Establishing Virtual Home Environment Across Terminals with Diverse Capabilities

Jasmina Šašak and Tomislav Marenić
Department of Telecommunications
Faculty of Electrical Engineering and Computing, University of Zagreb
Unska 3, HR-10000 Zagreb, Croatia
E-mail: tomislav.marenic@fer.hr

Abstract - **Virtual Home Environment (VHE) is a personalization concept introduced by 3GPP (Third Generation Partnership Project). Its purpose is to enable users' personalized settings to be portable across network boundaries and between terminals. This paper addresses a subset of VHE features, and tries to solve the problems related to availability of personal service collection when users are switching terminals. Special consideration is given to filtering user profiles according to technical limitations of the currently used terminal, so that user's personal service environment is automatically adjusted to terminal capabilities. Implementation is based on mobile agents and CC/PP (Composite Capabilities/Preference Profiles) technology for description of terminal profiles.**

Keywords - mobile agents, Virtual Home Environment (VHE), personal mobility, service mobility, Composite Capabilities /Preference Profiles (CC/PP)

I. INTRODUCTION

Rapid development of telecommunications has lead to the situation in which users are faced with a variety of terminals with significantly diverse capabilities. For example, an average user works on a PC at work, uses a mobile phone or palmtop on the way home, where he/she uses a laptop or another PC. Each of these devices offers a different interface and a different set of services. Furthermore, only a subset of user's personal data is available on each device, except when it is manually transferred between them (e.g. on a floppy disk or CD, by e-mail etc.).

Virtual Home Environment (VHE) is a personalization concept introduced by 3GPP (Third Generation Partnership Project). Its main goal is to enable personal mobility across network boundaries and between terminals, and thus solve all of the problems specified in the preceding example, as well as additional ones not explicitly mentioned. VHE should provide users with the consistent usage "look and feel", i.e. offer portability of personalized interface and services, within the technical limitations of networks and terminals.

In conformance with VHE definition, service mobility can be identified as one of the key aspects of all potential VHE implementations, since services present the most important part of a personal environment. Regarding VHE problems, services can be divided into two main categories, based on the place of service logic execution. Terminal Centric (TC) services are those that execute locally on the terminal, while Network Centric (NC) services execute on some server in the network.

This paper proposes a solution for problems related to TC services mobility in situations where users are switching terminals with diverse capabilities. The described concept is based on mobile agents and CC/PP (Composite Capabilities/Preference Profiles) technology, which is used for description of terminal profiles.

II. VIRTUAL HOME ENVIRONMENT

3GPP offers the following definition of VHE in [1]: VHE is a concept for personal service environment portability across network boundaries and between terminals. VHE ensures the users are consistently presented with the same personalized features, User Interface customization and services in whatever network and whatever terminal, where ever the user may be located, within the capabilities of the terminal and network.

This concept appeared in the 3G networks as a result of emerging need for portability of personalized service environments, supported by the increasing capabilities of terminals and networks. Therefore, the main interest of VHE is to provide [2]:

- Personalization of Service Environment - Personal Service Environment (PSE) describes how the users choose to personalize, modify, access and behave with the services that they have subscribed. PSE is the combination of type of subscription, subscribed services and network and terminal limitations. PSE is defined by one or more user profiles, which consist of general and service specific personalized settings.
- Adaptation of Service Environment - the customized environment follows the user while he/she is roaming within different networks and using different terminals. Since different terminals have different capabilities (e.g. some do offer the audio environment, some do not), and so do different networks (e.g. bandwidth), it is necessary to use adaptation according

to the terminal and network capabilities. Such service adaptations should comply with user preferences.

- Service Portability - a user is offered the same service experience in a visited network as in his home network.

Users can choose among different profiles, change the profile regardless of the location and terminal temporary in use, activate and deactivate profile services, and restate the user profile in case of lost or malfunction of terminal. The logical VHE role model from the user's point of view is shown in Fig. 1 (taken from [1]).

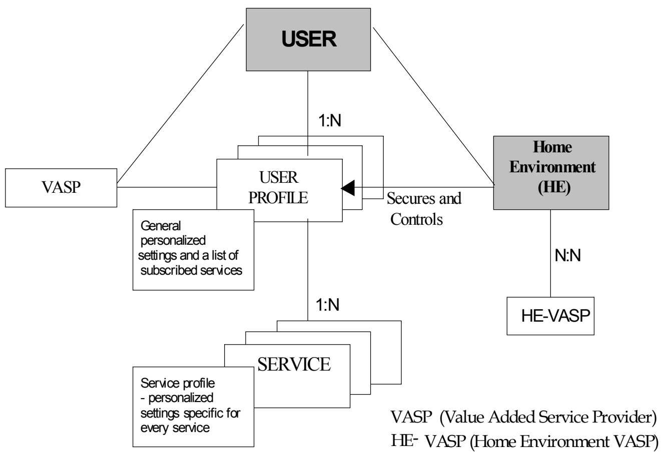

Figure 1. Logical VHE Role Model (user's view)

The terminal representation should be intuitive and any limitations indicated to the user when terminals change. Services that are available/unavailable should be displayed in a way that is familiar to the user, no mater what class of terminal (mobile phone, PC, etc.) is used.

III. SPECIFYING TERMINAL CAPABILITIES

The terminal profile specifies hardware and software capabilities and characteristics of a terminal. It can be stored at the terminal or at the manufacturer's server. Storing of profile at the server might seem easier to implement, especially for the terminals that are already in use. The problem is that the cost of bringing such profile to terminal would have to be settled by the user, and that is not acceptable.

Apart from storage, there is a question of unified format of terminal profile, which could be used for all comparisons and searches requested. The proposed language is CC/PP.

CC/PP [3] is an RDF (Resource Description Framework) based framework, introduced by W3C as a standard for describing device capabilities. RDF is a language designed by W3C (World Wide Web Consortium) for describing the metadata (data about the data). Although RDF is a general concept, not tied to any specific format, it is practically always encoded in XML (eXtensible Markup Language). CC/PP is designed to work with a wide variety of web-enabled devices, from personal computers, laptops, WAP (Wireless Application Protocol) phones, handheld computers, to specialized browsers for users with disabilities. CC/PP profile can contain various information, such as screen size, color depth, available audio and video codecs etc. Here is a simplified example of a CC/PP profile:

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:ccpp="http://www.w3.org/2000/07/04-ccpp#">
<rdf:Description rdf:about="TerminalProfile">
   <ccpp:Component>
      <rdf:Description rdf:about="ProcessingCapabilities">
            <rdf:Description rdf:about="ProcessorType">
            <name>P3 800</name>
            <MIPS>1066</MIPS>
      </rdf:Description>
      <rdf:Description rdf:about="Memory">
            <value>256</value>
      </rdf:Description>
      <rdf:Description rdf:about="DisplaySize">
            <x>1024</x>
            <y>768</y>
      </rdf:Description>
      <rdf:Description rdf:about="ColorDepth">
            <value>32</value>
      </rdf:Description>
      <rdf:Description rdf:about="SoundOption">
            <value>16</value>
            <stereo>yes</stereo>
      </rdf:Description>
   </ccpp:Component>
</rdf:Description>
</rdf:RDF>
```

IV. IMPLEMENTATION DESCRIPTION

This section describes one possible VHE use-case, and offers an implementation based on mobile agents. The basic scenario that this example tries to deal with is the case when user wants to use a terminal that doesn't normally belong to him/her (visited terminal) and is therefore not personalized according to his/her preferences. This can be some sort of a public terminal, terminal borrowed from a friend etc. VHE requirements specify that users should be presented with the same usage "look and feel", regardless of the currently used terminal, within its technical limitations.

There are several problems that have to be solved in order to satisfy those requirements. First of all, a secure way for the user to contact his/her HE (Home Environment) and to supply authentication data has to be established. After that, HE has to get a hold of the visited terminal's profile, which describes its capabilities and limitations, either from the terminal itself or from a manufacturer's site. User's personal service profile has to be compared to terminal capabilities, and only those services that can be executed on the visited terminal have to be filtered out. After all the groundwork is done, the selected services have to be delivered to the user at the visited terminal. Of course, most of this work has to remain transparent to the user.

Fig. 2 shows a UML (Unified Modeling Language) [4] use-case diagram, describing basic functionalities of the proposed solution, which is based on mobile agents.

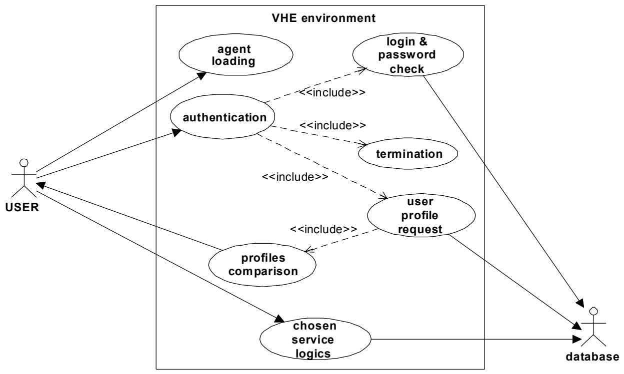

Figure 2. Use Case Diagram of Establishing VHE on the Visited Terminal

Grasshopper agent system [5] was selected, primarily because of its security features. There are two basic security mechanisms in Grasshopper: external and internal security. External security protects remote interactions between the distributed Grasshopper components. It is based on X.509 certificates and the SSL (Secure Socket Layer) protocol. SSL is an industry standard protocol that makes use of both symmetric and asymmetric cryptography, and therefore provides confidentiality, data integrity and mutual authentication of both communication partners [6]. Internal security protects agency resources from unauthorized access by agents. It is mainly based on Java security mechanisms. The described implementation uses SSL to protect all data transferred over the network.

The basic element of the proposed architecture is the VHE server, placed in the HE, whose purpose is to support VHE provisioning to roaming users. For the needs of this scenario, VHE server should contain a HTTP (HyperText Transfer Protocol) or FTP (File Transfer Protocol) server, an active Grasshopper agent system, an authentication database and databases containing user and service profiles.

One of the design goals was to reduce terminal requirements to the minimum, so that the proposed solution can be used from a wide variety of devices. Therefore, all that is required on the visited terminal is an active Grasshopper agent system and a CC/PP terminal profile. Because of simplicity, this implementation presumes that all terminals have their profiles stored locally. This does not present a serious limitation, because the basic concept makes no assumptions of the profile's location, and the implementation can be easily extended to support loading them from network locations. Fig. 3 shows an AUML (Agent UML) deployment diagram of the proposed VHE system. AUML is an extended version of UML used for modeling agent software. The only AUML-specific used in Fig. 3 is the `<<mobile>>` stereotype, which represents agent's migration from one node to another. Additional information about AUML can be found on [7]. This approach makes the mobile agent as lightweight as possible, thus reducing the use of network resources. Further on, authentication database stores logins and passwords for all users belonging to this HE, while user profiles contain a list of general preferences and subscribed services for each user.

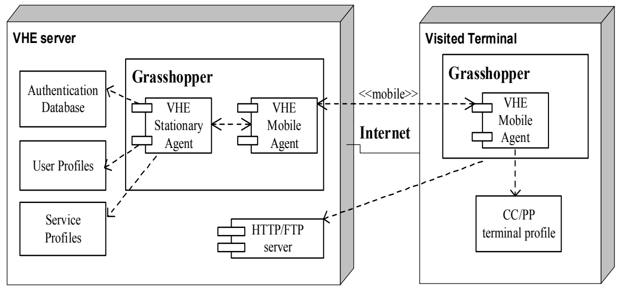

Figure 3. Implementation Deployment Diagram

Each of these services has a separate service profile, which specifies minimum hardware and software requirements that a device must meet to be able to execute that service. Since there is currently no standardized format for describing service profiles, this implementation will use a simple proprietary format. Here is an example of such a service profile:

```
<?xml version="1.0" encoding="UTF-8" ?>
<Profile>
   <Service name="JTextEditor">
      <location>
            http://myprovider.com/services/JTextEditor.jar
      </location>
      <Requirements>
            <ColorCapable>no</ColorCapable>
            <ImageCapable>no</ImageCapable>
            <SoundOutputCapable>no</ SoundOutputCapable >
            <Multimedia>no</Multimedia>
            <DateTime>yes</DateTime>
      </Requirements>
  </Service>
</Profile>
```

This profile also specifies the URL (Uniform Resource Locator) where service logic is placed, which does not necessarily have to be local. What exactly "service logic" contains depends on the type of the service, e.g. for a Java service it could be a .jar file and a script for running it (.bat or .sh), while for platform specific services it could be a single executable file. Fig. 4 shows an AUML sequence diagram which describes the behavior of the system when authentication is successful. Stereotype `<<stationary>>` shows that agent is stationary, with the location at the top of the arrow.

Once on the visited terminal, user initiates the creation of a mobile agent, which is loaded from a HTTP/FTP server in the HE. User has to supply the exact URL from which the agent can be loaded, but this is the only information he/she needs to know to establish VHE on the visited terminal. This is in line with the requirement that the procedure must remain as simple as possible to the user, since knowledge of a single URL, preferably in an easy to remember format (e.g. http://providername.com/servicename), is a rather reasonable request. After the mobile agent is created on the visited terminal, it offers an authentication GUI (Graphical User Interface) to the user. When the user enters the login and password, the mobile agent takes them and the terminal profile back to the VHE server. A stationary agent on the server takes over the information from mobile agent, and searches the authentication database.

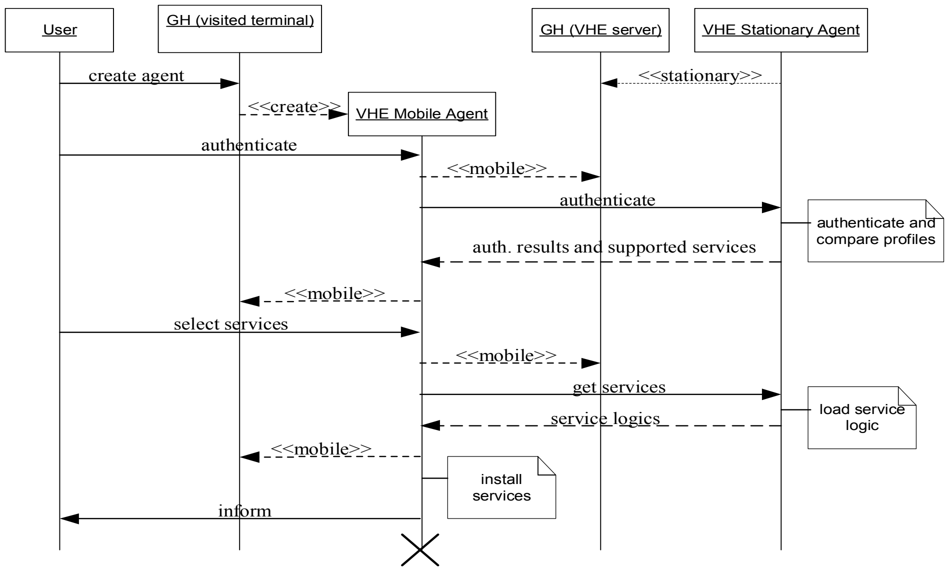

Figure 4. Sequence Diagram of Establishing VHE on the Visited Terminal (successful authentication)

If authentication fails, i.e. if the supplied login and password are not found in the authentication database, the mobile agent returns to the terminal with an appropriate notice for the user, and removes itself from the terminal. If authentication succeeds, a personal profile belonging to the specified user is reached and compared with the terminal profile brought by the mobile agent. The result of this comparison is the list of services that are both specified in the user profile and are supported by the terminal. However, the user might not want to use all of those services. Therefore, the mobile agent returns to the terminal and presents the list of supported services to the user. After the user selects desired services, mobile agent goes back to the server and contacts the stationary agent with the list of required services. Stationary agent loads those services and gives them to the mobile agent, which goes back to the terminal, installs them and informs the user how to start them. Finally, mobile agent removes itself.

V. CONCLUSION AND FUTURE WORK

This paper studied the VHE concept. After introducing the basic model of VHE, service mobility has been identified as one of the main requirements for personal mobility. A subset of service mobility issues, related to availability of personal service environments across terminals with different capabilities, has been studied in the rest of the paper.

An experimental solution for the problem of personalizing user's environment on a visited terminal has been developed and tested in a laboratory environment. The proposed solution is based on mobile agents, which perform all of the interactions autonomously. That way the complex parts of the procedure remain transparent to the users, so all they have to know is a single URL from which the agent can be loaded. Special emphasis is put on handling of the heterogeneity of available terminals, in a way that user profiles are filtered out to include only those services that can be executed on the visited terminal, due to its technical limitations. Terminal profiles are described in CC/PP format, which is a W3C standard for describing device capabilities. Security issues have also been addressed, by using SSL for exchanging confidential information across network.

Future work will concentrate on extending the use of mobile agents, by introducing additional intelligence, thus allowing more complex adaptations of user's working environment. Additional models will be developed for describing pre-defined contracts between different service providers, which would enable automatic VHE provisioning, instead of waiting for user request. Further on, security architecture will be improved to make use of smart cards and PKI (Public Key Infrastructure), which would allow use of digital signatures for authentication, instead of password-based approach currently used.

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