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

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Abstract—This paper addresses the Proxy Mobile IPv6 (PMIP) handover using bicasting in mobile/wireless networks. The bicasting scheme can be used to support the PMIP handover, which tends to waste the network resources of wireless links and incurs data losses during handover. We propose an enhanced scheme of PMIP handover, called the partial bicasting with buffering for PMIP (PBB-PMIP). In the PBB-PMIP handover, the bicasting is performed in the "partial" region between the Local Mobility Anchor (LMA) and the Mobile Access Gateway (MAG), when a mobile node is in the handover area. The data packets are buffered at the new MAG during handover to reduce data losses and are then forwarded to mobile nodes after handover. By ns-2 simulations, the proposed PBB-PMIP scheme is compared with the existing schemes of PMIP and PMIP with bicasting. The proposed scheme can benefit from the reduction of handover delay and packet loss, and the effective use of the network resources of wireless links, as compared to the existing handover schemes.

Keywords—Proxy Mobile IPv6, Handover, Partial Bicasting, Buffering, Simulation Analysis

1. INTRODUCTION

The Proxy Mobile IPv6 (PMIP) [1] was designed as a network-based mobility scheme. Some works have been made to support the PMIP handover, which include Fast Handovers for Proxy Mobile IPv6 (PFMIP) [2]. In the PFMIP handover, a "handover tunnel" is used between the two neighboring Mobile Access Gateways (MAGs), as done in the Fast Handovers for MIPv6 [3]. However, such a handover tunnel will be established between two MAGs, in addition to the "PMIP tunnel" between the MAG and Local Mobility Anchor (LMA). Moreover, it is not easy to effectively manage such a tunnel during handover.

In this paper, we consider bicasting [4] for handover, which can be used to minimize packet loss at a mobile node (MN) during handover. In particular, this can remove the "timing ambiguity" regarding when to start sending data packets to the new link of the MN. However, when the bicasting function is used to support the PMIP handover, the following concerns still need to be disposed. First, the PMIP handover with bicasting tends to waste the network resources of yje wireless link by sending duplicated data packets. Next, the bicasting scheme may still incur data

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losses by link switching during handover.

To address such issues, we propose a new scheme of Partial Bicasting with Buffering for PMIP handover (PBB-PMIP). In the proposed scheme, the bicasting is done by using the PMIP tunnel in the partial network region between LMA and MAGs. In addition, the data packets are buffered at the new MAG to reduce data losses that may occur by handover. The proposed scheme can benefit from the reduction of handover delay and packet loss, and the effective use of the network resources of wireless links, as compared to the existing handover schemes.

This paper is organized as follows: Section 2 describes the proposed scheme with the existing handover schemes of PMIP [1] and PMIP with bicasting (B-PMIP) [4]. In Section 3, we compare the performances of candidate handover schemes by ns-2 simulation. Section 4 concludes this paper.

2. PMIPv6 Handover with Bicasting

2.1 Network Model

To describe the existing and proposed PMIP handover schemes, we consider a simplified network model, as shown in Fig. 1. In the figure it is assumed that the Home Agent (HA) is co-located with the LMA, and that the MN moves from MAG_{old} to MAG_{new} during communication with a correspondent node (CN).

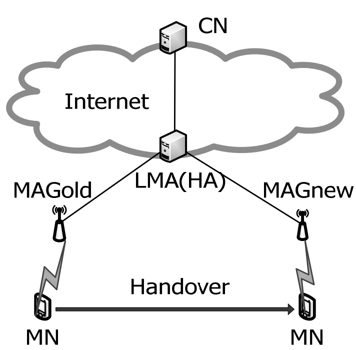

Fig. 1. Network model for PMIP handover

2.2 Existing PMIP and B-PMIP Handovers

We describe the existing handover schemes: PMIP [1] and PMIP with bicasting (B-PMIP) [4]. To support handover, we considered the following link-layer triggers of a new link: Link-Detected and Link-Up, which are defined in the Media Independent Handover (MIH) [5]. We noted that the Link-Detected trigger contains the information of a new MAG of MN.

Fig. 2 shows the operations of the existing PMIP handover. In the figure, when MN detects a new link, it sends an associated link layer-signaling message (e. g., MIH message) to the MAG_{old}. Then, the MAG_{old} will release the old PMIP tunnel by exchanging the Proxy Binding Update (PBU) and the Proxy Binding ACK (PBA) messages with the LMA, as shown in the figure, or by using an appropriate timer. When the MN gets a Link-Up trigger for the new link, it estab-

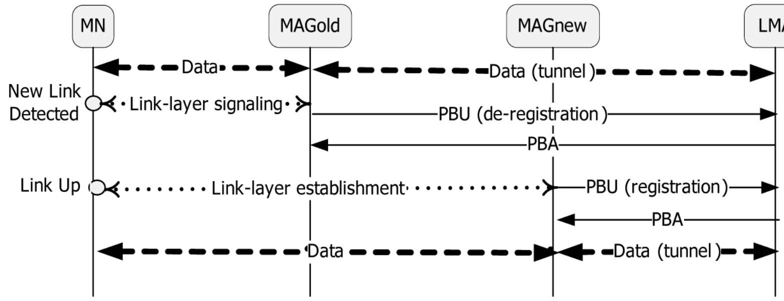

Fig. 2. PMIP handover

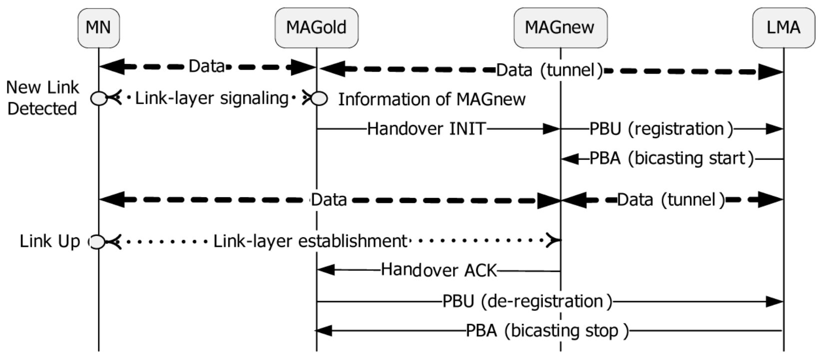

Fig. 3. B-PMIP handover

lishes a link connection with the MAG_{new}, and then the MAG_{new} begins to establish a new PMIP tunnel with LMA.

Fig. 3 shows the B-PMIP handover with bicasting, which is based on [4]. When MAG_{old} receives a link layer-signaling message from the Link-Detected, it requests the MAG_{new} to establish a new PMIP tunnel with the LMA by sending a Handover INIT message. The MAG_{new} will send a PBU to LMA, and then the LMA transmits data packets to both MAG_{old} and MAG_{new}. From this phase, the bicasting transmissions begin, in which LMA may employ the transient binding scheme for PMIP [6]. When the new link is established, MAG_{new} sends a Handover ACK message to MAG_{old}, and then MAG_{old} requests LMA to stop the bicasting transmissions and to release the old PMIP tunnel by sending the PBU message.

2.3 Proposed PBB-PMIP Handover

Fig. 4 shows the proposed PBB-PMIP handover, in which the initial handover operations are the same as those of B-PMIP, which include the transmission of Handover INIT from the MAG_{old} to the MAG_{new}, and the exchange of the PBU and PBA messages between the MAG_{new} and the LMA. Then, the bicasting transmission will be performed in the "partial" network region between the LMA and the MAG_{new}. On reception of PBA from the LMA, the MAG_{new} will begin to buffer the data packets arriving from the LMA, and will request for the MAG_{old}, so as to

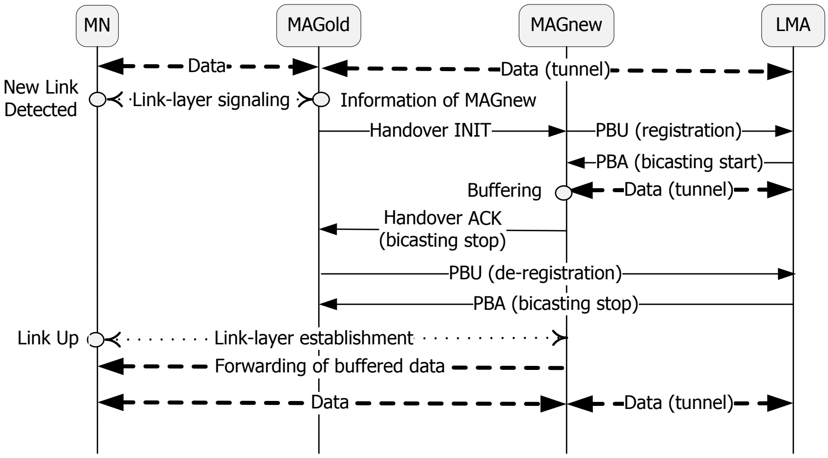

Fig. 4. Proposed PBB-PMIP scheme

stop the bicasting by sending a Handover ACK message. In turn, the MAG_{old} will release the old PMIP tunnel by sending a PBU message to the LMA. When the new link is established, the MAG_{new} forwards the buffered data packets to the MN. After that, the normal data transfer operation is performed between the MN and the LMA.

In the PBB-PMIP handover, the bicasting is performed in the partial region between the LMA and the MAG_{new}, and thus we do not have to use the network resources of the wireless link during handover. In addition, data losses during handover can be reduced by using buffering at MAG_{new}.

3. Performance Analysis by ns-2 Simulations

For performance analysis, we compare the proposed PBB-PMIP scheme with the existing PMIP and B-PMIP schemes by using the ns-2 simulator [7].

Fig. 5 depicts the network topology used in ns-2 simulations. As shown in the figure, the link between CN and LMA has a network bandwidth of 100 Mbps and link delay of 50 ms, and the wired links between the LMA and the MAG are configured with a bandwidth of 100 Mbps and a transmission delay of 10 ms. On the other hand, the wireless link between MAG and MN has bandwidth of 11 Mbps and a link delay of 10 ms, with random delay variations. During simulation, CN transmits CBR data packets over the UDP with a packet size of 1,000 bytes at the rate of 100 packets per second. The link switching delay is set to 100 ms by default, which will vary for performance analysis.

Fig. 6. shows the experimental results, in which the handover delays and packet losses are depicted for the three candidate schemes: PMIP, B-PMIP, and PBB-PMIP.

From the figure, we can see that the PMIP handover incurs severe packet losses and large handover delays, compared to the bicasting handovers of B-PMIP and PBB-PMIP. On the other hand, it is noted that the proposed PBB-PMIP scheme provides much lower packet losses than the existing B-PMIP handover. This is because the proposed scheme uses the buffering at the MAG_{new} to reduce data losses during handover.

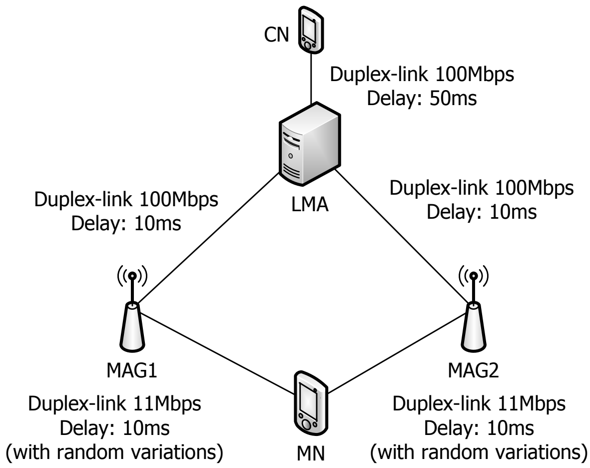

Fig. 5. Simulation topology

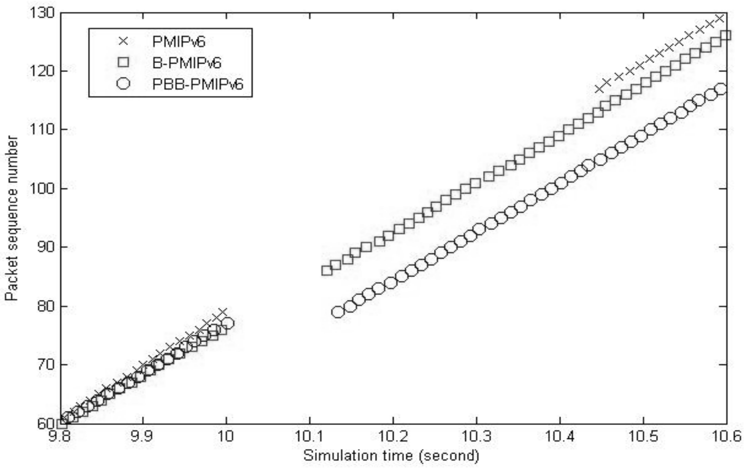

Fig. 6. Traces of data packets transmitted during simulation

Fig. 7 compares the utilization ratios of bandwidths for the wireless link that the MN is attached to. In the B-PMIP scheme, the link bandwidth tends to be severely wasted, compared to the PMIP and PBB-PMIP schemes, during handover (over the time interval from 10.0 to 10.5 seconds). This is because in the B-PMIP scheme the duplicated packets are transmitted to the MN over wireless links. In the meantime, the proposed PBB-PMIP scheme uses the network resources effectively at the same level with the PMIP handover.

Fig. 8 compares the handover delays of the three candidate schemes for different link switching times. In the figure we can see that the handover delays increase, as the link switching time gets larger for all the candidate schemes. It is noted that the bicasting schemes of B-PMIP and PBB-PMIP give lower handover delays than the pure PMIP handover. Both B-PMIP and PBB-PMIP provide almost similar handover delays for all the link switching times.

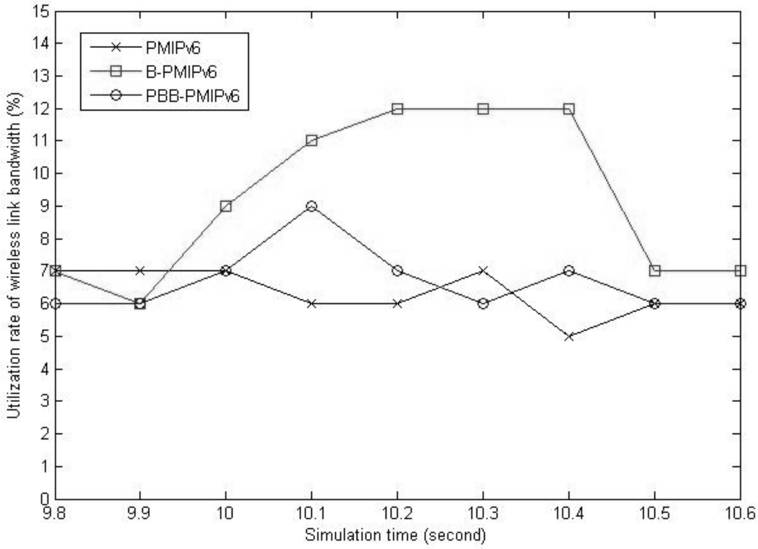

Fig. 7. Comparison of resource utilizations over a wireless link

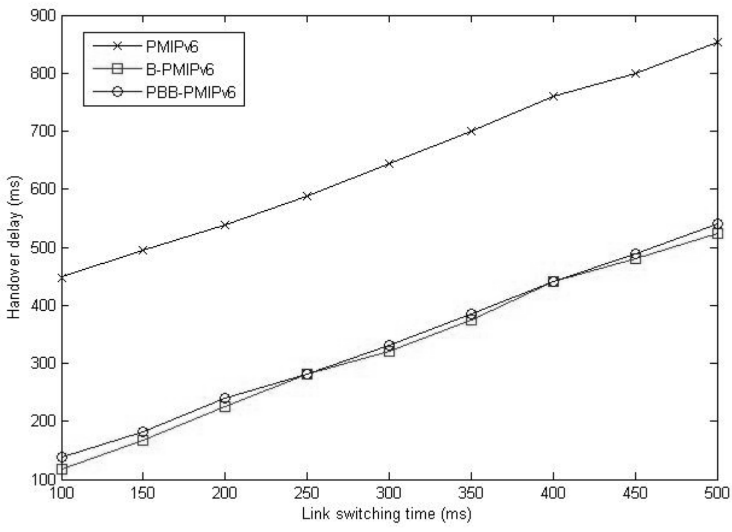

Fig. 8. Comparison of handover delays during handover

Fig. 9 shows the number of data packets that have been lost during handover. From the figure, we can see that the existing PMIP and B-PMIP schemes incur some packet losses, and the amount of lost packets get larger, as the link switching time increases. The proposed scheme is more effective when the link switching time is relatively large. In the meantime, the PBB-PMIP scheme gives almost zero packet loss, even though the link switching time increases. This is because in the proposed PBB-PMIP scheme the data packets are buffered at the MAG_{new} and are then forwarded to the MN when it is attached to the MAG_{new}.

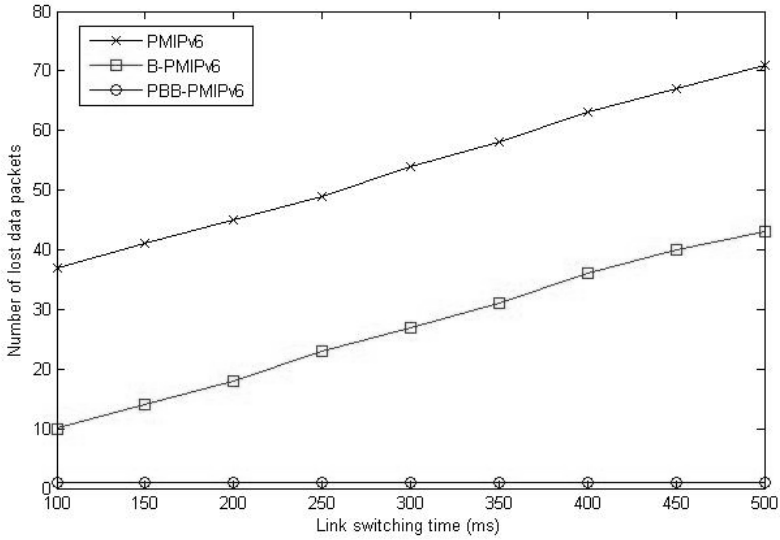

Fig. 9. Comparison of packet losses during handover

4. CONCLUSION

This paper presented partial bicasting with buffering for enhancing the performance of PMIP handover. In the proposed scheme, the bicasting is performed in the partial area between the LMA and the MAG, and the data packets are buffered at the new MAG during handover to reduce data losses.

From the simulation results, we can see that the proposed handover scheme can reduce handover delays and packet losses during handover, and that it can also effectively use the network resource of wireless links, compared to the existing handover schemes.

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