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An Architecture and Communication Protocol for IPv6 Pack-Based Picocellular Networks

HAN-CHIEH CHAO and YEN-MING CHU
National Dong Hwa University, Chunghwa Telecom Labs, Hualien, Taiwan

Abstract. In this paper, micro mobility problems in handoff binding latency in Mobile IPv6 and the enhanced Cellular Mobile IPv6 (CMIv6) are investigated using a new extension protocol. Frequent and fast movements usually characterize micro mobility. An enhanced handoff extension is adopted to solve the Mobile IPv6 handoff break in a micro mobility environment. The basic idea involves using the new field in the IPv6 header, "flow label", to assist the foreign router delivering packets to the mobile node. The Foreign Home Agent (FHA) is a new defined node in this proposition. FHA can accurately deliver packets according to the mobile node IP address even though the new binding messages have not arrived at the CN. The simulations shown in this paper prove that the enhanced CMIv6 scheme can minimize packet loss during handoffs.

Keywords: micro mobility, cellular, handoff, flow label, MPLS

1. Introduction

Although the Internet offers access to information sources worldwide, we don't expect to benefit from this access without being located at some familiar access point, home, office or school. However, the increasing variety of wireless devices offering IP connectivity, such as digital cellular phones, and PDAs, is beginning to change our perceptions of Internet access and use [12].

In the mobile communications environment, Mobile IP is defined to provide services to users that roam everywhere and integrate communication network systems into the Internet. The IETF Mobile IP defines three functional entities. There are mobile nodes (MN), home agents (HA) and foreign agents (FA) in this network. Mobile IP is based on and is compatible with IPv4. The Mobile IPv6 concepts are similar to Mobile IP with some new IPv6 functions bringing new features and schemes for mobility support.

Numerous breakthroughs have occurred in telecommunications technology. From the early *Advanced Mobile Phone system (AMP)* to the present *Global System for Mobile Communication (GSM)* and the third generation mobile communication system, people have gradually moved away from hard wire based communications. There are still many problems that need to be overcome, for example, resource management, larger bandwidth, lower power consumption and security issues [16].

The next generation mobile communications system will be the so-called *Mobile Internet.* All communications and network systems will be integrated into the Internet [16]. Enough bandwidth and a good protocol that can be used in various systems are in demand.

One of technical challenges for a cellular system is the handoff procedure that occurs when a mobile node traverses across the boundaries of neighboring cells. Using a complicated handoff process, the handoff can be made without degrading the on going communication quality [15].

This paper is structured as follows. In section 2, we will discuss the deficiency of IETF Mobile IPv6 handoff scheme. Section 3 reviews the other two main protocols presented by IETF. In section 4, the Cellular Mobile IPv6 is studied. In section 5, network modeling and simulation issues are studied and the simulation results are analyzed. Section 6 is the conclusion.

2. Motivation

The IETF proposed the Mobile IPv6 protocol to provide an efficient solution that implements mobility support over the existing Internet network architecture. The IETF IP Routing for Wireless/Mobile Hosts Working Group is currently specifying the Mobile IPv6 protocol. There has been increasing interest in Mobile IPv6 as a potential future mobility standard, common to the cellular system and the Internet as a whole. The benefits of adopting a common mobility solution include independent access network technologies and common solutions for fixed and wireless networks.

After a mobile node has moved from one network to another, packets destined for the node at its previous network address will not be routed to the new location. To receive packets at its new location, the node must obtain a new network address and advertise it to nodes wishing to correspond with it. Reducing the number of lost "in-flight" packets is our main purpose.

Although Mobile IPv6 handles local node mobility successfully, it is not suited to global cellular networks. In this section, we will discuss the problems in the IETF Mobile IPv6 protocol.

Providing seamless mobile station transmissions while a mobile unit is moving at high speed among small wireless cells (micro mobility) is an important issue for the future.

Recent initiatives to add mobility to the Internet and packet data services for the next generation cellular systems are being considered by many mobile service providers. At the same time, IPv6 is a new version of the Internet Protocol. It supports mobility and is presently being standardized by the IETF Mobile IP Working Group and should be a good candidate to provide solutions.

We will explain how the IETF Mobile IPv6 operates using figure 1.

(1) The mobile node discovers its HA using the *Home Agent Discovery* (HAD) mechanism.

(2) The mobile node moves to a Foreign Link-A away from its home network.

(3) The mobile node obtains a new care-of address CoA-A and sends the BU messages to its HA and CN.

(4) A CN wants to send packets to the mobile node's home address. The HA forwards the packets to the MN according to the care-of address (CoA-A).

(5) The mobile node moves to a Foreign Link-B away from Foreign Link-A.

(6) The mobile node obtains a new care-of address CoA-B and sends the BU messages to its HA and CN. By the "*Route Optimization*" mechanism, the CN sends packets direct to the MN.

(7) After receiving the BU message, the CN updates its BC and sends the packet to the MN with BA message.

(8) The mobile node returns to its home network.

(9) The mobile node returns to its home network and informs its home agent that it is no longer attached to a foreign network [14].

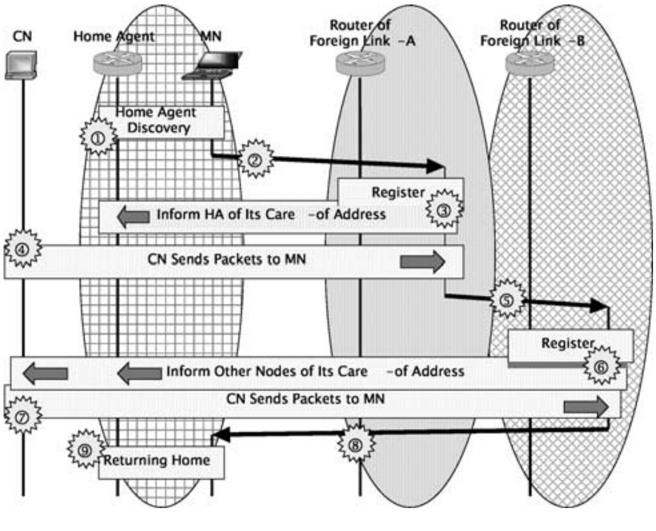

Figure 1. Overview of the IETF Mobile IPv6.

Node mobility in a wireless cellular network introduces a huge new complication [17]. In a cellular system, mobile node location management is a very important issue. In the IETF Mobile IPv6, a mobile node sends binding update messages to its home agent and its correspondent nodes each time it changes its location.

Handoffs should be completed quickly and incur little or no packet loss to avoid breaking these traffic streams [1]. From [7], we have three observations. First, handoffs can incur long delays because mobile nodes and agents or foreign routers may be separated by "X" hops in a wide-area internetwork, as the Internet. Second, data in transit to the MN may be lost while the handoff is completed and new routes to the MN converge. Third, frequent handoffs by a large number of mobile nodes could add significant loads to the internetwork.

We will explain the problems in IETF Mobile IPv6 in a cellular network at a high speed using figure 2 modified from figure 1. Figure 3 will also be used to assist in this explanation.

In figure 3 "*BS-A*" means that the base station is connected to interface A of the foreign router and "*BS-B*" connects to interface B. *MN@A* means that the mobile node is located at "*Cell-A*". So-called "*Cell-A*" is the area covered by BS-A and "*Cell-B*" is by "*BS-B*". *MN@B* is the mobile node at "*Cell-B*".

The environmental parameters are defined as follows:

- *CoA-A*: the care-of address of the mobile node in foreign link A. Its prefix is 3FFE:2F0A::/96.
- *CoA-B*: the care-of address of the mobile node in foreign link A. Its prefix is 3FFE:2F0B::/96.
- CN's Address is 3FFE:2F11::0080:C883:7861.
- HA's Address is 3FFE:2F05::00A0:C978:AAE1.
- MN's MAC address is 0040:0568:F240.

The scheme in figure 2 is explained as follows:

(1) This part is the same as in figure 1.

(2) The mobile node departs from its home link for *Foreign Link-A*.

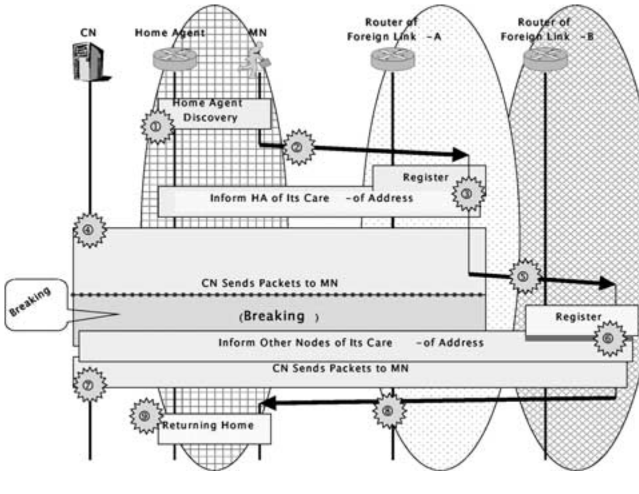

Figure 2. The Handoff Break in Mobile IPv6.

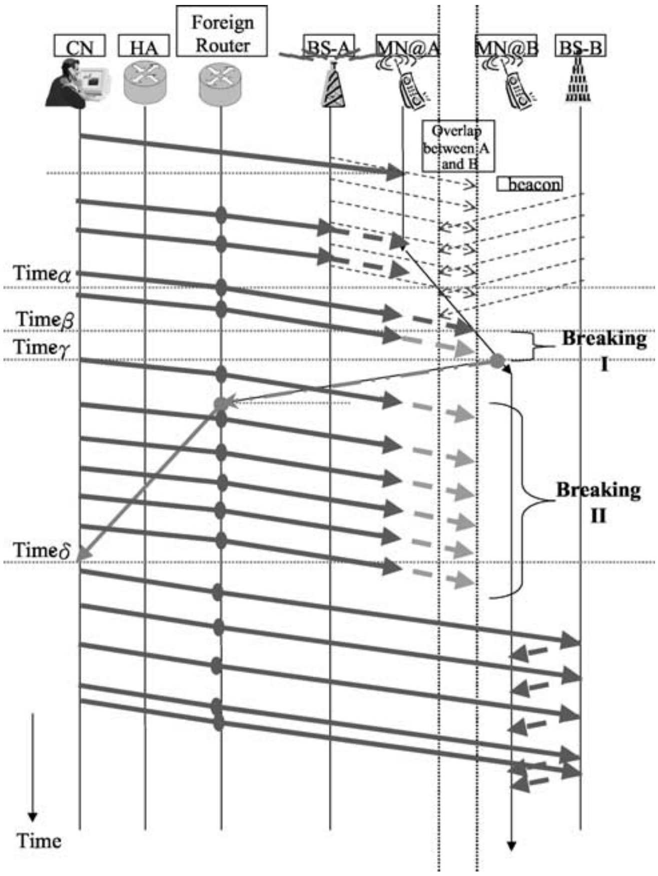

Figure 3. Timing diagram during handoff in Mobile IPv6 scheme.

(3) The mobile node obtains a care-of address, CoA-A, from the foreign router and then sends a binding update packet to its home agent.

(4) Using the IETF Mobile IPv6 protocol function, the correspondent node connects with the mobile node successfully. Through routing optimization, the connecting packets are delivered from the correspondent node directly to the mobile node. This part is shown in figure 3. The correspondent node continuously sends packets to mobile node.

(5) The mobile node wants to roam from *Foreign Link-A* into *Foreign Link-B*. *Time-*α in figure 3 shows this situation. The mobile node enters the overlap between *Cell-A* and *Cell-B* and keeps on moving to *Cell-B*. At *Time-*β, the mobile nodes are completely out of *Cell-A*. In other words, the mobile node has not received any packets or beacon signal form the *BS-A* since *Time-*β. Because *Time-*β to *Time-*γ, this is the first phase of handoff breaking, "*Breaking I*". This handoff latency time is not often too long. The factors that effect the latency time are the speed of the mobile node, the size of the overlap, the interval time between the beacon signals and the time during which the mobile node obtains a new care-of address.

(6) The mobile node obtains a new care-of address "*CoA-B*", its prefix is "*3ffe:2f0b::/96*". It then sends the binding update packets with *CoA-B* to its home agent and correspondent nodes individually.

In figure 3 the MN completes the stateless autoconfiguration and sends binding update packets at *Time-*γ. Due to the delay and packet loss in the Internet, the CN does not receive the binding update packet until *Time-*δ because the binding packet is lost in the vast Internet. After receiving the binding update, the correspondent node updates its *Binding Cache* and sends the *Binding Acknowledgement* packets, *Packet-*φ, with the current destination address, *CoA-B*, the actual location of the mobile node. *Packet-*φ is the first packet to arrive at the *BS-B* and is received by the MN as sent from the correspondent node after receiving the *Packet-*ν. However, the differentiation between *Packet-*φ and the previous other receiving packets is the destination address field of the *Packet-*φ is *CoA-B* (3FFE:2F0B::0040:0568:F240). We can see the second phase of handoff breaking, "*Breaking II*", namely since *Time-*γ to *Time-*δ. This handoff latency time is longer than the "*Breaking I*" latency time. The major effective factors for the latency time are the delay and packet loss in the Internet.

(7) After receiving the binding update, the correspondent node sends packets with the current destination address, CoA-B, to the mobile node.

(8–9) These two parts are similar to figure 1.

From the above explanation we can see that the IETF Mobile IPv6 cannot solve the cellular network handoff break problem. For all cellular networks, this is a location determination and management problem. The handoff latency time is the basic issue in this problem. It is solved using minimum delay and the amount of packet loss.

3. Mobility protocols for seamless Handoff

In this section, we extend the previous issue to discuss the problem of overabundance in binding messages. For mobile node home agent and correspondent nodes to know the MN's present location, binding is a very important and effective concept on IETF Mobile IPv6. A mobility protocol that provides a seamless micro-mobility scheme should have the following properties:

1. Manage local movements without having to inform the core network.
2. Decrease the update traffic at the new location.
3. Limit the diffusion of update messages.
4. Minimize the delay in new location updating.
5. Eliminate packet losses during handovers.
6. Provide superior QoS and support real time services.
7. Define optimal radio resource use.
8. Support paging.
9. Interact with Mobile IP.