A QOS-BROKER-BASED FRAMEWORK FOR PERSONALIZED WEB SERVICES PROVISIONING TO MOBILE USERS

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Abstract: This paper proposes a broker-based Web services provisioning system for mobile users with QoS requirements. It describes a set of cooperative brokers distributed over different sites that work together to provide personalized services for mobile users while they move from one location to another in their corporate and partners' networks. Access to QoS-enabled Web services is obtained in accordance with the users' home policies. This is made possible by negotiating the user profile and the terms of the service level agreement.

1 INTRODUCTION

With the advent of service oriented computing and the prevalent deployment of business applications on the web to reach a large base of customers, many organizations have moved their business online. Web Services are the current most promising technology based on the idea of service oriented computing. They provide the basis for the development and execution of business processes that are distributed over the network and available via standard interfaces and protocols.

Another development in the area of service oriented computing is the unprecedented rise in the number of mobile workers using a variety of handheld devices such as PDAs and SmartPhones to consume online services. Modern mobile devices are often fully equipped with broad capabilities. Most of them support several wireless communication options including Wi-Fi, Bluetooth, GPRS, and EDGE. They also come with advanced multimedia capabilities including streaming. These devices present now browsing capabilities that go beyond the simple WAP protocol. Mobile computing extends the e-business infrastructure to new classes of devices, delivering on-demand information wherever it is needed, using any device. With the proliferation of mobile devices, wireless business applications, i.e. messaging and voice services, are more and more developed and deployed using Web services. These services offer the possibility to overcome the limitations of individual mobile devices by making functionality offered by others available to them on an as-needed basis. Thus, using the service-oriented computing paradigm in mobile environments will considerably enlarge the variety of accessible applications and will enable new business opportunities in the mobile space by delivering integrated functionalities across wireless networks.

Mobile workers are increasingly requiring services tailored to their needs as they move from one location to another in their corporate and partners' networks. They are also requiring retaining access to their corporate services as they move to new locations. In this paper, we describe our broker-based framework, which aims to offer a working environment that allows mobile users to use home services as they move to new locations in their corporate or partners' networks.

2 RELATED WORK

Our work is motivated by the desire to provide mobile workers with local services tailored to their

needs and to their home-profiles as they move from one location to another in their corporate or partners' networks. To achieve this, two main aspects need to be considered. First, we need to identify the mobile worker's device in use at any particular time and its capabilities as well as his/her preferences and functional and non-functional service requirements, such as the minimum level of QoS they are willing to accept. Second, a close cooperation between the home location and the visited one needs to be established to negotiate and agree on issues related to the user's profile.

Several research works have studied the issue of service delivery to mobile users. The authors in (Ganna, 2003) proposed a policy-based service provisioning and users management using mobile agents. Their architecture is based on the notion of a domain that represents an administrative authority with its own behavior, policies, and users. Harroud et al. describe an agent-based service provisioning system for mobile users (Harroud, 2003). The system comprises a set of cooperative agents distributed over different sites that work together to provide personalized services for mobile users over the Internet. An Adaptive Service Presentation agent is used to adapt the service presentation to the capabilities of the users' mobile device. The work of Riva describes a two-tier model for providing services to mobile users (Riva, 2007). The model presupposes that the system is aware about the users' profiles and context as well as available services and has capabilities to match these with each other. The authors in (Nor Azhan, 2007) proposed a service-based content adaptation platform, which adapts content for display on mobile device without user intervention.

These works share some common goals with our proposed work. However, they were done in other contexts other done the service-oriented environment, which currently represents the most-predominant environment for service delivery. Our work takes advantage of the various standards that have been developed in the last few years for both Web services and mobile computing especially the standards for describing the mobile device capabilities.

3 SERVICES ON MOBILE DEVICES

Several service providers currently offer services that allow information to be pushed to a mobile device, or offered via a limited Web-browser interface. With a service-oriented architecture, it is becoming possible to offer services that fully use the power of the mobile device.

Nevertheless, mobile services access is still suffering today from interoperability and usability problems. This is to some extent attributable to the small physical size of the screens of mobile devices. It is also partly due to the incompatibility of many mobile devices with not only computer operating systems, but also the format of much of the information that is delivered to mobile devices.

The W3C Mobile Web Initiative (MWI) is a new initiative established by the W3C to develop best practices and technologies for creating mobile-friendly content and applications. The goal of the initiative is to enable the access to the Web from mobile devices and to make it more reliable and accessible. This typically requires the adaptation of Web content based on the device capabilities. The W3C has published guidelines (Best Practices, W3C mobileOK checker service) for mobile content (W3C,). The MWI Device Description Working Group is actively tackling the problem of device diversity by setting up a *repository of device descriptions* (W3C Mobile Web Initiative). Authors of Web content may use the repository to adapt their content to best suit the requesting device.

The OMA (Open Mobile Alliance) specification defines the User Agent Profile (UAProf) to describe capability and preference information of wireless mobile devices (Open Mobile Alliance, 2001). This information is to be used mainly by content providers to generate content in a suitable format for the specific device. It is based on the generic framework W3C CC/PP (Composite Capabilities/ Preference Profiles) (W3C, 2007). CC/PP defines a schema for the description of a device's profile, which is composed of components that describe characteristics of hardware, software, network, and so on. A CC/PP profile can be used to adapt Web contents to a specific device. A UAProf file describes the capabilities of a mobile handset, including Vendor, Model, Screen size, Multimedia Capabilities, Character Set support, and more.

4 SERVICE PROVISIONING FRAMEWORK

4.1 Service Provisioning Requirements

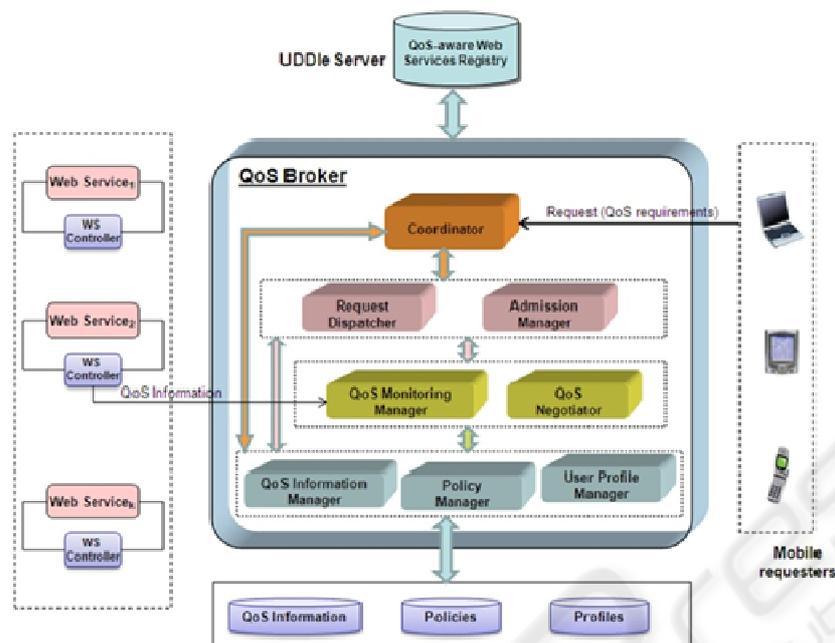To provide mobile workers with tailored services as

Figure 1: Framework components.

they move from one location to another in their
corporate networks or their partners' networks,
several issues need to be addressed.

1. Authentication and authorization control to
   identify the user and his/her authorized services
   on the home site.

2. Identification of the mobile user devices, so that
   the service presentation will be tailored to the
   capabilities of these devices.

3. Exchange of the user profile between the home
   site and the visited site to allow for identifying
   the user preferences, and providing access to
   local services using these preferences.

4. QoS monitoring and management so that the user
   will be provided with his/her required and
   authorized QoS.

4.2 Framework Components

To address these issues, our proposed framework is
based on a brokerage service to mediate on one hand
between the mobile user home site and the visited
site, and on the other hand between the mobile user
and local Web services on the visited site. The above
issues are handled by the broker components.
Another key component of the framework is the
Policy Manager, which is responsible for
maintaining authentication and authorization
policies, as well as polices for monitoring services

and their quality of service.

Figure 1 depicts the main components of the
framework at a given site. These components
cooperate to deliver personalized services to mobile
users with various devices across interacting sites.
They are under the control of the *Coordinator*
component and allow carrying out several
management operations: Admission control, QoS
negotiation, QoS-based service selection, QoS
monitoring, User profile management, and policies
management. The backend databases maintain
information about policies, user profiles and
preferences, and dynamic QoS information.

4.2.1 QoS Specification

Specification of QoS that providers can deliver may
be performed by incorporating QoS parameters, such
as response time, throughput and cost, into the
WSDL service description. This is the QoS model
supported by the UDDIe (Shaikh Ali, 2003). Other
works (Zuquim, 2006) (Ganna, 2003) have proposed
extensions to the Web services Policy Framework
(WS-Policy) to represent QoS policies of Web
services. WS_Policy does not specify how policies
are discovered or attached to a Web service. The
WS_PolicyAttachment specification (W3C, 2006)
defines such mechanisms.

In our framework, QoS policies are also stored in
the policies repository as well as the other policies

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concerning authentication, authorization, user profile and preferences management, and mobile devices profile management.Admission Control

The *Admission Manager* classifies incoming requests and verifies the provisioned classes of QoS. It is responsible of determining whether the received requests are allowed to use the requested services. This means that Web services access is denied to requests from users who did not negotiate the level of QoS with the selected Web services providers.

4.2.2 QoS-based Service Selection

The *Request Dispatcher* is in charge of implementing different policies for the selection of an appropriate web service that will deliver the user required service with the required QoS. It performs the match-making of required QoS with stored QoS. Various policies have been specified in the literature regarding service selection policies.

4.2.3 QoS Negotiation

The QoS negotiation process is carried out by the *QoS Negotiator* in order to reach a service level agreement (SLA) concerning the QoS to be delivered to the user. The SLA specifies the service to be provided by the provider to the client, the guaranteed QoS, the cost of the service, and the actions to be taken when there is a violation of the agreed QoS. The negotiation protocol is detailed in next section.

4.2.4 QoS Monitoring

QoS monitoring is carried out by the *QoS Monitoring Manager* and by the Web Service Controller (Figure 1). The QoS Monitoring Manager continually observes the level of QoS level rendered to clients. QoS parameters, such as response time and availability that need to be observed are specified in the contract. Observation is achieved through periodic measurement of these QoS parameters at some observation points at the server side and at the client side. QoS violation is detected when the measured value of a QoS parameter does not meet the requirements of the agreed one.

4.2.5 Profile Management

The *Profile Manager* is responsible for managing users' profiles, which include their preferences, in terms of personalized services, current location, and required QoS. It is also responsible for negotiating the user profile and authorized services at the visited site, as well as the devices profiles, that are described

using UAProf and CC/PP. Profile negotiation is detailed in next section.

4.2.6 Policies Management

Utilization of policies in Web services environments has been recognized since the specification of the first standards for Web services. In the WS-Policy specification (Bajaj, 2007), individual requirements or capabilities of a policy subject are declared using XML policy assertion elements. Policy assertions are the building blocks of policies. Each assertion describes an atomic aspect of a service's requirements (e.g. authentication scheme, authorization scheme, QoS/SLA characteristics, etc.). A policy expression can be comprised of one or more policy assertions assembled in Policy alternatives using logical policy operators. This expression can also be associated with a Web service resource, such as a service or endpoint, using WSDL or other mechanisms defined in WS-PolicyAttachment (W3C, 2006).

The *Policy Manager* is responsible for maintaining authorization policies, and polices for monitoring services and quality of service. It receives access control requests, processes them against a set of policies that define how the services are to be used by its mobile users, and returns access control responses. Figure 2 depicts the architecture of the Policy Manager. The *Policy Decision Point* (PDP) is the component that grants or denies access to services. It encompasses a rule engine that determines the policies to apply when a user requests access to a service. When a user attempts to access a service with QoS requirements, the *Policy Enforcement Point* (PEP) component sends a message to the PDP asking whether to approve the user request. It then replies with permission or denial of access to that service based on the rules that have been defined and the request parameters.
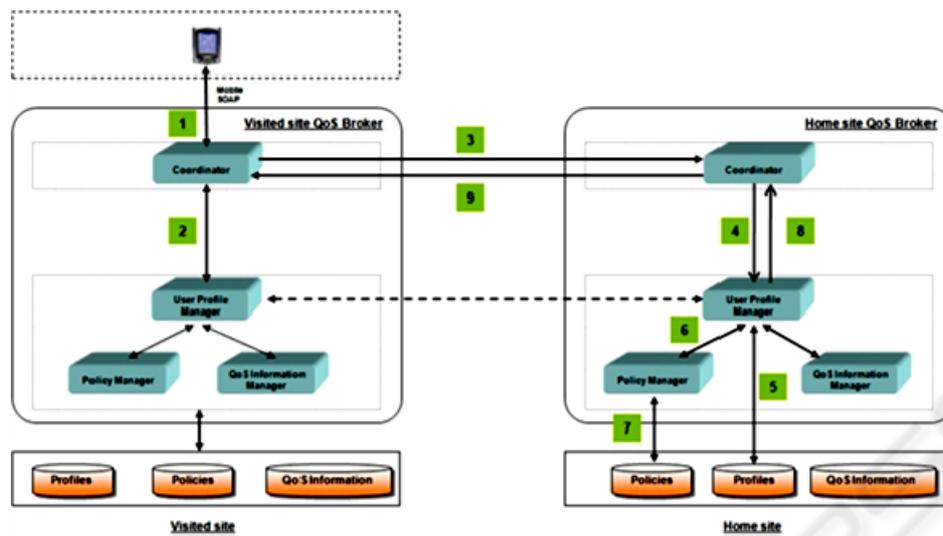

Figure 2: Policy Manager components.

Figure 3: Inter-site profile negotiation.

5 INTER-SITE NEGOTIATION

5.1 Profile Negotiation

Figure 3 depicts the interactions between the brokers at the visited site and the home site, to create a user's profile at the visited site.

1. The mobile user submits a request, including the CC/PP profile of the mobile device in use, at the visited site.

2. After processing the user's authentication on an authorized device, the *Coordinator* at the visited site requests the user's profile from its *User Profile Manager*. If the user profile is available locally, then the *Coordinator* starts negotiating the terms of service with the mobile user as described in the next section. Otherwise, the following steps are accomplished.

3. A request is sent to the *Coordinator* at the *home site* of the mobile user in order to get his profile. This is achieved through the following steps.

4. The *Coordinator* at the home site of the mobile user forwards the user profile request to its *User Profile Manager*.

5. The home *User Profile Manager* reads the mobile user profile from the profiles database.

6. The home *User Profile Manager* requests from the home *Policy Manager* the policies regarding the user, such as authorization policies to services available at other sites to which the user may have access and the type of access.

7. The home *Policy Manager* reads the policies regarding the mobile user from the policies database.

8. The home *User Profile Manager* returns the requested profile of the mobile user to its *Coordinator*.

9. The home *Coordinator* returns the user profile to its peer at the visited site. After getting the final profile of the user, the *Coordinator* at the visited site starts negotiating the terms of the service level agreement as described in the next section.

5.2 Policy-driven SLA Negotiation Process

Once the user profile has been determined, the mobile user and the QoS broker at the visited site start negotiating the terms of the SLA according to the following protocol (Figure 4):

1. The mobile user formulates a SLA request detailing service provisioning request and sends it to the *Coordinator* component at the visited site.

2. The *Coordinator* may decide whether the SLA proposal can be processed. This decision is based on the mobile user profile, determined in the previous process. If for instance the requested service is not among the services that are authorized for the user, then a rejection is sent to the user.

3. The *Coordinator* requests then the selection of a target Web service from the *Request Dispatcher*.
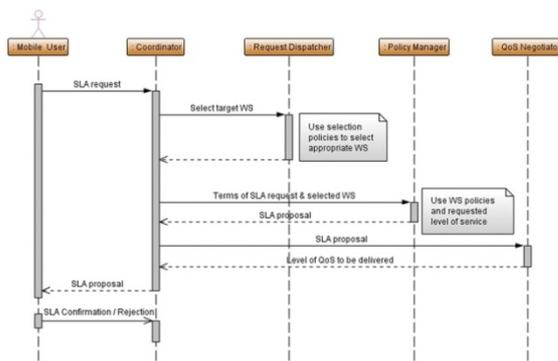
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Figure 4: SLA negotiation protocol.

4. The *Coordinator* sends the SLA proposal and the reference of the selected Web service to the *Policy Manager* to decide whether the mobile user request can be processed or not. This decision is based on the requested level of service and the Web service policies.

5. The *Coordinator* and the mobile user start then negotiating the specific terms of the service provisioning based on SLA requirements and Web service policies. The *Coordinator* requests from the *QoS Negotiator* to determine the final profile by negotiating the level of QoS to be delivered.

6. Proposals are returned to the mobile user, who can accept or reject offers – rejections typically trigger renegotiation.

6 CONCLUSIONS

In this paper, we have presented a cooperative broker-based Web services provisioning system for mobile users with QoS requirements. Policies are a crucial part of the framework. They are used at different levels: authorization, QoS specification, QoS service monitoring, and description of service policies. QoS brokers at the visited site and the home site are involved in determining the mobile user profile and in negotiating a final Service Level Agreement. This final SLA details the terms of service at the visited site according to several policies: WS policies, selection policies, and QoS policies.

A prototype of our proposed framework is under development. The implementation platform includes: NetBeans 6.5, the UDDIe registry, MySQL, and Apache Neethi, which provides a general framework for developers to use WS-Policy. As a future work, we intend to extend our proposed architecture with

security policies using standards such as WS_Security and WS_Policy.

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