Wireless Networks

- Catching the mobile future -

THE WALKSTATION PROJECT ON MOBILE COMPUTING

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Abstract: **Wireless LANs (WLAN) will soon be as popular as Ethernet is today. First products for DECT and 2.4 GHz systems will be available this year.**

How can these WLANs be connected to the Internet? Which problems arise when mobile users appear as guests in foreign networks?

The Walkstation project is realizing a testbed for such a mobile computing environment using a modified set of Internet protocols. These protocols are based on the work of the internet working group on mobile IP (Internet protocol).

Other aspects of the Walkstation project cover low power VLSI, cellular infrastructures, network integration, and mobility aware applications.

1. INTRODUCTION

The popularity of the Internet and its attractive applications make it a natural choice for mobile communication and computing.

Currently every 30 minutes [1] a new network is connected to the Internet. The Internet combines about 32.000 networks in over 80 countries in the middle of 1994. Some of these networks will be wireless networks for support of mobile clients.

The World Wide Web (WWW) [3,4] is an example for a new world-wide multimedia infrastructure based on the Internet. Easy-to-use information browsers made the WWW traffic grow within one and a half year from 0 to 600 Gbit/month [2] which is about 5% of the total traffic on the NFS backbone. This is one example of many attractive applications which are available for hosts using the Internet.

By their nature networks for mobile clients require more effort for communication than wired LANs. Suitable communication architectures have to deal with problems such as lower link quality, changing location of mobile clients, and security problems.

The reminder of this paper will describe the efforts of the Internet working group on Mobile-IP to integrate mobile communication into the Internet as well as work done in the Walkstation project [5,6] at the Royal Institute of Technology in Stockholm, Sweden.

2. MOBILE IP

The goal of the working group on Mobile-IP (established in June 1992) is to "allow transparent routing of IP datagrams to mobile nodes in the Internet" [7]. This requires the Internet protocol (IP) enhancements to be (1) transparent for the mobile user, (2) for fixed users, and (3) for existing routers in the network.

While most mobile networks handle mobility at the data link layer the proposal of the Mobile-IP group handles all at the network layer. This is important in order to get a standard suitable for existing and future networks independent of the underlaying network technology.

The Mobile-IP proposal achieves these goals by providing mobile hosts with a permanent "home address", regardless of its current point of attachment to the Internet, and a "care-of-address", which provides information about the current point of attachment.

Additional nodes at the home site, called "home agents", forward packets to the mobile host by tunneling encapsulated packets through the Internet. At the destination they are decapsulated either by the mobile host directly or by an additional node called "foreign agent".

The simplicity of the protocol allows easy implementation and early field trials.

Detection of the Network

Before a mobile node with a wireless inter-

face can start to communicate it must detect the network. Contact points to the network are offered by agents which act as base stations offering Internet connectivity.

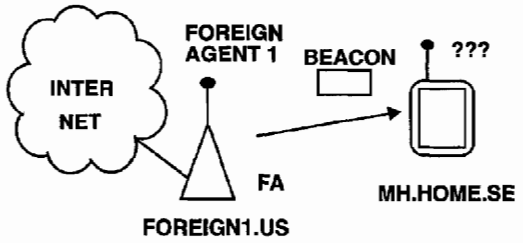

Figure 1: Foreign Agent Beaconing

A Mobile-IP agent announces its presence by regularly sending beacon messages (fig. 1). These beacons indicate not only that Internet service is offered but which agent is offering it.

Beacons can be requested by the mobile node through solicitation messages to which the agent answers by sending a beacon.

In the current draft these messages are based on ICMP Router Discovery [8].

Registration

Being aware of a contact point to the Internet the mobile host can now request service by registering with that agent.

If the node is in the "home network" then it will have to register with the "home agent", which maintains a list of mobile hosts for which it is responsible.

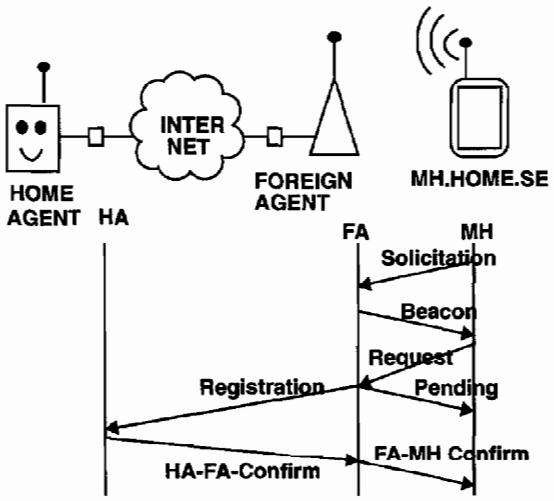

Figure 2: Registration at a foreign agent

As a guest in a foreign network the mobile host registers with a "foreign agent" (fig. 2). This foreign agent consults the corresponding home agent whether it is allowed to provide service. By receiving this registration the home agent can now update the location of the mobile host in its database. A confirmation message to foreign agent results in a successful registration of the mobile host.

Packet Forwarding

The cooperation of the home agent and the foreign agent after a successful registration allows the mobile node to exchange packets with nodes in the Internet.

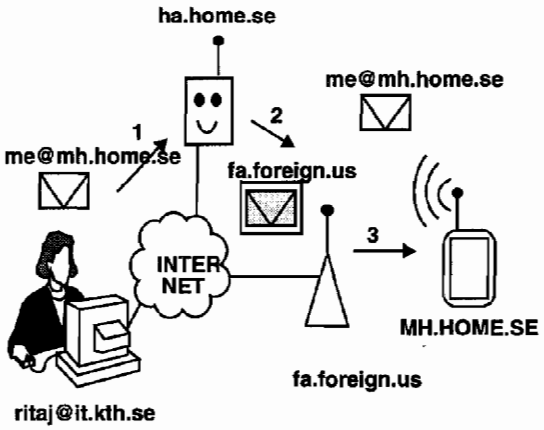

Figure 3: Packet Forwarding

A fixed user sends a message to the permanent home address of the mobile host. The message appears on the home network where it is received by the home agent in place for the mobile host which is currently registered as a guest in a foreign network.

The home agent encapsulates the packet into another IP packet which is sent to the foreign agent. The foreign agent recognizes the packet for the mobile host inside, decapsulates it and sends it to the mobile host.

The forwarding process was transparent for the fixed user, the mobile user and the network. No special actions were required from them.

Reconfirmation

The maximum time of service for a mobile host is supervised by timers at the foreign and at

the home agent (fig. 4). A mobile node has to re-register from time to time in order to avoid denial of service due to an expired timer.

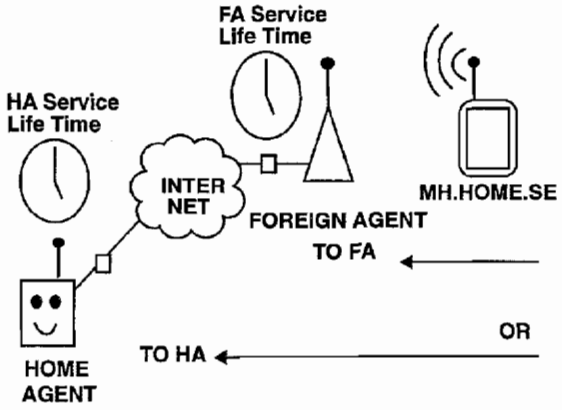

Figure 4: Communication monitoring

These timers help to detect nodes which have moved out of the service area of an agent, or which were simply switched off.

Hand-over

A mobile host may wish to register at a new agent due to movement or other reasons. A move might occur so fast that the mobile host loses contact to the previous foreign agent. It can therefore not tell the previous foreign agent that it has disconnected and reconnected at a new agent.

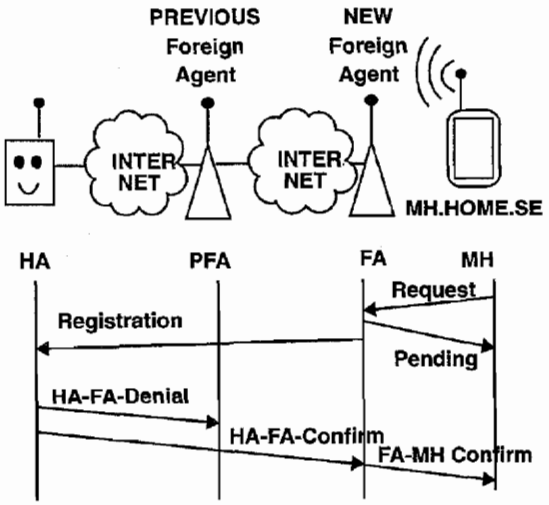

Figure 5: Hand-over between foreign agents

The hand-over in Mobile-IP handles this with an enhanced registration procedure (fig. 5). The mobile node detects that it should register with a new foreign agent. It sends a registration message to the new foreign agent which asks the home agent for service confirmation. The home agent generates two messages, one to deny service to the previous foreign agent and one to allow service to the new foreign agent

The home agent is now aware of the new location of the mobile node, while the previous foreign agent will stop to forward packets to the mobile node.

Packets still arriving at the previous foreign agent are decapsulated and sent back to the home network.

Deregistration

A mobile node can stop service by a deregistration procedure. This is useful for mobile nodes which are being switched off, and for hand-over procedures.

Open Questions

Route optimization allows exchange of packets without the use of the home agent. Two nodes located very close to each other, e.g., in US, need the help of a home agent, e.g., in Sweden to communicate with each other. Different proposals are discussed to optimize this inefficient use of bandwidth. Solutions discuss mobility aware hosts, which support Mobile-IP, and "caching agents" which participate in the protocol in order to redirect packets.

Security mechanisms are currently studied to mutually authenticate mobile nodes, foreign agents and home agents. Attacks by eavesdropping are much easier for wireless systems than for wired links. Proposed is an MD5 authentication scheme. The key distribution problem is however still an open issue.

Scalability from wide area networks down to local area networks may not be satisfying. In a local environment with multiple cells traffic would be forwarded from a home agent in one cell to a foreign agent in another cell. If cells are as small as rooms a lot of forwarding can take place inside the same department of an organization loading the network at least twice for each message.

Signalling effort for the support of mobile nodes may take a considerable part of the network bandwidth if nodes are very mobile like for a car or for pedestrians using pico-cells (e.g., radius < 50 meters). Measurements and simulations have to verify whether such signalling can overload a network.

3. THE WALKSTATION PROJECT

The Walkstation II project involves researchers from different areas in order to find a solution for mobile multimedia communication via a global system approach. Beyond the integration of mobile stations into existing fixed networks (Internet), areas being studied include mobile adaptive applications, mobile systems management and security, future communication architectures, use of multiple wireless interfaces, dynamic resource allocation and media access, direct sequence CDMA (code division multiple access) and low power VLSI integration.

Low power VLSI

An important task is the investigation of new low cost, digital, highly integrated radio interfaces which are small in size and have low power consumption. A current prototype of a Walkstation radio interface utilizes a Direct Sequence CDMA receiver [9] and transmitter operating with 500 kbit/sec at 2 GHz.

The simplicity of both the analog and digital parts should allow both low power operation and small area for a final BiCMOS implementation. The next prototype aims at 2 Mbit/sec at 2.4 GHz. It allows the parallel reception of multiple spreading codes as well as hardware reconfiguration for flexible bandwidth and new modulation schemes.

Cellular Aspects

In this task the focus is on design principles for distributed radio access schemes and performance evaluation of these schemes in wireless information systems. The main emphasis is on packet switched environments where both moderate speed interactive data communication systems as well as high-speed ATM-based systems for wireless access are considered. Currently we are studying the performance of indoor packet radio systems using diversity reception.

Network Aspects

In the Walkstation project the variety of networks (TDMA/CMDA-based, GSM, Mobitex, DECT, etc. [10]) and the difference of environments (indoor picocell, outdoor microcell, urban macrocell and rural areas) are harmonized at the network layer (fig. 6). The goal is to provide mobility transparent communication services to traditional, non-adaptive applications such as electronic mail, file-transfer, virtual terminal, information browsers and other applications common to users on the Internet.

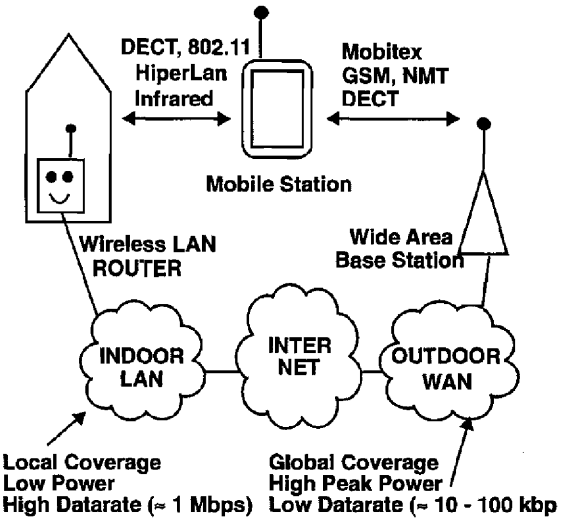

Figure 6: Integration of mobile networks

Not all differences of mobile networks can be hidden from user applications. Parameters such as available bandwidth, latency and setup time influence the responsiveness and performance of multi-media applications. New *adaptive* applications have to react to the available quality of service by, e.g., changing the presentation of user objects from full graphical display to simple character based interaction.

A device which can act either as a modem for mobile hosts or as a complete base station has been realized by the same kind of hardware but with different kinds of communication software. This device, called MINT (Mobile IP Router) [11,12], consists mainly of three parts, one for the connection to the host or backbone

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