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An Optimized Reactive Fast Inter-MAP Handover for HMIPv6 to Minimize Packet Loss

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Abstract

This paper proposes an optimized reactive fast inter-mobility anchor point (MAP) handover scheme for Hierarchical Mobile IPv6, called the ORFH-HMIPv6, to minimize packet loss of the existing scheme. The key idea of the proposed ORFH-HMIPv6 scheme is that the serving MAP buffers packets toward the mobile node (MN) as soon as the link layer between MN and serving base station is disconnected. To implement the proposed scheme, the MAP discovery message exchanged between MN and serving MAP is extended. In addition, the IEEE 802.21 Media Independent Handover Function (MIHF) event service message is defined newly. Through analytic performance evaluation and experiments, the proposed ORFH-HMIPv6 scheme can be shown to minimize packet loss much than the existing scheme.

Keywords: Hierarchical Mobile IPv6 (HMIPv6), Fast Handover, Reactive Behavior, 802.21 Media Handover Independent (MIH), Packet loss.

INTRODUCTION

The dramatic increase in wireless and mobile devices coupled with the desire to connect them to the ever-growing Internet is leading to a Mobile Internet, where support for terminal mobility would soon be taken for granted. Thus many kinds of protocol support and some enhancements have been standardized and researched[1]-[5].

Among them, fast inter-mobility anchor point (MAP) handover schemes have been developed to reduce handover latency of Hierarchical Mobile IPv6 (HMIPv6)[6]-[8] using the fast handover strategy for horizontal handover [9]-[11] as well as vertical handover [12].

The behavior of the fast inter-MAP handover scheme for HMIPv6, called the FH-HMIPv6, is classified by predictive and reactive according as the IP layer (L3) handover preparation is completed prior to the layer 2 (L2) handover or not. In the predictive FH-HMIPv6 scheme, the L3 handover preparation is completed prior to the L2 handover, which can reduce the L3 handover latency. In addition, since the target MAP buffers packets toward the mobile node (MN), packet loss can be minimized. However, due to the dynamic nature of wireless technologies, such as MN’s moving speed, a sudden degradation of L2 quality, an L2 handover decision rule, etc, there is no guarantee that the L3 handover preparation is completed prior to the L2 handover. That is, there can be no sufficient time to process all FH-HMIPv6 signaling messages before the L2 disconnection. Therefore, in this case, the FH-HMIPv6 should be operated by reactive behavior, which is called the RFH-HMIPv6. However, in the RFH-HMIPv6, the L3 handover latency increases since the L3 handover preparation is started after the L2 handover. In addition, the RFH-HMIPv6 does not support packet buffering function, which can introduce packet loss during the L3 handover procedure. In various real-time and throughput-sensitive multimedia services over Internet, packet loss can cause severe mutilation of received data, broken-up images, unintelligible speech or even the complete absence of a received signal[13].

Therefore, in order to minimize packet loss of existing RFH-HMIPv6 schemes, this paper proposes an optimized RFH-HMIPv6 scheme, which is called the ORFH-HMIPv6. The key idea of the proposed ORFH-HMIPv6 scheme is that the serving MAP buffers packets toward MN as soon as the link layer between MN and serving base station is disconnected. The MAP discovery message exchanged between MN and serving MAP is extended to implement the proposed scheme. Moreover, an event service message based on the IEEE 802.21 MIHF of [14] is defined newly. Via analytic performance evaluation, the proposed ORFH-HMIPv6 scheme can be shown to minimize packet loss much than the existing RFH-HMIPv6 scheme.

The paper is organized as follows. In Section 2, an optimized RFH-HMIPv6 scheme is proposed. In Section 3, an analytical performance evaluation is shown. Finally, concluding remarks are made in Section 4.

OPTIMIZED REACTIVE FAST INTER-MAP HANDOVER SCHEME FOR HMIPv6

As shown in [9]-[12], the behavior of the fast inter-MAP handover scheme for HMIPv6, called the FH-HMIPv6, is classified by predictive and reactive according as the IP layer (L3) handover preparation is completed prior to the layer 2 (L2) handover or not, which is described in Fig. 1. In the predictive FH-HMIPv6 scheme, the L3 handover preparation is completed prior to the L2 handover, which can reduce the L3 handover latency. In addition, since the target MAP access router buffers packets toward the mobile node (MN), packet loss can be minimized. However, due to the dynamic nature of wireless technologies, such as MN’s moving speed, a sudden degradation of L2 quality, an L2 handover decision rule, etc.,

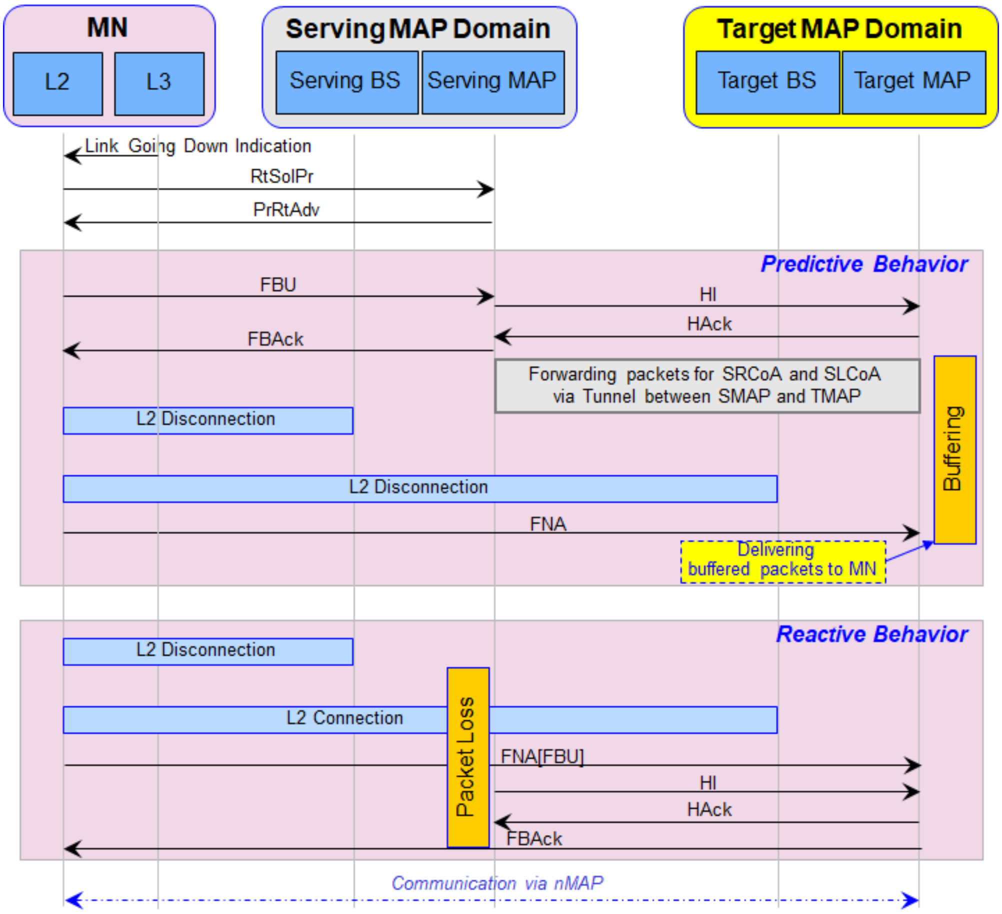

Figure 1. Comparison between predictive and reactive behaviors of FH-HMIPv6

there is no guarantee that the L3 handover preparation is completed prior to the L2 handover. That is, there can be no sufficient time to process all FH-HMIPv6 signaling messages before the L2 disconnection. Therefore, in this case, the FH-HMIPv6 should be operated by reactive behavior. However, in the reactive FH-HMIPv6 (RFH-HMIPv6), the L3 handover latency increases since the L3 handover preparation is started after the L2 handover. In addition, the RFH-HMIPv6 does not support packet buffering function, which can introduce packet loss during the L3 handover procedure. In various real-time and throughput-sensitive multimedia services over Internet, packet loss can cause severe mutilation of received data, broken-up images, unintelligible speech or even the complete absence of a received signal. Therefore, in order to minimize packet loss of existing RFH-HMIPv6 schemes, this paper proposes an optimized RFH-HMIPv6 scheme, which is called the ORFH-HMIPv6. When the MN in the serving MAP (SMAP) domain senses the signal strength of the serving base station (SBS) is becoming too weak, the MN's L2 produces a "`Link_Going_Down`" event message and sends it to the L3. The MN queries the SMAP to get information about the target MAP (TMAP) in target MAP domain by sending Router Solicitation for Proxy Advertisement (RtSolPr) message. As shown in [12], the RtSolPr message contains MN's MAC address (MACA) and serving regional care-of address (SRCoA), etc. In the proposed scheme, MAPs manage [MACA, SRCoA] pairs for MNs using a list called the "buffering-ready list". The SMAP updates the buffering-ready list by storing the MN's [MACA, SRCoA] pair. Then, the SMAP responds by sending the Proxy Router Advertisement (PrRtAdv) message that contains the SMAP's acknowledgement. These MAP discovery messages, RtSolPr and PrRtAdv, can be extended newly from the standard FH-HMIPv6 scheme in [9]-[11].

When the L2 between MN and SBS is disconnected, the MIHF of the SBS sends a remote Media Independent Event Service (MIES) message, "`MIH\_BUFF\_Start Indication`" to the SMAP's MIHF. This MIES message is defined newly and includes the MN's MACA. The SMAP's MIHF sends this message to the L3. Then, the SMAP's L3 must verify whether the MN's MACA contained in "`MIH_BUFF_Start Indication`" message exists in the buffering-ready list or not. In addition, it must be verified whether Fast Binding Update (FBU) and Fast Binding Acknowledgement (FBAck) messages are exchanged already between MN and SMAP in the serving network or not. If the MN's MACA exists in the buffering-ready list, and FBU/FBAck messages are not exchanged yet between MN and SMAP in the serving network, the SMAP intercepts and buffers packets toward the MN. On the other hand, if the MN's MACA does not exist in the buffering-ready list, the SMAP ignores "`MIH\_BUFF\_Start Indication`" message and does not buffer packets. In addition, if

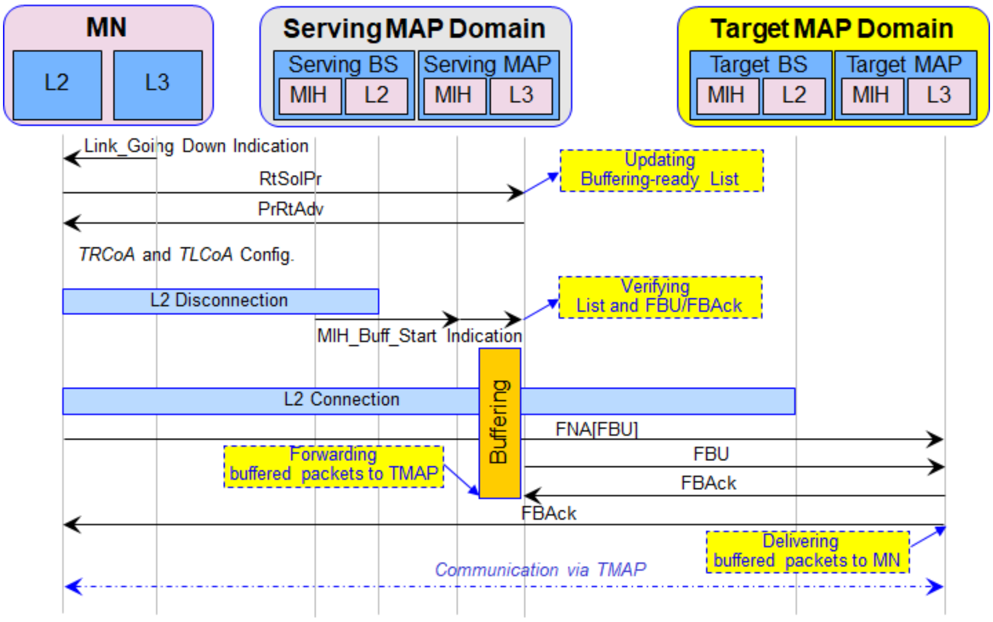

Figure2. Operation of proposed ORFH-HMIPv6 scheme

FBU/FBAck messages are exchanged already between MN and SMAP in the serving network, this means the FH-HMIPv6 scheme is operated by predictive behavior. Thus, the SMAP discards "`MIH_BUFF_Start Indication`" message and does not buffer packets.

When the MN moves to the target network and completes the L2 handover, the MN sends the Fast Neighbor Advertisement (FNA) message encapsulating the FBU message to the TMAP. Then, the TMAP sends the FBU message to the SMAP. The SMAP responds by sending the FBAck message and then delivers buffered packets to the TMAP. The TMAP delivers these buffered packets to the MN. Therefore, the packet loss can be minimized. The operation procedure of the proposed ORFH-HMIPv6 scheme is shown in Fig. 2.

Performance Evaluation

Through analytic performance evaluation, the proposed ORFH-HMIPv6 scheme can be shown to minimize packet loss much than the existing scheme. To present the analytical result, parameters are considered as shown in Table 1.

Table 1. Parameters for analytic performance evaluation

Parameters	Meaning
T_{L2HO}	Time required for L2 handover
T_{MIES}	Time required for one-way delivery of MIHF event service message to SMAP from SBS.
$T_{FBU-FBAck}$	Time required for exchange of FBU and FBack messages between sMAP and tMAP.
T_{FNA}	Time required for FNA including FBU to reach tMAP.
T_{PL}	Time interval that the packet loss can occur. It is called the packet loss interval.

As shown in Fig. 1 and Fig. 2, the L3 handover latency T_{L3HO} for both existing RFH-HMIPv6 and proposed ORFH-HMIPv6 schemes is same as shown in Table 2. The existing RFH-HMIPv6 scheme can lose packets toward MN during this time interval T_{L3HO} as shown in Fig. 1. Therefore, the packet loss interval $T_{PL(ORFH-HMIPv6)}$ of the existing scheme can represented by T_{L3HO}. On the other hand, in the proposed ORFH-HMIPv6 scheme, the SMAP buffers packets toward MN as soon as the L2 between MN and SBS is disconnected as shown in Fig. 2. That is, the SMAP buffers packets after the MIHF event service, MIES, message is delivered to the SMAP from the SBS. Therefore, the packet loss interval $T_{PL(ORFH-HMIPv6)}$ of the proposed scheme can represented by T_{MIES}. From analytical evaluation results in Table 2, the packet loss interval of the proposed ORFH-HMIPv6 scheme is shown to be explicitly shorter than that of the existing RFH-HMIPv6 scheme due to L2 handover latency as well as delivery time of signaling messages. Especially, the L2 handover latency T_{L2HO} can be varied diversely due to the dynamic nature of wireless technologies. Thus, the packet loss interval of the existing RFH-HMIPv6 scheme can increase much for some cases. Therefore, the proposed ORFH-HMIPv6 scheme might be superior to the existing scheme for packet loss. Especially, in case of real-time services, the performance superiority of the proposed scheme might be more remarkable.

Table 2. Handover latency and packet loss interval

	RFH-HMIPv6	ORFH-HMIPv6
Handover latency (T_{L3HO})	$T_{L2HO}+T_{FNA}+T_{FBU-FBAck}$	
Packet loss interval (T_{PL})	T_{L3HO}	T_{MIES}

CONCLUSION

In this paper, the ORFH-HMIPv6 scheme has been proposed to minimize packet loss of the existing scheme. In the proposed ORFH-HMIPv6 scheme, the SMAP buffers packets toward MN as soon as the link layer between MN and SBS is disconnected. In order to implement the proposed ORFH-HMIPv6 scheme, the MAP discovery message exchanged between MN and SMAP is extended. In addition, the IEEE 802.21 MIHF event service message is newly defined. Via analytic performance evaluation, the proposed ORFH-HMIPv6 scheme has been shown to minimize packet loss much than the existing RFH-HMIPv6 scheme.

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