Provision of VHE Services to Roaming Users

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Abstract: **Towards the deployment of 3rd generation systems, Virtual Home Environment (VHE), stemming from 3GPP, appears to be a powerful concept advocating the provision and delivery of personalized services to roaming users across network and terminal boundaries. This paper aims to expose the pathway for materializing the VHE concept, via the specification, implementation and evaluation of a prototype. Core aspects for realizing the concept such as the business and roaming models are presented, while a VHE enabling architecture utilizing key technologies (OSA/Parlay, MExE, and USAT) is introduced. The proposed architecture has already been evaluated by performing an initial trial demonstration. Currently it is being extended to support VHE service provision to roaming users, an aspect to be addressed by the final trial.**

Index Terms: **VHE architecture, business model, VHE roaming, UMTS, parlay/OSA, demonstration topology.**

I. INTRODUCTION

In the perspective of satisfying the growing demand for providing 3rd generation services in the future competitive telecommunications market, Virtual Home Environment (VHE) appears to be a key concept. It promises roaming users the ability to access a large range of personalized services over heterogeneous telecommunication networks, whatever their location or terminal, while always experiencing the same service environment. Several standardization bodies, such as 3GPP [1]–TTC [6] are working on the specification of the VHE, while several research projects have also elaborated on the validation of the VHE concept. IST project VESPER [7] is one of them and has acted as the motivation for the work presented in this article. Within its framework, a VHE enabling architecture was defined and validated in terms of an initial prototype, while currently the research is focused on the realization of the final prototype addressing a full range of VHE features. This paper aims to expose the main structures that serve as a basis to the realization of the VHE concept. The paper is organized as follows: Section II presents a short overview of relevant research carried out on the VHE concept and service provision during the last four years. Section III proposes a business model for the provision of VHE services and Section IV introduces the elaborated VHE architecture along with a brief description of the supporting technologies. Section V provides a VHE roaming approach. Section VI describes the first trial results and the design of the final trial. Finally in Section VII, conclusions are drawn and future plans are exposed.

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II. OVERVIEW OF THE VHE RELATED RESEARCH WORK

As VHE is an important concept for the provision of 3rd generation services, much effort has been spent worldwide towards its materialization. Apart from the standardization bodies, individual research and projects have been conducted, aiming to define VHE architectures and associate them with the appropriate enabling technologies. Some of these attempts to specify and realize the VHE are presented in this section.

In [8] it is supported that TINA platform can constitute an intelligent service platform providing multiple value-added services to the PSTN and the Internet. The Mobivas project [9] defines an architecture providing 3G services with many VHE features and coping with major issues like accounting, authentication, security and mobility management. Article [10] introduces MExE, WAP and HTTP-NG as building blocks for the realization of VHE and presents the MASE platform of the ACTS OnTheMove project, which enables roaming across different networks, terminal independence and personalized and location-based services. In the TRUST project [11], the concept of terminal reconfiguration is being researched as means to meet users' needs in their environment. Several researchers have proposed the usage of Mobile Agent (MA) Technology for the realization of the VHE concept and have defined service architectures based on it. Such a mobile agent-based VHE architecture in a UMTS environment is presented in [12]. Also, in the SOMA project [13], MAs are used for personal and terminal mobility support, while the CAMELEON project [14] demonstrated a full VHE architecture utilizing MAs. A similar approach is proposed in [15], while [16] describes a VHE architecture based on stationary agents. Moreover, [17] presents a VHE architecture, where the service logic is downloaded from the home network to the Service Control Point of the serving network and the mobile terminal. Eurescom's P809-GI project [18] deals with the VHE concept elaborating on the convergence of fixed and mobile networks, while P920-GI [19] uses the Mobile IP for mobility management in an all-IP network, offering Web-based VHE and seamless services across different access networks. A VHE architecture following 3GPP's approach is described in [20], along with the enabling technologies and some mobility scenarios, which cover important service portability aspects.

VESPER project offers the architectural framework for integrated solutions on the provision of VHE services. It provides the means to address personalization of service environment, terminal- and network- adaptation, service portability and session mobility for roaming users. Powerful technologies (Parlay, MExE, and USAT) are included in the realization of the system, while MA technology is utilized when necessary i.e., in media adaptation and provision of QoS. The project's results are frequently passed on to the aforementioned standardization bodies

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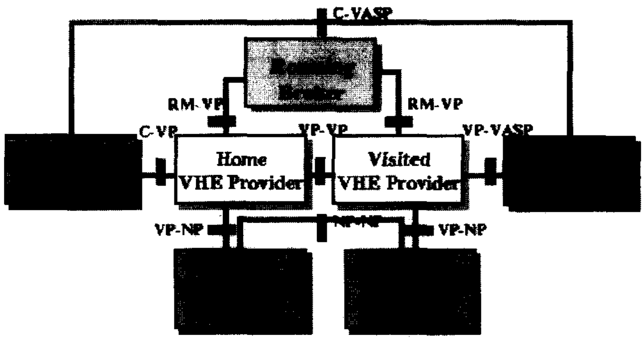

Fig. 1. Business roles involved in VHE provision.

through the appropriate channels.

The first VHE products and services are already available. An Operating System and Management Platform called MSS [21], for example, provides an end-to-end solution for providing value-added mobile services with VHE features. The Multi Media Services Environment [22] offers full service portability over networks and terminals, while mobile service platforms like [23] are now enabling the creation of VHE featured mobile portals.

III. BUSINESS ROLES IN VHE PROVISION

This section proposes a business model describing the physical entities involved in VHE provision and usage, as well as the interfaces between them. This model is elaborated according to the 3GPP vision for next generation service provision, while acting as a basis for the VHE architecture to be described. Fig. 1 depicts the proposed business roles.

Following both the 3GPP [24] and TINA [25] approach the proposed actor utilizing the provision of the VHE is the Consumer. The Consumer addresses both the properties of an End-User and a Subscriber that can physically exist on the same entity or on separate ones. To make use of VHE services, Consumers are obliged to establish a contractual relationship with a VHE Provider (VP) offering VHE functionality. The VP controls and manages user subscriptions and profiles, service registration, accounting data and service sessions. The VP represents the long-term business role to which the legacy role of operator may evolve. The VP may either be a Home VP (HVP) or a Visited VP (VVP) for a Consumer, depending on whether he/she has a subscription established with the specific VP or not and will be analyzed in detail in Section V. The VP offers a suite of services available by third parties named Value Added Service Providers (VASPs) that have contractual relationships with the VP. The VASPs could be mainly content providers (e.g., Video on Demand, language translation, speech to text, entertainment information provider) or providers of interactive applications. To obtain and control the requested connectivity, a VP uses services offered by a Network Provider (NP). The NP is independent of the VP and in roaming there is the Home NP (HNP) and the Visited NP (VNP), serving the Consumer in the Home and the Visited Domain respectively. Finally, the Roaming Broker (RB) is the role proposed for handling all necessary functions (regulatory, economic and technological) to support global roaming of end-users across disparate domains. Other approaches that have been presented in the past, as far as the VHE business roles are concerned, are reported in [26], [27].

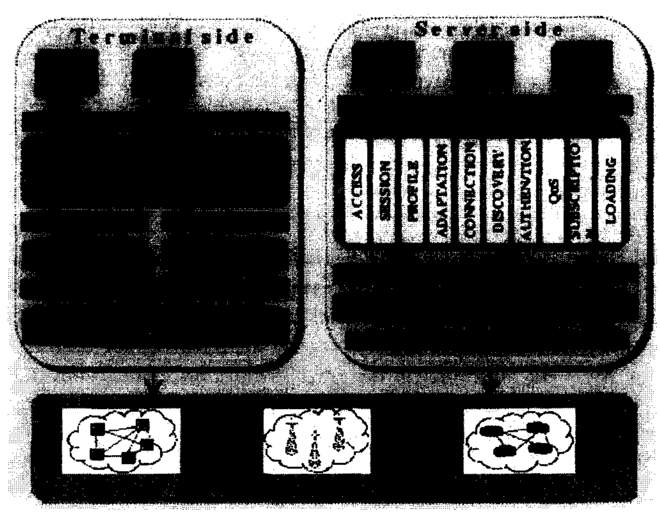

Fig. 2. VHE architecture.

IV. A VHE ARCHITECTURE

The connectivity path between the server and the terminal in VHE service provision is presented in Fig. 2, as well as the different types of access networks.

The VP provides VHE functionality through the VHE Components, which offer specific VHE APIs for applications. VHE server side components take advantage of the underlying network functionality via the OSA/Parlay APIs, while VHE terminal side components make use of the core terminal functionality via the USAT or MExE APIs. The described architecture addresses different types of networks: IP Networks (wired or wireless), Mobile Networks (GSM, GPRS, EDGE, and UMTS) and Fixed Networks (PSTN, ISDN, xDSL...).

The basic features of toolkits supporting VHE provision are briefly described here:

Open Service Architecture (OSA)/Parlay: 3GPP and the Parlay Group share the view that 3G services architecture should be layered and have standardized the interfaces between the network and the service layer in this perspective. The currently aligned OSA/Parlay interfaces [28], [29] distinguish between the network and the service execution and allow applications to access the full functionality of the network, as well as some generic support functions, in a secure way, independently of the underlying network technology. The offered functionality includes call control (generic single-party calls, multi-party, conference), user interaction, messaging and mobility services (user location and user status).

SIM Application Toolkit (SAT)/USIM Application Toolkit (USAT): SAT/USAT [30] provides a standardized execution environment for applications stored on the USIM/SIM card and the ability to utilize certain functions of the supporting Mobile Equipment (ME). SAT/USAT allows applications in the USIM/SIM to interact with any ME that supports the specified mechanism(s), independent of the involved manufacturers and operators. A transport mechanism is provided, enabling applications to be downloaded and/or updated.

Mobile Station Application Execution Environment (MExE): MExE [31] provides a flexible and secure application environment for 2.5G and 3G mobile devices. It specifies a set of requirements on a standard execution environment for applications in Mobile Stations (ME plus SIM card) and requirements for such applications to interact with service providers (addressing charging and security aspects). MExE currently classifies devices in four classmarks, aiming to address the wide and diverse range of current and future technology and terminals that will use wireless communication and provide services.

Based on the above architecture and technologies, a first prototype was implemented, in order to test and validate the VHE concept. Three services were chosen upon their ability to demonstrate well the basic VHE features: service personalization, user, terminal & service mobility, adaptation to terminals & networks and service continuity. These services are: Multimedia Delivery Service [32], Calendar Service [33], and Customer Care Service [34].

V. THE VHE ROAMING PERSPECTIVE

VHE is an important portability concept of 3G mobile systems. A roaming model on service provider level is needed in order to support VHE service provision to roaming users. Service and network provision are distinct in the VHE context, in the sense that even though the same stakeholder can offer both of them, the interface between service level and network level should be clearly defined. In this section a VHE roaming approach will be presented, while some advantages and open issues of this approach will be identified.

Our approach is aligned with 3GPP objectives and claims to address the interests of both network and service providers, in a quite balanced manner. In order to meet the requirements imposed by IMT - 2000 family and the UMTS Forum for a global provision of the Home Environment to a user, there is the prerequisite of establishing roaming agreements, either VVP to HVP or VNP to HVP. Currently, when two networks need to inter-work, they setup a bilateral roaming agreement based on the standard GSM MoU agreement. This involves opening a signalling connection for C7 MAP messages between the networks, and a commercial settlement procedure for exchanging billing records and net charges within set timeframes. Typically this procedure takes 2-4 weeks to setup, test and put online. If the VNP has an explicit roaming agreement with the HVP of the visited End-User, all interconnection details can be settled among the involved parties: HVP, VVP, HNP, and VNP. However, the given permutations of potential stakeholders' roaming agreements in the desired global roaming environment call for a more dynamic, real-time mechanism.

Dynamic roaming agreements may be established through the use of the RB [35], which means subscribers are entitled to widespread mobility support through all mobility providers contracting with the RB. As already mentioned, the RB will offer all necessary functionality (regulatory, economic, technological...) for the global roaming support of end-users across disparate domains. This role needs to be focused on the present roaming demands as interpreted in the 3GPP/UMTS environment [36]. The RB will not necessarily be a new organisational role that takes the responsibility, as it may be a federative mechanism distributed amongst HVP and VVP, HNP and VNP roles that ensure what is manifested in the RB role. In our approach, the VHE provider considers both types of agreements, a directly established bilateral roaming agreement or one established through an RB.

The initial contact of the user is always to the HVP, where he/she is authenticated and authorized to the Home domain. The Roamer Agent entity, established within the HVP, dynamically selects the most appropriate VVP to serve the user while roaming. Its decision is based on location, QoS, bandwidth, traffic, charging, User Profile (UP) and user statistics criteria. Of course users may also manually select any available VVP they like.

There are three VHE service control mechanisms proposed for roaming users [20].

1. *Home Domain Control.* In this scheme, direct service invocation is performed under the home network control. The VHE service provision will present the same "look and feel" as the one within the home domain, although the visited network might not be able to support the desired service. The service logic and its execution, the UP and service-related data are maintained by the HVP. No relay/transit function is to be performed by the VNP's service control element, while VVP is not required to have a service control platform attachment. There is the possibility of interacting with capabilities offered in the ME (e.g., USAT, MExE). Selected components may be downloaded directly into the ME. This approach supports a relation between software objects running on the mobile terminal and the HVP server. The service execution may take place within the USIM or the ME.
2. *Visited Domain Control.* This scenario requires the service logic and UP data to be downloaded from the HVP and stored to the VVP. The execution of the service will be affected by the requested service profile data. Other data relevant to the service can be retrieved from the HVP. An agreement shall allow the VVP to download and execute the service logic on demand and delete it, when it is no longer necessary. Users may modify their personalized service data while no interaction with the HVP will be required. This approach supports a relation between software objects running on the ME and the VVP.
3. *Distributed Control.* In this scheme, the service logic is shared between the HVP and the VVP. If the HVP allows it, it is possible to download the service logic, the UP information and the service-related data to the VVP and execute the service logic within the VVP's infrastructure. This case may propose an "end-to-end signalling association" to be established between the ME and the HNP call control element, for call and service control purposes. This approach supports a relation between software objects running on the mobile terminal, the HVP and the VVP.

In this paper, we propose a hybrid service control scheme for the provision of VHE services to roaming users. In our ap-

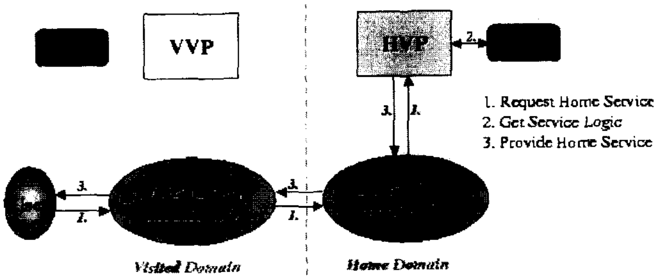

Fig. 3. Provision of home VHE services to roaming users.

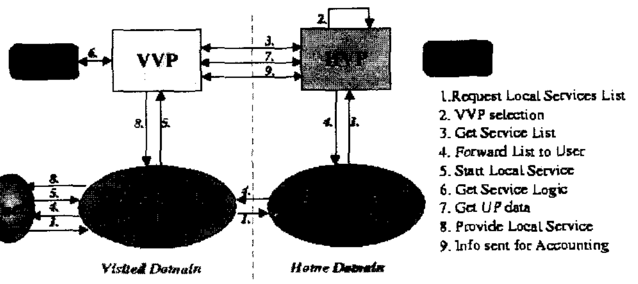

Fig. 4. Provision of Local VHE Services to roaming user.

proach, a distinction is made between the Home Services that have no similar ones offered by the VVP and the Local Services provided by the VVP. The scheme could be identified as an expansion of 3GPPs roaming ideas to the provision of Local Services. The HVP maintains full control of the Home Services that the user has subscribed to at home. Nevertheless, the user will also be able to access of the Local Services of his/her preference. When the user requests for a new Local Service or for similar-to-home Local Services, like location-based services, the service provision will be controlled by the VVP. Downloading of the service logic from the HVP to the VVP will not be necessary in any case. However the UP data downloading from the HVP and temporary maintenance by the VVP will be inevitable, so that adaptation of the service environment to user preferences is achieved at Local VHE Service provision. In both scenarios, it is assumed that the user is already connected to the HVP and has performed a successful login.

PROVISION OF HOME VHE SERVICES

Fig. 3 illustrates the Provision of Home VHE Services to roaming users. The scenario does not involve any information exchange between the VVP and the HVP or the user terminal. All home subscribed services not available by the VVP or involving the maintenance of personalized data within the VASP infrastructure, will be provided according to this scheme.

PROVISION OF LOCAL VHE SERVICES

Fig. 4 presents the involved roles within this scenario, when the user chooses to get a list of Local Services and the Home VHE Provider informs him/her about the ones available. This information could be sent on user request, or automatically at bearer registration or VHE Provider login time. Then he/she decides to make use of a Local Service. An overview of the information flow is also depicted.

In this case, when the user requests for a Local Service, the call is directly delivered to the selected VVP that retrieves the necessary service specific UP data from the HVP. The HNP or the HVP are not involved until the user terminates the service usage. Then the relevant accounting information is sent to the HVP so that the one-stop-shopping requirement of the VHE is fulfilled. Examples of Local Services that may replace similar home services are: (i) location based services, depending almost completely on the user location, (like weather forecast/report service, tourist or city entertainment guide) that would have no value provided from back home and (ii) services that require continuous transmission of high volumes of data (like multimedia delivery service) that would present an unacceptable cost and QoS level when provided by the HVP.

Some of the advantages of the proposed roaming scheme are: (i) Discovery, access and usage of Home Subscribed Services and Local Services in a personalised manner are fully supported, (ii) Home Service Environment Control, except for the location-based or multimedia services where a Visited Service Environment Control is proposed, (iii) The initial access and login to the VHE is always performed through the HVP without endangering authorisation/security-sensitive user data, (iv) The complex Inter Service Environment Roaming with the necessary co-operation between VPs is only necessary if the user requests for a Local Service, thus the overhead due to information exchange between VPs is low, (v) There is the opportunity for direct revenue generation from visiting users (inbound roamers), (vi) Everything is accomplished without any download of the Service Logic Modules to VVPs, (vii) The QoS provided is acceptable in any case as the high bandwidth required in the provision of particular services is a criterion to replace a Home Service by a similar local one and (viii) Combined and unified billing for the usage of Home and Local Services is provided.

Open issues that need to be further examined in this approach for service provision to roaming users are: (i) Accounting policies and models that support charging the usage of Local Services, (ii) VHE Subscription management and implications of online registration for new services in the visited domain, and (iii) The possibility of session hand-over between VASPs enabling suspending and resuming from different VASPs is to be examined (in this issue the compatibility of service models arises). The accounting and subscription models designed for the second trial address the first two issues by introducing two new entities for Accounting and one for Subscription Management. The "VVPvheAccountingContext" and "VisitedVASPvheAccountingContext" entities will gather the necessary information for charging Local Services usage and VASP content. Based on this information, the Accounting Component will then calculate the fees for each VP and VASP and pay them, deducting the total cost from the Consumer's account. The "TempVVPvheSubscription" entity will be used to accommodate the user's requests temporarily, when he/she registers online for a new service in the visited domain. Finally, as far as the session hand-over between VASPs is concerned, no efficient solution has been found yet. The service standardization work of the 1990's has not been widely accepted by the industry and market, therefore the compatibility of future service models is still questionable. It will be interesting to see whether and how this issue will be addressed in the future market. The only case for which there are efficient solutions is that of distributed replicated servers of the same VASP that use identical service logic.

The roaming model presented in this section is to be validated by the final trial, in an effort to demonstrate the feasibility of the VHE concept also for roaming users requesting the delivery of services outside their home domain. Some other research teams have also proposed interesting roaming models in the context of VHE provision in [37]–[39].

VI. FROM THEORY TO PRACTICE

A prototype VHE implementation was produced in the first phase of VESPER project. Even though various types of telecommunication networks will eventually be addressed (i.e., UMTS, IP, PSTN, ISDN, and GSM), the first trial was executed exclusively on an IP network. It took place in November 2001, in a laboratory of the National Technical University of Athens. In this section we will describe the VHE functionality demonstrated in the initial trial and the additional features to be presented in the final trial. A complete analysis of the first trial is presented in [40] and is out of the scope of this paper. However, an overview of the trial topologies and some important configuration details are given below.

Before determining the VHE architecture, the VHE requirements depicting the VHE features were defined and classified. The first trial demonstrated a substantial part of the VHE features. This trial aimed to demonstrate the feasibility of the Kernel Architecture, addressing the following core VHE requirements: (i) Adaptation to different terminals [41], (ii) Personalization of the Service Environment (User Interface Profile, Service Preferences) and (limited) Profile Management [42], (iii) Network Connectivity using Parlay (limited to HTTP, H323) [41], (iv) Session Management (supporting multiparty VHE service sessions) [43] and (v) Independent service development (i.e., not depending on Access & Authentication mechanisms, Profile Management, types of terminals and networks) [44]. The applicability of the specified kernel service elements was tested and validated on a single technological infrastructure, namely an IP network and various kinds of terminals with network facilities including both wired and wireless local transport resources. A Parlay/OSA Gateway, an H.323 Gatekeeper and the VESPER VHE Connection CORBA Component handled all connections. Several servers were installed and configured, i.e., one for the VHE functionality and one for each demo service. The Gateway (Siemens Parlay @vantage Gateway), the Gatekeeper, all server and client machines were connected to the IP-network via a Cisco Catalyst 1900 Series LAN Switch, supporting SNMP. The terminals included: multimedia PCs (with Web browser, WAP simulator -Nokia WAP Toolkit 2.0- and an H.323 client -MS NetMeeting), a Compaq iPAQ H3600 PDA and two Siemens optiPoint 300 basic H.323 enabled IP phones for user interaction during the demonstration.

The test cases, as described in [44], were carried out successfully in the end, after two phases of integration. A demonstration can often give substantial feedback to a project, but the real experience comes from the final stages of the implementation and the integration itself. That is when the most important mistakes and problems seem to appear. In our case, the greatest problems stemmed from our optimistic initial estimation of the effort needed for the integration of the CORBA VHE server/client components with the Parlay Gateway, the service platform and the three services. At the beginning of the project, we didn't really have any alternative, but for the next stage, we will have to consider replacing CORBA and the service platform with pure Java components. Of course, such a choice would mean more implementation effort, but the latest versions of Java could guarantee interoperability. In any case, there is a lot of work to be done on the remaining VHE features for the final prototype. These are: (i) Connectivity to different networks and service-to-network adaptation, (ii) Roaming (user/terminal mobility & network roaming), (iii) Subscription and accounting models, (iv) Content adaptation & QoS support, (v) Session mobility & continuity (suspend/ resume) and (vi) Service discovery & registration (static & dynamic).

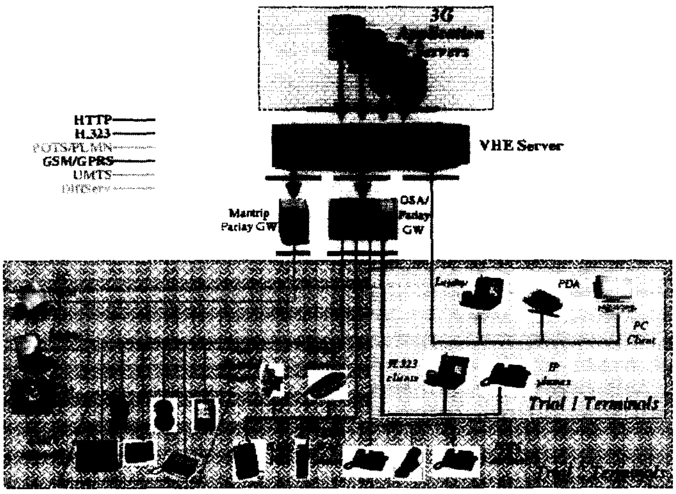

Fig. 5. Topology of the trials.

The demonstration topology and the initial trial infrastructure are depicted in Fig. 5. The applicability of the specified VHE components and architecture is to be tested at the beginning of 2003 on a heterogeneous network infrastructure involving: IP, DiffServ IP, GSM, UMTS, ISDN, PSTN, and PLMN networks. The types of terminals that will be used are: PCs & laptops, plain and GPRS-enabled PDAs, IP phones, UMTS terminals, POTS devices and WAP enabled, Java enabled and GPRS enabled GSM phones. Two Parlay Gateways are to be utilized for the final trial: the Siemens Parlay @vantage Gateway and the MANTRIP [45] Parlay GW (supporting interconnection only with IP DiffServ Network). Four locations are foreseen for hosting the VHE servers: Aveiro, Lisbon, Berlin and Athens. Portugal Telecom's CC3G infrastructures are to be used. The purpose of this trial is to demonstrate the functionality of the complete VHE prototype and the solid feasibility of the VHE 3G concept. With regards to the evaluation and validation of both prototypes, a final VHE architecture will be reached addressing all VHE requirements. This architecture will be disseminated to the appropriate standardization fora for the enhancement of VHE, OSA and Parlay standards.

Table 1. Acronyms – Abbreviations.

VHE	Virtual Home Environment
MA	Mobile Agent
(H/V)VP	(Home/Visited) VHE Provider
VASP	Value Added Service Provider
(H/V)NP	(Home/Visited) Network Provider
RB	Roaming Broker
OSA	Open Service Architecture
(U)SIM	(Universal) Subscription Identification Module
(U)SAT	(U)SIM Application Toolkit
ME	Mobile Equipment
MexE	Mobile Station Application Execution Environment
UP	User Profile

VII. CONCLUSIONS AND FUTURE PLANS

The initial VHE trial of the IST-VESPER project demonstrated the applied research carried out and validated the proposed Kernel Architecture. It proved the feasibility of the VHE concept via many multi-terminal and multi-protocol scenarios over an IP-network in a lab environment. Roaming capabilities, adaptation to heterogeneous networks, session mobility, subscription management and one-stop shopping accounting support are to be incorporated in the final prototype. The feedback from the trials will help us improve the specified VHE architecture and design more efficient OSA/Parlay and 3rd party services.

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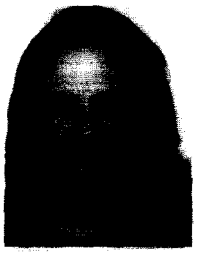

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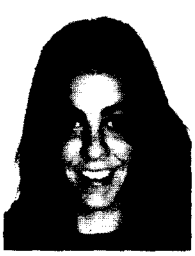

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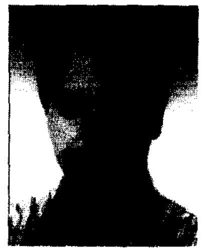

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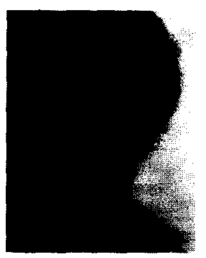

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