

Advanced Service Provision Architecture for Mobile Computing Environments^{*}

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ABSTRACT

The challenge of today's mobile computing environments is to give the users access to any information at any time, from any place, in any form.

A number of important service provision issues should be considered in this context. Such as: service discovery; flexible service downloadability; adaptability to terminal capabilities and network capabilities; support of user profiles.

In this paper, we address the challenging issue of service provision in mobile computing environments. After discussing some issues related to service provision, we introduce a distributed application platform capable of supporting flexible Value-Added Service (VAS) provision to mobile users. We focus on the terminal component of this platform and we describe how this component can support the following functionalities: user registration, service discovery, service downloading, service management and service adaptable provision to mobile users.

I. INTRODUCTION

Mobile users in the future mobile communication systems will be able to choose between a variety of service offerings from various network and service providers; they will have the possibility to invoke them via handheld, portable and movable terminals in the same way even when moving.

The main goal of our study is the design of a software platform that facilitates the service provision to mobile devices, responds to the challenges of mobility and, provides the mobile user with robust, personalized services irrespective of the terminal type and wireless network available. Moreover, this platform should fulfill the following requirements for service provision:

- Enabling the mobile users to transparently and easily reach a large number of remote services. These services can be hosted on servers belonging to heterogeneous environments.

- Customizing services and building interactive applications that function well on devices with different capabilities.
- Providing some QoS mechanisms which are mandatory for an acceptable provision of voice, video services and transmission of multimedia streams.

Various efforts have been undertaken by standardization work groups to meet the requirements of flexible service introduction and adaptability in future mobile systems and networks. In particular 3GPP [1] and ETSI [2] introduced OSA (Open Service Architecture) [3], MExE (Mobile station Execution Environment) [4] and USAT (USIM Application Toolkit) [5].

The remainder of this paper is organized as follows: first we discuss the requirements of a flexible service provision platform. Subsequently, we present a generic architecture for VAS provision. We particularly focus on the End-User Terminal (EUT) platform. To this purpose, we describe the generic End-User terminal functionalities and architecture, we present in details the EUT platform and, we explain how such a component meets the requirements for flexible service provision. The last sections of the paper are dedicated to conclusions and acknowledgements.

II. SERVICE PROVISION ISSUES

A flexible service provision platform is expected to fulfill the following functional requirements:

A. Support for service downloading and management

The software downloading and management requirement consists in moving the provided services from the service providers to the mobile terminal where they can be executed.

The service provision platform should offer an environment capable of supporting service downloading facilities as well as service execution capability in the mobile terminal. Moreover, it should address the following challenges:

^{*} This work was supported by the MOBIVAS (Downloadable MOBILE Value-Added Services through Software Radio & Switching Integrated Platforms) IST project, <http://mobivas.cnl.di.uoa.gr>

- *Terminal Capability Negotiation and Content Negotiation*

Both capability and content negotiation share the same purpose: optimize the services offered to the mobile terminal according to client's capabilities and the user's preferences.

Capability negotiation is performed prior to the service transfer to the mobile device to verify as far as possible the ability of the terminal to support any service to be downloaded.

Content negotiation represents the means by which the mobile terminal and the VAS provisioning entity inform each other of the requested and available form of the content of the service to be downloaded.

The MExE specification provides a standard for the terminal capability and content negotiation which is based on W3C CC/PP specification [6].

- *Software downloading*

The service downloading consists in downloading the requested service from the service provider to the mobile terminal.

- *Service management*

The service management consists in the following operations: control of the service execution on the mobile terminal, termination and suspension of the executing services on the mobile terminal and, service configuration.

B. Support for customization

Customization provides the means to apply user preferences to service functionality and user interface.

User profiles can be stored in a subscriber's database in the network. These profiles provide a means of determining the mobile device characteristics and the user preferences which have an important impact on the way information is presented to the application.

C. Support for mobility

Mobile computing requires the design and the implementation of a platform which integrates suitable tools and mechanisms to support the mobility issues. Two forms of mobility emerge in such environments [7]:

- *User or Personal Mobility* can be defined as the ability of a user to access services from any terminal on the basis of a personal identifier, and the capability of the network to provide those services according to the service profile of the user. In the personal mobility, neither users nor services are tied to the terminals. The users can travel, find suitable terminals, wherever they are, and start services.
- *Terminal Mobility* can be defined as the ability of a terminal to access services from different locations and while in motion, and the capability of the network to identify and locate the terminal. Terminal mobility provides the possibility to move the terminal while keeping the service active and to connect it to different point of attachment in the global network.

D. Service provision while Roaming

Roaming presents a mechanism by which users can access services according to their personal profiles even though they are visiting foreign networks.

The basic idea behind this requirement is that a roaming user will be provided with his/her own individually customized environment within different networks. This means that the user takes his/her subscribed and customized services with him/her while roaming.

The Universal Mobile Telecommunications System UMTS [8] proposes a service infrastructure based on the concept of a Virtual Home Environment (VHE) [9] in which users have access to the same personalized features, interfaces and services regardless of the current hosting network.

E. Support for adaptivity

The service provision platform could be faced with wide variations and rapid changes in network conditions and local resource availability during service provision.

The mobile user may move between different mobile environments or change the configuration of his/her mobile device. Consequently, the performance of services under downloading or execution in the mobile device, may drop significantly [10].

In order to enable service provision platforms to continue to operate in such dynamic environments, services on mobile environments are required to deal with drastic changes of network bandwidth and device configurations caused by the replaceable devices or user mobility. The platform must react by dynamically adjusting the functionality of a computation between the mobile terminal and the fixed network. In other words, the computation in the two parts has to be *adaptive* in response to the changes in mobile environments.

F. Support for security

Security is a vital consideration with reconfigurable terminals. In the increasingly deregulated world of telecommunications, both application and system software components will be available for download and installation from any number of terminal manufacturers, service providers and third party suppliers. Security issues arising from such interactions include privacy, integrity, confidentiality, authentication, availability and non-repudiation:

- **Privacy** is the control of what information is revealed about oneself and to whom it is revealed.
- **Integrity:** to protect authors from unlawful duplication and use of their works, a marking technique is needed to identify rightful owners.
- **Confidentiality** is obtained by means of cryptography.
- **Authentication:** Authentication is defined as consisting of those procedures and mechanisms that allow the system to ensure that the stated identity is correct. Traditionally authentication is achieved with physical presence and some sort of identification card (driver's license, passport etc.). In an electronic

world spoofing is easy and digital signatures, certificates, challenges and public-private keys are used to prevent it.

- **Non-repudiation:** services protect against one party to a transaction or communication activity later falsely denying that the transaction or activity occurred. Non-repudiation is important and traditionally it is achieved using signatures. In electronic world, it is possible to make sure that the sender has signed the message using private-public-key digital signatures. Since the sender only knows his/her private key, only he/she can sign the document with it.
- **Availability** in terms of authorized usage has become more complex. Examples include the right to use a video game for a certain period of time, the right to create a single copy or several copies, to disseminate a television broadcast for a certain number of times for a given length of time and over a given geographical area, using a specific medium...

III. AN ARCHITECTURE FOR SERVICE PROVISION

The network architecture intended to support the distributed software platform consists of three basic entities: the mobile terminal, the Network Operator (NO), and the VAS Providers (VASPs) which offer their services by connecting their network infrastructure to the operator's network (Figure 1) [11].

Software modules such as the VAS Manager (VASM), the Access Network Added Intelligence (ANAI), and the Charging-Accounting and Billing (CAB) system are added to existing access and core network architectures. The VASM is mainly responsible for the management of the provided service list. It should present the users with a complete and updated list of all available services. In addition, it should cope with the coordination of functions required for the seamless and consistent VAS downloading to the mobile users.

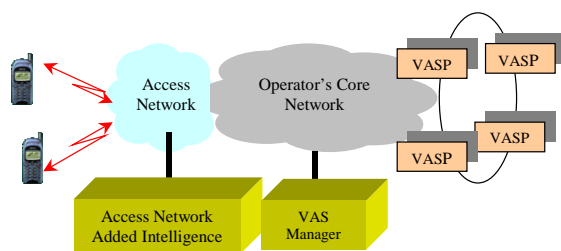


Figure 1 –An architecture for service provision

The ANAI supports a terminal classification and negotiation procedure between the mobile terminal and the VASM to acquire the terminal capabilities and user profile.

The CAB system deals with the charging, billing and accounting operations induced by a service downloading procedure.

During the negotiation procedure, the VASM identifies all the relevant parameters for the service downloading (e.g. terminal capabilities and user profile) and provides the mobile user with a Lookup Service yielding the list

of all available services that are applicable to his/her terminal capabilities.

After the user selects a VAS to use, the corresponding service components are downloaded from the VASP to the mobile terminal and the charging process is initiated and controlled by the CAB system.

In the following sections, we focus on the terminal component of this architecture namely, the End-User Terminal (EUT) Platform.

IV. ARCHITECTURE OF THE EUT PLATFORM

A. Terminal functionalities overview

According to the service provision platform functional requirements, the terminal is responsible for the following tasks:

- Supporting and managing a flexible and user-friendly interface from where the user can request several VASs,
- Managing the interaction with the other components of the platform: the VASM and the VASP,
- Managing the user registration and login to the VASM,
- Supporting the profile management,
- Managing the capability negotiation with the VASM,
- Managing the secure download procedure for the movable VAS components,
- Managing the service execution on the terminal part.

B. Mobile Terminal Interface Identifications

Based on the aforementioned functional requirements of the terminal, the interactions between this later and the other platform components are:

▪ Interface between MT and VASM

This interface supports the following purposes:

- User authentication procedure;
- Capability and content negotiation;
- Look-Up Service formulation.

▪ Interface between MT and VASP

This interface supports the download of VAS components and the VAS execution as well as the VAS interaction purposes like service usage and service termination.

▪ Interface between MT and ANAI

This interface is designed to support the download of protocols and the implementation of a protocol proxy approach.

C. Session sequence

Figure 2 depicts the different steps to be performed to ensure service discovery and provision.

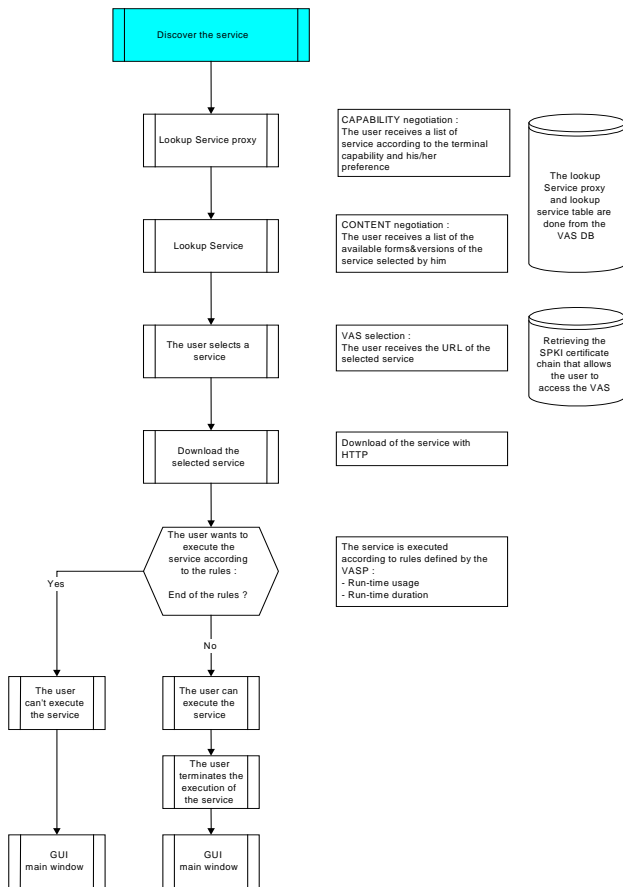


Figure 2 – Service discovery, downloading and management

When a user enters the operator’s network, a terminal and user registration/authentication procedure takes place.

In order for the user to be able to request services, he/she first starts by downloading a Look-up Service (LS) proxy to his/her terminal. The version of this proxy depends on the terminal capabilities which are specified when requesting the LS proxy downloading.

Through the LS proxy, the user can ask the VASM for a keyword-based VAS research, for lists of available VASs classified by categories or list of the user’s “favorite” services. The user’s request is sent to the VASM along with the current terminal capabilities. Based upon the entries of the VAS Data Base (VAS DB), the terminal capabilities, as well as the user profile from the User Data Base (User DB), the VASM formats the LS and sends it to the user’s terminal. The contents of the LS can be a list of VAS including the available service proxies as well as the information for the user (e.g.: service cost).

When a user wants to download a service that he/she has selected, a message is sent to the VASP. When the VASP receives this request, he packages the service and generates security parameters. These parameters are transmitted to the user, and the user stores them locally. When the user has received the security parameters, he/she can ask the VASP for the service.

The service is then downloaded to the mobile terminal and the user can execute it according to rules defined by the VASP.

D. EUT Platform Layered Architecture

Figure 3 depicts the layered components of the End-User Terminal Platform. The Application Support Programming Interface contains the necessary APIs for the service execution in the mobile terminal. The service Management component supports the modules which control and manage the service provision procedures; from the user network connection to the service execution in the terminal part. Adaptation component deals with low level issues which concern the QoS and the protocol downloading.

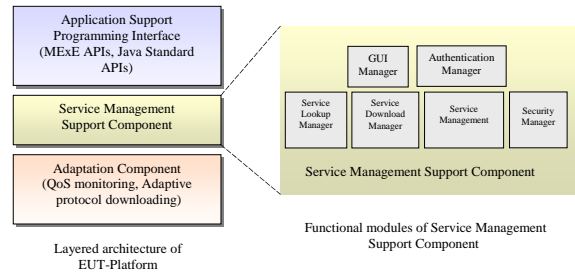


Figure 3 – EUT Platform Layered Architecture

■ Adaptation Component (AC)

This component deals with issues concerning the QoS monitoring and the adaptive protocol downloading. The AC provides the Service Management Support component with an interface to the QoS management. The Adaptation component provides also an adaptive protocol downloading that ensures necessary download protocol components to the mobile terminal from the ANAI.

■ Service Management Support component (SMS)

The different components of the Service Management Support Layer are:

1. Graphical User Interface (GUI) Manager

The GUI Manager gives the functionalities, which enable displaying a GUI, access and modification of the user and terminal profiles. Two types of profiles are defined : User Profile (includes User Interface Profile and User Services Profile) which could be stored in the core network and; Terminal Profile which is, a priori, stored in the mobile terminal.

2. Authentication Manager

This module is responsible for the User Registration and the User Authentication (User Login). The User Registration is performed only once when the user signs up a contract with the platform. The User Login is performed every time a user starts a new session.

3. Service Lookup Manager

This module is responsible for service lookup table formulation and service selection. It compiles several lists of available VAS according to the requirements of the terminal/network capabilities, user location, user preferences and user profiles. Then, it presents the filtered lists to the user.

4. Service Download Manager

This module is responsible for the secure download of the requested service as well as its invocation on the terminal. This component requests the download of a service proxy selected by the user. If the ANAI does not have an up-to-date version in its proxy cache, it initiates a download from the VASP.

5. Service Management

This module is responsible for execution and control of the downloaded service. It starts the service once downloaded to the terminal and controls its execution.

6. Security Manager

Security in the mobile terminal is involved in two aspects :

- the registration and authentication process are based on SPKI certificate, that is delivered to the user by the VASM. This certificate is used to authenticate the user in order to access to the Service Access Environment.
- the download process: the protection of Intellectual Property Rights (IPRs), the VAS conditions of use, the access rights to VAS (when a user wants to access a VAS for download, he must be given the access rights before), and the certification of code integrity for the MT.

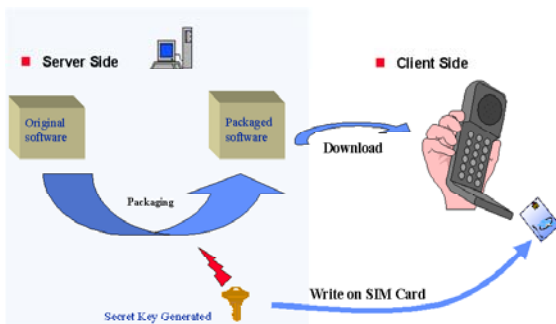


Figure 4 – Security packaging module

V. CONCLUSION

This paper investigated issues related to service provision in mobile computing environments.

A generic platform for VAS provision to mobile users was introduced. We particularly focused on the End-User Terminal platform. To this purpose, we described the generic End-User terminal functionalities and we presented in details the EUT platform.

The different EUT modules and all interactions with the other platform components have been implemented and successfully validated.

In order to test the adaptivity of our service provision architecture and particularly the EUT platform, two service scenarios were designed. The first service is a location based service. The second service is a streaming multimedia player service. Two versions of each of the two services were developed: one for a restricted capability terminal (SPIF [12]) and one for an enhanced capability terminal (laptop).

In the future we plan to investigate in more depth the service provision issues mentioned in this paper with

particular focus on service adaptability to network capabilities and QoS management in service provision platform.

VI. ACKNOWLEDGEMENTS

This work has been performed in the framework of the project IST MOBIVAS, which is partly funded by the European Community. The Authors would like to acknowledge the contributions of their colleagues from Thales Communications, Hellenic Telecommunications Organisation, NEC Europe LTD, University of Athens, Ecole Nationale Supérieure des Télécommunications, Technical University of Berlin, OTE Consulting, UNIS, IDATE, Innovators.

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