A novel approach to add semantics to web services

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Abstract:

Web services have been based on widely accepted industry standards and protocols. We have thousand of web services available on the web. An appropriate web service can be selected from the list of available services based on the description provided in WSDL. But this selection and invocation of web service requires human intervention. Web service semantics is all about adding meaning to a web service in such way that software can automatically handle various tasks like discovery, matching, composition, testing etc. This paper proposes a method to develop a semantic model in OWL and discusses how to publish and retrieve web service based on semantic information.

Key words: WSDL-S, Semantic web service, OWL, domain model, semantic mapping.

1. Introduction

There are thousands of applications available on the World Wide Web today. These services are implemented on various hardware/software platforms. With the development of web service standards accessing and communicating with these services have been standardized. Various standards used by the web services like XML, SOAP, WSDL, UDDI helps software to discover and access the web services available on the world wide web. But all this still need some kind of human intervention in selecting the most appropriate web service. The Web Services Description Language is used describe a web service. It only describes the interface of the web service and the format of messages used for communication. It does not describe the meaning of the service. That is where human intervention is required to select an appropriate service and interpret the response.

Web service semantics is all about providing meaning to the web service in such a way that software can automatically interpret the meaning. The concepts of any given domain can be represented using various domain model representations like UML, OWL etc. To add meaning to the web service the elements of a web service must be mapped to the concepts and objects of the domain model. One way of representing these mapping in through extensibility feature of WSDL. WSDL-S is a specification for adding semantics to WSDL. The semantics of a web service must facilitate the discovery, invocation and composition of web services automatically.

The W3C community developed the Web ontology language (OWL) to address this problem [1]. It is a machine understandable description language that is capable of describing resources in a manner much richer than the traditional flat taxonomies and classification systems. OWL-S is a set of ontology developed specifically to describe web services [2]. After the semantic service descriptions are created, the next step is to advertise them in a registry capable of fine-grained semantic matchmaking. Universal Description, Discovery and Integration (UDDI) is a Web-based distributed registry for the SOA [3]. It is clear that semantic annotation and matchmaking for Web services will produce much more refined search results than UDDI-style syntactic matching [4, 5]. The remainder of the paper is organized as follows: Section 2 presents...
related work done in semantic web services. Section 3 explains about Syntax and Semantics, the need for web service semantics. Section 4 gives briefs about ontology, WSDL-S. Section 5 explains about WSDL Extensibility. Section 6 reports our work done to develop an application in web service semantic. And section 7 concludes the paper.

2. Related work

[8] proposes how to develop a Semantic Search Agent (SSA) to discover required web services from web. The system uses OWL-S for describing semantics of web services and discovers suitable semantic web services through these semantic descriptions [9]. In the paper [10], they introduce an approach to allow for support of semantic service descriptions and queries using registries that conforms to UDDI V3 specification. The business integration and other fields such as bioinformatics. Current Web services technologies such as WSDL, UDDI, BPEL4WS and BSML are not semantic-oriented. Several proposals have been proposed to develop Semantic Web services to facilitate the discovery of relevant Web services [1,8]. [6] Proposes a framework called Soft Semantic Web services Agent (SSWSA) for providing high QoS Semantic Web services using soft computing methodology. [7] added semantic support to UDDI by placing add-on modules on the registry side. This means the existing registry infrastructure needs to be modified extensively to provide semantic support.

3. Syntax and Semantics

Syntax is a set of formal rules used to construct valid statements in a language. Any language (human or computer) is governed by the syntax of that language. Syntax is only concerned with the grammar of a statement i.e. the order of the words. Statement which is grammatically correct can be treated to be syntactically correct. Semantics refers to a set of rules which defines the meaning of a statement. Semantics deals with the meaning of words and their impact in given context. An individual’s prior knowledge is required for semantics. Knowledge is not limited to the language and extends to various domains where the language is applied

3.1 Need for Web Service Semantics

The main purpose of a web service is to provide inter-operability between applications. With the current technologies and standards used for web services, a lot a human intervention is required in this process. This is because the applications need to understand the data and various operations involved. Semantic Web adds meaning to the content on the Web. In the same way semantics can be used to add more meaning to the web services. Web services can be described in a machine readable form which in turn will allow more automation reducing human intervention in accessing the services.

In order to achieve semantic web services a computer must be able to understand the meaning of a service by itself. The language used to describe the web service must enable the following tasks

Discovery – semantic web service describes its properties and operations so that a software can determine the purpose of the service automatically.

Invocation – Software must be able to automatically identify how to invoke the service. This may involve a sequence of steps. This also involves describing the inputs and outputs of the service.

Composition – Software should be able to identify the relationship between web services so that a combination of web services can be selected to execute certain task.

WSDL describes a web service. It defines the operations supported by the web service and the messages used for interacting. WSDL by itself only defines the syntax of the web service. It does not define the semantics or meaning of the web service. WSDL is a good source for adding semantic information about a web service. UDDI must enable the support of these semantics published by a web service. So when a search is done on the UDDI registry a more appropriate service can be picked up automatically.
4. Ontology
Ontology is the description of a domain. It represents the vocabulary of the domain. All the objects that belong to the domain along with their properties and behavior are described by ontology. Ontology serves as a knowledge base of the semantics present in the semantic web. Components of Ontology are Concepts, Structure and Attributes of concepts. Ontology is responsible for eliminating the ambiguity of various concepts and terms from the real world. Ontology represents the real word in a manner in which it can be processed by a machine or software. The Web Ontology Language (OWL) is a language which is widely accepted for representing Ontologies.

4.1 WSDL-S
WSDL describes a web service by defining the supported operations along with the input and output messages that are exchanged. Any requestor can access the web service based on the description provided on the WSDL. So this description plays a key role in finding an appropriate web service. Present WSDL is sufficient when a human does a search but when the application tries to find a service or when a service is required at run time it is not sufficient enough. This problem can be overcome with the help of Ontologies which provide semantics to the service with no ambiguity. So adding semantics to WSDL will increase the expressivity of the web service.

5. WSDL Extensibility
The extensibility of WSDL is used to add semantic information. We can define new elements and attributes on certain elements of the WSDL document.
The listing below shows all the parts of a WSDL document that can be extended to add semantic information.

        <wsdl:definitions>
          <wsdl:types> <!-- extensibility element -->
            <!-- extensibility element -->
          </wsdl:types>
        </wsdl:definitions>

WSDL-S Specification

5.1 Extensibility Attributes
1. modelReference: modelReference attribute associates a WSDL entity with a concept in a semantic model. It can be added to a complex type, element or operation. Can also be added on the extensible elements precondition and effects.
2. schemaMapping: schemMapping handles structural differences between elements of Web Service and the concepts of a semantic model. This is added to the XSD element and complex types.

5.2 Extensibility Elements
5.2.1. Precondition: Used to specify a set of conditions to be met before a web service is invoked. This is added to operation. There are 3 attributes on precondition.
   name – unique identifier within a set of precondition in a WSDL document
   modelReference – specifies an URI to map the precondition on a semantic model
   expression – in a language used to represent the semantic model
The attributes modelReference and expression are mutually exclusive.

5.2.2 Effect: Defines the result of invoking the service. This is added to operation. Effect can just be the output of the operation performed or it can
be the expected change in states on invoking the operation. There are 3 attributed on effect.
name – unique identifier within a set of precondition in a WSDL document
modelReference – specifies an URI to map the precondition on to a semantic model
expression – in a language used to represent the semantic model. The attributes modelReference
and expression are mutually exclusive.

5.2.3. Category: This is added to the service element of a WSDL. It helps in categorizing the service at a high level. The search result can be narrowed down based on this service categorization. There are 4 attributes supported by category.
categoryName – category name in a taxonomy
taxonomyURI – URI to taxonomy definition
taxonomyValue – the value associated with the category in the taxonomy
taxonomyCode – the code associated with category in the taxonomy.

6. Training calendar, An application in web service semantic
In this paper we have discussed about an application called training calendar A Semantic Web Service using WSDL-S. There are institutions which train students on various subjects. An institution had to maintain the schedule of the courses provided. Training Calendar represents this schedule. The domain model had been designed in OWL (Web Ontology Language). Protégé 4.1 is used to develop the domain model.

The various entities and concepts involved are represented by the following OWL classes:
1. Course
2. Trainer
3. Student
4. Registration

The relation between various entities are represented by the following object properties.
1. registeredFor – Student to Course
2. takesCourse – Trainer to Course
3. trainedBy – Course to Trainer

The data properties of various entities are as follows.
1. Course - courseName, durationInHours, endDate, maxStrength, startDate, studentEmail, trainerName.
2. Trainer - trainerName
3. Student - studentEmail.

6.1 Semantic model
A web service had been implemented in Java using Netbeans IDE. Web service had been deployed in GlassFish application server which is integrated with Netbeans. Operations supported by the web service are listCourses – list all the courses available along with the course details. Input is none and output is list of courses.
register – allow a student to register for a course input is student email id and course name and output is success/failure message
studentsRegisteredForCourse – list all the students who are registered for a course input is course name and output is list of students.

Fig 1: Domain Model of Training Calendar
6.2 Semantic Mapping

The next step in adding semantics to web service is to identify the mapping between the various elements of the WSDL to elements of a domain model.

Fig 3: Mapping WSDL elements to Training Calendar domain model

6.3 Adding Semantics to WSDL using WSDL-S

Once the mapping between WSDL and domain model had been identified, this information had to be added to WSDL based on the WSDL-S specification. As part of WSDL-S, references to the OWL ontology are added to the WSDL. Radiant plugin for eclipse is used to add semantics to WSDL using WSDL-S.

6.4 Publish Web Service with Semantics

Setup an UDDI registry to publish the web service. JUthDDI an implementation of the UDDI registry is used. Publish the service to the registry using Radiant plugin for eclipse. The service can also be published through the interface provided by JUDDI.

Fig 4: Select a registry to publish WSDL using Radiant eclipse plugin

6.5 Discover Web Service based on Semantics

The final step is to search the registry based on the semantics. Since the registry itself does not support semantic search, Lumina an eclipse plugin is used to perform the search based on semantics.
7. Conclusion
The main problems of current web service technologies are the shortage of semantic parts, increasing number of web services in the web, and syntactic-based search operation for web services. We presented an approach to develop a semantic model in OWL using protégé 4.1. To publish and retrieve web services using semantic, plugins Eclipse (Java Helios SR2) is used. To publish a web service with semantics to JUDDI registry Radiant is used and Lumina is used to retrieve a web service from JUDDI registry based on semantic information. As we all know semantic web service allows automatic web service discovery and access and part of semantic web is likely going to be the core of Web 3.0 we can extend this work for other applications and try composing these semantic web services.

9. References