A Semantic-based Meteorology Grid Service Registry, Discovery and Composition Framework

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Abstract

Meteorology Grid Computing aims to provide scientist with seamless, reliable, secure and inexpensive access to meteorological resources. In this paper, we presented a semantic-based meteorology grid service registry, discovery and composition framework by combining grid technologies and the advantages of semantic web techniques. The main objective of the framework is to support automating the discovery, selection, and workflow composition of semantically described heterogeneous meteorological grid services, which offers the possibility of facilitating geographically distributed meteorological scientists to resolve complex scientific problems cooperately. With this framework, the key technologies such as semantic registry, semantic matchmaking, QoS ranking and composition model, will be discussed.

1. Introduction

Currently, floods, tornadoes, hail, strong winds, lightning, and winter storms caused hundreds of deaths, routinely disrupt transportation and other economic loss. In order to avoid the huge economic loss caused by so-called weather events, it is very important to accommodate the real time, on-demand, dynamically-adaptive weather forecast service. In response to this pressing need, as a part of china semantic grid projects (Semantic Grid: Theory, Model and Methodology, five year National Grand Fundamental Research Plan project led by Hai Zhuge), the project of semantic meteorology grid computing is being developed. The aim is to offer a flexible, secure, coordinated meteorological resource sharing and problem-resolving environment by making good use of grid and semantic web technologies[1-3]. In this paper, we presented a semantic-based meteorology grid service registry, discovery and composition framework by combining grid technologies and the advantages of semantic web techniques. Figure 1 shows the semantic framework overview of our meteorology grid computing environment. The main objective of the framework is to support automating the discovery, selection, and workflow composition of semantically described heterogeneous meteorological services, which offers the possibility of facilitating geographically distributed meteorological scientists to resolve complex scientific problems cooperately. Our semantic framework has the following important features, which partly distinguish other web service composition techniques.

- Efficiently cooperating with meteorology grid components, such as grid security, transaction mechanism;
- Presenting a model of meteorology grid service semantic annotation and semantic publication;
- Semantically extended UDDI to support QoS tModel;
- Including QoS ranking besides semantic matchmaking capability in service discovery engine;
- Automating the composition process ensuring semantic and data type compatibility.

The remainder of this paper is structured as follows. Firstly we present semantic framework overview. Secondly, we examine the main components of the framework and give related key technologies (Section 2). Finally, we give the status of the implementation and conclude by discussing future directions.

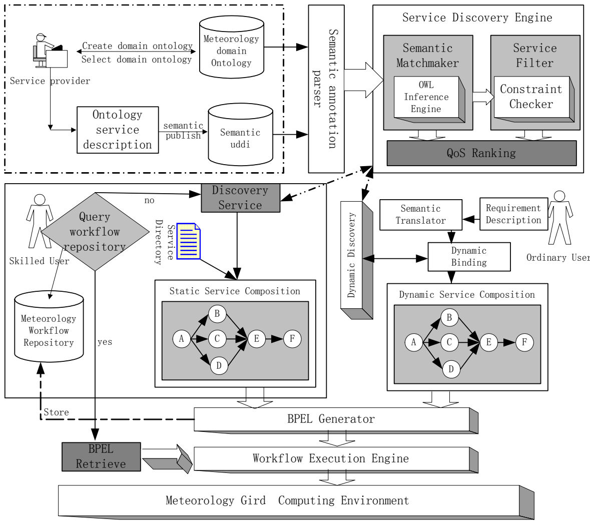

Figure 1. Semantic Framework

2. Framework Components and Key Technologies

2.1. Semantic Service Registry

Semantic Service Annotation. In order to enhance service discovery and matchmaking capabilities, semantic service annotation is a critical step. WSDL (Web Services Description Language) is an XML format for describing network services in abstract terms derived from the concrete data formats and protocols used for implementation[4]. However, WSDL is limited in their ability to express what the capabilities of the services are, and does not support semantic description of services. WSDL-S is a semantically enriched WSDL 2.0 document by trying to overcome the above limitations[5].Owing to the advantages of WSDL-S, we are using it to describe meteorology grid services. Currently, some eclipse plug-ins, the semantic tools for Web Services have been developed by IBM and Meteor-s project group[6]. These tools provide a way to add the semantic information to a WSDL document. In our semantic framework, we are also cooperating with these semantic tools, and have integrated some functions to facilitate service provider to annotate their wsdl documents through meteorological grid portal[7].

Semantic Service Publication. Service providers should advertise their semantic service description and other related information to UDDI[8], so that their services are readily accessible by service requestors. Methods in [9-12]. have brought us some significant reference for designing our semantic UDDI. Dynamic discovery of meteorology grid service in large scale, open grid systems is difficult because of the need to filter out and select services suitable to the task at hand from a potentially huge available service repository (UDDI). In order to facilitate grid service discovery and dynamic composition, we have integrated UDDI in our semantic framework, and we are also using a mechanism to bind UDDI data model to meteorological semantic model. UDDI used in our framework was extended semantically not only to enhance semantic service capability matchmaking, but also to support QoS records.

2.2. Semantic Service Discovery

Semantic service discovery is achieved via semantic UDDI and semantic matchmaking module. Semantic matchmaking module is used to meet the functional matchmaking of service requirement, such as IOPE (input, output, pre-condition, effect) terms. However, with the ever increasing number of functional similar grid services being made available on the meteorology grid, there is a need to be able to distinguish them using a set of well-defined Quality of Service (QoS) criteria. By making use of individual service’s QoS information (non-functional properties of services), QoS ranking module can rank functional similar grid services based QoS evaluation criteria. Finally, through the computing of the weights of semantic matchmaking and QoS ranking specified by user, we can derive the optimal service among functional similar grid services.

Semantic Matchmaking. We extend the semantic matchmaking algorithm presented in[10, 13]. When a request is submitted, the request description is firstly transformed to WSDL-S specification. Semantic annotation parse module will parse the request specification and split the related concepts and properties, such as service category, input parameters, output parameters. The referred service categories can do good to limit the scope of service search. These parsed concepts will be grouped request input list vector, and request ouput list vector named reqinputlist and reqoutputlist respectively. The reqoutputlist matching are firstly executed by the matchmaking algorithm, this is because the final matching result will fail if the request output matching fail. Then the reqinputlist matching will be executed if the reqoutputlist matching returns a valid degree of match. Our extended matchmaking algorithm will efficiently cooperate with the OWL inference engine and semantic UDDI API. OWL inference engine based on JESS(a rule-based engine)[14] is used to reason the relationship between the concepts stored in the specific domain semantic model, which the degree of match between two outputs or two inputs depends on. Semantic UDDI APIs are used to retrieve information from UDDI, which interact with the interfaces of OWL parser and OWL inference engine.

QoS Ranking. Semantic service matchmaking can find functional similar grid services by making use of inferring capabilities of OWL ontologies. However, with the increasing number of functional similar services, semantic matchmaking has no capability of selecting the best service to meet the requirements of user while ensuring the quality of service. Therefore, only semantic ranking is not enough, and other nonfunctional properties of services such as price, reputation and reliability should be computed and ranked. Unfortunately, although QoS-based service selection and ranking have been a hot topic research area, it's hard to come up with a standard QoS model that can be used for all services in all domains. This is because QoS is a broad concept that can encompass a number of context-dependent nonfunctional properties. Moreover, when evaluating QoS of web services, we should also take into consideration domain specific criteria[15]. For example, we assume that service s1 is functional similar to s2 after semantic matchmaking, and s1 has a higher price while a less execution time than s2. If user thinks a lot of execution time, s1 should be selected. Conversely, if user thinks a lot of price, s2 should be selected. Additionally, even if s1 has a higher semantic ranking than s2, s2 will possibly be preferable to be selected when all comes to all including QoS computing.

About the meteorology domain, QoS criteria are mainly referred to the following factors, such as response time, reliability, availability, reputation. Of course, these factors can be adjusted dynamically with the change of user requirement environment. In our QoS evaluation model, QoS information is primarily collected from the following sources, service providers, user's feedback and active execution monitoring. How to collect and evaluate these QoS information is beyond our topic of this paper, and the detailed discuss of QoS ranking is done in another research paper.

2.3. Semantic Service Composition

Service composition which is emerging as the technology of choice for building cross-organizational applications on the Web refers to the process of combining several services to provide a value-added service if no single service can satisfy the functionality required by the user. For example, meteorology scientific experiments are often so complex that autonomous services need to be combined together as required into a workflow to process the intensive data. In this context, there is a great need for service composition in service-oriented meteorology grid environment. Moreover, we are developing a semantic-based service composition framework, which can provide significant new capabilities to scientists by facilitating the composition and execution of experiments from a large pool of available services. Our composition approach includes static service composition and dynamic service composition. Static and dynamic composition strategies concern the time when services are composed. They are equivalent to design-time and run-time composition. The main components about service composition in figure 1 are introduced as follows:

Static composition: It takes place during design-time, and it is provided for skilled users. Skilled users usually have good knowledge about the function of available services, and they also know how to find, select and compose the related service to finish a complex task. For example, skilled user first browses available services by uddi browser. If they don't find the required service, they can submit the requirement description to the service discovery module. The service discovery module can search the related service through the semantic service discovery engine by parsing the functional and nonfunctional constraint information of requirement description. The workflow service template can help user build up the process flow by dragging and dropping the required services.

Dynamic composition: It is primarily provided for ordinary users. Usually, it is difficult for these users to build up workflow service composition by manual way like static composition. What they need to do is to give the requirement description. Semantic translator handler will extract the key information such as output, input and type, constraint information. According to the information, the abstract process module can build up the abstract process flow by employing a backward chaining algorithm and cooperating ontology reason method. During run-time, dynamic binding module interacts with dynamic discovery module which communicates with the semantic service discovery engine. Therefore, the design of dynamic composition is transparent to users.

Whether static composition or dynamic composition, the process flow is translated to the workflow representation of BPEL, a language for expressing interactions and message exchanges between partner entities. It can be automatically interpreted and executed by a workflow engine. A BPEL specification can be abstract or executable depending on whether binding information has been excluded or included.

BPEL generator module is responsible for the production of workflow execution language BPEL. Finally, the concrete service described by BPEL is invoked by workflow execution engine and executed in the meteorology grid computing environment.

3. Implementation and Future Work

Currently, a team is contributing to the research and development of semantic meteorology grid computing, and a basic grid platform has been implemented and deployed (http://grid.cma.gov.cn:8080). Our semantic service registry, discovery, and composition framework were implemented in meteorology grid computing. As an initial work to semantic service discovery and dynamic workflow compositio， we have presented the semantic annotation and publication model by making use of uddi4j and juddi APIS. The semantic matchmaking algorithm was cooperated with the Jess API, QoS computing model was based on the statistical theories and methods. Although our work about workflow composition algorithms is yet superficial, some new ideas by combining fuzzy optimal theories will be presented soon.

However, there is yet a major distance to achieve our goals. For example, some more efficient algorithms need to be developed and further proved to be valid; the establishment of meteorology ontology vocabularies needs more meteorology experts and knowledgeable engineers to collaborate. Semantic Service composition is a very complex and challenging task, especially in the meteorology grid environment. Although we have made a progress in the research of the semantic architecture and service discovery algorithms in Meteorology Grid Computing, lots of research and implementation work about semantic service composition framework will be needed to do in the future.

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