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Autor: Linder, Jan / Blanca, Ferran Moreno

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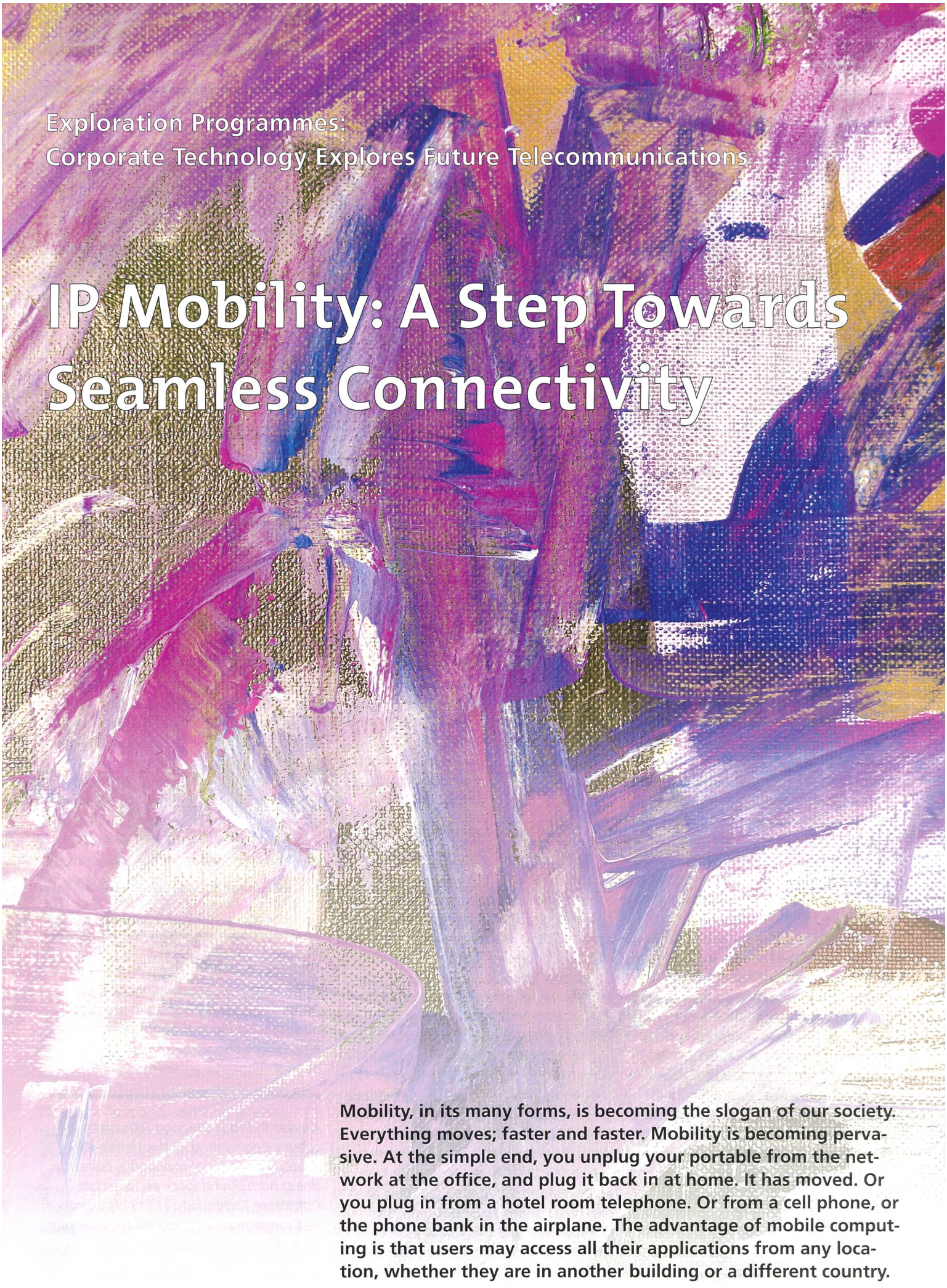

Exploration Programmes:
Corporate Technology Explores Future Telecommunications

IP Mobility: A Step Towards Seamless Connectivity

Mobility, in its many forms, is becoming the slogan of our society. Everything moves; faster and faster. Mobility is becoming pervasive. At the simple end, you unplug your portable from the network at the office, and plug it back in at home. It has moved. Or you plug in from a hotel room telephone. Or from a cell phone, or the phone bank in the airplane. The advantage of mobile computing is that users may access all their applications from any location, whether they are in another building or a different country.

The Exploration Programme "Broadband Communication Opportunities" explored last year new broadband services and communication opportunities enabled by the new 10 Gigabit Ethernet technology, managed all-optical networks, the evolution from ADSL to broadband heterogeneous access networks (fixed and mobile/wireless) and Peer-to-Peer network models.
With its Exploration Programmes, Corporate Technology is exploring telecommunication technologies and new service possibilities with a long-term view of 2–5 years. Further, the expertise built up in the course of this activity enables active support of business innovation projects.

JAN LINDER AND FERRAN MORENO BLANCA

During the last few years the Internet revolution has dramatically changed businesses and the way mobile business subscribers work. The society has gradually moved into an information society where companies and their employees have become more and more dependent on information stored in computer networks. Reliable and flexible access to the company e-mail and Intranet services, as well as to the Internet is a must for most business professionals today.
Simultaneously, the mobility of employees has significantly increased. People are no longer bound to fixed working places; most workers today perform their daily routines in several different locations, such as the office, meeting rooms, airports, hotels and home. Most mobile business subscribers have replaced their old desktop PCs and fixed phones with modern, lightweight laptops and mobile phones which provide an optimal mobile office solution and make it possible to perform daily routines at any location.
In today's cellular networks users do not have to bother about changing SIM cards when they move from one location to another. Applying the same paradigm for mobile data services implies that the user can keep his IP address while moving from one location to another. However, the current protocol IPv4 was not made for mobility; therefore, the basic requirement to enable such a service is Mobile IP add-ons to the existing network infrastructure.
The next version of IP (IPv6) will have new possibilities and mobility will be one of these built-in features. Definitively, there is a vast impact on business when the office goes mobile (fig. 1) and the combination of the two phenomena, Internet and mobility, will radically affect our lives (fig. 2) [1].

During recent years, two major phenomena have dramatically changed the way people communicate. The first one is the rapid growth of the Internet. The second change has been the introduction of mobile communications. The combination of these two phenomena, the Internet and mobility, will radically affect our lives: Anytime@Everywhere & Always On!

One of the main objectives in the Exploration Programme "Broadband Communication Opportunities" was the implementation of a broadband service mobility architecture to demonstrate seamless mobility. Demonstrations of handover in heterogeneous networks (e.g. roaming/handover Ethernet, WLAN, GPRS, UMTS) were performed. For example, the users were able to start a streaming session (Internet radio) from an Ethernet connection in the office, then taking the laptop and moving to a near WLAN private hot spot without losing connectivity and without interruption of the application. Now the reader may imagine situations where someone wants to be always connected, independent of the location (in the office, at home, in a taxi, at the hotel, at the airport …) and independent of the connection type (the usual Ethernet cables, a GPRS phone, a WLAN card …).
This article gives an overview of the prototype implemented in our laboratories and points out the benefits of a solution for seamless connectivity over heterogeneous networks.

Prototype Implementation
In order to get a proof-of-concept of the seamless mobility service, a prototype based on Internet drafts was implemented.
The first step was the study of the new Internet protocol known as Mobile IP, responsible for handling mobility in the IP level. Examining the details of the Mobile IP protocol led to the conclusion that it provided a starting point, but fell well short of the requirements of a complete IP mobility service. First of all a lack of security was evidenced, as the standard

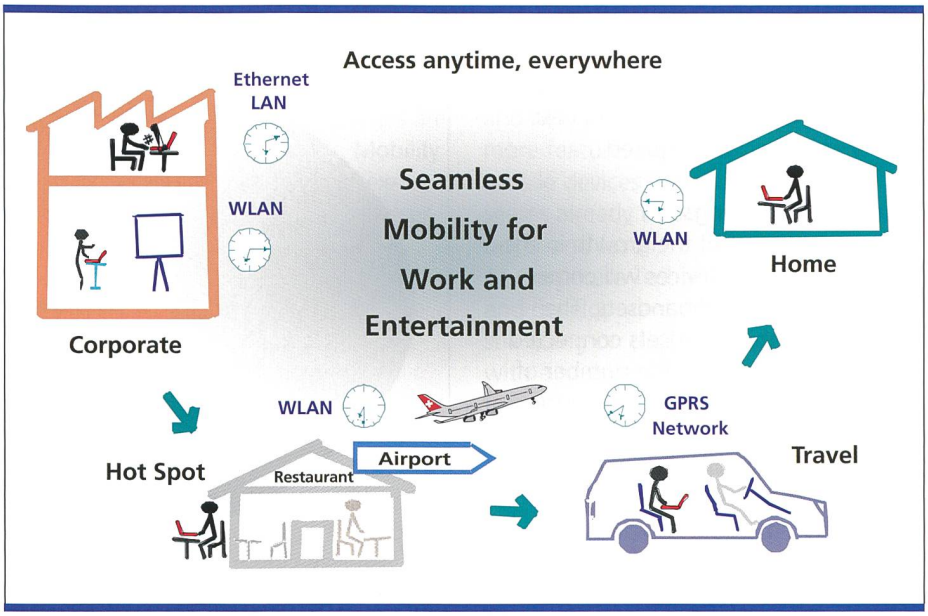

Fig. 1. IP Mobility concept.

was designed for an open Internet with hardly any concern for security or support for private networks. So the next logical step was to look for a way to secure the mobile communications. The new standard for securing data in the IP layer, called IPSec, was the perfect candidate for the purpose. Because the IPSec protocol suite is compatible with the normal IP protocol (IPv4), it is enough to support IPSec on the end systems [2], [3]. The network in between can continue to work just as it works now.

The prototype implementation was intended to be developed on a Linux operating system. Hence, some existing Linux solutions of Mobile IP and IPSec were needed. Dynamics Mobile IP, implemented by the Helsinki University of Technology (HUT), was chosen as a Mobile IP solution. On the other hand, FreeS/Wan, an IPSec implementation for Linux available for free, was selected as a security solution. Both were chosen because of their open source. Many adaptations had to be done before they worked successfully together. The result was a successful architecture able to perform handovers between Ethernet and WLAN technologies (fig. 3).

Because the use and management of available network interfaces are not addressed in the standard, explicitly leaving the user with the "cumbersome" task of managing these interfaces, a new middleware application was defined in order to overcome this issue. The requirements for this module were [4]:

- intelligent management of network interfaces
- support of multiple, heterogeneous networks
- handover decision considering availability, throughput, delay, and cost
- no user interaction required

Results and Findings

An increasing part of the growth in the number of mobile devices will come from web-connected handsets. The number of mobile handsets connected to the Web will exceed the number of PCs connected to the Internet by the year 2003. The convenience of mobile access to information and services everywhere results in an increasing demand for customised mobile Internet access. Technical solutions do not yet exist for ensuring updated routing information and for a relevant name base connection for mobile hosts in a domain name sys-

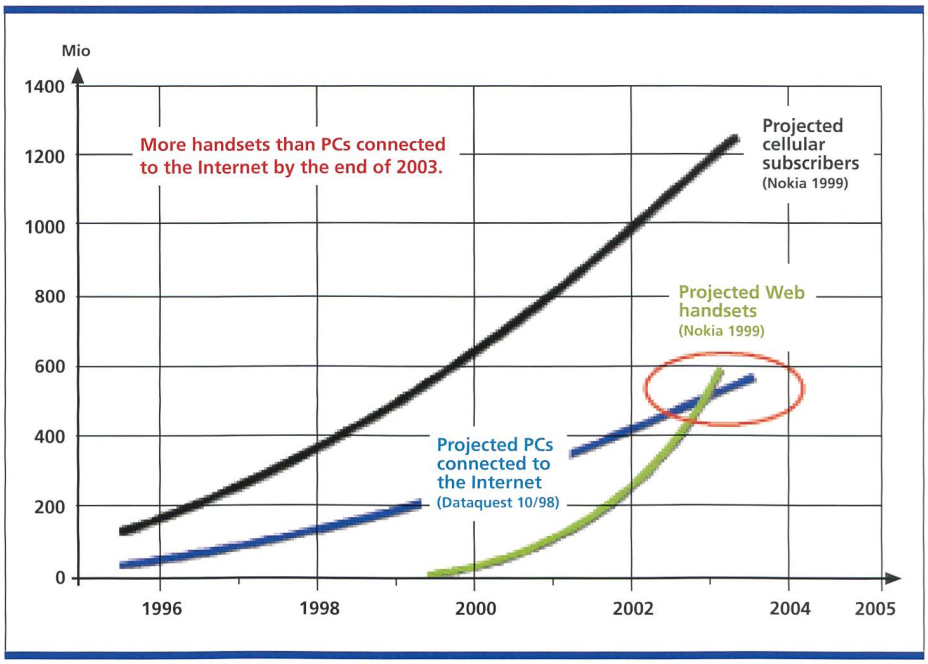

Fig. 2. Mobile-Internet convergence is going to prove a mobility trend.

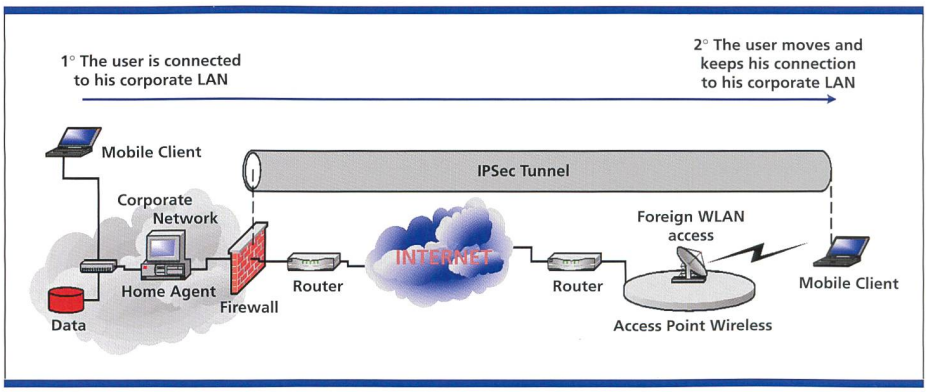

Fig. 3. Logical view of the network infrastructure used for seamless connectivity.

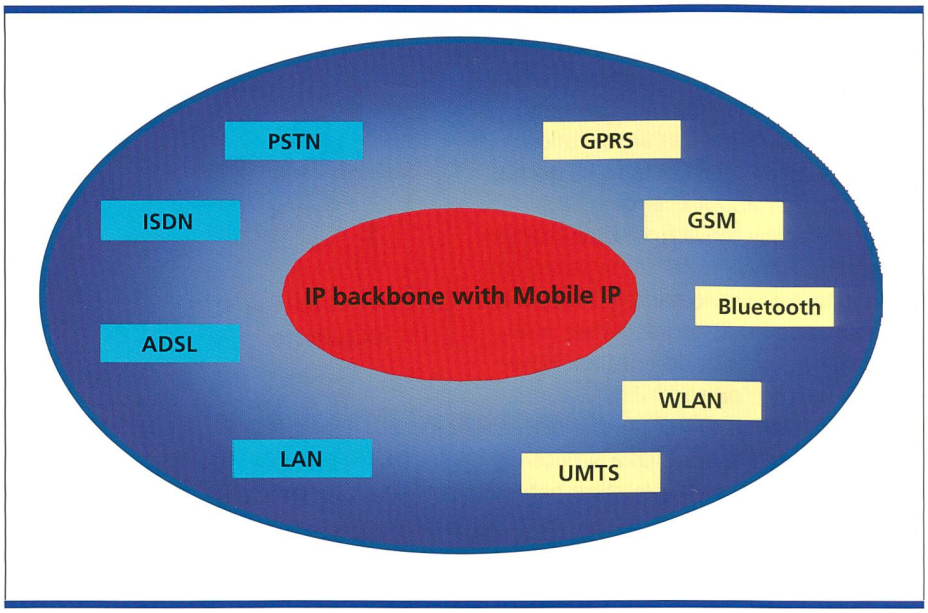

Fig. 4. Mobile IP integrates and complements different technologies.

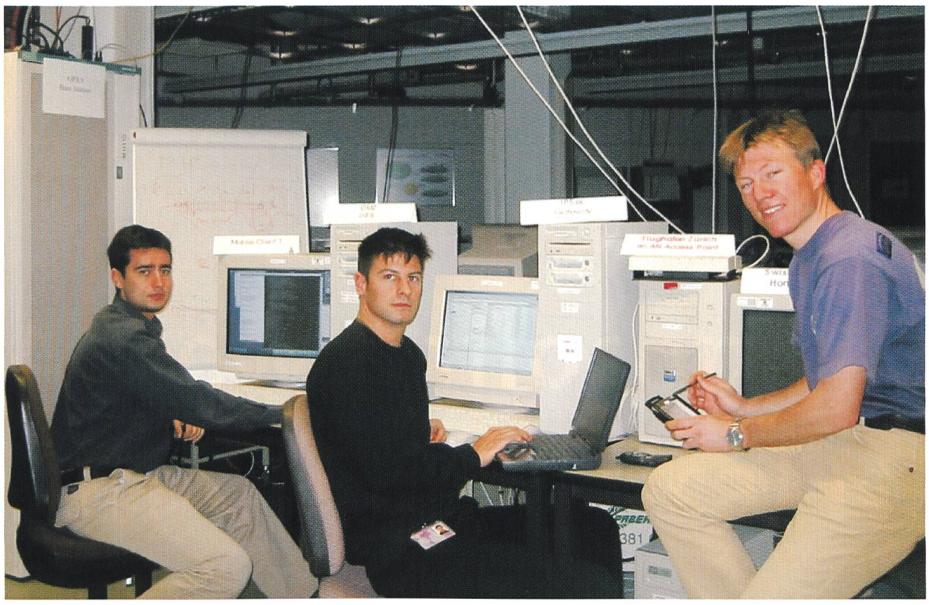

Fig. 5. People working in the mobility lab of Corporate Technology.

tem accommodating millions of constantly moving devices which can be randomly switched on and off. This will be an interesting challenge for the developers of the future Internet and mobile communication technologies.

Although there are no solutions available on the market having all the functionalities explained in this article, such as mobility, security and make-it-simple interface, our work has proved this concept has a great potential to develop new mobile services.

All the demonstrations have been made up of audio streaming applications and the handovers have evidenced poor performance, mainly due to the IPSec module, which needs a lot of time to process the data. The ongoing work is focusing on the integration of micro mobility features in order to improve the prototype. This way the user would be able to use applications like video-conferencing under a WLAN infrastructure.

Nowadays the market is offering very powerful VPN client solutions without any concern about mobility, while the demand for such a service is emerging incredibly fast. With our work we are merging mobility and security aspects into a complete product, ending up with a "Mobile VPN" solution which clearly lies ahead of current solutions.

The key issue solved in this project has been the application independence of the solution, opening the door for new coming technologies and applications and all together respecting the standards (fig. 4).

Conclusions

"Mobility is about more than just cellular phones. It is about providing users with access to services (over IP), whether they are at home, in the office, in a hotel, in their own country or abroad. Mobility means taking your (IP) services with you wherever you are, and cellular networks are only a part of the solution." [5]

This could be a very good definition of what we understand as future mobility and all its implications. Therefore and based on the hands-on experience acquired through the development of the prototype the main conclusions are:

- Cellular operators can propose their global coverage as a value added service and obtain more traffic as users can access the cellular network automatically. How? By using algorithms for heterogeneous handovers between, for example, GPRS-WLAN. No changes are needed at the GPRS network. Mobility propositions would serve as an extended service to the current data services.
- Fixed network carriers can play a central role in mobility. Mobile IP can be introduced easily in their IP core networks. Mobile Agents (FA,HA) just need to be located in the access routers, without any further change on the configuration of these routers. With Mobile IP, core infrastructures for IP can support their full portfolio of existing services and mobile/cellular ones. The fact is that wherever the network is present the fixed network carrier will reach the customer, thus having the possibility to offer mobile services.
- Advantages/Drawbacks for the users: Users can use Mobile IP for seamless roaming for always-on services, or, due to the independence of Mobile IP of the physical layer (wired or wireless), to optimally access their services using the best access network technology at any time. On the other hand, today no operators or independent brokers are offering such a complete mobility service.
- Support for IP roaming has not been at the core of Telco strategies, however, as the range of end-user terminals and applications continues to grow, the limitations of current roaming will become increasingly obvious to users. It will become a significant point of differentiation between carriers.

Outlook

The study of IP Mobility solutions as well as the platform implemented as a demonstrator enabled a lot of visions on future services for mobile units. The integration of different network devices seems to be the next step towards full connectivity. The prototype was tested with Wireless LAN, Ethernet and HSCSD devices and worked well. Tests with GPRS and Bluetooth are already planned. Further work is also being planned to minimise handover delays. The Mobile IP topic is becoming hot nowadays; everybody wants to have full connectivity all the time. Most of the operators' networks are becoming IP networks. The need for the Mobile IP is undisputed. [6]

The development in this sector is amazing. Research institutes and even manufacturers present nearly every week new results on how to communicate faster and new products that have more and more features included. The market for mobile devices and mobile services seems already to be endless and growing faster and faster.

At Corporate Technology, exploration and development of mobility services is still going on (fig. 5). In combination with a middleware that manages the different communication devices (GPRS, Wireless LAN, etc.), a mobile device will be able to maintain all connections without any interruption and without any user interaction. The device would always automatically choose the best network device to connect to the home network. When airports and hotels offer wireless access points mobile users will

connect to the Internet and VPNs with much higher bandwidth than mobile networks such as GPRS or UMTS will ever offer. With upcoming ad-hoc network technologies, the visiting mobile machines will be able to use local infrastructure such as printers, beamers, etc. Several issues have still to be resolved, like real-time application support. Nevertheless the biggest R&D departments are focusing strongly on this topic, proving that mobility services are a real trend. Corporate Technology is convinced that although there is a lot of work in front of us these visions will become reality. 10

Jan Linder *received his master's degree from the EPFL (Ecole Polytechnique Federale de Lausanne) in electrical engineering. He did his diploma work on the development of simulation tools for high bit rate optical network planning. In July 1998 he joined Swisscom, Corporate Technology, where he worked for the next generation simulation tools for network planning. For the past two years, his main activity has been mobility in heterogeneous networks. He is active in different projects to propose solutions for new services using WLAN technology and other access technologies. The projects exploring seamless handover in future heterogeneous network are currently his main focus.*

Ferran Moreno Blanca *is a Telecommunications Engineer from the Universitat Politècnica de Catalunya (UPC), Barcelona (Spain). After working in frequency planning through GIS applications for Retevision in Barcelona, he did his diploma work at Swisscom, Corporate Technology, in the domain of IP mobility. Since November 2001 he has been working as a Research Engineer at Swisscom, Corporate Technology. He is involved in projects dealing with future wireless technologies and his fields of interests mainly concern mobile computing and their impact on our society.*

Links

Dynamics Mobile IP:
http://www.cs.hut.fi

IPSec for Linux:
http://www.freeswan.org

IP Mobility video-demo:
http://ctep.swissptt.ch/ep35/ (Only available for Intranet-allowed users)

European Telecommunications Standards Institute (ETSI): www.etsi.org

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[2] James D. Solomon: "The Internet Unplugged", Prentice Hall 1998.
[3] Charles E. Perkins: "Design and Principles of Mobile IP", Addison Wesley 1998.
[4] Ferran Moreno Blanca: "Advanced IP Mobility Solution", Diploma Work 2001, Swisscom Corporate Technology.
[5] Marc Danzeisen: "Secure Mobile IP communication", Diploma Work 2001, Swisscom Corporate Technology.
[6] MAIN WS Conference in Berlin, April 2001.

Abbreviations

ADSL:	Asymmetric Digital Subscriber Line. Technology that enables rapid transfer of digital information through regular telephone cables.
Bluetooth:	Radio system that allows electronic devices to communicate with each other over short distances without connecting cables.
FA:	Foreign Agent. Software located in a visited network. Responsible to handle and allow connection to incoming visitors.
GPRS:	General Packet Radio Service. An enhancement to the GSM mobile communication system that allows continuous flows of Internet data at rates from 56 up to 114 kbits/s.
HA:	Home Agent. Software located in a home network. Responsible to forward all the data arriving to the location of a home user which is connected to a visited network.
HSCSD:	High Speed Circuit-Switched Data. An enhancement of data services of current GSM networks. It allows to access non-voice services 3 times faster.
IP:	Internet Protocol. Standard which regulates computer connections on networks which are part of the Internet.
IPSec:	Internet Protocol Security. Standard defining a set of protocols to secure communications in the IP layer.
IPv4:	Internet Protocol version 4.
IPv6:	Internet Protocol version 6. Also known as IPng—next generation.
LAN:	Local Area Network.
SIM:	Subscriber Identity Module. A card that contains subscriber identifying data about a user that can be used to gain access to a network.
UMTS:	Universal Mobile Telecommunications System. A so-called "third generation" (3G), broadband, packet-based transmission, offering a consistent set of services to mobile computers and phone users no matter where they are located in the world.
VPN:	Virtual Private Network. Technology arrangement that allows certain users access to a fully operational corporate network via the Internet.
WLAN:	Wireless Local Area Network. A computer network that allows the transfer of data and the ability to share resources, such as printers, without the need to physically connect each machine with wires.