:: GENERAL INFORMATION ::

This is the 25th of the International Conference on Information Networking (ICOIN), which was started under the name of Joint Workshop on Computer Communications in 1986. At that time, it was a technical meeting for researchers and engineers on the Internet technologies in East Asian countries, where several technical issues were discussed, especially “how to connect each other.” In 1993, the meeting was reorganized as an international conference known as ICOIN.

Recent past editions were held in Busan, Korea (2010), Chiang Mai, Thailand (2009), Busan, Korea (2008), Estoril, Portugal (2007), and Sendai, Japan (2006).

The ICOIN 2011 conference looks for significant contributions to the computer communications and wireless networks, in the theoretical and practical aspects. Original papers are invited on wired/wireless network architecture, design, protocol, service, analysis, implementation, measurement and simulation.
## Poster Session 1P

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Proxy Mobile IPv6 with Partial Bicasting for Seamless Handover in Wireless Networks

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Abstract—This paper proposes an enhanced handover scheme of the Proxy Mobile IPv6 (PMIPv6) with partial bicasting in wireless networks. In the proposed PMIPv6 handover scheme, when a mobile node (MN) moves into a new network and thus its Mobile Access Gateway (MAG) performs the binding update to the Local Mobility Anchor (LMA), the LMA begins the ‘partial’ bicasting of data packets to the new MAG as well as the previous MAG. Then, the data packets will be buffered at the new MAG during handover and then forwarded to MN after the handover operations are completed. The proposed scheme is compared with the existing schemes of PMIPv6 and PMIPv6 with bicasting by ns-2 simulations. From the performance analysis, we can see that the proposed scheme can reduce handover delays and packet losses, and can also use the network resource of wireless links more effectively, compared to the existing schemes.

Keywords: Proxy MIPv6, handover, bicasting, buffering

1. INTRODUCTION

The Mobile IPv6 was designed as an IPv6-based mobility scheme [1], in which each Mobile Node (MN) should be equipped with the MIPv6 functionality to perform the mobility management signaling. Such a protocol is referred to as ‘host-based mobility management’ protocol. In the wireless network environment, however, it is not effective that each MN performs the MIPv6 protocol operations, due to the scarce resources of wireless network such as link bandwidth or MN power. Moreover, this scheme requires all the hosts to implement the mobility control software.

Recently, a network-based mobility control is proposed to enable IP mobility for a host, in which the network is responsible for managing the IP mobility control operations on behalf of the host. It is referred to as the Proxy Mobile IPv6 (PMIPv6) protocol [2], which has been standardized in the Internet Engineering Task Force (IETF). In PMIPv6, the mobile agent, called Mobile Access Gateway (MAG), located in the network will perform the mobility signaling instead of MN and will keep track of the movement of MN.

It is noted that the PMIPv6 is used mainly for binding update of the location of MNs. The PMIPv6 may be used for support IP handover. However, there are still a lot of issues that need to be solved in the perspective of seamless handover.

In this paper, we consider the ‘bicasting’ for handover, in which the PMIPv6 Local Mobility Agent (LMA) will bicast the data packets to the Previous MAG (P-MAG) and New MAG (N-MAG) toward MN, when MN is in the overlapping region between the two associated MAGs. Then, the bicasting can be used to minimize the packet loss and handover latency at a MN during handover. However, when the bicasting function is used to support the PMIPv6 handover, the following issues shall be disposed. First, this scheme may still incur data losses during handover when the underlying link is switched, since MN can receive data packets from only one of the two links at a time. Next, the PMIPv6 handover with bicasting tends to waste the resources of wireless links by sending duplicated packets.

To solve these issues, we propose a new handover scheme of PMIPv6 with Partial Bicasting, in which the bicasting is done by using the PMIPv6 tunnel in the partial network region between LMA and MAG. In addition, the N-MAG will buffer the data packets to reduce the data packet losses that may occur at the link switching time. From the performance analysis by ns-2 simulations, it is shown that the proposed scheme can benefit from reduction of handover delays and packet losses, and effective use of network resource of wireless link, compared to the existing handover schemes.

This paper is organized as follows. Section II describes the related works on the PMIPv6 and PMIPv6 with bicasting in the handover point of view. In Section III, we present the proposed scheme of the PMIPv6 with partial bicasting and buffering for seamless handover. In Section IV, the proposed scheme is analyzed and compared with the existing schemes by ns-2 simulations. Section V concludes this paper.

II. RELATED WORK

A. Network Model

Figure 1 shows a network model for PMIPv6 handover schemes. We consider a simplified network model, in which MN moves from P-MAG to N-MAG during communications with a correspondent node (CN) that is not located in the same PMIPv6 domain. Note that P-MAG and N-MAG as the first IP-level nodes in the viewpoint of MN.
B. Basic Handover in Proxy Mobile IPv6

Figure 2 shows the basic handover operations of PMIPv6 [2]. By movement to a new network region, MN changes its point of attachment. At the same time, the P-MAG will detect the MN’s detachment and will perform the Proxy Binding Update (PBU) operations with LMA to remove the binding state associated with MN.

When MN gets a Link-Up trigger of the new link, it establishes a link connection with N-MAG, and then N-MAG sends a PBU message to establish a new PMIP tunnel with LMA. Upon receiving the PBU request, the LMA will identify the concerned MN and update its binding table of the MN with the CoA of N-MAG. LMA then sends the Proxy Binding ACK (PBA) to N-MAG with the home network prefix (HNP) of MN. The N-MAG sends Router Advertisement (RA) with the HNP of MN. In this period, a certain amount of handover latency may be taken. During this handover period, some packet losses occur.

C. Handover scheme on Proxy Mobile IPv6 with Bicasting

Figure 3 shows the handover operations of PMIPv6 with bicasting, which is based on the work [3].

When the P-MAG receives a link layer signaling message of Link-Detected, it requests N-MAG to establish a new PMIP tunnel with LMA by sending a Handover Init (HI) message that includes the MN’s Proxy-CoA and Home address (MN-HoA). The N-MAG receives HI message, it should examine whether a tunnel to the LMA already exists or not. If the tunnel has not been established, it should establish the tunnel with the LMA.

To establish the tunnel, N-MAG sends a PBU message to LMA. It includes MN-Identifier and MN-HoA. On reception of PBU from N-MAG, the LMA creates a new binding cache entry. It then sets the tunnel with N-MAG, which is used to send and receive the data packets between N-MAG and LMA.

After the successful establishment of the PMIP tunnel, the LMA will transmit the data packets to both P-MAG and N-MAG. From this phase, the bicasting transmissions begin, in which LMA may employ the transient binding scheme for PMIPv6 [4] and N-MAG sends a Handover ACK message to P-MAG. When the new link is established, N-MAG requests LMA to stop the bicasting transmissions and to release the old PMIP tunnel by sending the PBU message which includes the MN-identifier and the Proxy-CoA of P-MAG.

On reception of this PBU message, the LMA deletes the binding cache entry associated with the P-MAG, and stops bicasting to the P-MAG. In response of PBU message, the LMA sends a PBA message to the N-MAG. Now, the handover operations are completed.

III. PMIPv6 with Partial Bicasting

In this paper, we propose an enhanced scheme for seamless handover, in which we will extend the PMIPv6 handover
scheme. The proposed scheme can be used to reduce the packet loss and handover latency during handover in the PMIPv6 wireless network.

Figure 4 shows the operation of the proposed scheme.

In the figure, the initial operations for handover are the same with those of PMIPv6 with bicasting (as already described in the previous section). By movement to a new MAG, the Handover Init message is sent to N-MAG and the PBU and PBA messages are exchanged between N-MAG and LMA. However, the bicasting transmission is performed in the ‘partial’ network region between LMA and N-MAG, rather than between LMA and MN.

On reception of the PBA message from LMA, the N-MAG will begin to buffer the data packets arriving from LMA. At the same time, it will request P-MAG to stop bicasting by sending a Handover Init ACK message. In turn, the P-MAG will release the old PMIP tunnel by sending a PBU message to the LMA.

After the new link is established, the N-MAG forwards the buffered data packets to MN. So, we can minimize the packet losses during handover. After that, the normal data transfer operation will be performed between MN and LMA.

In the proposed handover scheme, the bicasting will be performed only in the ‘partial’ region between LMA and MAG, rather between LMA and MN, and thus we can use the network resources of wireless link more effectively. In addition, data losses during handover can be reduced by using buffering at N-MAG.

**IV. EXPERIMENTATIONS FOR PERFORMANCE ANALYSIS**

In this section, we compare the proposed handover scheme (PMIPv6 with partial bicasting) and the existing schemes (PMIPv6 and PMIPv6 with bicasting) using the ns-2 network simulator [5]. In simulation, we consider the MN moves from P-MAG domain to N-MAG domain, as shows in Figure 5. We use the IEEE 802.21 Media Independent Handover (MIH) [6] so as to implement the link-layer triggers from access network.

As shown this figure, the wired link between CN and LMA has a network bandwidth of 100 Mbps and link delay of 50 ms, and the wired links between LMA and MAGs are configured with bandwidth of 100 Mbps and transmission delay of 10 ms. On the other hand, the wireless link between MAGs and MN has bandwidth of 11 Mbps and link delay of 10 ms. During simulation, CN transmits CBR data packets with UDP packet size of 1,000 bytes at a transmission rate of 100 packets per second. The link switching delay is set to 100 ms by default, which will vary for performance analysis.

Figure 6 shows the simulation results, in which the handover delays and packet losses are depicted during for the three candidate schemes: PMIPv6, PMIPv6 with Bicasting and PMIPv6 with Partial Bicasting.
From the figure, we can see that the PMIPv6 handover incurs more packet losses and larger handover delays, compared to the other candidate schemes using bicasting. On the other hand, the proposed scheme provides much lower packets losses than PMIPv6 with Bicasting scheme, while the handover delays are almost the same for the two schemes.

Figure 7 compares the wireless resource utilization of network bandwidth that MN is attached. In the PMIPv6 with Bicasting scheme, the network resource tends to be severely wasted, compared to PMIPv6 and PMIPv6 with Partial Bicasting schemes during handover from 10 seconds to 10.5 seconds. This is because the PMIPv6 with Bicasting scheme transmits the duplicated packets to MN over wireless links during handover. In the meantime, the proposed PMIPv6 with Partial Bicasting scheme uses the similar performance with the existing PMIPv6 handover. When more packets are generated, the performance gets worse in the PMIPv6 with bicasting.

![Figure 7. Comparison of resource utilizations over wireless link](image1)

In the figure, we can see that the handover delays increases as the link switching time gets larger for all of the candidate schemes. It is also noted that the bicasting schemes give lower handover delays than the existing PMIPv6 handover. Both the bicasting schemes provide almost similar handover delays for all the link switching times. In other words, the handover delays are dependent on link switching time.

Figure 8 compares the handover delays of the three candidate handover schemes for different link switching times. In the figure, we can see that the existing handover schemes (PMIPv6 and PMIPv6 bicasting) incur some packet losses, and the amount of lost packets get larger, as the link switching time increases. In the meantime, the proposed PMIPv6 with Partial Bicasting handover scheme gives almost zero packet loss, even if the link switching time increases. This is because in the proposed scheme the data packets are buffered at the N-MAG and forwarded to MN, when it is attached to the N-MAG, without any packet loss.

![Figure 8. Comparison of handover delays during handover](image2)

Figure 9 shows the number of data packets that have been lost during handover. From the figure, we can see that the existing handover schemes (PMIPv6 and PMIPv6 bicasting) incur some packet losses, and the amount of lost packets get larger, as the link switching time increases. In the meantime, the proposed PMIPv6 with Partial Bicasting handover scheme gives almost zero packet loss, even if the link switching time increases. This is because in the proposed scheme the data packets are buffered at the N-MAG and forwarded to MN, when it is attached to the N-MAG, without any packet loss.

![Figure 9. Comparison of packet losses during handover](image3)

Figure 10 shows the number of data packets that have been dropped during handover. From the figure, we can see that the
existing schemes (PMIPv6 and PMIPv6 bicasting) incur some packets drops. Moreover, the amount of dropped packets gets larger, as the link switching time increases. Note that even the PMIPv6 with bicasting scheme has experienced some packet drops. In the meantime, the proposed scheme gives almost zero dropped packets, even if the link switching time increases. This is because the data packets are buffered at the N-MAG in the proposed scheme.

V. CONCLUSIONS

This paper proposed an enhanced handover scheme of the PMIPv6, which is based on the partial bicasting. In the proposed scheme, the bicasting of data packets is performed to the N-MAG as well as P-MAG. In addition, the N-MAG performs the buffering of the data packet, until the link is established between N-MAG and MN.

The proposed scheme is compared with the existing schemes in terms of handover latency, packet loss, and usage of network resources. The proposed scheme can reduce the packet losses (drops) by using the buffering at the N-MAG. Moreover, the proposed scheme can minimize the network resources by releasing the old PMIP tunnel in advance.

ACKNOWLEDGMENT

This research was supported by the IT R&D program of MKE/KEIT(10035245: Study on Architecture of Future Internet to Support Mobile Environments and Network Diversity) and the ITRC program of MKE/NIPA(NIPA-2010-C1090-1021-0002).

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