# Semantic Service Discovery with QoS Measurement in Universal Network

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**Abstract.** The service of Universal Network is different from that of current network, because the former has QoS (Quality of Service) grading. Therefore, service discovery of Universal Network is quite distinct from that of present network. In this paper, we present service discovery with QoS measurement to adapt to Universal Network. Many researches adopt semantic web technology-OWL-S (Web Ontology Language for Services), which is innovative for service discovery. With the aim 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. Moreover, we also propose a matching algorithm that allows matching on the bases of capabilities and QoS descriptions of services.

**Keywords:** service discovery, semantic service, QoS, Universal Network.

## 1 Introduction

The Universal Network, which combines Telecom Network with IP Network, is under developing. Providing services based on it for clients is a core of research in the world. Providing QoS grading is one of the most important features in the Universal network. Present Internet supplies best-effort services, which can not meet users' requirements. Users often need service with specified QoS.

The promotion of services has stimulated providers to develop and publish their services. Consequently, service requesters can discover services which they want through looking up registry center. In the Universal Network, Services with distinct QoS will be published in the registry center, and requesters can get services with distinct QoS. Thus, discovering services now requires more sophisticated pattern.

In this paper we concentrate on discovering services with QoS measurement in Universal Network for satisfying requesters' high-grade demand. In practice, we divide service discovery into two steps. In the first step, a requester discovers the service using the basic ability description-what the service does, its input and output parameters, preconditions, and effects [1]. This step satisfies the requester's basic need. The second step is to identify sufficiently similar service

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for the requester with QoS measurement. This second step is the emphasis of our research.

At present, many service discovery processes use keyword-matching technique to find published services. This method often discontents requester with so many unrelated results and leads to a bit of manual work to choose the proper service according to its semantics. In order to realize automatic discovery, we adopt 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 semantic markup at the service registry or ontology-enhanced search engine could be used to locate the services automatically [2].

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 [3]. It describes the basic ability of service, so it is helpful for fulfilling the requirement of the first step of service discovery mentioned afore.

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 Universal Network for satisfying users' high-class requirement.

The rest of this paper is organized as follows: Section 2 introduces the architecture of the Universal Network. Section 3 gives details about OWL- QoS which is ontology with QoS descriptions. Section 4 discusses a matching algorithm between advertisements and requests described in OWL- QoS that recognizes various degrees of matching. Section 5 provides concluding remarks.

## 2 Services in the Universal Network

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 can not satisfy diversified requirements essentially. It is very meaningful to form Universal Network. The universal Network Model is specified in [16] and [17].

According to [4], we give the definition of the service in the Universal Network: Service is self-contained, modular applications 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. Paying more can get more. It means if user wants to have high quality service then he should pay more.

QoS refers to connectivity, security and so on. The details will be discussed in section 3.1. Pay means the spending of the user. For example, how much money is invested.

## 3 Ontology with QoS

A fundamental component of the Semantic Web will be the markup of services to make the computer-interpretable, use-apparent, and agent-ready. The Web Ontology Language for Semantic Web Services (OWL-S) supports automatic service discovery via matchmakers through its service profile language constructure [5]. For the sake of automatic service discovery, we adopt OWL-S markup for describing services and so we can call the services marked by OWL-S as semantic services. We can also call service discovery with OWL-S as semantic service discovery. For the purpose of discovery with proper QoS in Universal Network, we append service's quality description to service profile. We will discuss QoS in detail as follows.

### 3.1 The Definition and Classification of QoS

**QoS Definition[6].** According to ITU-T QoS Study Group the term of 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) [7].

International Organization for Standardization has proposed another definition in ISO/IEC 10746-2 [8] for the term of 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 [9]:

"a set of service requirements to be met by the network while transporting a flow"

We can see that ITU-T Study Group gives definition from the user's point of view while IETF Network Working Group defines QoS from network's point of view.

**QoS Classification.** From network's point of view, we provide QoS with several properties: Delay, Loss Probability, and QoS Spectrum.

Delay is classified into four grading:

1. Delay Time $\leqslant$ 1s(It is applied to Interactive Service)
2. 1s $<$ Delay Time $\leqslant$ 3s (It is applied to Response-Service)
3. 3s $<$ Delay Time $\leqslant$ 10s (It is applied to Timely Service)
4. Delay Time $>$ 10s (It is applied to Delay-Insensitive Service)

Loss Probability has three classes according to threshold which is given by the Universal Network as f ollows:

1. Loss Probability $\ll \tau$
2. Loss Probability is approximate to $\tau$
3. Loss Probability $\gg \tau$

While Expedited Forwarding, Assured Forwarding and Best Effort [10] belong to QoS Spectrum.

Properties of QoS are not only Delay, Loss Probability, and QoS Spectrum, but also Connectivity, Security and Trustworthy Degree from user's point of view.

Table 1 shows the mapping from user's view to network's view. This mapping is prepared for the matching of user's request and network's supply.

**Table 1.** Mapping from user's view to network's view

| QoS properties from user's view | | QoS properties from network's view | |
|---|---|---|---|
| Connectivity | Excellent | Delay | Delay Time $\leqslant$ 1s |
| | Good | | 1s $<$ Delay Time $\leqslant$ 3s |
| | bad | | Delay Time $>$ 10s |
| Security | High | Loss Probability | Loss Probability $\ll \tau$ |
| | Medium | | Loss Probability $\approx \tau$ |
| | Low | | Loss Probability $\gg \tau$ |
| Trustworthy Degree | High | QoS Spectrum | Expedited Forwarding |
| | Medium | | Assured Forwarding |
| | Low | | Best Effort |

### 3.2 OWL-QoS

We call our ontology OWL-QoS which is designed for Universal Network; it is a complementary ontology that provides detailed QoS information for OWL-S.

**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 that refers to the entity that provides the service. Specifically, the functional description of the service specifies the input required by the service, the output generated, 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 [2].

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

**Appending QoS specification to Service Profile.** As service profile mostly supports automatic discovery of the service, we add QoS specification to it for adapting to the service discovery of the Universal Network and it forms OWL-QoS.

The new service profile model which includes QoS is depicted as Fig.1.

Others are classes and properties which are the same as those in [2]. Class QoS is the common superclass for all QoS specification. RequesterQoS and ProviderQoS are subclasses of class QoS. RequesterQoS is the requester's QoS description and ProviderQoS is the QoS description from the Universal network's viewpoint.

ProviderQoS has three object properties which are mentioned afore: Delay, Loss Probability and QoS Spectrum. DelayValue and LossProValue which are data properties belong to class Delay and class LossPro respectively. Class QoSSpe owns three data properties: ExpeditedForw, AssuredForw and Best Effort.

RequesterQoS also has three object properties mentioned in section 3.1. They are Connectivity, Security and Trustworthy Degree. Data properties such as Excellent, Good and Bad belong to Class Connectivity. Both Class Security and Class Trustworthy Degree have three identical data properties: High, Medium and Low.

We give definitions of classes QoS, ProviderQoS, and Delay in profile as follows. Definitions of RequesterQoS and ProviderQoS are identical while the definitions of Loss Probability, QoS Spectrum, Connectivity, Security and Trustworthy Degree are similar to the definition of class Delay.

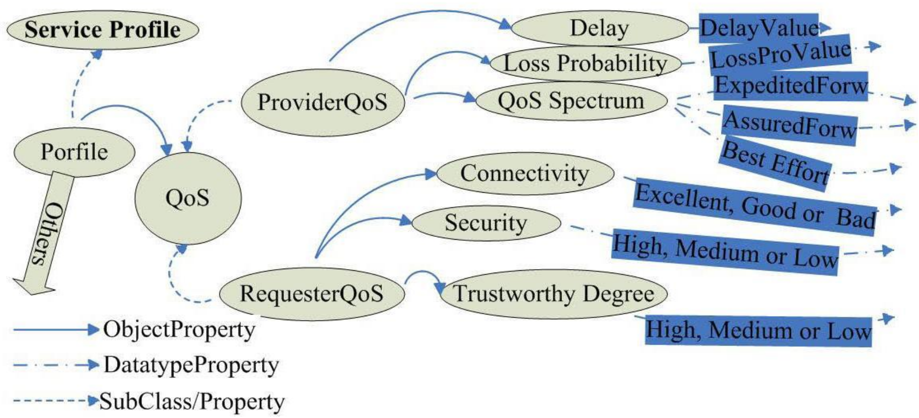


**Fig. 1.** Service profile model with QoS

## 4 Semantic Service Discovery with OWL-QoS

Semantic service discovery 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 constrats [2]. Using OWL-QoS markup of services of Universal Network, the information that is useful for service discovery could be specified as computer-interpretable semantic markup at the service web sites [11]. A server could proactively advertise itself in OWL-QoS with a service registry, which is also called middle agent [2, 12, 13, 14], while requesters can find the needed services when they query the registry. So OWL-QoS is helpful for automatic service discovery.

### 4.1 Semantic Service Discovery Model

Because the services of the Universal Network are graded according to the properties of QoS, it is essential to use profile with QoS for semantic service discovery. Fig.2 shows the semantic service discovery model with QoS measurement.

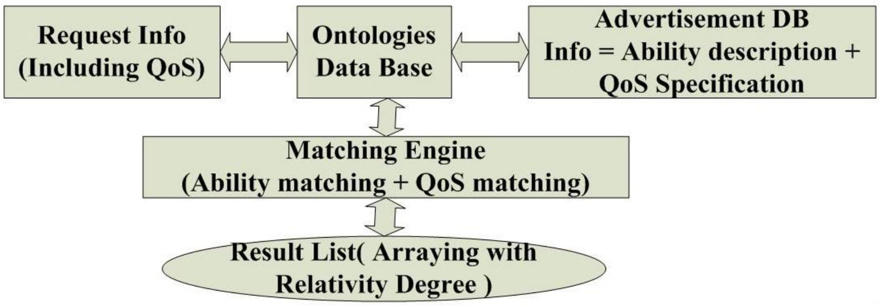


**Fig. 2.** Service profile model with QoS

Advertisements DB stores advertisements provided by service providers and the advertisement info includes basic ability description and QoS specification of service. After receiving a request, the Matching Engine chooses the advertisements that are relevant for the current request from Advertisements DB according to Matching Algorithm. This Matching Algorithm will be detailed in the next section. It includes QoS matching as its one point.

### 4.2 Matching Algorithm with QoS Measurement

Matching algorithm is a key for semantic service discovery. Some earlier algorithms are too restrictive. An advertisement matches a request, when the advertisement and the request describe exactly the same service. This is too restrictive, because advertisers and requesters have no prior agreement on how a service is represented and they have different objectives. Such restrictive a match inevitably bounds to fail to recognize similarities between advertisements.

We give a flexible matching algorithm. The result of the match is not a hard true or false, however it relies on the degree of similarity between the concepts in the match. The matching algorithm composes of two parts: basic ability matching and QoS matching.

In this section we will discuss the matching algorithm in some detail. At first we will present the main program. The request is matched against all advertisements stored in Advertisements DB in Fig.2. When a match between the request and any of the advertisement is found, it is recorded and scored to find the matches with the highest degree [15].

```
match(Request) {
   ResultMatch = empty
    forall Adv in advertisements do {
      if Match(Request, Adv) then
         ResultMatch.add(Request, Adv) }
         return Sort(ResultMatch);}
```

A match between an advertisement and a request consists of the match of all the outputs of the request against the outputs of the advertisement; all the inputs of the advertisement against the inputs of the request; all the QoS requirements of the request against the QoS requirements of the advertisement. The algorithm for output matching is described as follows. The degree of success is due to the degree of match detected. The QoS matching algorithm is the same as output matching's. The matching algorithm of inputs is similar to that of outputs, but with the reversed order of the request and the advertisement, i.e. the advertisement's inputs are matched against the request's inputs [15].

```
OutputMatch(OutputsRequest,OutputsAdvertisement)
  globaldegreeMatch =Excellent
  forall OutR in outputsRequest do
  find OutA in OutputsAdvertisement such that
        degreeMatch =maxdegreeMatch(OutR,OutA)
    if (degreeMatch = error) return Failed
    if (degreeMatch < globaldegreeMatch)
     globaldegreeMatch = degreeMatch
    return globaldegreeMatch;
```

The degree of match between two outputs, two inputs and two QoS depends on the relation between the concepts associated with those inputs, outputs and QoS. We give rules for outputs matching degree and QoS matching degree respectively. The inputs matching degree rules are identical to ouputs'.

```
degreeMatch(OutR,OutA)
  if OutA = OutR then return Excellent
  if OutR is a subclassOf OutA then return Exact
  if OutA subsumes OutR then return PlugIn
  if OutR subsumes OutA then return Subsumes
  otherwise Error

degreeMatch(QoSR,QoSA)
  if QoSA = QoSR then return Excellent
  if |QoSR-QoSA| = 1  then return Distinguishing
  if |QoSR-QoSA| > 1 then return Distinguishing
  otherwise Error
```

In the above QoS degree matching, |QoSR-QoSA| = 1 means that according to table 1, the distance between QoSR and QoSA is equal to 1. For instance, if requester requires that the connectivity isent and the advertisement provides 1s<Delay Time $\leqslant$ 3s, then the distance between QoS of requester and QoS of provider amounts to 1.

At last, the sorting rule is showed. It reflects that it will select the match with the highest score in the outputs firstly. If the outputs' matching scores are equal, then choose the match with the highest score in the QoS. Finally input matching is used only to break ties between equally scoring outputs and equally scoring QoS.

```
SortingRule(Match1,Match2) {
   if Match1.output > Match2.output then Match1 > Match2

   if Match1.output = Match2.output & Match1.QoS >
      Match2.QoS then Match1 > Match2

   if Match1.output = Match2.output & Match1.QoS =
      Match2.Oos & Match1.input > Match2.input then
      Match1 > Match2

   if Match1.output = Match2.output & Match1.QoS =
      Match2.Qos & Match1.input = Match2.input then
      Match1 = Match2}
```

## 5 Conclusion

Services are classified and have various qualities in Universal Network, so service discovery of Universal Network is different from that of current Network. This paper contributes to this challenge by presenting semantic descriptions of services with QoS measurement, and we call it OWL-QoS. Describing a matching algorithm with OWL-QoS is another contribution of this paper. This algorithm allows matching of advertisements and requests not only on the bases of the capabilities that they describe, but also on QoS which they specify. In the future, the research on Universal Network will still be a point. As part of our future work, we would like to delve into automatic service invocation, composition and interoperation in Universal Network.

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