, because it has to abstract from the superficial differences between representations of the services provided, and the services requested to recognize semantic similarities between the two. Current Grid Services technology based on UDDI and WSDL does not make any use of semantic information and therefore fails to address the problem of matching between capabilities of services. They provide limited support in automating the Grid service delivery tasks. Mainly, the lack of a machine processable language that enables to make explicit the semantics of service descriptions limits the usability of web services.

In our work, we present a new framework which incorporates semantic description by extending UDDI architecture. This framework provides both service publishing and service discovery. We identify three kinds of semantic relationships. Demonstrated by the prototype, this framework has good performance. The relationship between real world concepts is indeed complex. The semantic type we identified in this paper is limited. In the future work, we will use OWL as the ontology representation language to describe the semantic relationship between concepts. We will concentrate on using planning techniques to develop automatic service discovery.

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