Mobile Extranet Based Integrated User Services (MOEBIUS)

C. Blondia[1], O. Casals[2], A. Dyson[3], E. Monticelli[4]

[1]University of Antwerp, Dept. Mathematics and Computer Science
Universiteitsplein 1, B-2610 Antwerp - Belgium
Tel: +32 3 8202404, email: chris.blondia@ua.ac.be
[2]Polytechnic University of Catalunia, Dept. Computer Architecture,
Gran Capitan, Mod. D6, E-08071 Barcelona – Spain
Tel: + 34 93 4016985, email: olga@ac.upc.es
[3]Medgate AG
Medgate AG, Gellertstr. 19, Postfach, CH-4020 Basel, Switzerland
Tel: +41 61 3778844, email: anthony.dyson@medgate.ch
[4]Siemens Information and Communication Networks
Via Monfalcone 1, I-20092 Cinisello (Milano) - Italy
Tel: +39 02 2733 7391, email: emanuel.monticelli@icn.siemens.it

ABSTRACT

The IST project MOEBIUS (Mobile Extranet Based Integrated User Services) [6] is developing a platform for remote access to intranet services using mobile access technology and investigating its performance characteristics to demonstrate the advantages for health care and business applications. This paper deals with three important aspects the project is dealing with: the MOEBIUS network architecture, the applications and mobility management in future MIPv6 networks.

I. INTRODUCTION

Recently, we may observe the explosion of the concept of Intranet and, as a natural evolution, of extranet, allowing the access to relevant (private) information by closed user groups over the public Internet, making use of the internet communication paradigms. This availability of services over an extranet is intrinsically coupled with the need for personal and/or terminal mobility, leading to the notion of Mobile Extranet.

The IST project MOEBIUS (Mobile Extranet Based Integrated User Services) [6] is developing a platform for remote access to intranet services using mobile access technology and investigating its performance characteristics to demonstrate the advantages for health care and business applications.

This paper deals with three important aspects the project is dealing with: the MOEBIUS network architecture, the applications and mobility management in future MIPv6 networks.

The MOEBIUS project identifies and integrates a mobile service platform using state of the art technology (such as Mobile IP and GPRS) provided with the appropriate security mechanisms required to support a variety of applications. This is discussed in Section II.

The mobile extranet concept [5] creates the opportunities for patients to have more responsibilities for their health care decisions. If patients are provided with a client terminal that is highly mobile and permanently connected and reachable, new types of communications become possible, such as automated time-based or event-based notification schemes, informing a physician of important clinical developments, prompting a patient to take a certain action. In Section IV, two trials involving patients with several health problems are described.

The requirements of permanently connected and reachable mobile patients impose new challenges to future network infrastructures. Current research efforts seem to focus on providing an “all-IP” end-to-end solution with QoS support in an environment of heterogeneous networks, both wired and wireless. Layer 3 mobility management schemes that support IP services transparently in a highly heterogeneous infrastructure independent of the underlying physical layer are discussed in Section V.

II. MOEBIUS NETWORK ARCHITECTURE

The MOEBIUS architecture can be divided in four main sections: (i) Mobile Station, (ii) GPRS Access Network, (iii) Internet Public Domain, (iv) Private Internet.

The **Mobile Station (MS)** is composed by the Terminal Equipment (TE) and the Mobile Terminal (MT). The Terminal Equipment is the part of the user equipment independent from the particular type of access network, e.g., PC, palmtop. The Mobile Terminal is a GPRS Mobile Terminal.

The **GPRS access networks:** the GPRS access network provides the wireless access to MS and consists of the following network elements.

- the Base Station System (**BSS**), that is the access element of the GPRS network terminating the radio protocols and connecting to the core elements
- the Serving GPRS Supporting Node (**SGSN**), that is the node serving the Mobile Station. When the MT attaches to the network, the SGSN creates a record containing information regarding mobility and security
- the Gateway GPRS Supporting Node (**GGSN**), that is the node terminating all GPRS protocols. It is the interface between the GPRS System and the Internet Public Network. The GGSN could support edge-router specific functions and could have connectivity to several ISPs or corporate networks. From the Internet point of view, the GGSN can be considered as a normal IP router.

The **Internet Public Domain**: In the Internet Public Domain, the ISP-m and the ISP-a have been distinguished. They are respectively the ISPs providing access to the PLMN and to the Intranet. The transmission of packets from and to the mobile through the Internet involves the GGSN of the GPRS network and the firewall/gateway (FW) of the Intranet.

The **Private Intranet**: it is the site containing the server part of the applications. The relevant elements are:

- *The Firewall*: this component provides firewall functions, such as access control, authentication and content security. All these functions are enhanced with functionality typical for the Intranet infrastructure (e.g. tunneling, SVN).
- *The Application Server (AS)*: this component provides the information and services offered to an Intranet user. The information and services are accessible for a trusted terminal both inside and outside the Intranet infrastructure.
- *The WAP Gateway*: this component allows a mobile terminal with display and bandwidth capacities to easily access the Intranet information.
- *The Home Agent*: this is a server of the Intranet where the TE address is known as co-located.

IPv6 protocol is the key protocol used in the MOEBIUS Architecture. From the TE to the Application Server IPv6 is used at the Network Level. Obviously IPv6 is encapsulated in IPv4 in native IPv4 network (The Public Internet). IPv6 has many advantages that in a Mobile Scenario bring some interesting added values: Secure Transport (IPsecv6), Mobility Management (MobileIPv6). IPsecv6 and MobileIPv6 are at the base of the MOEBIUS environment.

III. THE MARA APPLICATION

MARA is an extranet business applications characterized by the following attributes: (i) the support of real-time interactions with customers, (ii) complex transactions with multiple input and output dialogs, (iii) a GUI typically provided by a Web/WAP browser, (iv) business logic accessed via Web/WAP servers, (v) communications over the mobile data network, e.g., GPRS network, or internal corporate LAN, (vi) designed for users with a common business purpose.

Through the extranet solution it is possible to realize a 'virtual company': a company whose actors are distributed all over the world, and are mobile.

MARA (Mobile Applications for Remote Access) offers a virtual environment to various classes of users, such as salesman force, management, trusted customers, giving to each of them the access to the business information and services according their need and regardless of their physical location.

The information is stored in central databases inside the Intranet protected from access by unauthorized users.

The players who interact with MARA are the customers, the salespersons and the managers. An overview of the actions performed by each player is given in Table 1. The characteristics of each role are as follows:

Salesman: The principal users of MARA are the salesmen. They are mobile users visiting their customers in person. To do their job efficiently, they need access to customer and order information any time, from wherever they happen to be. The salesman has a list of customers with whom he works, and he interacts with MARA using the handy or portable equipment (PDA/Laptop with GPRS mobile equipment). The salesman interacts with the system in order to look up information regarding the customers, and to make new orders. He may submit orders for his own customers, and may check the status of these orders. He may also manage the personal data of his customers, and has access to the product catalogues and current stock levels.

Customer: The customer is associated with a zone and a salesman; the authority can grant the customer to submit orders directly. The role of a customer is to read his own records and to submit orders for items on the standard or a custom price list. He is also allowed to check the status of his own orders. Customer normally are not mobile, but it is of advantage to them to access the MARA order database, so that they can place a new order for an item on their own customized price list, and check their own order status.

Manager: The manager is the chief of salesman force and has full access to all information and services provided by MARA. Managers are in charge of the salesman force. They can access all functions to manage price list, seller's list and customer's list.

MARA represents an instance of the more generic Extranet application. The principle behind MARA could be applied to any generic applications requiring data service mobility and the secure access to data.

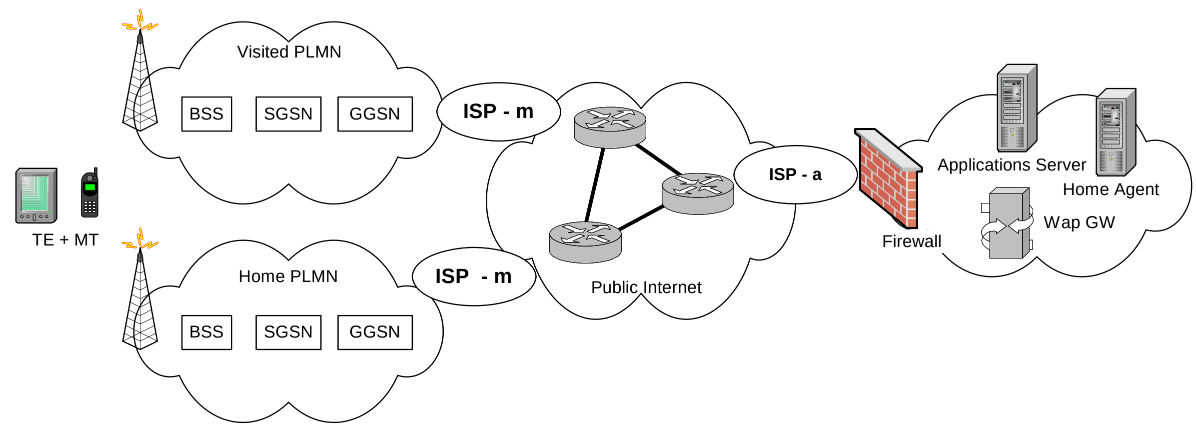

Fig 1 : *MOEBIUS Reference Architecture*

	Reads own Record	Reads record of somebody else	Read standard price list	Read own custom price list	Submit Orders based on not own custom price list	Submit Orders based on own custom price list	Read own Order Status	Security Admin
Customer	✓	✗	✓	✓	✗	✓	✓	✗
Salesman	✓	✗	✓	✓	✗	✓	✓	✗
Manager	✓	✓	✓	✓	✓	✓	✓	✗

Legend: ✓: GRANT ✗: DENY

Table 1: Roles and Role Players.

Note that in some cases the reading of data may be partially granted. For example, a customer may only be granted access to only certain parts of his/her records.

IV. THE HEALTH CARE APPLICATION AND TRIAL

A. Integrated Mobile Health Care Solution

The major emphasis in the MOEBIUS health care applications is on innovative approaches to therapy and disease management, in which communications technology is leveraged in order to provide advantages for both patient and doctor over the course of a particular therapy. These applications form just part of a larger disease management framework, which we refer to as an *integrated mobile health care solution* (IMHCS).

An IMHCS provides, amongst other things, highly available communication mechanisms to enhance the exchange of information between a patient, his physician, and an associated center of competence (CoC). The CoC would typically be a large hospital or university with expertise in the relevant therapeutic area In our case, the University Hospital Basel fulfils this role. Communications are facilitated and coordinated through a medical contact center.

The information exchanged between patient, physician and CoC can be medical data (textual or numeric), images, or voice.

B. The Healthcare Trials

MOEBIUS included two clinical trials, in which an IMHCS was used to manage a patient group over a period of between 6 weeks and 4 months.

The Risk Reduction Trial (RRT) was a program to reduce cardiovascular risk factors. In this program, the participants were provided with education regarding such risk factors, physiotherapy, dietary advice, medication, and a means to track their own progress. The integration of these various therapy aspects, and the necessary coordination of the health care professionals who provided each of them, was a critical factor.

In the Anti-Coagulation Trial (ACT), patients who were already subject to medicated anticoagulation were provided with a means to measure and track their current status from home. These measurements supplemented, rather than replaced, the standard measurements done in the hospital at the regular anticoagulation clinic.

C .The Healthcare Applications

The mobile extranet applications facilitated a number of aspects of the trials, the most important of which being: (i) the acquisition and transmission of biodata measured by the patient, (ii) monitoring of biodata by patient, physician, and center of competence, (iii) two-way communication between patient and care-giver (physician).

The patients each had a mobile station consisting of the relevant diagnostic devices (blood sugar meter, blood pressure meter, coagulation time meter), a Compaq iPAQ handheld computer running Windows CE 3.0, and a data-ready mobile terminal. Data communication between iPAQ and devices took place over a standard RS-232 cable interface. The mobile terminal was connected to the internet over GPRS where this was available, or CSD otherwise, and was connected to the iPAQ using Bluetooth.

A standalone Java application running on the iPAQ acquired biodata from the sensors and dispatched them to a listener component on the server.

All other interactive functionality was incorporated in a web application, implemented using Java servlets. This was accessed using a standard internet browser, from either the iPAQ or a typical PC. Both patients and physicians were provided with customized views of the current patient records. This included tabular and graphical representations of the acquired biodata, incident reports, status summaries, and so on. In addition, a messaging interface was provided for information interchange between patient and doctor.

An additional feature was an automated notification of both doctor and medical contact center whenever an out-of-range measurement was received. This notification took place both by email and SMS.

Patient records were stored in a centralized SQL database, which was secured against intrusion, whilst simultaneously being highly available to authorized users. A server-side java component provided access to this database for the interactive web applications and the biodata upload listener.

D. Healthcare Trial Results

The RRT ran from September 2001 until February 2002 in the region of Schwyz (CH), with 15 volunteer participants, ranging in age from 19 years to 60 years. In addition to the care provided by the supervising doctor, these participants measured and uploaded blood sugar and blood pressure daily.

The results of the trial are still being evaluated, but it is nonetheless possible to make some preliminary statements. In over three quarters of cases, significant progress was made towards the specified weight loss targets. This was generally accompanied by reductions in blood pressure and stabilization of blood sugar levels. Patients reported that recording, uploading and monitoring these provided them with reliable and immediate feedback regarding their progress, as well as providing extra motivation to stay with the diet and exercise aspects of the program. During the wrap-up interview, the majority expressed satisfaction with the reliability and performance of the technical components, and the desire to continue participating in the therapy program beyond the end of the MOEBIUS project.

Acceptance of the technical devices and compliance with the defined procedures was pleasingly high, even though around half of the participants did not previously have a mobile telephone, and none of them had previously used a handheld computer. This high acceptance can be partially accredited to the intensive 3-hour small-group training session each participant received in the use of the system. Additionally, 24-hour telephone support for both technical and clinical issues was provided by the medical contact center at Medgate AG in Basel.

Although the use of the system from anywhere, via the mobile telephone network, was one of the key requirements in the specification, only 3 of the 15 participants transmitted or viewed data from locations other than their home. Some participants reported that they had no need to do this, others said that they preferred to carry out the various procedures in private. A further factor may have been that the diagnostic devices alone, i.e. separate from the entire client kit, are small and portable and capable of storing a large number of data points. In many cases it was more convenient for the patients to perform transmissions from home, even when the measurements themselves had been done elsewhere.

A full description of usage patterns awaits the completion of the analysis.

The ACT is currently underway, and will run until the end of April 2002.

V. MOBILITY MANAGEMENT IN FUTURE MIPv6 NETWORKS

A. Future Network Architecture

As the number of wireless handheld devices (mobile phones, PDAs, laptops) is growing exponentially, it is anticipated that those devices will become the terminal of choice in the near future. As a consequence, the wireless access network infrastructure will have to support a variety of applications and access speeds resulting in a service with similar level of quality as wireline users. The third generation mobile radio communication systems (UMTS, CDMA2000) use a packet data transfer and switching technology as preferred solution. Migrating from the current 2G systems (GSM), operators have already adopted evolution strategies, commonly referred to as 2.5 G, such as GPRS, which rely on packet switching. At the same time, the research community is investing a major effort to provide an “all-IP” end-to-end solution, a major goal of future 4G mobile systems. 4G systems will support IP services transparently in a highly heterogeneous infrastructure independent of the underlying physical layer.

Future network infrastructures will therefore consist of a set of heterogeneous networks, both wired and wireless, using IP as common network layer protocol. Due to this inherent heterogeneity, IP mobility support will be an indispensable feature of those systems. A major concern is whether IP layer handover latency is limited enough to support real-time services, or more generally, to ensure seamless IP mobility support.

Mobile IP, the current support of mobility in IP networks, has to communicate a temporary Care-of-Address to a possibly distant Home Agent, which may lead to high associated signaling load and unacceptable disturbance to ongoing sessions in terms of handoff latency and packet losses, in particular in an environment with frequent handoffs. Therefore, different solutions using a hierarchical mobility management approach have been proposed (see e.g. [2]). Many of them propose Mobile IP for wide area mobility, while local mobility is handled by more optimized micro-mobility protocols. These protocols should fulfill a number of requirements with respect to simplicity to implement, scalability with respect to the induced signaling and efficiency and performance with respect to packet loss and introduced delay. In the next subsection we discuss a number of the current proposals.

B. Mobility Management Schemes

The different micro-mobility proposals can be classified according to the type of hierarchical mobility they support [3]: (i) hierarchical tunneling or (ii) mobile-specific routing. Hierarchical tunneling [4] is an extension of Mobile IP to support efficiently the micro-mobility. The proposals rely on a multi-levels hierarchy of foreign agents. The packets destined to the mobile host are first intercepted by the home agent and tunneled to the root foreign agent. Each foreign agent in the hierarchy decapsulates and retunnels them as they are forwarded towards the mobile host's point of attachment. Mobile-specific routing proposals avoid the overhead introduced by decapsulation and reencapsulation schemes. In the access network packets are routed using mobile-specific routing without tunneling. Cellular IP and Hawaii are two examples of micro-mobility protocols that use mobile-specific routing.

C. Evaluation of Mobility Management Schemes

In the System Studies work package of the MOEBIUS project, we have studied the performance of two important micro-mobility schemes, namely Cellular IP and HAWAII, both by simulation and analytical modeling. The details of this investigation can be found in [1] and [2]. For each protocol we have developed an analytical model that allows computing characteristic performance measures of the handoff scheme that is used. These measures are related to packet loss and experienced delay. The models that are proposed are simple M/M/1 queueing networks that incorporate propagation delays between routers and processing times within routers. Validation by means of detailed simulation using in the NS simulator have shown the accuracy to the approximation.

The following reference network is used for this analysis (see Fig. 2). A Mobile Host (MH) moves between two Base Station (Old Base Station BSO and New Base Station BSN). Packets originating from the Corresponding Host (CH) reach BSO (resp. BSN) via the Domain Root Router (DRR), the crossover router R0 and the intermediate router R1 (resp. R2).

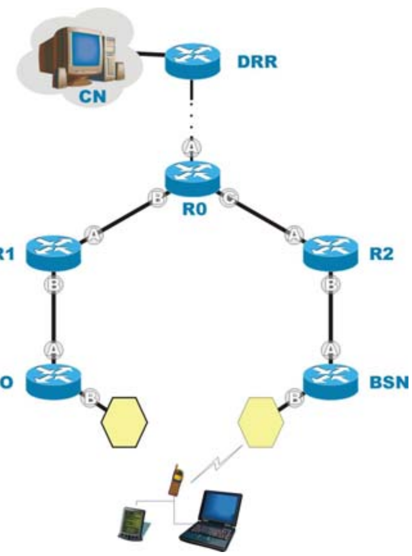

Fig. 2. *Reference Network*

Consider the system presented in Fig. 2., where the routers have a service rate μ of 10 packets/ms, the load of each router is given by ρ=0.8, the distance between neighbouring nodes on the old route (i.e. on the route R0-R1-BSO-MH) is 20 ms and the distance between the neighbouring nodes on the new route is variable, taking

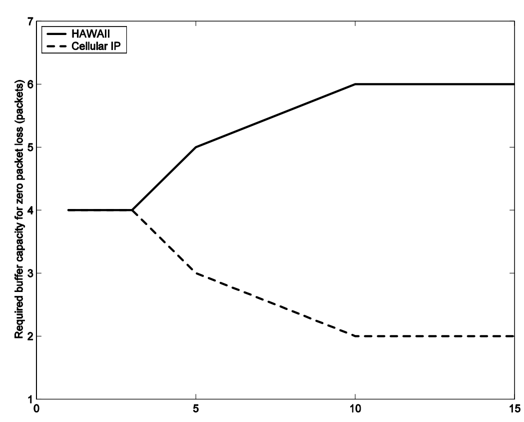

Fig 3: *Comparison of the buffers required in MSF HAWAII and Semi-soft Handoff in Cellular IP*

values 1 ms, 3 ms, 5 ms, 10 ms and 15 ms. We consider a stream of packets arriving at R0 with a constant interarrival time of *T*=20 ms. Fig. 3 compares the number of buffers required in BSO to obtain a zero packets loss, when using the HAWAII MSF scheme with the number of buffers required in R0 when using the Semi-soft handoff scheme of Cellular IP. This result shows that Cellular IP requires less buffers than HAWAII. This is due to the fact that in Cellular IP the buffers are needed to compensate for the time difference between the old path and the new path, while in HAWAII, the buffers need to accommodate packets arriving during a time equal to the sum of the

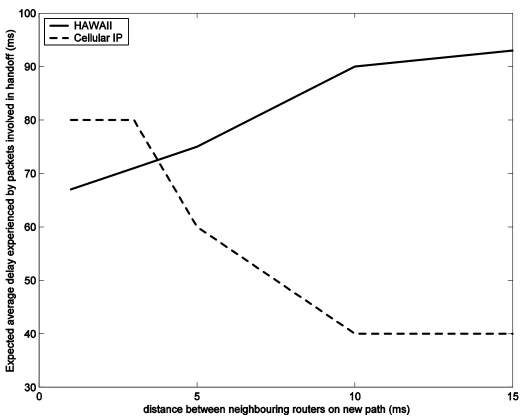

Fig 4: *Comparison of the delay experienced by packets involved in the handoff in MSF HAWAII and Semi-soft Handoff in Cellular IP*

old path and the new path. Clearly, the longer the new path, the more buffers HAWAII requires. Cellular IP on the other hand requires less buffers since a longer new path leads to less difference between the new and old path.

Next we compare the delay introduced by both schemes. Consider again the same system as defined in the above example. Fig. 4 shows that, apart from the case of very small distances between neighbouring nodes, packets in Cellular IP will experience (in average) less delay than packets in HAWAII. Remark however that in this numerical example, we have assumed that the difference in length (in ms) between the old and new path is known. In a real environment, this difference is not known and a conservative (worst case) value has to be selected, possibly leading to much longer delays. Moreover, In HAWAII, not all packets experience the same delay. The first packets may have a much longer delay than the last packets that are involved in the handoff.

VI. CONCLUSIONS

In this paper we have described the business application and the health application together with the clinical trials included in the MOEBIUS project. We have also given an overview of the research work done in the workpackage of System Studies to evaluate the performance of several micro-mobility protocols that could be included in future networks to improve the behaviour of Mobile IP.

REFERENCES

[1] C. Blondia, O. Casals, L. Cerda and G.Willems, “Performance analysis of a forwarding scheme for handoff in HAWAII”, to appear in Proceedings of Networking 2002, Pisa 2002. win-www.uia.ac.be/u/pats/publications.html

[2] C. Blondia, O. Casals, P. De Cleyn and G.Willems, “Performance analysis of IP Micro-Mobility Handoff Protocols”, to appear in Proceedings of Protocols for High Speed Networks 2002 (PfHSN 2002), Berlin 2002. win-www.uia.ac.be/u/pats/publications.html

[3] A. Campbell, J. Gomez, “IP Micro-Mobility Protocols”, ACM SIGMOBILE Mobile Computer and Communication Review (MC2R), Vol. 4, No. 4, pp 45-54, October 2001.

[4] E. Gustafsson, A. Jonsson, C. Perkins, “Mobile IP Regional Registration”, Internet Draft, draft-ietf-mobileip-reg-tunnel-02, work in progress, March 2000.

[5] K. Koutsopoulos, C. Konstantinopoulou, P. Demestichas, A. Dyson, T. Toniatti, M. Theologou, "Establishment of Mobile Extranets with the use of Mobile IPv6 over GPRS", in Proceedings of IST Mobile Communications Summit 2001, Barcelona, Spain, September 9-12, 2001.

[6] MOEBIUS IST project (Mobile Extranet Based Integrated User Services), www.ist-moebius.net