### Session 2 10:40 ~ 12:00

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B-PMIPv6: PMIPv6 with Bicasting for Soft Handover

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Abstract — This paper proposes an extension of Proxy Mobile IPv6 (PMIPv6) with bicasting for soft handover, named B-PMIPv6. The proposed scheme is compared with the existing PMIPv6 handover scheme by the theoretical analysis and the network simulator. From the experimental results, we can see that the proposed B-PMIPv6 scheme can provide smaller handover latency and reduce packet loss than the existing schemes.

Keywords — PMIPv6, Bicasting, B-PMIPv6, IP Handover.

1. Introduction

To support IPv6 mobility, the Mobile IPv6 (MIPv6) was standardized in the Internet Engineering Task Force (IETF) [1]. The MIPv6 protocol can be used to maintain IP connectivity for the mobile node (MN). To perform the mobility management signaling, each MN should be equipped with the MIPv6 functionality. Such a protocol is referred to ‘host-based mobility management’ protocol.

In the wireless network environment, however, it is not effective that each mobile node (MN) perform the MIPv6 due to the scarce resource of the wireless network such as link bandwidth or terminal power. In particular, it is not easy for MN to implement any mobility software such as MIPv6.

Recently, the Proxy MIPv6 (PMIPv6) protocol was proposed for providing the network-based IP mobility management support for MN, without requiring the participation of MN in any IP mobility signaling [3]. In the PMIPv6, the mobile agent located in the network will keep track of the movement of MN and will perform the mobility signaling, instead of MN.

It is noted that PMIPv6 is used mainly for registration or binding update of the location of MNs. A recent work has been made on the PMIPv6-based handover. However, in the perspective of seamless handover, the PMIPv6 still needs to be for further study.

This paper proposes a new scheme of B-PMIPv6 (PMIPv6 with bicasting) for seamless IP handover, in which the PMIPv6 Local Mobility Agent (LMA) will bicast the data packets to the old and new Mobile Access Gateways (MAGs) toward MN, when MN is in the handover region. From the ns-2 network simulator experimentation, it is shown that the proposed scheme can improve the handover performance.

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2. Related Works

Figure 1 shows the operation of PMIPv6 in the handover scenario, in which MN moves from the Previous Mobile Access Gateway (P-MAG) to the New Mobile Access Gateway (N-MAG).

Figure 1. PMIPv6 handover operation

After the initial address configuration in the PMIPv6 domain, 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 the LMA to remove the binding and routing state associated with MN.

Upon receiving this PBU request, the LMA will identify the concerned MN and accept the PBU request. After that, the LMA will wait for a certain amount of time for allowing the N-MAG to perform the PBU operation. In this period, a certain amount of handover latency may be taken. During this handover period, some packet losses may occur. Accordingly, it is not easy to achieve seamless handover.

To support the PMIPv6-based handover, the Fast Localized Proxy Mobile IPv6 (FLPMIPv6) was proposed. The FLPMIPv6 may be used to reduce the handover latency and packet loss. FLPMIPv6 scheme is based on the Fast Mobile IP (FMIPv6) [4]. Figure 2 shows the overview of FLPMIPv6 operations. In FLPMIPv6, MN moves from Previous Proxy Mobile Agent (PPMA) to New Proxy Mobile Agent (NPMA). PPMA and NPMA are used for the MN’s default router.
Figure 2. FLPMIPv6 handover operation

In this figure, MN moves from Previous Proxy Mobile Agent (PPMA) to New Proxy Mobile Agent (NPMA). PPMA and NPMA are used as the default router of MN. By movement, a handover tunnel will be established between PPMA and NPMA, as done in FMIPv6. However, FLPMIPv6 operates based on the additional handover tunnel management and buffering at the NPMA.

3. PMIPv6 with Bicasting

The proposed scheme of B-PMIPv6 is an extension of PMIPv6, which can be used to reduce the packet loss and handover delay during handover using bicasting in the PMIPv6 domain.

Figure 3 shows the reference network configuration for B-PMIPv6.

Figure 3. B-PMIPv6 Overview

In the figure, MN moves from P-MAG region toward N-MAG region. When MN is in the overlapping region, LMA will begin the bicasting of data packets to the N-MAG as well as P-MAG. This bicasting is performed to minimize the possible packet losses and handover latency during the handover, since the MN could receive the data packet from one of the P-MAG and N-MAG.

When MN moves to the bicasting region, it receives a Link-Going-Down (LGD) indication from the Media Independent Handover Function (MIHF) [5]. Then, the MN’s MIHF sends the MIH Handoff Initiate (MIH_HO_Init) command message to the current P-MAG. This message includes N-MAG’s [AR-ID, ARInfo] tuples.

After P-MAG receives an MIH_HO_Init, the PMAG sends MIH_HO_Init_Ack to MN where the MIH_HO_Init_Ack message includes the whether the message is sent or not and the P-MAG sends Handover Initiate (HI) message to N-MAG where the HI message includes the MN’s IP address (PCoA) and MN’s Identifier. The N-MAG receives HI message, it should examine whether a tunnel to the LMA exists for PCoA or not. If the tunnel has been already established, it could imply one of the following two cases:

1) HI message from P-MAG is spurious and N-MAG had already setup tunnel with LMA.
2) There is already a node with the same PCoA address on the link. The N-MAG verifies the MN’s identifier to see whether it is the same node or not. If it is the same node, it returns failure indicating Duplicate Address.

If N-MAG successfully processes the HI message, it sends a PBU (Bicasting Init) message to the LMA so as to establish the tunnel from LMA. The PBU (Bicasting Init) message includes PCoA as the home address as well as it can optionally include the MN’s unique identifier.

When LMA receives the PBU (Bicasting Init) message, it creates a new binding entry. Once the LMA successfully processes the PBU (Bicasting Init), it sets the tunnel with N-MAG for sending and receiving packets. After successful establishment of the bicasting tunnel, the LMA sends a PBA (Bicasting Ack) message to N-MAG. When the N-MAG...
receives a successful PBA (Bicasting Ack) message, it examines whether or not the PBU (Bicasting Init) message was processed successfully. If there is a failure, the PBA (Bicasting Ack) message indicates the failure. Otherwise, N-MAG creates a tunnel to the LMA and ensures that the packets with destination address as PCoA are copied and forwarded over the tunnel. It also creates a host route for forwarding packets to the MN. The N-MAG sends a Handover Ack message back to the P-MAG to indicate that the handover procedure was successfully done.

When the MN connects to the new link, MN receives a Link Up indication from MIHF. The MN sends MIH HO Com message to N-MAG. In response to MIH_HO_Com message, N-MAG sends MIH_HO_Com_Ack message to the MN. And then the N-MAG sends a PBU (Bicasting Completion) message to the LMA. This message includes MN-identifier, information of N-MAG. On reception of this HC message, the LMA deletes the binding cache entry associated with the P-MAG, and stop the bicasting (i.e., release the bicasting tunnel between LMA and PMAG). In response to PBU (Bicasting Completion) message, LMA sends PBA (Bicasting Completion Ack) message to the N-MAG. By thus, the bicasting operations are completed.

4. Comparison of Handover Schemes

This section compares the PMIPv6 handover protocols that are PMIPv6, FL-PMIPv6 (Fast Localized Proxy Mobile IPv6)[4], and proposed scheme named B-PMIPv6.

Table 1 describes the comparison of the PMIPv6 handover protocols.

<table>
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<tr>
<th>Handover Latency</th>
<th>PMIPv6</th>
<th>FL-PMIPv6</th>
<th>B-PMIPv6</th>
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<tbody>
<tr>
<td>Packet Re-ordering Problem</td>
<td>None</td>
<td>Possibly occur</td>
<td>None</td>
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First of all, PMIPv6 has the handover latency that consists of Movement Detection (MD) delay and Proxy Binding Update (PBU) delay. But it does not have packet reordering problem.

Secondly, FL-PMIPv6 reduces the handover latency that is L3 MD delay, because it uses 802.21. But it is based on FMIPv6 scheme, thus the routers have the buffering overhead for handover. In particular, if MN moves to another MAG other than N-MAG, all the packets buffered at N-MAG will be lost. Furthermore, it performs the buffering, so it has packet re-ordering problem between the packet received from P-MAG and the packet received from LMA.

Finally, B-PMIPv6 is the proposed scheme. It reduces the handover latency, because it uses 802.21, too. And it is that LMA will bicast the data packets to the old and new MAGs toward MN, when MN is in the handover region. So the packet losses will be reduced. Moreover, the proposed scheme does not need any additional forwarding and buffering operation, so MAGs have no additional overhead. In the proposed scheme, MN will not release the connection to P-MAG before handover completion. Thus, the proposed scheme prevents the packet loss that may occur due to a wrong prediction of MN’s movement or handover. And B-PMIPv6 does not perform the buffering, it has no problem the packet is re-ordered. By bicasting, the proposed scheme can enhance the handover performance.

5. Experimental Results

This section describes the experimental results for PMIPv6 and B-PMIPv6 that are performed over the Network Simulator-2 (NS-2) [6]. To perform the experiments, we construct a small test network where consists of LMA, two MAGs, CN(Correspondent Node), and MN in simulator. Figure 5 shows the network topology of the test network.

The test network has two subnets: P-MAG and N-MAG. In the test network, MN is initially connected to P-MAG. At the 10s after the experiment, we enforced the MN to perform L2 handover to N-MAG. In B-PMIPv6, P-MAG detects the MN’s movement at 9.5s, and N-MAG detects handover completion at 11s.

Figure 6 plots the sequence numbers of data packets transmitted for comparison during handover.

Figure 7 plots the throughput of data packet transmitted for comparison during handover.

From the Figure 6 and 7, it is shown that the PMIPv6 handover latency is 0.5s, whereas B-PMIPv6 handover latency is less than 0.1s. It is possible that MN receives the data packet when it connects to N-MAG in N-MAG region. But PMIPv6 goes through PBU procedure. So it takes more handover latency than B-PMIPv6.

For experiment, we enforced MN to perform the L2 handover from P-MAG region to N-MAG region at the time of 10s. From the figure, it is shown that B-PMIPv6 provides short handover latency and reduces packet losses.

From the results, we can also see that these empirical results are nearly similar to the theoretical analysis that was described in Section 4.
For further study, the proposed scheme of B-PMIPv6 needs to be compared by simulation and experimentations more another PMIPv6 including FL-PMIPv6.

REFERENCES


6. Conclusion

In this paper, we have compared the handover latency of PMIPv6, FL-PMIPv6 and B-PMIPv6. We first analyzed the schemes theoretically associated with handover. We then compare the handover performance of PMIPv6 and B-PMIPv6 over Network Simulator by experimentation.

For the analytical and experimental results, we can see that B-PMIPv6 does not have the packet re-ordering problem. In particular, B-PMIPv6 gives shorter handover latency than PMIPv6. This is because B-PMIPv6 receives the data packet P-MAG during handover operation, so it needs only the L2 handover delay taken link down and up, whereas PMIPv6 requires delay taken MN’s movement detection and PBU delay.