

Multi Agent System for Establishing 'Virtual Home Environments' in the convergence of fixed and mobile telecommunications networks

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Abstract

This paper proposes a multi-agent system using an Intelligent Network trigger for implementing a Virtual Home Environment (VHE). VHE is the ability to roam between telecommunication networks and still experience a consistent set of services, thus "feeling" on a familiar home network. Network operators are increasingly supplying value-added services and this trend is likely to accelerate rapidly in the mobile domain when third generation mobile, Universal Mobile Telecommunications System (UMTS) becomes available. UMTS aims to build on and extend the capability of today's mobile technologies by providing a far greater range of services over fixed and mobile networks. Services are likely to include high speed Internet access, electronic mail, interactive education, home shopping and on-line banking. The research described in this paper is concerned with the preliminary analysis and design of an agent approach to the provision of the VHE. The agents in the system will focus, in particular, on negotiating service functionality and optimising effective routing paths.

1 Introduction to UMTS¹

Telecommunication network operators are increasingly supplying value-added services, as a result of customer demand and as a way of differentiating their network on a basis other than price. This trend is likely to accelerate rapidly in the mobile domain when third generation mobile, Universal Mobile Telecommunications System (UMTS), becomes available. UMTS follows on from first generation mobile systems, which brought analogue voice communications, and second generation systems, such as GSM, which provided users with international roaming, flexibility and digital security [1]. UMTS seeks to build on and extend the capability of today's mobile technologies by providing increased capacity, data capability and a far greater range of services over fixed and mobile networks.

Telecommunications will become a combination of fixed and mobile services to form a seamless end-to-end service for the user. The key differentiators between UMTS and second-generation systems are:

- combined and consistent access to services from all networks;
- personalisation of service to customers through adaptive terminals;
- open systems for the creation of new services and applications on demand;
- support for multimedia services with high capacity voice, data and video support.

UMTS is being promoted internationally by ETSI (European Telecommunications Standards Institute), CEPT (the Conference of European Post and Telecommunications Administrations), UMTS Forum and the European Commission. It has the support of the major fixed and mobile network operators and the manufacturing community. It will initially use radio spectrum around 2GHz partly allocated globally and partly allocated regionally for Third Generation mobile use and will be the European implementation of a global family of mobile systems known collectively as IMT 2000 - "International Mobile Telecommunications 2000" [1]. UMTS is conceived as a global system, comprising both terrestrial and satellite components. With new terminals, a subscriber will be able to roam between private and picocellular/micro-cellular public networks, then into a wide area macrocellular network and finally into a satellite mobile network (see figure 1). This could be followed by a complete change over onto a fixed network during a call with identical service representation.

Speech will remain the dominant service for many years but users will increasingly want advanced data and information services [2] and a number of key new services have been proposed as a result of greater bandwidth and enhanced network intelligence. Services are likely to include high speed Internet access, electronic mail, interactive education, home shopping and on-line banking and

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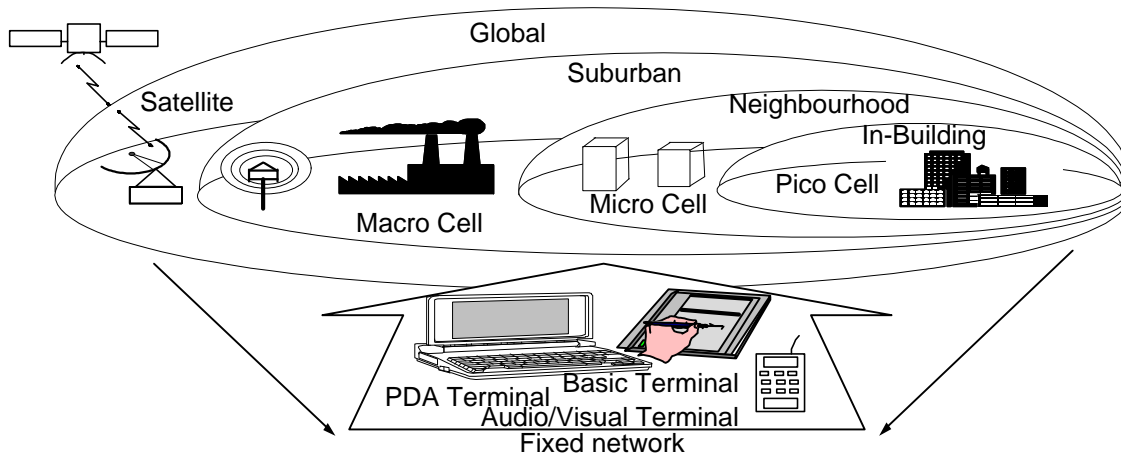


Figure 1 Integrated Mobile and Fixed Networks

entertainment services. The simplest of these services are call-divert and voicemail, but seamless access to email and FAX facilities of the office or home and more advanced facilities such as voice recognition, database access and videoconferencing are likely to be required. One problem that inhibits the take-up of these services is the difficulty that users have in dealing with different access techniques for the same services when accessed from different networks. Another problem occurs when the local networks do not support the services that a user has subscribed to in a home network. One of the applications being introduced through the UMTS network is The Virtual Home Environment (VHE). The VHE will attempt to make the 'user experience' of the services identical, wherever access is made.

In this paper we propose a Multi Agent System for the provision and support of the VHE. Section 2 describes what will be expected from a VHE followed by the benefits of using intelligent agents explained in section 3. Section 4 focuses on the physical architecture of a converging telecommunications network and introduces Intelligent Networking (IN) principles into the VHE provision. The proposed agent architecture is detailed in section 5 and section 6 concludes the paper.

2 What is Virtual Home Environment?

For a VHE it is envisaged that the user will have a mobile terminal that may be designed for mobile or fixed use. The user will be able to customise services and their presentation, and will be able to maintain these even when roaming to other networks on a global platform [1, 2, 3]. UMTS will offer a consistent service through a Virtual Home Environment. The expectation will be for a range of services each selected in a uniform way with consistent

procedures, performance and quality irrespective of the:

- means of access (mobile or fixed);
- application (cellular, cordless, paging, satellite, etc.);
- service provision (public or private);
- environment (home, street, transportation, office, shop, etc.);
- location (service area or global);
- terrain (urban to rural to mountain).

When roaming between networks (fixed and mobile) a personal user will experience a consistent set of services thus "feeling" on their home network. The user will appear to have identical services offering familiarity and ease of use. Currently if a user is on a foreign network only the local network operator functionality and "look and feel" is experienced or a subset of the features is available. From the user's perspective the VHE scenario enables transparent access to subscription-based services when roaming. There will be one global access environment for the user that will be familiar, simple, and effective – to the user it appears identical. From the network perspective, however, the VHE implementation scenarios may require several technical developments and commercial agreements.

Fixed network mobility is expected to have developed considerably by the time UMTS is introduced. Personal numbering and personal profiles will be available as customer services; these lead to the idea that customers on fixed networks will no longer be identified primarily by a particular geographical location or by a physical network termination point.

Service creation and provision is seen as fundamental to the success of UMTS [1]. It is planned that the network, together with the user's personal profile should define the

services required and that these should be maintained even when roaming to other networks. Functionality will be negotiated with the visited network, so that it will provide "home-like" service in a potentially alien environment.

Complete standards and specifications for the VHE are yet to be defined. The main technical problem with a Virtual Home Environment is to provide the same services, globally, in a consistent environment. Considerations when modelling the VHE must include common call processing, common service processing and service interaction between mobility processes, invoking changes without the need for human interaction from the telecommunications provider and security and authentication control.

3 Agents as a Tool

Currently, there are projects investigating mobile agent-based services in fixed and mobile telecommunication environments [4, 5, 6]. However, mobile agents require a highly secure execution environment, which could limit their performance and functionality in telecommunications applications [7]. There is an overhead with the messages for intelligent stationary agents but in a telecommunications environment this may not outweigh the security issues and overheads raised by using mobile agents. Therefore it is proposed to develop a solution using stationary agents.

Extensive definitions and overviews of agents can be found in [8, 9, 10] and their application in the telecommunications field is well documented in [11, 12]. VHE is a service that can exploit the properties of agent technology – autonomy (to make decisions without human assistance), reactivity (to perceive changes and react accordingly), pro-activity (to have goal oriented behaviour) and social ability (to interact with other agents to achieve goals). A Multi-agent system (MAS) is a collection of agents with specific roles within an organisational structure [13]. It provides a high level paradigm whereby agents can assume roles within the VHE application area and also provide robustness against failure due to their distribution across networks. Multi-agent systems provide a combination of local reactivity and global planning. Each agent may be specialised at solving a particular aspect of the VHE (e.g. translation of '192') while a complex task (e.g. service provision across various network platforms) could be achieved through communication and co-operation amongst agents. Agents could provide accurate monitoring and quicker and more efficient local decision-making regarding the use of resources [14] (e.g. when negotiating service functionality for the VHE or optimising effective routing paths). By

using agents, provision of the VHE can dynamically evolve, adapt and therefore improve performance measurements over time.

Agents are being used in other work related to this area including:

- Cameleon (Communication Agents for Mobility Enhancements in a Logical Environment of Open Networks) is an ACTS project focussed on developing a Java-based Mobile Agent Framework to prototype chosen end-user services and to show the feasibility of a mobile-agent based VHE approach [15].
- Grasshopper is a mobile agent development and runtime platform that is built on top of a distributed processing environment [4]. Several ACTS projects involved in UMTS are using Grasshopper.
- On The Move is developing a mobile multimedia service environment for UMTS. This environment, the MASE (Mobile Application Support Environment), is being designed to control quality of service for providing the full variety of adaptive personalised mobile multi-media applications [16].

4 IN as a Trigger to the VHE

GSM has successfully automated inter-operator roaming with the provision of basic, standardised service sets [17]. The GSM complete system specification has enabled operators to rapidly deploy feature rich networks, however differentiation through original services has been reduced. The GSM community has addressed this problem via the development of the GSM CAMEL (Customised Applications for Mobile network Enhanced logic) feature [18]. CAMEL is the integration of Intelligent Network (IN) techniques into the GSM network that will enable an operator to provide specific services when a subscriber is roaming. CAMEL uses evolved IN capability [19].

It is proposed that the IN will act as an intermediate layer between converging telecommunications networks to provide an interface to a multi-agent system for the VHE as shown in figures 2 and 3. IN functionality is being developed by both fixed and mobile network providers to separate the mobility and service layer from the switching layer. One of the prime technical aims of UMTS is to separate out the mobility and service support layer from the transport and switching layer [20]. The IN architecture provides several important advantages, like the opportunity to create or modify network capabilities without any changes at the switches. This provides speed of deployment and flexibility to the network operators. However, due to the rising number of users and the increasing number of IN services, improvements are

required. The IN architectures are effectively centralised, complex and difficult to handle [21]. The functionality in the areas of service creation and management is insufficient and real interoperability of services is difficult to achieve. IN development using agents has already been undertaken [22].

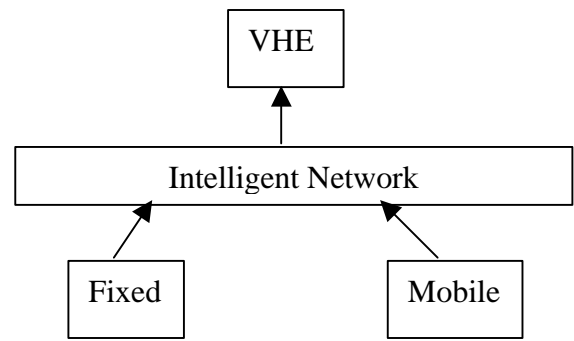
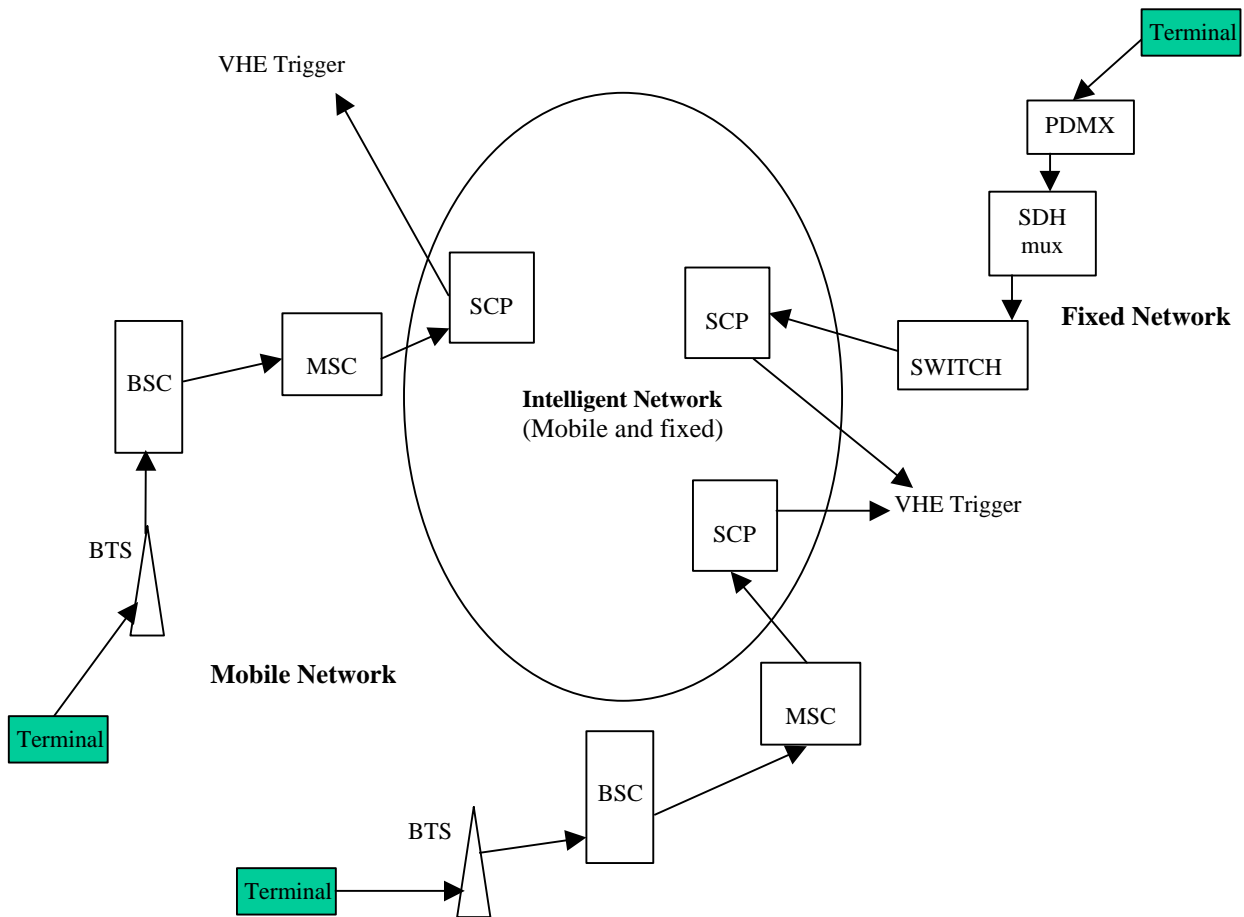


Figure 2 An IN platform triggers the MAS Virtual Home Environment



Key

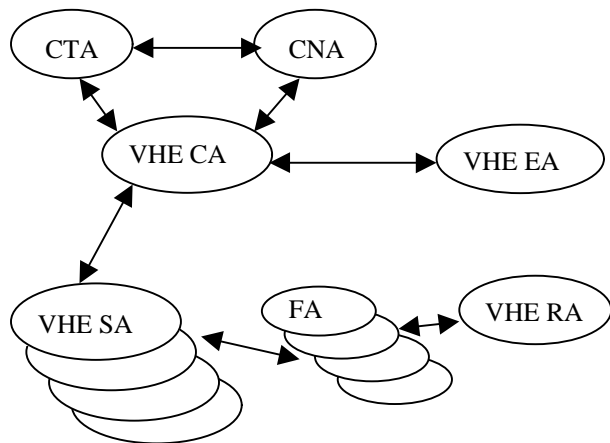
- BTS Base Transceiver Station
- BSC Base Station Controller
- MSC Mobile Switching Centre
- SCP Service Control Point
- SDH Synchronous Digital Hierarchy
- PDMX Programmable Digital Multiplexer

Figure 3 Physical Network Architecture

5 Proposed Agent Architecture

A customer terminal agent will be housed in each terminal. The terminal will be used for fixed or mobile service. If the terminal is mobile and is switched off or loses a connection then the control will automatically be given to a Customer Network agent. The customer network agents will then negotiate on behalf of the customer terminal agent until the mobile is back on-line and gains control (refer to figure 4).

When a VHE is requested by either of the customer agents a VHE Controller agent will negotiate to enable the features required for that particular service within the VHE (always to the customers “look and feel”). This can be negotiated from the home or preferably the visited networks. Each service is made up of features. An agent represents each service and each feature. A feature agent may incorporate a routing function if required for that feature. Routing will need to be optimised; especially if a call needs to be routed back to a home network. If required within a feature agent then a VHE Routing Agent will be used to find the most effective path. An Emulation agent will be working for each VHE controller agent. If negotiation fails to provide service as requested the emulation agent is responsible for providing a backup for the user with the consistent “look and feel”.



Key	
CTA	Customer Terminal Agent
CNA	Customer Network Agent
VHE CA	VHE Controller Agent
VHE EA	VHE Emulation Agent
VHE SA	VHE Service Agents
VHE RA	VHE Routing Agent
FA	Feature Agents

Figure 4 Agent Interaction Relationships

The VHE Controller agent will continue to negotiate with the local service agents to provide the features for the next request for the VHE, even though emulation may have been needed in the previous instance. The immediate goal of the VHE controller agent will be to manage a VHE service agent to provide a consistent service. VHE Controller agents will be part of the Service Provider. Service and feature agents could be service provider or network operator.

From [9], the complete architecture of a multi agent system applied to a specific environment is divided into two levels:

- The architecture of the whole system that defines how the agents communicate between themselves, coordinate their activities, negotiate in an overall plan and resolve conflicts.
- The internal architecture for each agent.

The two levels will need to be evaluated for the most suitable implementation architecture for the VHE.

6 Conclusion

This paper has focussed on using a multi agent system to design a VHE in a UMTS environment for converging networks. The main technical problem with a Virtual Home Environment is to provide the same services, globally, in a consistent environment. VHE could be achieved using a set of protocols but they remain fixed and will not have the autonomy, reactivity and interactivity that MAS offers. We are currently at the design stage of this work with future stages including an investigation into the advantages and disadvantages of using a simulator, an agent framework or a novel alternative approach.

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