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ORIGINAL ARTICLE

Bring QoS to P2P-based semantic service discovery for the Universal Network

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Abstract Services in the next generation Internet, Universal Network, is distinct from that in the current network. The reason is that the former has QoS (quality of sevice) grading. In the universal network, different services have different QoS; therefore, service discovery in the Universal Network is quite distinct from that of the present network. In this paper, we put QoS measurement into service discovery so as to adapt to Universal Network. A lot of research works adopt semantic web technology, OWL-S (web ontology language for services), which is innovative for service discovery. For the purpose of service discovery in Universal Network, we append QoS descriptions to OWL-S. Such OWL-S with QoS information is called OWL–QoS, which is the groundwork for service discovery in the Universal Network. Secondly, we present a matching algorithm that allows matching on the basis of capabilities and QoS descriptions of services. Moreover, we also adopt P2P as an infrastructure to fulfill the service discovery because of the large amount of services in the network.

Keywords Service discovery · Semantic service · QoS · Universal Network · OWL-S · P2P

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1 Introduction

Universal Network, which combines telecom network with IP network, is being developed. Providing services for clients based on it is a core of research at present. Present Internet supplies best-effort services, but it still fails to meet users' requirements. Users often ask services with specified QoS, and so providing QoS grading for services is one of the most important features in future service discovery systems.

The promotion of services has stimulated providers to develop and publish their services. Current proposals for service discovery focus on centralized approaches such as UDDI [1, 2]. Service descriptions are stored in a central repository, which has to be queried in the process of discovering services. Such a centralized approach introduces single-point failure, exposes vulnerability to malicious attacks and does not suit a large number of services. This disadvantage is fatal to the evolving trend of ubiquitous and pervasive computing, in which more and more devices and entities become services, and service networks become extremely dynamic due to constantly arriving and departing service providers [3–5]. In order to achieve high scalability, we try to develop a decentralized discovery approach. In the Universal Network, we make use of P2P infrastructure to prevent single-point failure.

In this paper, our research concentrates on P2P-based service discovery with QoS measurement for the Universal Network. Service discovery with QoS measurement can satisfy requesters' high-grade demand. In practice, we divide service discovery into two steps. In the first step, a requester discovers the service by using the basic ability description: what the service does, its input and output parameters, preconditions, and effects [6]. This step satisfies the requester's basic need. The second step is to identify a sufficiently similar service for the requester through QoS measurement, and this step is the emphasis of our research.

At present, many service discovery processes use keyword-matching techniques to find published services. This method often causes discontent in the requester, with so many unrelated results, and leads to a bit of manual work in choosing the proper service according to its semantics. In order to realize automatic discovery, we adopt a semantic web technique, OWL-S, which is innovative for service discovery. With OWL-S markup of services, the information necessary for service discovery could be specified as computer-interpretable [7, 8].

OWL-S provides three essential types of knowledge about a service: a service profile (what the service does), a service model (how the service works) and a service grounding (how to use the service). The service profile describes what the service can do, for purposes of advertising, discovery and matchmaking [9]. It describes the basic ability of the service, and so it is helpful to fulfill the requirement of the first step of the service discovery mentioned previously.

In order to accomplish the second step of service discovery, we propose to add QoS descriptions to OWL-S to specify the service's QoS information in the Universal Network to satisfy users' high-class requirements.

The rest of this paper is organized as follows. Section 2 introduces the preliminaries; Sect 3 describes OWL–QoS; Sect. 4 gives details of our P2P-based semantic service discovery with OWL–QoS and a matching algorithm between advertisements and requests described in OWL–QoS. The experiment and comparison is specified in Sect. 5, and finally we conclude and present our future work in Sect. 6.

2 Preliminaries

In the present Information Network, one kind of network mostly supports one kind of service. For instance, Telecom Network basically faces phonetic business, while IP Network mainly supports data business. Due to the limitation of the original model, the existing network cannot essentially satisfy diversified requirements. So establishing a Universal Network is extremely urgent. The Universal Network Model is specified in [10] and [11].

According to [12], we defined the service in the Universal Network: service is self-contained, modular application that can be described, published, located, and invoked over the Universal Network.

Providing various qualities of services for different users is one of the greatest features of the Universal Network. Quality depends on user's request and pay. More pay can get more. It means that if the user wants to have high-quality service, then he should pay more.

QoS refers to connectivity, security and so on, and the details of it will be discussed in Sect. 3.1.

3 OWL-S with QoS

The OWL-S supports automatic service discovery via matchmakers through its service profile language construct [13, 14]. For the sake of automatic service discovery, we adopt OWL-S markup for describing services and we call the services marked by OWL-S as semantic services. Service discovery with OWL-S description is addressed as semantic service discovery, which is a process for location of semantic services that can provide a particular class of service capabilities and a specified QoS, while adhering to some client-specified constraints [7, 8].

In order to realize service discovery with QoS, we append the service's quality description to the service profile. We will discuss QoS in detail in the next subsecction.

3.1 Definition and classification of QoS

3.1.1 QoS definition

According to the ITU-T QoS Study Group, QoS is defined as "collective effect of service performances that determine the degree of satisfaction by a user of the service" (ITU-T R.E.800) [15, 16].

International Organization for Standardization has proposed another definition in ISO/IEC 10746-2 [17] for the term QoS as follows: "a set of qualities related to the collective behavior of one or more objects" and the Internet Engineering Task Force (IETF) Network Working Group has proposed the following QoS definition in RFC 2386 [18]: "a set of service requirements to be met by the network while transporting a flow".

We can see that the ITU-T Study Group gives the definition from the user's point of view, while the IETF Network Working Group defines QoS from the network's point of view. In this paper, we prefer to adopt the definition of QoS that comes from IETF.

3.1.2 *QoS classification*

From the network point of view, we provide QoS with several properties: latency, reliability, and QoS spectrum.

Latency is the time taken between the arrival and the serving of the service request [19]. It is classified into three grades:

1. Latency ≤5 s (It is applied to interactive service)
2. 5 s < latency ≤60 s (applied to response-service)
3. Latency >60 s (applied to latency-insensitive service).

Reliability represents the service's ability to perform its required functions under stated conditions for a specified period of time [19]. It can be measured by: mean time between failure (MTBF), mean time to failure (MTF) and mean time to transition (MTTT). In this paper, we classify reliability into three classes according to the threshold, which is given by the Universal Network as below:

4. Reliability « τ
5. Reliability is approximate to τ
6. Reliability » τ.

While expedited forwarding, assured forwarding and best effort [20] belong to QoS spectrum, properties of QoS are not only kept within latency, reliability and QoS spectrum, but also include scalability, capacity and so on. Following are their definitions:

Scalability: the system's ability to process the number of operations or transactions in a given period. It is related to performance.

Capacity: the limit number of concurrent requests for guaranteed performance.

These properties, as mentioned before, arises from the network's point of view. Most of the users are not able to understand these standards. Therefore, we give the mapping from the user's view to the network's view in Table 1. This mapping is prepared for the matching of the user's request and the network's supply.

3.2 OWL–QoS

In order to satisfy the user's requirement for QoS, we supply QoS to service profile and call such an ontology as OWL–QoS. The structure of OWL–QoS is listed in the following part. Using OWL–QoS markup of services of Universal Network, the details that is good for service discovery could be specified as computer-interpretable semantic markup at the service web sites [21].

3.2.1 *Original service profile*

An OWL-S profile describes three types of information: the organization that supplies the service, the function of the service and the features of the service. The provider information consists of contact information. Specifically, the functional description of the service specifies the input required and the output generated by the service, the preconditions required by the service and the expected effects. The features specify the category of a given service, quality rating of the service and so on [7].

The provider information and the feature descriptions are the nonfunctional aspects of the description, while the function of the service is the functional aspect of the description.

Table 1 Mapping from the user's view to the network's view

QoS properties from the user's point of view		QoS properties from the network's point of view	
Connectivity	Excellent	Latency	Latency ≤ 5 s
	Good		5 s < Latency ≤ 60 s
	Bad		Latency > 60 s
Reliability	High	Reliability	Reliability « τ
	Medium		Reliability is approximate to τ
	Low		Reliability » τ
Trustworthy degree	High	QoS spectrum	Expedited forwarding
	Medium		Assured forwarding
	Low		Best effort

3.2.2 *Appending QoS specification to the service profile*

As service profile mostly supports automatic discovery of the service, we add QoS specification to it for adapting to the automatic service discovery in the Universal Network and it forms OWL–QoS. The new service profile model, which includes QoS is depicted in detail as follows (Fig. 1).

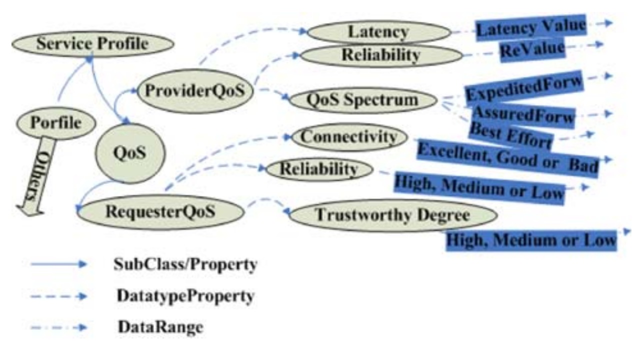

Fig. 1 Service profile model with QoS

Others are classes and properties, which are the same as those in [7]. Class QoS is the common superclass for all QoS specification. RequesterQoS and ProviderQoS are subclasses of class QoS.