Route Optimization Scheme for Global Handover in PMIPv6

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Abstract

Proxy Mobile IPv6 (PMIPv6), a network-based localized mobility protocol, allows a mobile node (MN) to move around within the same PMIPv6 domain by keeping the same IP address. However, PMIPv6 does not support the global handover since it supports only an intra-domain handover. To support the global handover, MNs need to load the protocol stack for the global mobility. Our proposed scheme enables the MN's session to be connected without any support of PMIPv6 protocol during the global handover. In addition, it reduces the packet transmission delay by performing the Route Optimization (RO) after the MN's global handover. In this paper, we compare our proposed scheme with the existing Roaming scheme. As a result, the proposed scheme reduces the packet transmission delay by 25% and the packet loss by 78% compared with the existing one. In other words, our scheme supports the seamless and reliable handover for MN.

Keywords: *Route Optimization, PMIPv6, MIPv6, Global handover, Fast handover, Seamless handover, Crossover Router, Packet loss, Packet transmission delay*

1. Introduction

Mobile IPv6 (MIPv6), which is a host-based mobility management protocol, provides Internet service. MIPv6 has several problems although it is a stable technology; it is not suitable for small devices and it imposes the MN on performing complicated message signaling. In PMIPv6, a network-based mobility management protocol, since the MN does not participate in mobility-related signaling, wireless network resources and the MN's power consumption are reduced. However, PMIPv6 supports only an intra-domain handover [1]. During the movement of a MN from intra-domain to inter-domain, the MN experiences an interruption in service. The schemes which prevent this problem have been studied in order to support seamless roaming service to MNs [2-5].

The Roaming scheme is one method to support a global handover in PMIPv6. In case of the Roaming scheme, the MN supports seamless service by exchanging information about the MN's address between the AAA servers in each domain. Thus, the MN does not need the protocol stack for global mobility management. However, the packets transmitted from a correspondent node (CN) to an MN are lost during the global handover. Moreover, it suffers from increased packet transmission delay because the packets are traversed via the home and foreign domains. The proposed scheme improves the Roaming scheme by two ways. First, it buffers all the packets between the MN and the CN at the LMA in the home domain, called an hLMA, to prevent packet loss. Second, the LMA in the foreign domain, called an fLMA, finds a Crossover Router (CR), which has the route information about both the hLMA and the fLMA, to support the RO path. In this way, it reduces the packet transmission delay between the MN and the CN since they are transmitted via only the fLMA.

The rest of the paper is organized as follows. Section 2 describes the schemes for seamless handover in PMIPv6 and explains the operating procedures and characteristics in the Roaming scheme. Section 3 illustrates the motivation, assumptions, operating procedures, and signaling procedures for the proposed scheme. Section 4 gives the comparison of simulation results for packet loss and packet transmission delay in the proposed and the Roaming schemes. Finally, Section 5 concludes the paper and describes our future work.

2. Related Work

2.1. Global Handover in PMIPv6

PMIPv6 supports an MN's mobility only in the LMA domain and does not support the seamless service to the MN during the global handover. In other words, the MN uses a new address allocated from a foreign domain instead of the address allocated from its home domain. Due to this, the data packets transmitted from the CN to the MN are lost during the global handover. Thus, an enhanced scheme is required to provide seamless service for the MN when the MN moves to another domain.

The Roaming scheme is a method to solve the translation problem of the MN's address and packet loss problem during the global handover. In the Roaming scheme, the AAA servers in the home and foreign domains interwork with each other to provide seamless service for the MN that moves around between different PMIPv6 domains. The Roaming scheme assumes that it regularly shares the MN information through bi-directional tunnel established between each domain's AAA servers. Therefore, during the global handover, the Roaming scheme can acquire the MN's IP address after exchanging the MN information between the AAA servers.

However, since the Roaming scheme does not support route optimization, if the MN moves frequently among domains, so that the hLMA is far away from the fLMA, then three problems could occur. First, if the hLMA is farther away from the fLMA, packet loss increases as long as the fLMA receives the MN information from the hLMA increases. The Roaming scheme causes packet loss during the global handover because it does not consider the buffering of transmitted packets from the CN to the MN. Secondly, since the packets exchanged between the MN and the CN are always passed via the hLMA, packet transmission delay increases. Lastly, since the hLMA manages the MNs that have moved from the hLMA domain to another domain and are still belong to the hLMA, its load increases. After the handover, our proposed scheme solves the problems in the Roaming scheme by performing route optimization.

2.2. CR (Crossover Router) Discovery

During the global handover, the packets exchanged between the MN and the CN are passed via the home domain and then delivered to the foreign domain. Therefore, packet transmission delay increases. To solve this problem, the CR discovery scheme for the route optimization is proposed. Figure 1 shows the network structure of CR Discovery.

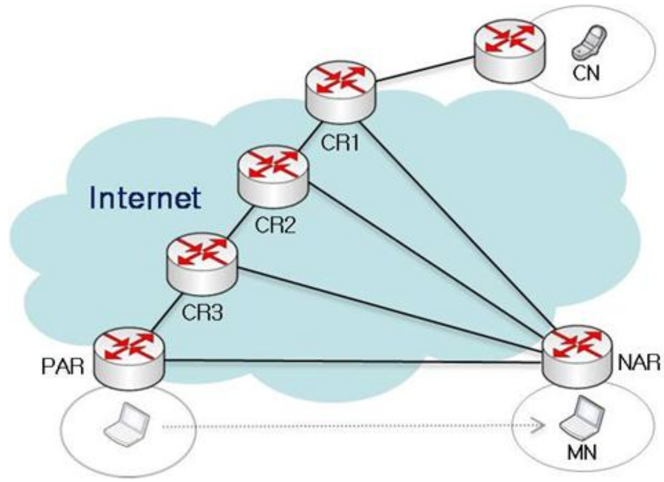

Figure 1. Network Structure of CR Discovery

The Previous Access Router (PAR) is the router to which an MN connects before the global handover, and the New Access Router (NAR) is the current router connecting the MN. The CR is a router having the addresses of the PAR and NAR, is placed at the intersection of the paths before and after the MN's global handover. The CR discovery is one of the route optimization schemes. It performs route optimization by searching the closest CR to the CN among multiple candidate CRs as presented in [6, 7].

This scheme solves the packet transmission delay problem after handover based on the method studied in [7]. When the global handover starts, the hLMA searches for the CR's location based on the addresses of the hLMA, the fLMA and the CN. After the CR is found, the hLMA provides the found CR's address to the fLMA. Finally, a tunnel is established between the fLMA and the CR based on the CR's address after exchanging messages.

This CR discovery scheme performs route optimization, so the packet transmission delay decreases. However, based on PMIPv6, the packets are lost while the CR discovery scheme is performing route optimization. It spends a large amount of time to find the CR location and to make a tunnel by exchanging the messages between the fLMA and the CR. During the route optimization, the packet loss occurs if buffering for packets passed via the existing path is not considered. In our proposed scheme, packet loss could decrease by packet buffering during route optimization.

3. Proposed Scheme

3.1 Overview

The proposed scheme supports seamless service for the MN as follows. Roaming service is provided using the MN's NAI, assigning the same address to the MN such that it is continuously used across domains. In addition, our proposed scheme buffers packets to prevent packet loss during the global handover. Moreover, it guarantees low packet transmission delay from the MN to the CN by performing route optimization after the global handover to find the CR based on the information using the roaming method at the fLMA.

Figure 2 shows the network architecture of the proposed scheme. The network structure is divided into the home domain and the foreign domain. Each hAAA and fAAA is connected via a bi-directional tunnel. If the MN performs the handover from the home

MAG (hMAG) to the foreign MAG (fMAG), the fMAG requests authentication of the MN to the fAAA. The fAAA obtains the MN information through a bi-directional tunnel with the hAAA. The hAAA grasps the global handover of the MN by exchanging messages with the fAAA, and then transmits a message to the hLMA to buffer packets from the CN to the MN. After the fLMA exchanges the buffering request messages for buffered packets with the hLMA, it performs the CR discovery using the addresses of the hLMA, the fLMA, and the CN. The CR that has the addresses of the hLMA and the fLMA in the routing table is located among the hLMA, the fLMA, and the CN.

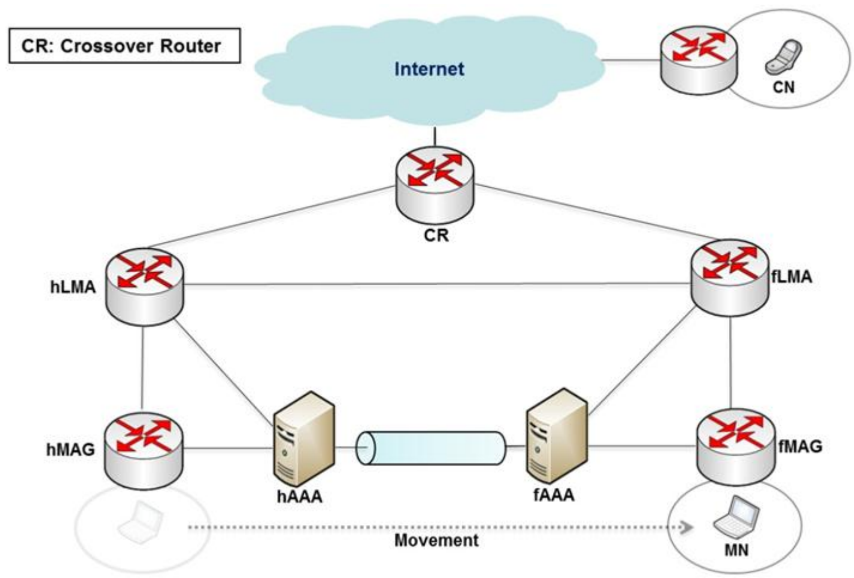

Figure 2. Network Topology

3.2 Seamless Service for Mobile Node

The Roaming scheme supports continuous service for the MN by allowing the MN to use the same address in not only the home domain but also the foreign domain. However, data packets between the MN and the CN could be lost while the MN connects to the foreign domain via the bi-directional tunnel established between the fLMA and the hLMA. To solve this problem, our scheme performs the following procedure. When the inter-AAA servers exchange the MN information with each other, the hAAA forwards the buffering request message to the hLMA because it grasps that the MN moves to the foreign domain. When the hLMA receives the buffering request message, it buffers all data packets from the CN to the MN until reception of the message to request packet forwarding to the fLMA.

In PMIPv6, there are two types of services for the MN. One service is fast but it brings on high packet loss. The other service is slow but seamless. In our scheme, when the MN is performing the global handover procedure, the handover latency occurs. However, our scheme uses the buffering for MN to achieve the seamless service. Therefore, when using for the fast services, for instance VoIP, our scheme can reduce handover delay by abandoning buffering.

3.3. CR Discovery

Applying the roaming scenario in PMIPv6, the packets sent from the CN are transmitted to the MN via the hLMA and then via the fLMA. When the MN moves to another domain, it repeatedly reestablishes the bi-directional tunnel between the hLMA and the fLMA in the new domain. During continuous movement, the distance between the hLMA and the current fLMA may increase and the transmission delay may also correspondingly increase. To solve this problem, our scheme proposes that the fLMA performs route optimization using CR discovery to identify the crossed router on the path from the fLMA to the CN and the path from the hLMA to the CN.

The fLMA obtains the MN information from the fMAG through a PBU message in order to find the CR and it sends a CRD_Act message to the CN based on the addresses of the MN, the CN, the hLMA and the fLMA.

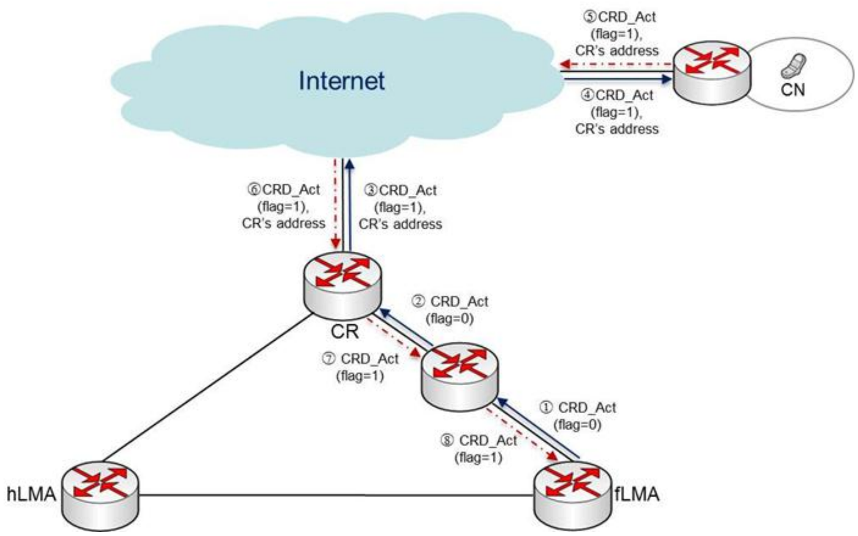

Figure 3. CR Discovery Procedure

Figure 3 shows the procedure of the CR discovery scheme. If the fLMA transmits a CRD_Act message to the CN, the message checks the router hop by hop. The router includes the route information of the fLMA and the hLMA on the path from the fLMA to the CN. If the router contains the route information of the fLMA and the hLMA is searched, the value of F flag of CRD_Option changes from 0 to 1, and then the message including the CR address is transmitted again to the CN. When the MAG connected to the CN receives the CRD_Act message, it transmits a request message to the fLMA, and the fLMA is aware of the location of the CR. Then, the fLMA directly establishes a tunnel to the CR. Once the tunnel is established, the transmitted packets from the CN to the MN are no longer transmitted via the hLMA but transmitted to the fLMA through the optimized route.

4. Performance Evaluation

In our simulation, we measure the performance of the proposed scheme and compare it with that of the Roaming scheme in two different aspects. First, during the global handover, we measure packet loss in the Roaming scheme and our proposed scheme. Second, we investigate packet transmission delay from beginning to the end of the global handover.

4.1. Simulation Environment

We use the ns-2 simulator for measuring packet loss and packet transmission delay during the global handover in the proposed and the Roaming schemes. Especially, we use UDP packets to accurately measure the packet loss and packet transmission delay. All data packets are generated every 5 milliseconds (msec) with a size of 200 bytes in the CBR mode.

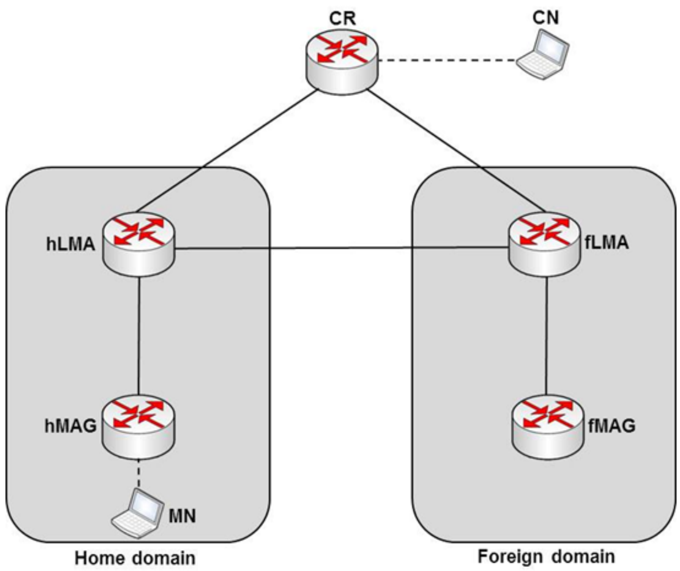

Figure 4. Simulation Network Model

Table 1. Parameters

Descriptions	Value
Distance between MAG and LMA	Average 16 hops
Distance between LMA and LMA	Average 20 hops
Distance between MAG and MN	Average 1 hop
Bandwidth of the wired link	100 Mbps
Packet size	200 ~ 500 bytes
Velocity of MN	1 ~ 50 m/s
Simulation time	5,000 msec

Figure 4 shows the network model for simulation that consists of 5 wired routers (CR, hLMA, hMAG, fLMA, fMAG), MN, and CN. The parameter values are shown in Table 1. Where the average hop distance between MAG and LMA is 16, and the average hop distance between two LMAs is 20 [8-12].

4.2. Packet Loss

Figure 5 shows the packet loss results during the global handover in the Roaming scheme and the proposed scheme. Figure 5(a) shows the simulation result of the Roaming scheme. In this scheme, 9 packets are lost during transmission because of no buffering in the hLMA. Figure 5(b) depicts the simulation result of the proposed scheme, in which only 2 packets are lost. After the global handover is completed, the slope increases more, and the packet disordering occurs. After flushing the buffered packets to the MN, the slope is the same as it is before the global handover.

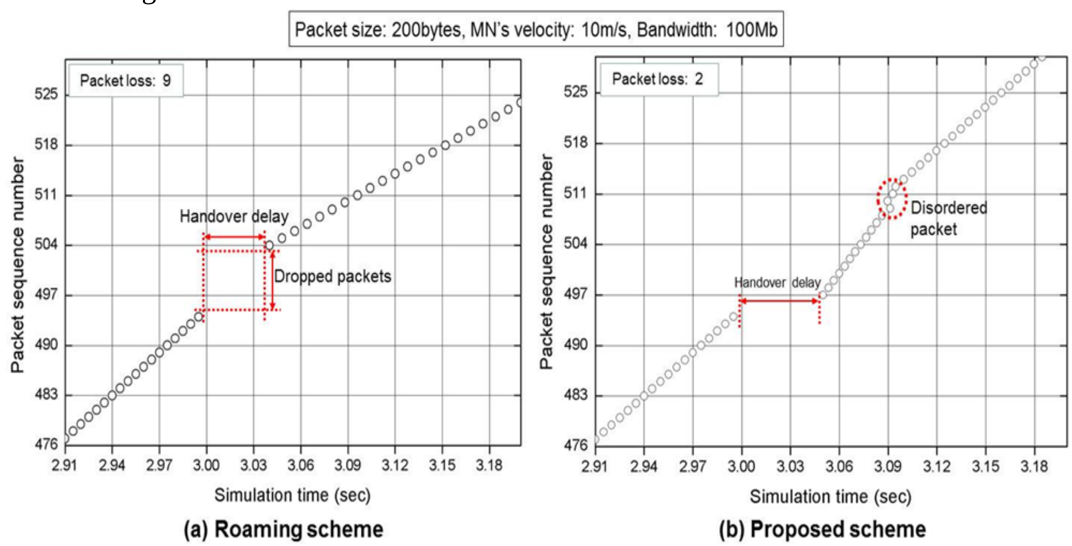

Figure 5. Comparison of Packet Loss between Two Schemes

In the proposed scheme, the handover delay increases slightly due to the procedure in which the hAAA grasps the global handover of the MN, requests buffering to the hLMA, and provides MN information to the fAAA. In addition, the transmission rate increases after the completion of the global handover because the buffered packets at the hLMA are flushed to the fLMA. The packet disordering also occurs because the buffered packets at the hLMA and transmitted packets from the CN are transmitted to the fLMA simultaneously. A small number of packet loss is inevitable since the global handover starts before the hLMA receives the buffering request message.

4.3. Packet Transmission Delay

Figure 6 shows the result of packet transmission delay during the global handover in the Roaming scheme and the proposed scheme. Before the MN performs the global handover, the Roaming scheme and the proposed scheme have the same packet transmission delay. During the global handover, the Roaming scheme experiences packet loss, and the packet transmission delay increases after the global handover. In the proposed scheme, after the global handover, the packet transmission delay increases, and the packets arrive disorderly. After the handover, the packet transmission delay is the same with the one in its previous state.

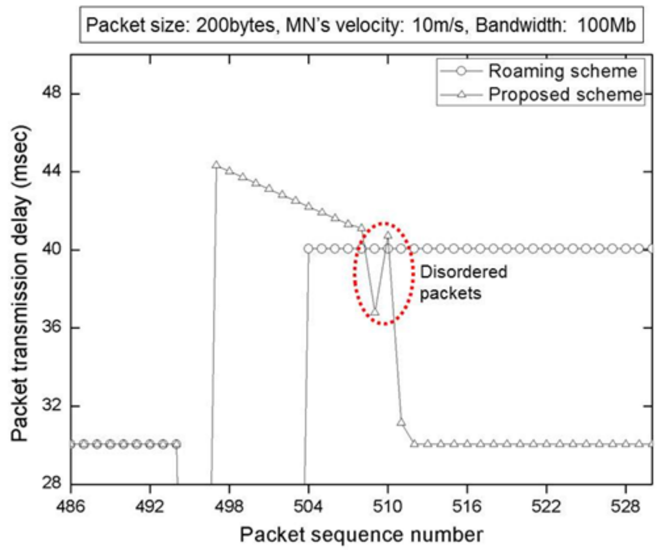

Figure 6. Comparison of Packet Transmission Delay between Two Schemes

In the proposed scheme, the transmission time of some packets is higher than that of the Roaming scheme due to buffering in the hLMA. Some packets arrive disorderly because the buffered packets in the hLMA and transmitted packets from the CN are simultaneously transmitted to the fLMA, resulting in mixing of the sequence numbers of the packets. After the global handover, the packet transmission time of the Roaming scheme increases because packets are continuously routed via the hLMA; in contrast, the proposed scheme performs route optimization, which assures that the packet transmission time after the global handover is the same with the one before the handover.

5. Conclusion

If the MN performs the global handover in PMIPv6, the proposed scheme supports seamless global mobility without changing the address of the MN, permitting continuous use of the new domain through the way of roaming. In addition, we execute buffering in the hLMA when the MN performs the global handover, so the amount of packet loss is reduced as much as significantly. The proposed scheme applies CR discovery that increases the signaling cost but it provides fast packet transmission time between the MN and the CN after the global handover is completed.

In PMIPv6, if the MN moves between domains with high speed, the MN performs global handover continuously. In this case, the proposed scheme is efficient. In our scheme, if the MN performs the global handover continuously, it transmits packets to the MN quickly through route optimization by finding CR. In the simulation result, the sequence of received data packets from the CN to the MN is mixed. In the future, we will research an ordering method in the proposed scheme to give reliability to a user by considering the sequence of data packet transmission from the CN to the MN.

Acknowledgements

This research was supported in part by MKE and MEST, Korean government, under ITRC NIPA-2012-(H0301-12-3001), NGICDP(2012-0006420) and PRCP(2012-0005861) through NRF, respectively.

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