Augmenting the mobility services supported in a mobile computing context

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Abstract

The requirements on mobile systems and the advantages in wireless networking technology have brought in the foreground new research topics like personal mobility and mobile computing. In this paper we propose enhancements to the mobility services supported in a mobile computing context, by exploiting pertinent work, i.e., a software architecture, conducted in the personal mobility area.

1. Introduction

Future cellular communication systems will have to provide a wide variety of sophisticated services over the widest possible service area. Some of the key factors for success will be the provision of universal service access to the widest possible set of users, and the provision of adequate quality services in a cost efficient manner. The challenges outlined above combined with the advances in wireless networking technology have brought in the foreground new research areas like *mobile computing* and *personal mobility*.

Mobile computing aims at the provision of continuous network connectivity to users carrying portable devices (mobile hosts), regardless of their location. Therefore, users, through their mobile hosts and the mobile computing infrastructure, are enabled to roam and have access to services that are offered in a distributed computing environment (e.g., Internet services). Personal mobility may be defined as the ability of the user to access services that are personalized with their preferences and identity ubiquitously, independently of both physical location and specific features of the equipment used. A factor that differentiates the personal mobility paradigm is the absence of an explicit association between the user and a terminal.

An interesting topic is the augmentation of the mobility services offered in a mobile computing context. In this perspective, a promising alternative is the exploitation of the work done in the personal mobility area. The aim of this paper is to show how a software architecture, specialized in the support of personal mobility services, may be applied in a cellular communication system, in order to enhance the set of features provided in the mobile computing context. Our approach is the following. In the following section, the software architecture is presented. It should be noted that this architecture is independent from the underlying network. Then we address the deployment of the software architecture in a cellular communication network, in order to augment the set of services in that environment.

2. Software Architecture for Personal Mobility Services

This section describes the software architecture that supports personal mobility services. In this respect the following approach is adopted. First, a service provision scenario (business case) will be specified. In the sequel, the additional functionality needed for supporting these services will be presented. As a basis the service architecture framework specified by the Telecommunications Information Networking Architecture consortium (TINA-C) [1,2] will be used, even though the practices of this paper are applicable to other models as well. The extensions introduced for the support of the advanced personal mobility concepts will be specified in terms of the new functionality needed and the corresponding software components. Finally, the resulting software architecture will be presented. The *intelligent mobile agent* software technology will be considered for the realization of the new components.

2.1 Service Provision Scenario

The service provision scenario is built on the assumption that users may have subscription contracts with a number of retailers *(Home Retailers-HR)*, but may use services promoted by other retailers (Visited Retailers) as well. Due to techno-economical or administrative reasons a retailer offers services only inside a domain which may be either the Home or the Visited Retailer Domain depending on the user's physical location. In this context, we consider the following scenario. The user is outside of his Home Domain for a specific service and requests to make use of this service, through an appropriate terminal *(TSW)*. The terminal may be served by a number of retailers *(Candidate Retailers-CR)*. Therefore, an interesting option that should be offered to the user is acquiring the service through the most appropriate retailer, i.e., the one offering, at a given period of time, adequate quality in a cost efficient manner.

It is assumed that a *default retailer (DR)* undertakes the responsibility of interacting with the user, until the candidate retailer selection is completed. The default retailer selection may be made either automatically, i.e. by means of terminal mechanisms, or after user intervention. In principle, the Home Retailer should maintain the information necessary for identifying a user, as well as the service subscription data. Enabling the service usage through the most appropriate retailer requires that the three general phases in Figure 1 are conducted.

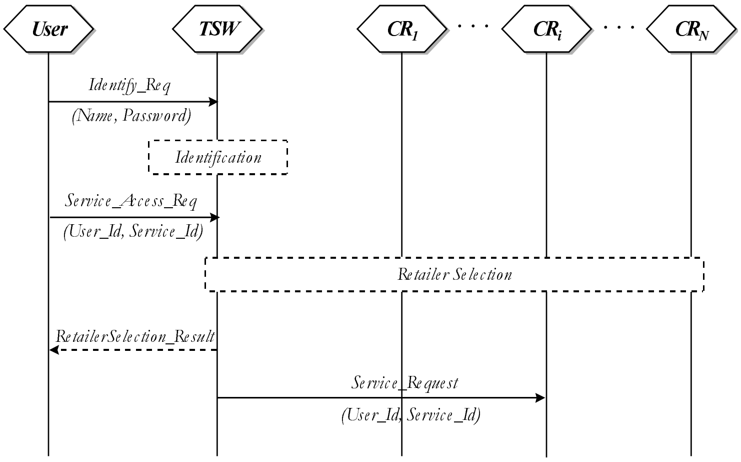

Figure 1: Selection of the most appropriate visited retailer

The aim of the first general phase is user authentication. This aspect requires the cooperation between the Home Retailer and the Default Retailer. The aim of the second general phase is retailer selection. For this reason, the Home Retailer is invited to apply the relevant mechanisms, so as to select on behalf of the user the most appropriate retailer for the service at hand. It may be assumed that the set of the Candidate Retailers is determined by means of a directory service. This aspect will not be further addressed. The basis for the selection comprises the personal profile information, the relevant service subscription data (i.e., desired quality levels), the list of eligible retailers, and the service offerings (e.g., cost at which the desired quality levels are provided). At the third phase, the result of the negotiation is made known, which means that an association, and consequently a service usage, may be started among the user and the selected retailer.

2.2 Introduction of advanced Personal Mobility features

This section introduces the extensions in the service architecture that are necessary for supporting the set of advanced service access capabilities required for the scenario presented above.

2.2.1 Identification of additional functionality and definition of new components

The TINA access session offers the framework for user authentication and service invocation. The novel feature that is not supported is the overall task of retailer selection. As a first step, this aspect requires an entity that will act on behalf of the user. Its role will be to capture the user preferences, to deliver them in an appropriate form to the appropriate retailer entity, to acquire and evaluate the corresponding retailer offerings, and ultimately, to select the most appropriate retailer. As a second step, the retailer selection requires an entity that will act on behalf of the retailer. Its role will be to collect the user preferences, and to make a corresponding offer after contacting the underlying connectivity providers. The overall object model is depicted in Figure 2.

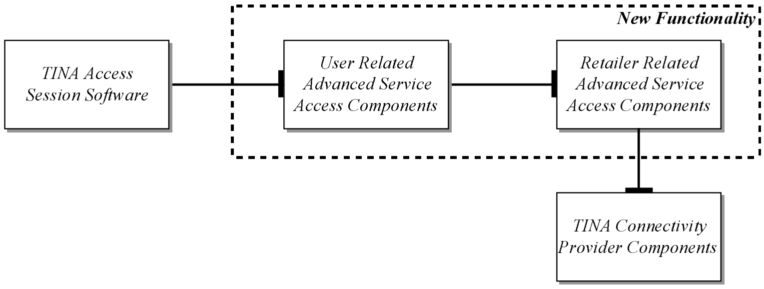

Figure 2: High level representation of the required access functionality

New components are defined for undertaking the functionality identified above, and in order to comply with the requirement to introduce the functionality by minimally impacting the service architecture. The mobile intelligent agent technology is considered for the realization of the new components, due to performance reasons [3,4] and due to the capabilities offered for computing platform independence and user specific customization.

The *Subscribed User Agent* (SUA) is defined so as to select on behalf of the user the most appropriate retailer for the requested service. Moreover, the *Retailer Agent* (RA) is defined and designated with the role to promote the services offered by the retailer. The SUA knows the user requirements and constraints, may interact and negotiate with the RAs, and may select the most appropriate retailer for the desired service. The RA promotes the service offerings of the retailer, negotiates with SUAs and the underlying connectivity provider mechanisms.

2.2.2 Integration in the service architecture

This sub-section describes the integration of the new components with the TINA service architecture. This is accomplished by providing a formal description of the business cases and the interactions among the involved service components. The interactions that take place among the involved service components of the business case are described below and depicted in Figure 3.

It is assumed that a user who has a subscription to a service, accesses a terminal, supplies personal identification data (e.g., User_Id, Password) and issues a request for the specific service usage, by means of the UAP and the PA that reside in the terminal (*Step 1*). The PA forwards this request to the IA of the default retailer (IA_Default) (*Step 2*) which, in the sequel, uses the user's identification data so as to determine the user's home retailer, in particular, the UAH (*Step 3*). Thereafter, authentication is conducted through the co-operation of the default and home retailer, and in particular of the IA_Default and UAH components (*Step 4*). The IA_Default creates a UA_Default together with its subordinate objects (SOs) (*Step 5*) and furthermore invokes the created UA_Default in order to initialise itself (*Step 6*). The outcome of this phase is an access session establishment between the default and home retailers.

During the retailer selection phase, the PA forwards the service usage request in the default retailer domain and in specific to the UA_Default (*Step 7*). Eventually, the UAH processes the request and identifies that the SUA-based mechanism should be initiated (*Step 8*). Therefore, the UAH is invited to create the SUA in the Default Retailer Domain and provide him the end user's service subscription data and the personal profile information (*Step 9*). The SUA uses a brokerage service in order to retrieve the list of eligible (on the basis of federation agreements) candidate retailers (*Step 10*). Then, the SUA replicates itself and the replicas are sent to the nodes of the candidate retailers where they will interact with the local RAs (*Step 11*). The SUA replica and the RA in each candidate visited retailer domain negotiate on the basis of service requirements and service offerings (e.g., level of quality of service provided in accordance with communication costs). The overall model of SUA negotiation is depicted in Figure 4.

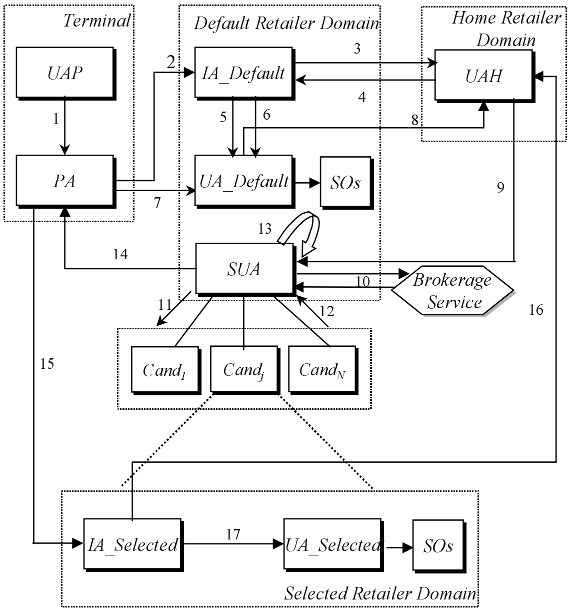

Figure 3: Access Session Establishment and Retailer Selection Procedure

The results of the negotiations between each SUA replica and the RA of each candidate visited retailer domain are sent to the SUA residing in the default retailer domain (*Step 12*). This "parent" SUA is responsible for selecting (on behalf of the user) the retailer that makes the best offer. This decision is stored in the SUA along with the results of the negotiation and the object reference of the selected retailer (*Step 13*). Hereafter, the access session with the default retailer will be released (if the default retailer is not selected) and an access and a service session will be established among the selected and home retailers. The SUA residing in the default retailer domain requests the PA to start a service session within the retailer domain that was selected (*Step 14*). For that reason, the PA sends an *AccessSessionRequest* to the IA_Selected (*Step 15*). The authentication process for the end-user takes place between IA_Selected and UAH (*Step 16*). Afterwards, the IA_Selected creates a UA_Selected together with its subordinate objects (SOs) and invokes the UA_Selected to initialise itself (*Step 17*). The IA_Selected completes the establishment of an access session by returning a reply to the PA. The PA requests from the UA_Selected to start a service session providing also the Service_id. The UA_Selected analyses the PA's request and also requests the SF (Service Factory) to create the SSM (Service Session Manager) and the USM (User Session Manager).

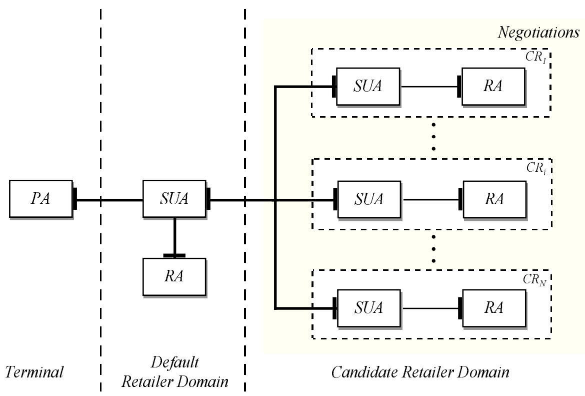

Figure 4. Negotiation among the SUAs and the RAs

3. Deployment in a Cellular System

In this section we discuss aspects related to the deployment of the previously presented software architecture in a cellular system. The following approach is adopted. First, the additional features and capabilities introduced in the mobile computing context will be presented. Second, various software deployment alternatives and corresponding protocol stacks will be provided. Finally, evaluation criteria for the various alternatives will be given as well as relations with the challenges that are currently addressed in the mobile computing context.

3.1 Implications

In this subsection we present the additional capabilities offered to the mobile computing users by the software architecture that was presented above. Let us assume the existence of multiple operators inside a domain. The mobile terminal could identify the potential retailers serving the area the user is currently roaming and for a service request find the most appropriate one in terms of quality offered with respect to the total cost. Therefore, our proposed architecture provides a mobile user the ability to establish an association with the most appropriate retailer for service use at a given period of time. Such a mechanism should be encompassed to all competitive and open environments.

Additional capabilities are stemming from the use of Mobile Intelligent Agent Technology for the realization of the newly defined components (namely SUA, RA) in conjunction with the issues raised by the wireless communication, mobility and portability, essential properties constituting the notion of mobile computing. Wireless communication implies susceptibility to disconnection, low-bandwidth availability and highly variable network conditions. Mobility involves dynamically changing network addresses, and communication locality that deteriorates as mobile users move away from their servers, while portability places string constraints on the design of a mobile system, such as low power, risk of data loss and small area available for the user interface. The use of Mobile Intelligent Agent Technology in our proposed framework may offer some potential advantages. Among them are reduced communication cost and reduced bandwidth, as the SUA migrates to the identified nodes of the respective RAs and engages locally in a high bandwidth communication with them in order to accomplish the overall retailer selection procedure. Moreover, the user is given the ability to create “personalized” services by tailoring the SUA according to his service preferences and requirements. Additionally, our itinerant agent framework supports the operation of mobile terminals in a disconnected mode. The user forms and issues a “special” request for a service usage. The appropriate components identify that selection of the most appropriate retailer is desired and the SUA-based mechanism is instantiated. When launched the SUA could proceed with the request even if the terminal is temporarily disconnected from the network. The SUA’s response regarding user’s request could be collected during a subsequent connection session. Finally, the proposed architecture is fault-tolerant as failures and malfunctioning of communication infrastructure would result to the retransmission of the agent instead of abortion and re-establishment of a lengthy communication session.

3.2 Deployment alternatives

In this sub-section we will present some alternatives that may be followed in the deployment of the software architecture that was presented above. The differentiation among the alternatives is in terms of the network elements that will be affected and the corresponding supporting protocol stacks (e.g., CORBA or socket-based, etc.).

The architecture of a third generation mobile system may be depicted as in Figure 5 or Figure 6 [5,6]. Two alternatives are envisaged. The first one follows the Intelligent Network (IN)-based paradigm. According to this one the system architecture is split in three parts. The radio network consists of the Base Transceiver Stations (BTSs) and the Radio Network Controllers (RNCs). These comprise call and mobility control related functionality (e.g., call set-up, handover, etc.). The Local Exchange may be any legacy switch or an ATM element (as assumed in the figure). Therefore, the retailer related components (e.g., IA, SUA, etc.) are deployed in the IN segment, namely, the Mobility and Service Control Point (MSCP) and the Mobility and Service Data Point (MSDP).

The second alternative regarding the mobile system architecture assumes that Local Exchanges are IP-based routers. Therefore they have the capabilities of hosting the retailer-related components. Naturally, due to performance reasons these components may be distributed over several LEs. For simplicity reasons, as well as space limitations, this issue is not further considered in this study.

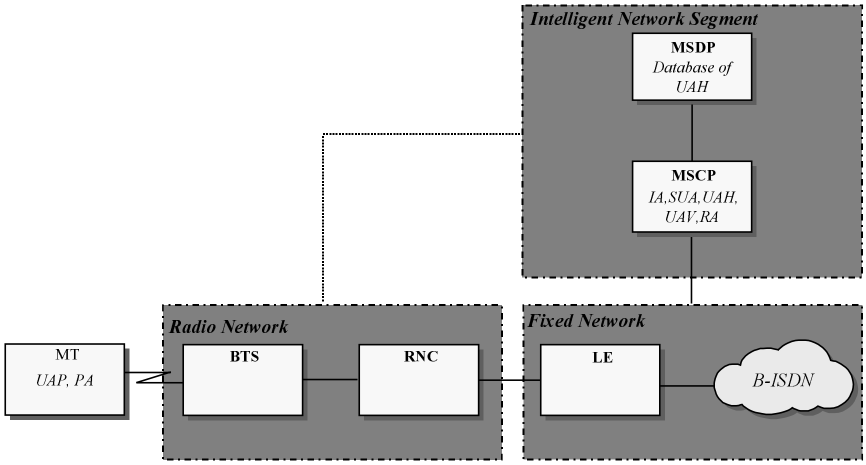

Figure 5. Software deployment pattern in case the cellular system architecture is based on the Intelligent Network principle

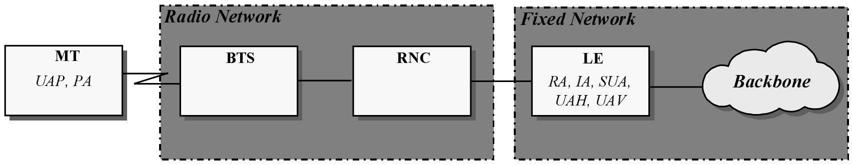

Figure 6. Software deployment pattern assuming an IP-based fixed network

In this paper we propose enhancements to the mobility services supported in a mobile computing context. Pertinent work conducted in the personal mobility area was used as a basis and adapted.

4. References

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