

ROAMING OF MOBILE DEVICES BETWEEN CELLULAR IP NETWORKS

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ABSTRACT

Nowadays, Internet uses the Internet Protocol version 4 (IPv4) in the network layer. IPv4 assumes that computers are always attached to their networks without the possibility to communicate if they move to a remote location. Mobile IP is an extension to IPv4 that permits the once fixed terminal to “visit” a foreign network and to maintain seamless communication without changing its IP number. However, Mobile IP presents difficulties such as the routing scheme and the need for registration of the mobile terminal with its Home Agent every time it migrates to a new network. Some proposals have been developed that aim to minimize the number of registrations when the mobile terminal is within a limited area. For example, Cellular IP applies mobility management functions of cellular systems within a network domain, but when the mobile device is migrating between two domains, the registration follows Mobile IP. This paper proposes a functional entity to locate mobile terminals when roaming between Cellular IP networks. The cellular infrastructure is used in this proposal to benefit from paging and passive connectivity features that are absent in Mobile IP.

KEYWORDS

Cellular systems, Cellular IP, mobile systems, Mobile IP, mobility management functions, wireless local area networks.

1 Introduction

Mobile devices have the ability to handle Internet services, in environments such as cellular systems and wireless local area networks (WLAN). Cellular systems provide a large coverage area to the mobile users who profit from voice and data communications. On the other hand, in WLANs, mobile devices are connected to a local area network that can offer a direct access to the Internet.

In this article, mobility principles from cellular systems are applied to reduce the amount of registrations that are necessary to keep track of a mobile terminal position while the mobile user is roaming between

Cellular IP networks. The proposal challenge is to use the benefits of a well-structured cellular infrastructure with well-established roaming agreements among WLANs [1]. The terminal location needs to be determined only when there is data to be received. Likewise, the terminal may be always ready to connect to the network if it needs to transmit without having to establish previous registrations with its home network.

Next section shows the main concepts of Mobile IP and Cellular IP that are used in this research. Section 3 introduces a proposal for location registration of mobile devices roaming between Cellular IP networks. Finally, Section 4 presents the main conclusions about our work.

2 Internet Mobility

2.1 Mobile IP

RFC 2002 (updated by RFC 3220) presents an extension to IPv4 to support mobility [12][10]. In short, the addition of the following entities gives support to mobility in IPv4 [11]:

- Home Agent (HA) is a router in the home network with the following functions: registration of the mobile device when it is away; interception of received data and data delivery through a tunnel to the foreign network. This tunnel may be created, for instance, using IP encapsulation within IP;
- Foreign Agent (FA) is a router in the visited network that gives an address to the mobile device and has the function to desencapsulate data sent by the Home Agent. It is also a passive component in the registration procedure, relaying the Mobile Host's requests to the Home Agent;
- Mobile Host (MH) is the terminal visiting a foreign network. In order to communicate properly, it must have an address on the new network. This address is called Care-of Address (CoA) and may be an address of the Foreign Agent or an address externally obtained (e.g., by Dynamic Host Configuration Protocol). In this case, it is called Co-located Care-of Address;

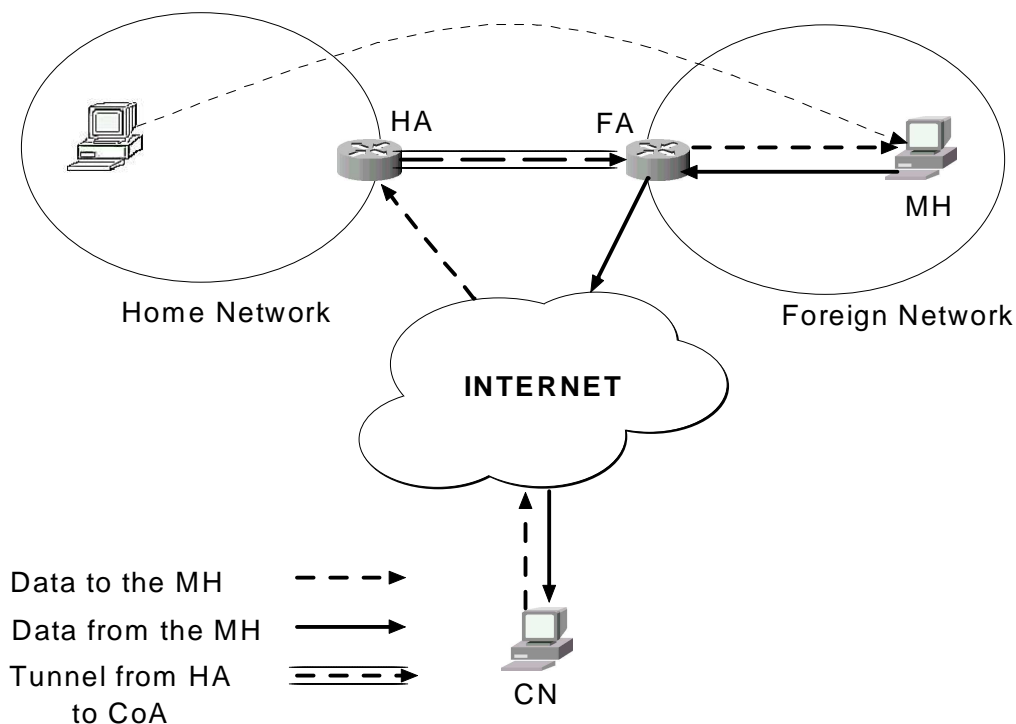


Figure 1. Routing in Mobile IP

- Correspondent Node (CN) is a host that the Mobile Host is currently communicating with .

Three related functions are performed by Mobile IP: Agent Discovery, Registration and Tunneling[11]. Agent Discovery begins when the Mobile Host (MH) arrives on a foreign network and receives agent advertisement messages. If it wants, MH may solicit such messages. After obtaining an address to be used on that network, the MH tries to register with its HA. This registration can be done by the MH itself in case of obtaining a Co-located Care-of Address or through the FA, when the address belongs to the FA. After that, all packets sent to the MH are intercepted by the HA and sent through a tunnel between the HA and the Care-of-Address.

Mobile IP lacks the ability to locate a Mobile Host if it does not register with its HA. When a registration is done, a new entry in the HA routing table is created. In order to tell the HA its current location, the MH sends this information to the HA. If the Mobile Host is not yet in a new network, it will not be accessible without trying again to register in this new network. However, it might use a network structure to tell the Home Agent about its new location.

2.2 Cellular IP

Cellular IP (CIP) proposes mobility within a local access network, assuming that a random access protocol is present on the air interface [3]. The access network is connected to the Internet through a common gateway to all nodes. While in a Cellular IP network, the Mobile Host does not need to register when roaming between paging areas.

Figure 2 shows the architecture of a Cellular IP network. Base stations (BSs) periodically send beacon signals that allow mobile hosts to identify the nearest network. Packages are transmitted to the base station and forwarded to the gateway. While data packages from the Mobile Host go through a node, a table is updated with the identification of the MH that has sent the package and the neighbor from which it was received. This table will keep track of the routing information for the MH. When packages need to be sent to a MH, they are routed according to those tables.

When a MH goes out of an access network, it becomes unavailable until finding another access network and registering to it according to the Mobile IP procedure.

3 Macromobility Management Function

This article proposes a functional entity that is responsible for managing mobility when mobile devices are roaming

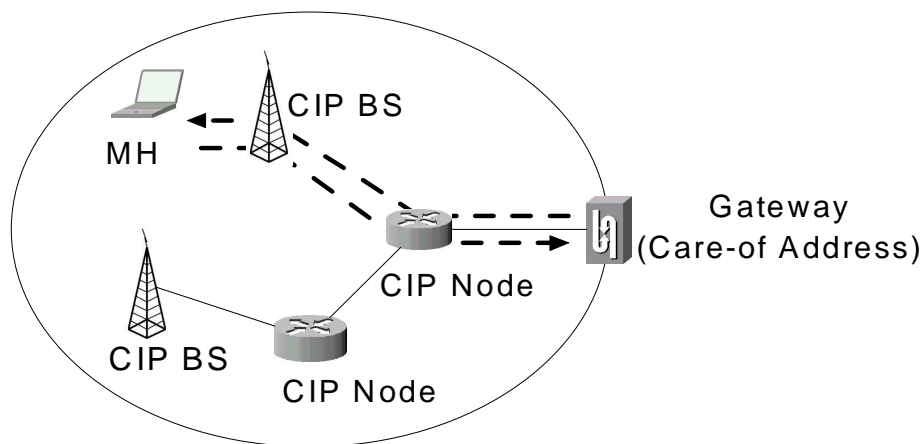


Figure 2. Cellular IP Network

between Cellular IP micromobility areas. This entity is called Macromobility Management Function (MMF) and it acts as a gateway to the MHs.

The MMF main function is to keep track of mobile hosts when they are visiting another network. Features such as passive connectivity and paging are now used in a macromobility scenario. These features are included in the Cellular IP proposal [3] and they are absent in Mobile IP. If there is no data to transmit, the Mobile Host does not have to register with an agent or to be reachable by its Home Agent. This passive connectivity feature avoids resource consumption and it saves bandwidth.

When the network receives data to a certain Mobile Host, the Home Agent intercepts them and it is necessary to find this host using the paging function. So, in order to become passively connected to the network, the Mobile Host must periodically send packets that update its location.

This proposal assumes that Cellular IP is used for micromobility. In a micromobility area, the Mobile Host updates its location using paging-update packets, as proposed by Cellular IP [3]. As long as it notices a new Mobile Host in its local area network, the gateway for the access network sends this information to the MMF that updates its database. When the Mobile Host leaves this local area, the timeout period expires and the gateway sends this new information to the MMF that becomes aware that the Mobile Host is not visiting that network anymore.

Once the Mobile Host is out of the visited network, it must send packets with location update. For this purpose, it may utilize base stations of the existing

cellular networks. These packets are relayed to the MMF, which will update its database. When the Home Agent needs to send data to the Mobile Host and does not have an entry in its routing table, it shall consult the MMF that will give the current location of the MH. If it is still migrating between two networks, the MMF itself may act as a gateway for that region and the registration request is made. The Mobile Host registers with its HA and utilizes the MMF IP address as Care-of Address. Therefore, the MMF becomes the end of the tunnel for the data that will come from the Home Agent, as shown in Figure 3.

In order to communicate with WLAN devices and the cellular telephony system, the mobile devices must have a dual adapter able to recognize different base stations signals and change its behavior accordingly.

As soon as it achieves a new micromobility region, the Mobile Host tries to register with the gateway for the new network, releasing the external network resources. During the registration procedure, the new location and the Care-of Address are sent to the Home Agent. A new tunnel is established and this information is also sent to the MMF for a location update of its database.

For security purposes, the MH must utilize an identification that identifies itself and its network.

The MMF functional entity is meant to be part of the cellular system structure coping with other entities such as VLR (Visitor Location register) and HLR (Home Location Register). This proposal demands that the cellular system communicates with the IP network and the MMF acts also as a gateway so that signaling may be interpreted properly. For example, the MMF functions can work with those of the GGSN (Gateway GPRS Support Node) present in GPRS networks.

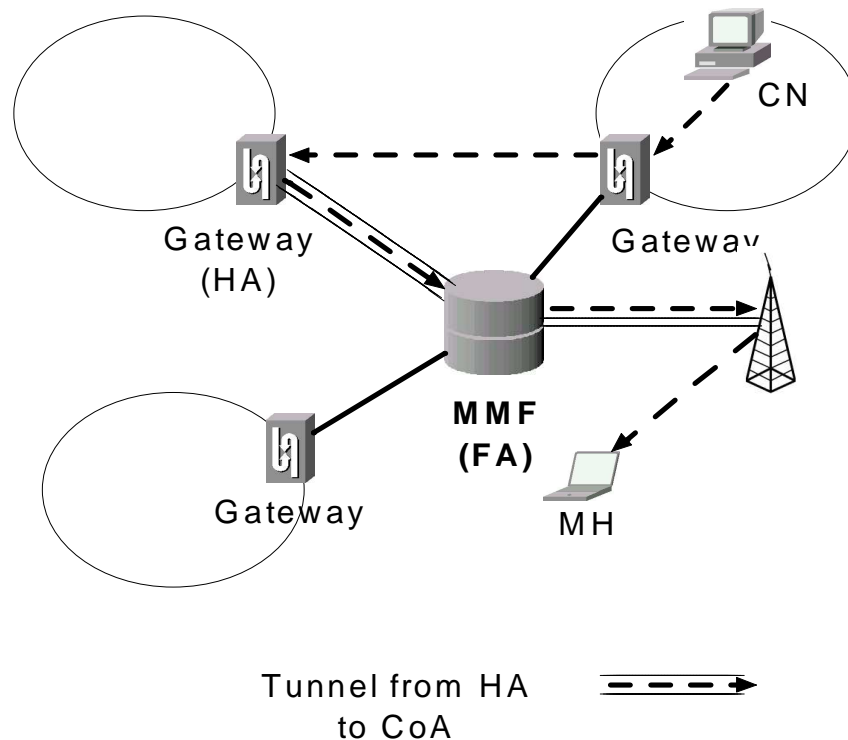


Figure 3. A Foreign Agent in the Cellular Network

4 Simulation

In this paper, we simulate a scenario with the Macromobility Management Function (MMF) using the Network Simulator (ns-2). In this scenario, a Mobile Host goes through a Cellular IP (CIP) network and enters a new cellular network. The roaming is recognized by the beacon signals emitted by the new base station. In order to simulate that, we used an original example of a Cellular IP network simulation [6] and the simulation of Cellular IP with multiple gateways [8]. The MMF is added and acts as a new gateway when the Mobile Host was out of the old Cellular IP range and received a beacon from a base station belonging to the current cellular network.

As a new scenario, a second Cellular IP network was added. This simulation aimed to verify the behavior of the entities while the MH left the first CIP network, went through the external network and entered another CIP environment. Some extra signalling was necessary, so new types of CIP packages were created to simulate the MH registration with the gateway of the network. However, this registration was not relayed to the HA which was not implemented in the simulation. This extra

signalling was responsible for increasing the handoff latency.

During the simulation, some limitations have been identified. For instance, in order to simulate the information flow from the correspondent node to the Mobile Host in the cellular systems, it is necessary to create a new node to represent the CN in every new visited network. The base station parameters are the same for both types of networks, as though the migration path occurred from a Cellular IP network to another. In spite of these limitations, the entities behave as proposed and the Mobile Host could migrate between the networks without any interruption on the data flow.

5 Conclusion and Future Work

Some aspects of the specification were not simulated. As future work, the registration with the Home Agent and the update of the MMF table are going to be included in the simulation. After that it will be possible to simulate the paging procedure in order to find the MH. Another aspect that shall be focused is the inclusion of route optimization.

In short, our main conclusion is that, if it is possible to transfer signalling information between the entities present in cellular systems and the gateways present in

WLANs networks, it is also possible to, through the IP network, keep the Home Agents aware of the location of their mobile devices. The reuse of features such as paging allows the network to look for the Mobile Host everytime data have to be sent to it even if the MH is roaming between CIP networks.

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