

# A Multicast Scheme for Provision of Seamless Service in Proxy Mobile IPv6 Networks

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**Abstract** — The Proxy Mobile IPv6 (PMIPv6) have been widely studied as a mobility management protocol to effectively use the limited wireless resources. Recently, there have been some researches to apply PMIPv6 to multicasting, which is core technology of Internet broadcast system. However, PMIPv6 based multicasting has a problem in that it shows the disconnection of services during the handover because it does not solve the packet loss problem during binding and group joining procedure when handover occurs. Hence, we propose a new multicasting scheme which provides the seamless multicast service in PMIPv6 networks. The proposed scheme achieves lower latency than the existing scheme because it combines binding and group joining procedure, also it does not cause the packet losses due to the buffering. We present the simulation results which show that the proposed scheme achieves the loss-free and low latency through the NS-2 simulation.

**Keywords** — Proxy Mobile IPv6, Multicast Mobility, Multicast Handover, Seamless Service, Packet loss.

## I. Introduction

Currently, Multicast technology is mainly used in fixed network environment. However, the mobility of service in mobile network environment is gaining attention nowadays, as the portable device such as smart phones and PDAs have been popular recently. Also, a lot of application services require the mobile environment. Therefore, the importance of the multicast mobility technology, which can provide a seamless service in the mobile environment, is uprising. As a multicast mobility technology, Mobile Multicast Protocol (MoM)[1] scheme was proposed, which provides the Multicast technology in the mobile environment. MoM is built on the Mobile IPv6 (MIPv6)[2], which is the most universal mobility protocol that provides the mobility of IP. MIPv6 has been the basis for many other studies over the many years. However, MIPv6 have some weaknesses. First of all, MIPv6 needs many signaling in order to provide the mobility of the mobile devices, and this makes limited link resource overloaded. Secondly, it costs a lot to implement the function that performs the operation of MIPv6 into the mobile devices. Finally, there is a battery exhaustion problem because of many Signaling. These are why MIPv6 has difficulties in order to be applied to the actual network market. To remedy these weaknesses of MIPv6, many studies have been conducted. Recently, the Proxy Mobile IPv6 (PMIPv6)[3] has come into the spotlight as the replacement of MIPv6.

Like MIPv6, PMIPv6 provides the mobility and it was enacted by NETLMM (Network-based Localized Mobility Management) WG (Working Group), part of the IETF (Internet Engineering Task Force), in August 2008. To remedy the weaknesses of MIPv6, PMIPv6 makes the network mainly perform the signaling that is needed to provide the mobility of the Mobile Node (MN) in stead of MN. So, MN can be provided the mobility without implementation of the complicated signaling function. With the appearance of PMIPv6, the study on the multicast mobility based on PMIPv6 has also begun instead of MIPv6. However, the study on multicast support in PMIPv6 has a problem in that it shows the service disconnection during the handover. The service disconnection is mainly caused by the group joining procedure and the binding procedure. This service disconnection leads to degradation of the overall performance of service. Therefore, a study on the multicast that provides the seamless service has to be conducted,

The remainder of the paper is organized as follows. In section 2, as the related works, we will explain about the PMIPv6 network and existing multicast scheme in PMIPv6 network. In section 3, we will explain about the multicast scheme for the provision of seamless service. Next, in section 4, Simulation result of the proposed scheme will be explained. And then, in section 5, we will conclude this paper.

## II. Related Works

### A. Proxy Mobile IPv6

PMIPv6 was designed to provide network-based IP mobility management support to an MN in a topologically localized domain, without requiring the MN to participate in any IP mobility related signaling. The core functional components used to support mobility in PMIPv6 are the Policy Store (PS), Local Mobility Anchor (LMA), and Mobile Access Gateway (MAG). The PS is the entity that manages an MN's authentication and maintains the MN's profile which is a set of parameters configured for a given MN. Meanwhile, the LMA is similar to the HA (Home Agent) in MIPv6, however, it has additional capabilities required to support PMIPv6. The main role of the LMA is to maintain reachability to the MN's address while the MN moves around within the PMIPv6 domain. The LMA includes a Binding Cache Entry (BCE) for each currently registered MN. Finally, the MAG typically runs on the Access Router (AR), and its main role is to detect the

movement of an MN and send mobility related signaling to the MN's LMA on behalf of the MN. In addition, the MAG establishes a tunnel with the LMA for packet transmission. Also, the MAG ensures that an MN can obtain an address from its Home Network Prefix (HNP) and receive its HNP anywhere within the PMIPv6 domain. As a result, the MN believes it is using the same link obtained with its initial address configuration, even after changing its point of attachment within the network. Figure 1 shows the PMIPv6 network.

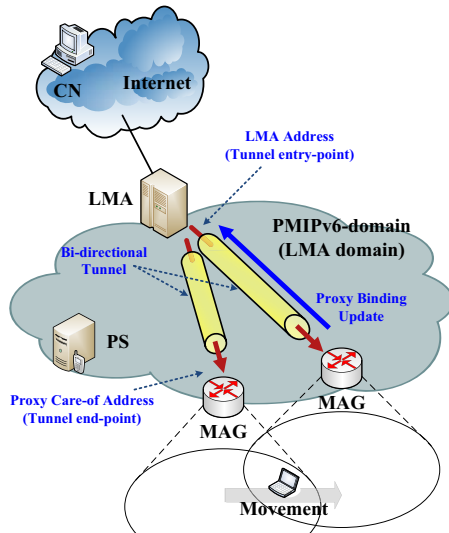


Figure 1. PMIPv6 Network

### B. Multicast scheme in PMIPv6

In order to provide the multicast in PMIPv6 networks, it is necessary for MAG and LMA to perform the group joining procedure of MN. That is, MAG and LMA should join a multicast tree and perform a forwarding role that delivers the packet to MN. Figure 2 shows the existing multicast scheme in PMIPv6 networks [4].

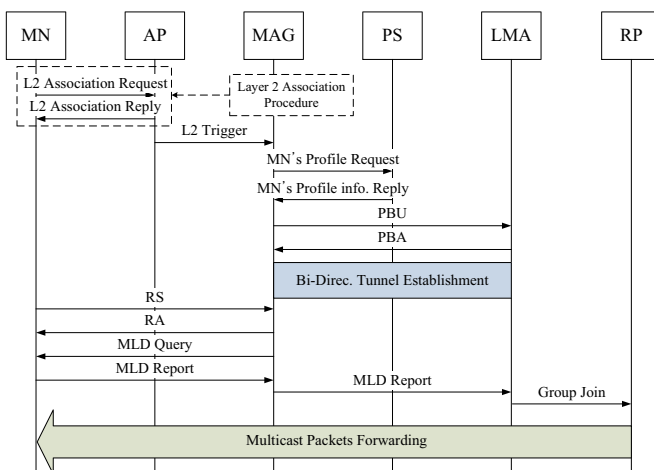


Figure 2. Multicast scheme in PMIPv6

The existing multicast scheme in PMIPv6 network is initiated by exchanging the additional MLD (Multicast Listener Discovery)[5] messages after the binding procedure. When the initial MN connects to network, MAG and LMA exchange the PBU (Proxy Binding Update) message for the binding of MN and setup the tunnel. After that, MAG sends the RA (Router Advertisement) message to MN periodically to track the movement of MN continuously.

After completion of the binding procedure, MN sends to MAG the MLD Report message that requests the joining of multicast group to receive the multicast packet. The MAG that receives the MLD Report sends this message to LMA. Through this procedure, MAG requests the joining multicast tree to LMA. LMA joins multicast tree by sending the group joining message to RP (Rendezvous Point) of the existing multicast tree. After this MLD message exchange procedure, MN can be provided the multicast service. The aforementioned existing multicast scheme in PMIPv6 network exchanges the MLD message for group joining after completing binding procedure. So, if MN moves to other MAG and wants to be provided the service continuously, the necessary binding procedure and the additional exchange of joining group message have to be occurred. If we assume that the movement of MN occurs continuously among MAGs, MN can't be guaranteed the continuity of connection. Because whenever MN moves to a new MAG, the binding procedure and the exchange of group joining messages are accompanied successively. And this makes the state of disconnection last long. This problem makes the continuity of diverse service that applies multicast hard and causes a lot of packet loss. Therefore, the plan of improving this problem has to be studied.

This paper proposed the multicast scheme that provides seamless service in PMIPv6 network as the way of improving this disconnection problem of service. This scheme processes the registration of MN at high speed by using PS server and performs the buffering function.

### III. Multicast scheme for provision of seamless service in PMIPv6

In this section, the proposed seamless multicast scheme is presented. The signaling procedure which happens when MN connects PMIPv6 network initially is same as the existing scheme. However, in the proposed scheme, MAG updates the multicast information of MN to the PS after the general procedure ends because multicast information is obtained using the PS. After the multicast information of MN is updated to the PS, MN receives a multicast packet.

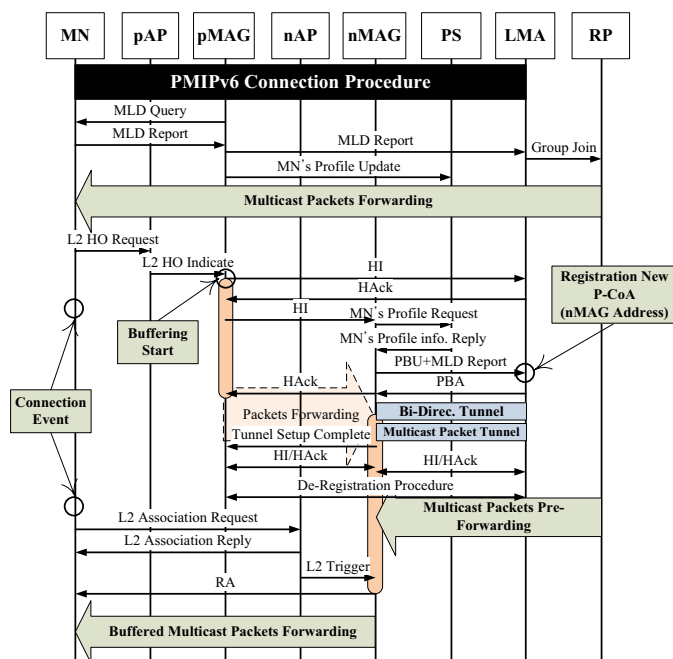


**Figure 3.** Proposed Multicast scheme

After completion of the initial connection and while being received the service, the MN can detect a handover. In order to inform its handover, MN sends the L2 HO Request (Layer-2 Handover Request) message that requires the layer-2 handover to AP providing the service currently. The L2 HO Request message sent at this procedure is commonly used in layer-2 handover by MN. The type of message that is related to layer-2 handover varies with the protocol, but the purpose is similar. So, we use the common type such as the Layer-2 Handover Request and Layer-2 Handover Indicate (L2 HO Indicate). P-AP, which receives the L2 HO Request message, sends the L2 HO Indicate message to p-MAG that is connected to it. P-MAG, which perceives the handover of MN by this layer-2 trigger, sends the HI message (Handover Init message) to LMA. This HI message was proposed in Fast Handovers for Mobile IPv6 (FMIPv6)[6]. HI message includes the target MAG (n-MAG) address, so LMA determines this mobility is either the intra mobility or the inter mobility. This paper deals with only intra mobility case, but and this message can also be used for inter mobility case.

The p-MAG that sent HI message to LMA performs the buffering at the point of message transmission. This is for preventing the loss of packet because p-MAG knows that MN is going to be disconnected from p-MAG. LMA which has received the HI message determines whether the handover is intra mobility or Inter mobility and informs to p-MAG using the Hack message because it is intra mobility. The p-MAG that received the Hack message realizes this mobility means the intra mobility and sends HI message to n-MAG. Before receiving the Hack message from n-MAG, multicast packet which is delivered from LMA is buffered continuously in p-MAG. While p-MAG is performing the buffering, n-MAG that receives the HI message accesses the PS to prepare the handover and the multicast group joining of MN. We assume that the profile of MN exists in the PS and it is updated periodically by MAG that provides the service to MN. So, the

profile of MN can include the information such as the MN's multicast group ID for the multicast service. When n-MAG accesses the PS, it can acquire the MN's multicast group information as well as MN's profile. Based on this acquired information, n-MAG can perform the binding update and group joining for MN in advance.

To perform the binding update and group joining in advance during MN's handover time, n-MAG sends the PBU message and MLD Report message to LMA based on the MN's profile and group ID. LMA that receives these messages starts searching the BCE and the entry for the multicast of itself. This procedure checks whether LMA joins the group ID that is received from n-MAG. The additional multicast tree joining does not occur because we assume that MN moves to other MAG after the initial connection. If the case that multicast tree joining has to be required occurs because the RP's Lifetime is expired, the group joining occurs again in this multicast entry search procedure.

The LMA, after completion of the searching BCE and multicast entry, delivers the PBA message to n-MAG to inform the binding response. The n-MAG, after receiving the PBA message, starts the two procedures. The first procedure is requesting the delivery of buffered packets in p-MAG by sending a Hack message to p-MAG. Since the moment that p-MAG receives the Hack message from n-MAG, it sends the packet that is being performed buffering by itself to n-MAG. When n-MAG starts to receive the buffered packets, n-MAG starts to perform the buffering of this packet. The second procedure is to set up the tunnel between n-MAG and LMA. The n-MAG sets up the multicast tunnel as well as the bi-directional tunnel to LMA for the unicast. In this procedure, the reason why the MAG sets up a new tunnel for the multicast packet is as follows: Let's assume that there are many MNs which join the same group in one MAG. In case of using the existing unicast tunnel, tunnel is formed as much as the number of MNs that join one multicast group. This caused the waste of link resource. So, MAG sets up another tunnel for the multicast packet. After setting up two tunnels, n-MAG sends the tunnel set up completion message to p-MAG. The purpose to send this message to p-MAG is to inform n-MAG that it will receive the multicast packet for MN because the tunnel set up procedure is finished.

The n-MAG performs the buffering of multicast packet that is received from LMA after buffered packets received from p-MAG. After forwarding the last packet, p-MAG sends HI message that include last datagram ID to n-MAG. The n-MAG that has received this HI message sends another HI message to LMA that allows it can start to send packets for MN. Thus, the reason why p-MAG sends an additional HI message is to solve the overlapped packets and out of sequence problems through the buffering. The LMA that has received the HI message sends multicast packets to the n-MAG from this time. And, the n-MAG performs the buffering of the multicast packet that is received from the LMA after buffering of multicast packet from the p-MAG.

MN accesses New AP (n-AP) while n-MAG is performing the buffering. When the MN is connected to n-AP, like the initial connection, MN performs the layer-2 Association procedure and n-MAG receives the layer-2 trigger from n-AP

through this procedure. The n-MAG, after receiving the layer-2 trigger, sends the RA message to MN right after the trigger because it completed the binding and joined the multicast group for MN in advance. And then, n-MAG sends the buffered packets to MN immediately. Therefore, MN can be provided the seamless service without the binding procedure and the additional MLD message exchange even though MN connects to the n-MAG.

#### IV. Simulation

In order to evaluate the performance of proposed handover scheme, we use the NS-2 network simulator. Figure 4 shows the topology used for the simulation. The topology includes a mobile node that is provided the service as it moves, source node that generates the multicast traffic, two AP nodes that is connected to MN, MAG, LMA and PS node that controls these domains. The topology also includes RP node that is connected to source node. In the given topology, the wired link transmission delay is set to 50ms and the wireless link transmission delay is set to 100ms. Also, the wired link transmission delay between RP node and source node is set to 200ms, and the delay between RP node and LMA node is set to 100ms. The delay between MAG nodes is set to 20ms. The data transmission distance between AP and MN is set to 100m and the distance among MAGs are set to 5km. We use 802.12b as the MAC protocol. In order to simulate the effect of proposed scheme according to the traffic type, we use both TCP and UDP traffic as data. Also, we use PIM-SM (Protocol Independent Multicast-Sparse Mode) that has been widely used recently as the multicast routing protocol. In this topology, MN receives the packet that is transmitted from the source node through the AP1. And then, after 60 second later, MN starts moving to AP2 at constant velocity, 60m/s. To measure, compare and analyze the performance, we measure the UDP Datagram ID, TCP Sequence Number, UDP and TCP Throughput when the movement among the MAGs occurs. The simulation parameters are listed in Table 1.

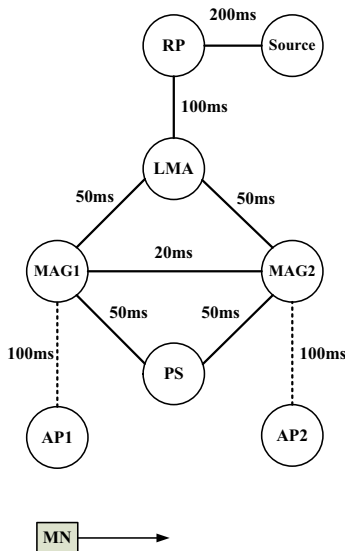


Figure 4. Simulation topology for performance evaluation

Table 1. Simulation Parameters

| Parameter                  | Value    |
|----------------------------|----------|
| Simulation time            | 120 secs |
| MAC protocol               | 802.11b  |
| Transmission range         | 100 m    |
| Distance between MAGs      | 5 km     |
| Link bandwidth             | 2 Mbps   |
| Velocity of MN             | 60 m/s   |
| Bit rate                   | CBR      |
| Packet size                | 1 Kbyte  |
| Multicast routing protocol | PIM-SM   |

Figure 5 shows the simulation results on UDP datagram ID that MN receives when source node sends the UDP traffic. As shown in figure 5, the existing scheme cannot receive the UDP datagram from 65.9 second to 67.6 second. This packet loss occurs because of the binding procedure and MLD message exchange procedure after completing layer-2 handover among APs. On the other hand, proposed scheme can receive the UDP datagram during disconnection period from 65.9 second to 66.35 second. That is, proposed scheme does not experience the packet loss because the datagrams that are generated while MN is moving is saved and transmitted. Also, the proposed scheme receives datagram IDs with a little bit higher IDs than the existing scheme during the same time interval. This result is caused by the fast binding procedure of the proposed scheme. The binding and group joining occur at the same time in the proposed scheme while the existing scheme performs the binding after completing layer-2 connection, and processes group joining after performing the binding. So, the proposed scheme can receive the packet a little bit faster.

This result affects the UDP throughput as shown in figure 6. the UDP throughput in the proposed scheme drops to zero for about 1700ms because of the effect of the handover, the binding procedure and group joining procedure. However, the UDP throughput in the proposed scheme drops just for about 450ms because it processes the binding procedure and group joining procedure at the same time. We can also notice that the proposed scheme prevent the throughput from dropping to zero because it performs the buffering.

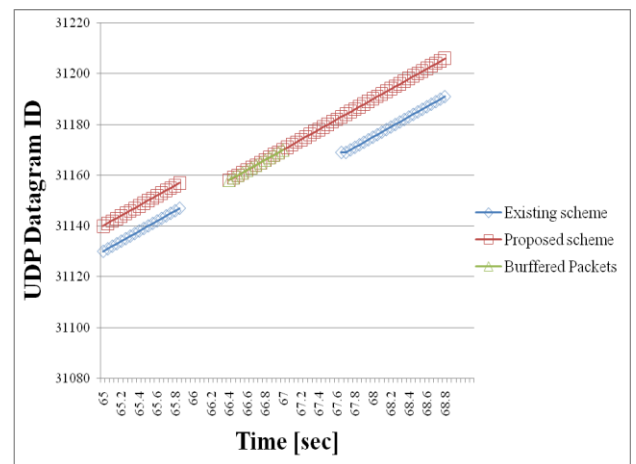


Figure 5. Comparison of UDP datagram ID

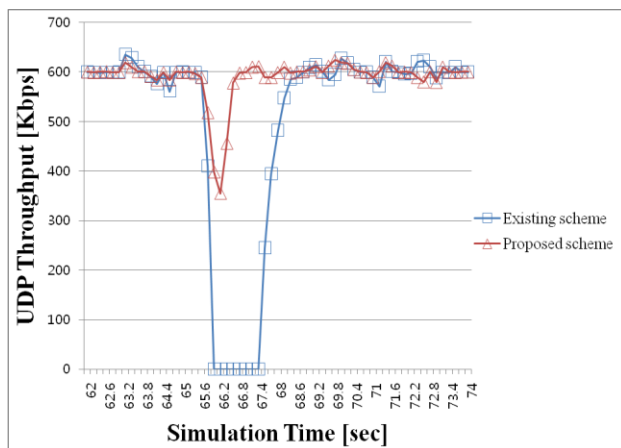


Figure 6. Simulation result of UDP throughput

Figure 7 and 8 show the simulation results of the TCP sequence number received by MN. Figure 7 shows the TCP sequence number received by MN when the existing scheme is used. We can notice that the delay of the binding procedure and the group joining procedure caused by the MN's handover occurs for about 1700ms similar to UDP. The packet that cannot be delivered during this delay time is re-transmitted by the TCP algorithm. There is an additional delay because MN receives the re-transmitted packets while it is receiving new packets from new network. On the other hand, figure 8 shows the TCP sequence number received by MN when the proposed scheme is used. We can notice that the delay time caused by the handover is greatly reduced and that there is no additional delay. Also, MN can be constantly provided the packets from network because the re-transmitted packet is significantly decreased due to the buffering function.

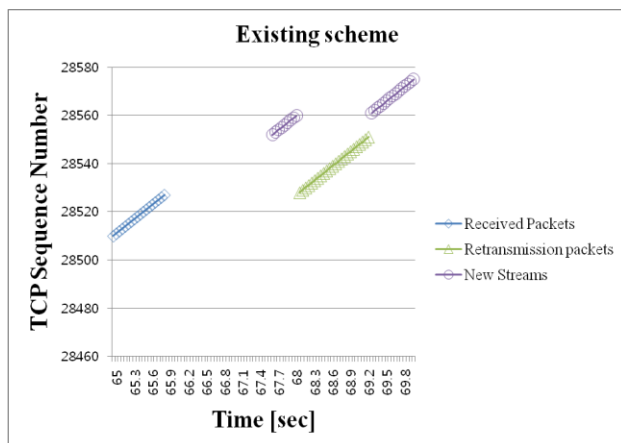


Figure 7. TCP sequence number of existing scheme

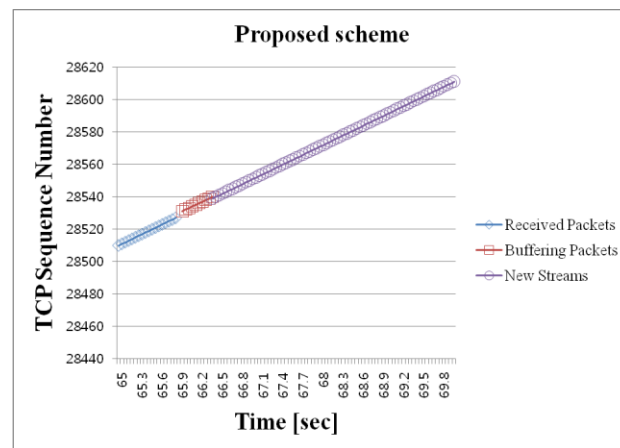


Figure 8. TCP sequence number of proposed scheme

Finally, figure 9 shows the result of TCP throughput comparison. Like the previous result of UDP case, we can notice that TCP throughput of the existing scheme drops to zero for about 1700ms while the proposed scheme does not drop to zero for about 450ms. Therefore, the proposed scheme is superior to the existing scheme in terms of TCP throughput as well as UDP throughput. As we examined the previous result, the proposed scheme in this paper can receive the packet a little faster because the binding procedure and the group joining procedure occur at the same time. Also, the proposed scheme provides the seamless multicast service through minimizing the packet loss caused by MN's movement by using the buffering function. Therefore, the proposed scheme outperforms the existing scheme in the multicast performance of MN movement.

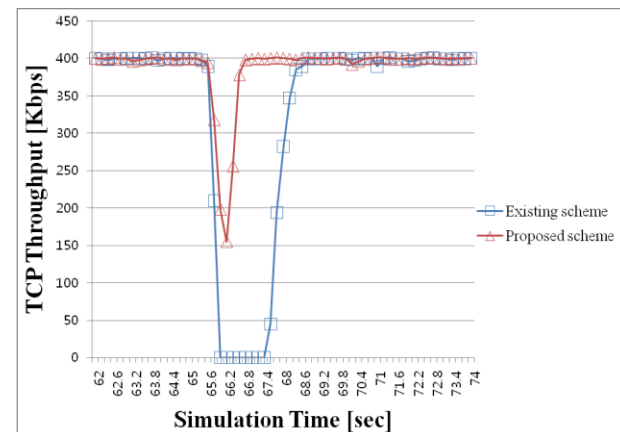


Figure 9. Simulation result of TCP throughput

## V. Conclusion

In this paper, we propose a new multicasting scheme which provides seamless service in PMIPv6 networks. Before discussing the proposed scheme, we explained the network architecture and existing multicast scheme in PMIPv6 network.

When MN's handover occurs (MN connect to n-MAG), the existing multicast in PMIPv6 suffers from the disconnection of service because MLD messages are exchanged after completing the binding procedure for n-MAG connection for joining of multicast group. However, the proposed scheme in

this paper reduced the unnecessary delay time by p-MAG to make n-MAG ready to accept MN's handover and multicast group joining procedure in advance using layer-2 handover trigger. Also, the packet loss can be prevented because both p-MAG and n-MAG perform buffering while MN is disconnected from the link.

Using the NS-2 simulation, we showed that the proposed scheme reduces unnecessary delay time with the result of UDP and TCP throughput comparison between the existing multicast scheme in PMIPv6 and the proposed scheme. Also, we showed that it can prevent the packet loss with the result of UDP datagram ID and TCP sequence number comparison between the existing multicast scheme in PMIPv6 and proposed scheme.

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