Service Discovery and Measurement based on DAML-QoS Ontology

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ABSTRACT

As more and more Web services are deployed, Web service's discovery mechanisms become essential. Similar services can have quite different QoS behaviors. For service selection and management purpose, it is necessary to clearly specify QoS constraints and metrics definitions for Web services. We investigate on the semantic QoS specification and introduce our design principles on it. Based on the specification refinement and conformance, we introduce the QoS matchmaking algorithm with multiple matching degrees. The matchmaking prototype is designed to prove the feasibility. Well-defined Metrics can be further utilized by measurement organizations to monitor and evaluate the promised service level objectives.

Categories and Subject Descriptors

H.3.5 [**Online Information Services**]: Web-based services; D.2.8 [**Software Engineering**]: Metrics-*Performance measures*

General Terms

Languages, Performance, Measurement

Keywords

Web Service Discovery, QoS, Semantic Web, Matchmaking

1. INTRODUCTION

With the industry's efforts in promoting the use of Web services, a huge number of Web services are being developed and made available on the web. Service requesters are presented with a choice of service offers that provide similar functions. Different offers may have quite different quality of service (QoS). To find the service with certain QoS, it requires more sophisticated patterns of service discovery and negotiation. Take dynamic supply chain for example, normally the retailer is tightly integrated with supplier because of high integration cost. However, it is ideal for the retailer to integrate a number of suppliers in their processes and dynamically choose the suppliers based on their response time, availability, cost, and so forth, to achieve the competitive advantage. In this scenario the QoS specification is critical.

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As to the service discovery, current service discovery process adopts keyword-matching technology to locate the published Web services. This matchmaking is based at syntax level. The returned discovery result may not satisfy the service requester's intended requirements. This leads to a bit of manual work for choosing the proper service according to its semantics. To make Web service discovery, composition, and cooperation more dynamic, automatic and across enterprise boundaries, it requires domain specific knowledge.

The semantic web technology is a promising solution for automatic service discovery process. It requires that data be not only machine readable, but also machine understandable. With the help of Semantic Web, unifying system among different partners can be created with minimum misunderstanding. DAML-S Ontology [2] (now OWL-S) is one of the semantic research group's efforts for Web services. DAML-S aims to enable automated Web service discovery, invocation, composition and monitoring. However, the specification has not provided a detailed set of classes, properties and constraints to represent QoS descriptions[1]. We have tried to develop a proper QoS Ontology design pattern for the formal specification of QoS constraints and QoS metrics as a complement to the DAML-S. This novel QoS Ontology is based on DAML+OIL and named DAML-QoS. As a following step of the DAML-S service profile's matchmaking, our work facilitates the QoS selection between services with similar functions. The metric Ontologies can also provide a powerful solution for measurement organization to monitor against the agreed upon SLAs. For the purpose of clarity and compactness, in this paper we will use the Description Logic (DL) notions in place of the DAML+OIL syntax for the instruction.

We organize the rest of this paper in the following way. In section 2 the design of the DAML-QoS Ontology is presented. Then section 3 introduces the conformance definition and matchmaking algorithm for the system. Section 4 briefly introduces the measurement framework of the system.

2. MODELING

Our Ontology can be viewed as a design pattern to model the QoS constraint information in the DL style. It contains three layers: the QoS profile layer designed for matchmaking purpose; the QoS property definition layer for defining the property and elaborating the property's domain and range constraints; the metrics layer for metrics definition

and measurement. DAML-QoS is designed as a complement Ontology to provide additional QoS information for DAML-S. It mainly deals with the non-functional aspect of the system. Non-functional aspect of the system describes the constraints such as the Quality of Service, management statements, security policies, pricing information, and other contracts between Web services. We have chosen the following design principles: the specification should be easy to use and understand; it should be precise and flexibly; reuse is in Object Oriented style; automatic validation is preferred; the design duties is separated among developers and measurement parties.

In our Ontology design, the QoS Profile Layer defines the Service Level Objective (SLO) for the Web service interface. Cardinality constraints are added in the concept definition to represent the QoS constraints; QoS property definition layer constrains the property's domain and range information. Each property's domain is defined as the QoSProfile class or its subclasses. The range of the property is defined as one QoS metric class. Each Web service's QoS profile is defined by the conjunction of these property constraints. DL reasoner can utilize these restrictions to classify the relationship between different profiles; QoS Metrics Layer provides the QoS metrics definition for the QoS property's range constraints. It also defines precise semantic meanings for service measurement partner to measure the service and check against the guarantee.

By defining and sharing new properties and QoS metrics, flexibility of the specification can be achieved. The reuse of the specification is supported by refining the specification in Object Oriented Style. The refinement result is the conjunction of the original specification and the new constraints. It replaces the weaker constraints with new stronger ones. DAML-QoS Ontology complements DAML-S. Developers can benefits from DAML-S for semantic matchmaking of service capability, as well as the well-defined process model and the grounding information. Meanwhile, the developer benefits from DAML-QoS for QoS matchmaking and QoS measurement. Multiple QoS Profile individuals of one Web service can refer to the same DAML-S' service profile individual. This provides multiple service level objectives for the targeted Web service.

3. MATCHMAKING

Constraint conformance is defined as follows: QoS profile P conforms to QoS profile Q iff P is stronger than, or equally strong as, Q. In DAML-QoS, the conformance checking problem is converted to the Ontology's subsumption problem. P conforms to Q iff Q's concept definition subsumes P's concept definition. According to the conformance definition, the matchmaking algorithm between service requester and service provider is defined accordingly. For the request R and advertisement A, *Subsume* ($A \sqsubseteq R$), *Exact* ($R \equiv A$), *PlugIn* ($R \sqsubseteq A$), *Intersection* ($\neg(A \sqcap R \sqsubseteq \bot)$), and *Disjoint*($A \sqcap R \sqsubseteq \bot$)[3] are from the best matching degree to the worst matching degree respectively.

Figure 1 shows the system design of our matchmaking prototype. When the service provider publishes their service QoS profile through the publish interface, the Ontology will be parsed by the Jena parser first. If the parsing process ends successfully, the Ontology is stored in the server's Ontology repository. Meanwhile the Ontology is also loaded into the main memory and represented in the form of the OilEd's Ontology data structure. This Ontology data is then rendered into Racer's description through a special Racer Render. Now we have finished the parsing and the converting process of the Ontology. The Racer engine accepts this KRSS description and keeps this in its own knowledge base. By classifying on its knowledge base, the Racer engine organizes the Ontologies' taxonomy. The system is now ready for inquiry. When the service requester submits an inquiry, the matchmaker will return the *Subsume*, *Exact*, *PlugIn*, and *Intersection* matching list respectively. The experiment shows that the matchmaking is suitable for small or middle sized advertisement repository.

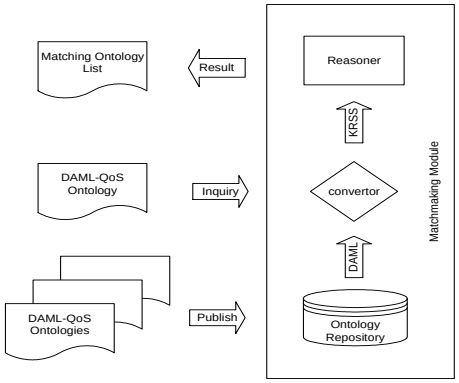

Figure 1: Matchmaker System Prototype

The validation of the specification is necessary for big projects. The syntax of the specification is evaluated by the Ontology parser, such as Jena. The semantic correctness of the specification is checked according to the matchmaking algorithm. If the specification is equivalent to $\bot$ concept, there's contradict in the specification and it is recognized as a semantic error.

4. MEASUREMENT FRAMEWORK

The measurement framework is maintained by the measurement partner to guarantee the agreement. In our prototype implementation, measurement codes are implemented as service handlers to minimize the influence on the original Web service system. According to the metrics' concept definitions and their individual definitions, the measurement code can be generated by traversing the metrics definition tree. A summary collector creates the summary QoS profile according to the received handlers' data. Furthermore, it will judge whether the summary QoS profile conforms to the agreed QoS profile.

5. REFERENCES

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