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Abstract

This paper aims to explore the feasible mining and proper selection of QoS-aware services for a P2P-based business process enactment framework, and enhance the relevant workflow prototype.

Through observing and analysing unpredictable dynamic changes which commonly exist in e-service workflow, we propose a set of QoS specifications and monitoring mechanisms in a P2P workflow framework. These specifications are an evolving extension of services' description with semantic Web facilitators for P2P-based e-services.

It has been demonstrated that our QoS-OWL approach can be effectively used to describe and exploit e-services, particularly in decentralised environment. QoS-OWL is also able to provide the deliberation of geographic information for e-services, and facilitates the peers' effective cooperation and automates business processes. It is recommended the approach be adopted in the dynamic online information system environment to increase efficiency and reduce costs in running e-services.

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Mining E-Services in P2P-based Workflow Enactments

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Abstract

Purpose - This paper aims to explore the feasible mining and proper selection of QoS-aware services for a P2P-based business process enactment framework, and enhance the relevant workflow prototype.

Design/methodology/approach - Through observing and analysing unpredictable dynamic changes which commonly exist in e-service workflow, we propose a set of QoS specifications and monitoring mechanisms in a P2P workflow framework. These specifications are an evolving extension of services' description with semantic Web facilitators for P2P-based e-services.

Findings - It has been demonstrated that our QoS-OWL approach can be effectively used to describe and exploit e-services, particularly in decentralised environment. QoS-OWL is also able to provide the deliberation of geographic information for e-services, and facilitates the peers' effective cooperation and automates business processes. It is recommended the approach be adopted in the dynamic online information system environment to increase efficiency and reduce costs in running e-services.

Practical implications - The QoS attributes discussed in this paper are relatively typical for benchmarking purposes, so the extension of the QoS metrics specifications and related protocols need to be discussed in the future work.

Originality/value - We propose an approach to dynamically selecting appropriate service-oriented peer in a P2P network, where the composition of e-services in a business process can be enhanced significantly. The approach is based on ontology and QoS perspectives, and the descriptions of services have rich semantic features in an attempt to make the service selection more intelligent and reliable, therefore our proposal offers e-service providers innovative initiatives to reengineer their business services.

Keywords Semantic Web, Workflow, Web services, QoS, P2P, Process mining

Paper type Research paper

Introduction

In recent years we have witnessed a huge popularity and growth of e-service application. In a dynamic e-service environment, it is desirable for service consumers and providers to offer and obtain 'service' guarantees with regard to their capabilities and requirements (Oldham *et. al.*, 2006). The innovation and development of semantic Web service are playing a significant role in better exploiting services at both business and technical levels (Sheth *et. al.*, 2005). While Quality of Service (QoS) (e.g. performance, reliability and availability) has been a major concern in this area throughout the recent years, only a few researches have concentrated their efforts on improving the composition of Web services through QoS-based selection in the dynamic environment, though some e-business researchers are interested in developing QoS for Web services (Taher *et. al.*, 2005; Zeng *et. al.*, 2003). Yet, the dynamic composition of distributed services still has a few of problems (e.g. selection of proper peers, performance measurement and monitoring) existing in peer-to-peer (P2P)-based e-service processes. Similarly in our earlier

work, there was little QoS ontology consideration in a preliminary P2P-based workflow enactment system, SwinDeW-B (Shen *et. al.*, 2005), which exploits BPEL (Business Process Execution Language) (Dong *et. al.*, 2006; OASIS, 2007) to link Web services. In order to conquer those restrictions and enhance the performance of e-service processes, we design a framework based on a P2P model for effective selections of e-service and a set of methods to fulfil the overall QoS with OWL-S (OWL-S Coalition, 2006) ontology.

In this paper, we propose an ontology called QoS-OWL, which namely represents that the expression of QoS properties is associated with OWL-S ontology, and the new ontology has the following three contributions. First, it enables e-service providers to translate their services' profile (including geographic information) into the extended description by OWL-S, since OWL-S ontology is able to semantically describe Web services for preference-based selection. In e-commerce business processes, it is significant to know what the performance level they will exhibit before making the service available to its requestors. Secondly, it allows the task allocation for peers to proceed intelligently and reliably. As P2P-based network carries out more complex and mission-critical tasks, our QoS mechanism serves to ensure that each selected peer strictly satisfies the requirements (e.g. response time and the range of distance) for performing effective and flexible compositions of Web service in a whole business process, so that to offer a better and more responsive service experience to requesters. Thirdly, it can facilitate the monitoring mechanism in heterogenous environments. In our model, the performance of selected peers can be rigorously and constantly monitored throughout their lifecycles so as to assure its compliance with both initial QoS requirements and targeted objectives.

This paper presents a typical application in e-service mining and selection for P2P-based environments and a method to design and utilise the QoS-OWL. We start by investigating OWL-S and the relevant QoS features, which are necessary to properly characterise Web services. We not only target the QoS profile for Web services, but also consider service's geographic information and investigate the corresponding metrics to develop a real and usable P2P-based QoS model. In our SwinDeW-B, quality metrics are associated with the criteria in selecting peer and tasks' allocation. The evaluation of peer's QoS is based on the matching of requirements and metrics. We intend to present how SwinDeW-B can be coupled with a typical Web service by applying QoS and OWL-S ontology.

The paper is organised as follows. The next section describes the background and requirements analysis about the OWL-S and QoS for SwinDeW-B. Based on our scenario, OWL-S requirement is derived and the current limitations of QoS in P2P model are briefed. In the design and implementation section, we mainly present QoS-OWL's structural design and the implementation in SwinDeW-B, such as QoS profile with OWL-S ontology and the QoS metrics, and propose a method for incorporating e-service's geographic features into selective preference. Then we demonstrate how QoS-OWL in our prototype is fulfilled in the prototype section. The following section discusses related work on QoS and OWL for Web services. The final section concludes current work and indicates further research.

Background and Requirements Analysis

Background: OWL-S and QoS

OWL-S is ontology to describe Web services with rich semantics. It allows software agents to discover, invoke, compose and monitor Web services with high degree of automation under dynamic circumstances. OWL-S (OWL-S Coalition, 2006) ontology consists of three main components: the service profile, the process model and the grounding. The service profile is for

advertising and discovering Web services. The process model is used to describe detailed operations of services and define composite Web services. And the grounding is used to map the abstract definition of services to concrete specifications of how to access the services.

Our approach in this paper is based on the services' description and evaluation, so herein we present an overview of the service profile component of the ontology. Basically, the service profile does not mandate any representation of services; rather, using the OWL subclass it is possible to create specialised representations of services that can be used as service profiles. OWL-S provides one possible representation through the class "Profile". An OWL-S "Profile" describes a service as a combination of three basic types of information: what organisation provides the service, what functions the service computes, and a host of features that specify characteristics of the service. In this way, the complement descriptions about Web services including the QoS can be extended in the service profile, so that we can improve the automation and reliability of Web services' composition in dynamic circumstance.

QoS is an important criterion for e-service selection in dynamic environment. In general, QoS refers to the capability of a network to provide better service to selected network traffic over various technologies. As for P2P-based network, the dynamic and unpredictable nature in e-service processes always affects the service's composition and performance significantly. In addition, the dynamic e-business vision calls for a seamless integration of business processes, applications, and e-services over the Web space and time. In other words, QoS properties such as reliability and availability for an e-service process are highly demanded. Furthermore, changes and delay in traffic patterns, denial-of-service attacks and the effects of infrastructure failures, low performance in executions, and other quality issues over the Web are creating QoS complications in a P2P network. Quite often, unresolved QoS issues cause critical transactional applications to suffer from unacceptable performance degradation. Consequently, there is a need to distinguish e-services using a set of well-defined QoS criteria (Liu *et. al.*, 2004).

With the large number of e-services, consumers definitely would like to require a means to distinguish between 'good' and 'bad' service providers. In such a case, QoS is the means to select a 'better' e-service among various providers. From another aspect, the different collaborating e-services applications will compete for network resources in an unreasonable and uncontrollable manner if their interactions are not coordinated by any agreements or specification on QoS differentiation. Naturally, these factors will force service providers to understand and achieve QoS-aware services to meet the demands. Also, a better QoS specification for e-service will become more significant by being a unique selling point for service provider. Fundamentally, the Web services QoS requirement refers to the quality, both functional and non-functional, aspects of an e-service. This includes performance, reliability, integrity, accessibility, availability, interoperability, and security (Mani and Nagarajan, 2002). The properties become even more complex when adding transactional features to e-services. Therefore, how to properly design and integrate QoS criteria in P2P-based e-service process is an important innovation for e-business development in decentralised network.

SwinDeW-B: extending SwinDeW with BPEL

SwinDeW (Yan *et. al.*, 2006) is a JXTA-based (Halepovic and Deters, 2003; JXTA, 2007) decentralised workflow management system developed by our earlier colleagues to overcome the problems like poor performance, poor scalability, unsatisfactory system openness, and lack of support for incomplete process. SwinDeW-B is the extension of SwinDeW based on BPEL (Shen *et. al.*, 2005) technology.

Figure 1: System architecture of P2P-based e-services workflow

Figure 1 depicts the overall architecture of the SwinDeW-B's composite Web service engines. The engines are composed of a P2P-based system built in the JXTA framework. BPEL (OASIS, 2007) is chosen as the language to orchestrate composite Web services. A composite Web service is described by a BPEL file and a set of WSDL files. By processing the files a Coordinator peer obtains the knowledge of which activities to be performed and the temporal order of performing them to complete a composite Web service. The Coordinator peer then converts the knowledge into the format that can be distributed into the P2P network without losing any information about the structure of the process. The member peers hosted elsewhere on P2P network are chosen to allocate parts of the process based on their capabilities. One capability is the ability whether a peer can invoke a Web service when its owner plugs a specific Web service invocation component in it, i.e. a relevant task in whole business process. The process is executed by executing its activities hosted by individual member peers. The output result of the execution on a peer is transferred to the other peers of the post activities through messaging mechanisms of the JXTA pipes. Communications between the peers and their Web services are via the SOAP protocol. Each peer that was appointed for a task by coordinator in a group can invoke the required Web service from service providers, and there is no difference between coordinator and peer after the coordinator assigning tasks, so they are able to actively cooperate in the P2P network to execute the composition and invocation of Web services with same manner.

Typical application case

The administrator of a SwinDeW-B peer can register Web services with the peer. When a Web service is registered with the peer, the peer can be discovered by a SwinDeW-B Coordinator peer to perform the <invoke> activity which needs the Web service. The register information includes the description of the Web service and the full name of a Java class and method which is plugged into the peer so that the peer is able to call the Web service.

Figure 2: Workflow for loan approval case

Figure 2 shows a typical loan application process deployed in SwinDeW-B. At the beginning, Customer sends a loan request to financial organisation, and then a Coordinator peer, who has the knowledge of whole BPEL process, will seek appropriate peers to fulfil the whole task by sending Pipe messages and evaluating peers' performance. For the whole process, it consists of two small single services (i.e., task or activity): 'riskAssessment' and 'loanApproval'. 'riskAssessment' is to provide the service about evaluating customer's reputation and loan amount, so that it will generate the risk assessment of loan. Only when the risk assessment meets the requirement (e.g. higher reputation with more permitted loan amount) of 'loanApproval', can the loan application be approved; otherwise, the loan request will be rejected.

Figure 3: CFG in LoanApproval example

As figure 3 shows, a BPEL process can be converted into the CFG (Control Flow Graph)

(Nanda *et. al.*, 2004; Shen *et. al.*, 2006) form so as to ensure the coordinator split the business process without constraints. For the purpose of orchestrating and executing composite services, nodes in the CFG graph are basic activities. Each node knows a set of its predecessors and a set of successors as well as the conditions for it to be executed, if any. In this way, the task allocation for different peers can be intelligently performed (Shen *et. al.*, 2006). Therefore, the decentralised run-time environment can be coordinated and self-managed effectively with services being located to wide area peer hosts, who communicate with each other according to the de facto standard business process or workflow definitions.

Design and Implementation

As we mentioned, we are focusing on preference-based service selection in decentralised environment, and found the lack of QoS is a big potential challenge in dynamic composition. Particularly, let us consider a scenario, Coordinator in the previously model tried to look for a peer that can perform the 'invokeAssessor' activity, and after a while it received three replied messages from peer1, peer2 and peer3 respectively, and all the three peers said each one of them can do the work. Despite their capability and performance are different, the three peers were treated as same, and one of them was chosen randomly by Coordinator to fulfil the task, as there was not any QoS premise for selection. Obviously, for the real dynamic circumstance, that would be quite inappropriate for Coordinator to allocate tasks without any consideration on different peers' performance in decentralised network.

While the e-services ontology is developing quickly, the semantic requirement on service's description is becoming necessary for more complicated and unpredictable services processes. QoS and OWL-S are able to relieve this pressing situation for distributed e-services in real e-business environment. For this purpose, we exploit a set of methods to meet the dynamic demands and we will elaborate them in this section.

QoS-OWL approach

Service providers can proactively provide high QoS to the service requestors by using two approaches: generating QoS information according to different services and pre-loading the QoS-OWL by Peer. In the JXTA network, the two approaches can be done at both Coordinator level and at Peer service levels. Pre-loading the QoS-OWL is to prioritise various types of QoS parameters such as reliability (e.g. ResponseTime) and the services' availability (e.g. Expiration Time of Service) in order to ensure that each service provision is reflected appropriately to the performance value as it represents. Each peer can advertise its capacity through the broadcast function in JXTA and pass its QoS information to the Coordinator so that the Coordinator is able to choose the appropriate peers to perform the distributed service tasks. A service provider can also categorise the QoS for Web service by different standards for different tasks, like the risk assessment and loan approval. The Coordinator provides differentiated services by identifying the capacities of Peers to determine the capacity needed for different tasks and service types, in order to ensure appropriate QoS levels for different applications to be affiliated with relevant Peers.

Figure 4: Associated QoS Profile within OWL-S context

The figure 4 shows the structural relationship between QoS preferences and service profile in our model. QoS profile as a subclass of OWL-S Service Profile has various QoS preferences: “startTime”, “endTime”, “responseTime”, etc. QoS Metrics can provide the definition of specifications for service selection. OWL-S is used to describe the QoS information for service provider with its semantic features. By loading QoS Metrics, Coordinator can identify which peer satisfies the selection criterion, where there are a few corresponding property specifications, such as Response Time, Start Time, End Time, etc. The QoS information of individual peer is generated based on its performance and capability, i.e. a different peer usually has different QoS values. In this way, we can ensure that Coordinator is able to distinguish and select the most appropriate peer by matchmaking to fulfil assigned tasks in spite of unexpected dynamic changes.

Geographic information as a service selection criterion

In a decentralised network, geographical locations are also important factors in both service selection and composition. Quite regularly, there would be no guarantee that a service can be found or composed that would exactly satisfy the requested location requirements. In practical applications, business process managers must deal with alternatives that deviate from the requested service requirements. We are interested in identifying those alternatives where the deviation is minimal, such as the nearest available service. In a P2P-based business process, peer’s geographic information is usually related to services’ accessibility, particularly for location based service (LBS), which is a recent concept that integrates a mobile device’s location with other information in order to provide added value to a user (Kim *et. al.*, 2006). In order to effectively enhance services’ quality for accessibility in P2P network, we herein consider the basic geographic information about peer and incorporate it into the QoS profile as an extension of QoS specification.

Figure 5: Datatype property and high-level structure in Geo profile

Figure 5 indicates the relationships between QoS profile and Geo profile, and the logic of using geographic features for distributed services. Each peer's coordinate (either two-dimension or three-dimension) can be generated from a geographic coordinate system, and it is easy to calculate the distances between peers and Coordinator, so that Coordinator is able to select the nearest peer to invoke a service, especially a location based service. Service composition is to leverage and make use of distributed peer's QoS information to derive the optimal QoS of the composite service, but that is still an ongoing research direction. In our project, we recently aim to give this consideration of geographic information by semantic Web, not necessary to be OWL-S, expression in related location based services, and the geographic information can be viewed as a sort of criteria of service selection.

<!-- Example geographic information is defined below -->

```

<owl:DatatypeProperty rdf:about="http://localhost:8080/DefineQoS.owl#DistanceRange">
  <rdfs:domain>
    <owl:Class rdf:about="http://localhost:8080/DefineQoS.owl#QoSProfile"/>
  </rdfs:domain>
  <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
</owl:DatatypeProperty>
  
```

The above is the definition of "DistanceRange" in the QoS profile for service selection. As described by OWL-S, it enjoys semantic features when the geographic information is being processed. In other words, the service selection can be more intelligent and effective for a location based process.

Metrics definition about "DistanceRange":

```

<owl:Restriction>
  <owl:onProperty rdf:resource="http://localhost:8080/QoSMetrics.owl# DistanceRange"/>
  <owl:maxCardinality
    rdf:datatype="http://www.w3.org/2001/XMLSchema#nonNegativeInteger">100</owl:maxCardinality>
</owl:Restriction>
  
```

The metric of “DistanceRange” is viewed as a basic criterion of choosing appropriate peer to invoke requested services, and it can be set according to different service requirements so as to enhance the service accessibility. It is feasible to establish a better link between a potential service (or partially composed service) and an expected or requested set of location requirements, and also be able to use this approach to rule out less viable compositions earlier in the whole process.

Implementation of QoS-OWL

We deploy the QoS-OWL ontology together with its QoS-aware services discovery framework in a P2P environment. Within our SwinDeW-B model, the Coordinator initially extracts and analyses the Peers’ QoS information in OWL file and then selects the right peer according to the QoS requirement of service requestor. The matchmaking method for QoS property constraints with multiple matching requirements has been implemented by corresponding algorithms. Well-defined metrics and monitor can be further utilised by Coordinator to check whether the service provider conforms to the agreement. For different usage phases of the QoS-OWL, we develop the QoS description framework and the matchmaking framework for SwinDeW-B. Based on the ontology level, semantics in the specification helps to achieve better interoperability, automation and extensibility. In this section, we explain several basic and typical QoS aspects in real e-service application.

In general, time is a common and universal measure of performance. The philosophy behind a time-based strategy usually demands that businesses deliver the most economic and service value as fast as possible. Quicker response of workflow execution allows for a more efficient service, thus bringing a competitive advantage. Our most important measure of time is response time (RT). Response time corresponds to the time a task instance takes to be processed by a peer. The response time can be broken down into two major components: delay time and service processing time. Delay time (DT) refers to the network situation, i.e. communication and negotiation between peers. Service processing time (SPT) is the time a workflow instance takes at a peer while processing, and mostly depends on the peer’s capability; in other words, it corresponds to the time a peer needs to process a service. Therefore, response time for a task can be computed as: $RT(t) = DT(t) + SPT(t)$. Both DT and SPT can also be broken down into various pieces so as to give more detailed evaluation for a business process. In many situations, the different attributes are set by different people. As we focus on the QoS-OWL ontology, we would like to use the calculated value of response time as a QoS attribute. The following are samples of profiles:

<!-- Example profile definitions used in DefineQoS.owl -->

```
<owl:DatatypeProperty rdf:about="http://localhost:8080/DefineQoS.owl#responseTime">
  <rdfs:domain>
    <owl:Class rdf:about="http://localhost:8080/DefineQoS.owl#QoSProfile"/>
  </rdfs:domain>
  <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#dateTime"/>
</owl:DatatypeProperty>
```

The ‘responseTime’ is used for measuring the service performance of peer. This parameter is loaded by peers who can provide the requested services. The values of ‘responseTime’ are sent to Coordinator peer, then the Coordinator peer would select the most appropriate one to fulfil the requested service.

Availability (e.g. `startTime` and `endTime`) of e-service is another criterion for the QoS-aware service discovery and measurement, and it is also designed as a complementary OWL-S profile to provide the semantic description about an e-service for selection and evaluation. The following is a definition of service's expiration (measure the services' availability):

```
<owl:DatatypeProperty rdf:about="http://localhost:8080/DefineQoS.owl#startTime">
  <rdfs:domain>
    <owl:Class rdf:about="http://localhost:8080/DefineQoS.owl#QoSProfile"/>
  </rdfs:domain>
  <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#dateTime"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:about="http://localhost:8080/DefineQoS.owl#endTime">
  <rdfs:domain>
    <owl:Class rdf:about="http://localhost:8080/DefineQoS.owl#QoSProfile"/>
  </rdfs:domain>
  <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#dateTime"/>
</owl:DatatypeProperty>
```

The 'startTime' and 'endTime' yield the restriction to choose the available peers to fulfil the service task, thus avoid allocating the task to an unavailable-therefore inappropriate-peer. The date format is 'XMLSchema#dateTime' that is a standard format of date. Based on the properties in QoS profile, we've built a series of mechanism to value peers' performance of service in dynamic situations, especially for the beginning task to choose the right peer at present.

The following is a sample of QoS metric for Coordinator to select peers, i.e., metrics definition about 'currentTime' and 'responseTimeMS':

```
<owl:DatatypeProperty rdf:about="http://localhost:8080/QoSMetrics.owl#currentTime">
  <rdfs:domain>
    <owl:Class rdf:about="http://localhost:8080/DefineQoS.owl#QoSProfile"/>
  </rdfs:domain>
  <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#dateTime"/>
</owl:DatatypeProperty>
<owl:Restriction>
  <owl:onProperty rdf:resource="http://localhost:8080/QoSMetrics.owl#responseTimeMS"/>
  <owl:maxCardinality
    rdf:datatype="http://www.w3.org/2001/XMLSchema#nonNegativeInteger">5000</owl:maxCardinality>
</owl:Restriction>
```

Coordinator can use the current system time to compare with peers' service start time and end time, in order to ensure the service's availability. Peers would be considered to perform a task as long as its service's start time is earlier than the current time, and the service end time is after the current time. Another metric 'responseTimeMS' is for a Coordinator to identify peers' 'responseTime' of processing a service. For example, in some scenario, only the 'responseTime' of a peer is less than 5000ms, will the peer be chosen to perform the task.

QoS monitoring mechanism

In dynamic environment, peer's performance and reliability are constantly changing due to the unpredictable nature. When a peer accepts lots of tasks and runs over its original capability, the service's performance and quality will definitely degrade, and the peer will not be qualified any

more to continue serving for certain business processes which it has been involved in. Furthermore, service's reliability is also a very important aspect in a workflow. It is possible but improper that Coordinator chooses a peer that seems appropriate during enactments but fails many times in executing tasks. In general, the reliability should not be ignored in dynamic environment. In order to effectively and dynamically reflect peer's on-the-fly performance and reliability, we utilize "Busy Rate" and Peer's "Reputation" to observe and analyse the changes during the enactment and execution of business process. Fundamentally, "Busy Rate" refers to the number of allocated tasks, and it's a quantitative parameter with a maximum value. Once peer's "Busy Rate" reaches the maximum value, the peer will not be able to accept tasks any more until its "Busy Rate" goes down or comes back to normal (i.e. it has finished or failed some of the other current tasks). In this approach, when peer accepts a new task, its "Busy Rate" will increase "1". Likewise, the "Busy Rate" will decrease "1" when a task is completed or failed. On the other hand, peer's "Reputation" is also a type of numeric parameter, which can compare the task completion ratio (possibility of success versus failure) and indicate service's reliability during the peer's life cycle. Every time a task is completed or failed, the value of reputation will be computed automatically and recorded in an XML file. Afterwards, Coordinator analyses the value of peer's reputation and then decides whether the peer is reliable to process requested services. In a word, the above monitoring methods provide a standard form of evaluation for peer, and are effective to observe peer's quality and reflect service's reliability.

Prototype

We have implemented the QoS-OWL specifications and integrate them successfully onto SwinDeW-B. Metrics such as responseTime, startTime and endTime are the exemplar and representative requirements for the QoS of e-services. The following is a peer's QoS profile for its e-service selection.

```
<?xml version="1.0" encoding="ISO-8859-1" ?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
xmlns:owl="http://www.w3.org/2002/07/owl#"
xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
xmlns:serviceqos="http://localhost:8080/DefineQoS.owl#"
xmlns:PeerProfile="http://localhost:8080/PeerProfile.owl#">
.....
<serviceqos:startTime
  rdf:datatype="http://www.w3.org/2001/XMLSchema#dateTime">2006-09-24T09:00:00</serviceqos:sta
rtTime>
<serviceqos:endTime
  rdf:datatype="http://www.w3.org/2001/XMLSchema#dateTime">2008-09-24T09:00:00</serviceqos:end
Time>
<serviceqos:responseTime
  rdf:datatype="http://www.w3.org/2001/XMLSchema#string">200</serviceqos:responseTime>
...
</rdf:RDF>
```

As this QoS model is developed to facilitate the e-service application in P2P workflow, the model allows service suppliers to specify the duration, quality, response time, etc., for the services. Specifications can be defined at design-time, when designers build workflow applications, or can be adjusted on-the-fly at run-time. Algorithms and strategies are involved to

estimate the QoS of a peer both before instances are started (e.g. responseTime) and during instance execution (e.g. busyRate). The estimation of QoS before instantiation allows service suppliers to ensure that the processes to be executed will indeed exhibit the quality of service requested by customers. The monitoring on Peer's QoS during the instance execution allows Coordinator to constantly check and adjust the peer's performance according to the QoS metrics.

Figure 6: Enhanced prototype with QoS-OWL

From figure 6, which is monitor window in an enhanced version of SwinDeW-B considering QoS, we can see that the Coordinator received the messages from three peers. Peer1's response time is claimed as 200ms, and Peer2's is 500ms, and Peer3's is 8000ms, but the QoS requirement on Response Time is 5000ms, so obviously the Peer3 cannot meet the requirement of Coordinator, and Peer1 is the most appropriate one to fulfil the task. Then the Peer1 can be assigned to perform that activity. Furthermore, Coordinator is monitoring the peers' situation, and using the busy rate to identify the burden and performance of current peer, for example, if Peer1 has been assigned a task, then the Peer1's busy rate would be set to 1 (0 is the default value), likewise, once Peer1 get another task assigned, its busy rate will be increased by 1, to 2. And each time when Coordinator is going to choose a peer to fulfil an activity, the peer who not only meet capacity requirements and also has the lowest busy rate will be assigned the task. Thus, the resources of Peer can be utilised completely and rationally.

Related Work

Functionality and non-functional properties are two essential aspects for semantic Web service. Functionality is used to measure whether this Web service meets all the functional requirements of an anticipated Web service, i.e. Web services matchmaking; while non-functional properties are qualified to evaluate the performance of the Web service. This has been viewed as a sufficient means to distinguish functionally similar Web services. Recently, QoS-Aware service selection and composition have gotten considerable attention. In Zhou *et. al.*, (2004), authors provided QoS ontology as a complement for DAML-S (Ankolekar *et. al.*, 2002) ontology to provide a better QoS metrics model, which is very significant for enhancing non-functional properties. On

other hand, authors of (Oldham *et. al.*, 2006) developed so-called WS-Agreement and agreement matching, so that service providers and consumers may automatically make the most accurate and effective partnerships which are tailored to user preferences. In practice, the METEOR-S (LSDIS, 2005) project proposes a framework for the annotation of Web services and analyses the dimensions of cost, time and reliability. The use of semantics in describing the functional and non-functional capabilities of Web services is the approach in Verma *et. al.*, (2005) for process configuration.

Many research works have been done to take QoS requirements into evaluation as well as selection and composition of Web service. Some significant QoS attributes for Web service are discussed in Rosenberg *et. al.*, (2006), and those attributes can be adopted to evaluate and monitor the performance of service execution, but our main purpose in this paper is to testify the possibility of QoS-aware service in P2P network by a set of typical and simple specifications. In Ran (2003), the author proposed a QoS model which offers a QoS certified to verify QoS specification from the Web service providers. This approach lacks the ability to satisfy the dynamic situations where the performances of service providers are constantly changed, especially in decentralised network (Shen *et. al.*, 2007). In Zeng *et. al.*, (2003), authors proposed a global planning approach to optimally select component services during the execution of a composite service. This proposed approach was quality-driven and using Multiple Attribute Decision Making (Köksalan and Zionts, 2006) approach to select optimal execution plan. Currently, this approach is not efficient and appropriate for P2P network composite distributed services, despite that it can process much more complicated services selection and composition in dynamic environment. The main problem is that it requires generating all possible execution plans, and the computation cost is higher for P2P network. On the contrary, the QoS-Aware Web service profiles in our SwinDeW-B, are based on inherent decentralised Web services composition, so we can improve the composition efficiency and performance of Web service in decentralised network.

Many works have been done to develop languages for specifying the QoS description for Web services. OWL-S ontology is the most popular QoS Web service approach that supports the description of non-functional requirements parameters. In Dobson *et. al.*, (2005), an ontology QoSOnt was proposed as an extension to OWL-S and works in symbiosis with OWL-S. It is designed to provide a common QoS conceptualisation for services provider, services requesters or a third party inter-mediator. In addition, Dobson and Sánchez-Macián (2006) tried to produce a unified QoS ontology, and the authors evaluated existing QoS ontology by explaining deficiencies and possible improvements, so their research results would be helpful for development of QoS-Aware service. On geographic service aspects, Lemmens *et. al.*, (2006) discussed some syntactic descriptions of geographic services for enhancing a business process, but they only focus on the analysis of geographic perspectives and have little ontology consideration.

Conclusions and Future Work

In this paper, we discussed the importance of QoS ontology adoption for mining and selection in e-services, and presented a comprehensive background analysis about QoS and OWL-S. In dynamic and decentralised environments, how to incorporate QoS and OWL-S semantic features into e-services' composition is a significant issue, and it brings a new set of critical challenges and requirements that need to be explored and answered. Many e-commerce applications are composed of e-services in workflow form with BPEL, which in turns represents an abstraction of

cross-organisational business processes. We extended the semantic description of e-services by involving QoS perspectives and geographic information. The proposed specifications of QoS increased the added value of the performance in a P2P-based service network, and brought much higher competitive advantages for e-service providers. Meanwhile, the geographic preference profiles have been designed to enhance P2P-based workflow's flexibility and scalability in its enactment, and they can be incorporated into OWL-S based QoS selection specifications (e.g. the range of distance). In our design, the QoS parameters and values can be automatically loaded before services' selection. This feature is essential, especially for large and complex processes which may contain hundreds of tasks in many cases. For the practical purposes, we presented a new model that described the fundamental QoS metrics which were based on the loan approval case, and then took advantage of the QoS-OWL specifications to automatically and intelligently select the most appropriate peers to fulfil the allocated tasks by Coordinator. Finally, we demonstrated how SwinDeW-B can be enhanced with QoS features to carry out efficient e-service mining.

In the near future, the QoS-OWL will be designed to incorporate much more substantial service profile and metrics, and also the P2P based SwinDeW-B will be applied to develop specific strategies and policies under the dynamic circumstance more effectively. In this sense, we will be extending more complicated and useful specifications (e.g. representing more complicated geographical knowledge) as well as protocols to enhance the accessibility, reliability and availability of e-services in decentralised network.

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