

## M-FHMIP mechanism for mobile multicasting in IP networks

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### ABSTRACT

*Fast handover is essential to support seamless multicast service in MIPv6. To reduce handover latency of multicast, there are two handover mechanisms, one is M-FMIP that prepares fast L3 handover before L2 handover and the other is M-HMIP that performs local area mobile multicast management. This paper proposes M-FHMIP that integrates an advantage of M-FMIP and M-HMIP, and analyzes the multicast handover latency.*

*Keyword: MobileIP, Multicasting, M-FHMIP, M-FMIP, M-HMIP*

### 1. INTRODUCTION

The wireless internet needs high quality and broadband to service multimedia service at wired and wireless convergence communication network. Specially, multicast technology is deeply considered for IPTV service.

Today's internet transfer technology is based on unicast, it must keep every connection in 1:N transfer, so host get overhead and has disadvantage at equipment efficiency and network bandwidth usage.

However, multicast can transfer the traffic only dedicated subscribers. So it can reduce the resource waste. Compare to unicast, multicast has many advantages in the viewpoint of IPTV and video conference service.

IETF proposed MIPv6 (Mobility support in IPv6) that support mobility in IPv6 environment [1]. But MIPv6 needs long delay time to perform handover. To solve handover latency problem in MIPv6, HMIP (Hierarchical MobileIP) [2] performs local area mobility management and FMIP (Fast handover for MobileIP) [3] prepares fast L3 handover before L2 handover. Also, M-FMIP (Multicast support in FMIP) [4] and M-HMIP (Multicast support in HMIP) [5], deployed multicast function to HMIP and FMIP, are developed.

In this paper, we propose M-FHMIP that integrates predictive handover of M-FMIP and local area management of M-HMIP. Therefore, the proposed M-FHMIP can perform a fast mobility

management in multicast.

The rest of this paper is organized as follows. Section 2 analyzes multicast support in MIPv6, M-FMIP, M-HMIP and section 3 explains mechanism of M-FHMIP and performs performance analysis. Section 4 explains about performance evaluation and section 5 explains about numerical results. Lastly, section 6 makes conclusion.

### 2. RELATED WORKS

#### 2.1 Multicast Support in Mobile IPv6

There are two multicast supporting methods in Mobile IPv6, RS (Remote subscription) based on FA (Foreign Agent) and HS (Home subscription) based on HA (Home Agent)[6].

In the case of HS, handover transparency is guaranteed because it receives the multicast service through the HA's tunneling when MN(Mobile Node) moves other network. But because it has a problem that HS always receive multicast packet through the tunnel, it can not optimize multicast route.

And HS has many overhead between duplicated tunneling of MN and HA, and HA do not have its recovery mechanism that packet is acknowledged or not.

Figure 1 shows operations of RS in MobileIPv6. In the case of RS method, MN rejoins to multicast tree through FA at moved network. It has an advantage that optimization of mobility path by MN rejoin to multicast tree.

But it makes handover latency and all hosts must support

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multicast router.

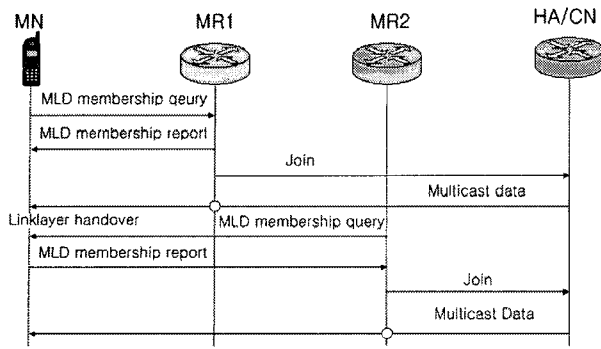


Fig. 1. Remote Subscription in Mobile IPv6.

2.2 M-FMIP

The most important problem in multicast support MIPv6 is the degradation of service quality caused by packet loss when performing

To prevent from service quality deterioration, M-FMIP imports concept of FMIP at multicasting. The NAR (New Access Router) join to multicast tree as fast as possible when performing handover. And during the process of handover, multicast packets are received by PAR (Previous Access Router) through tunneling

Figure 2 shows that M-FMIP predictive mode. Basically, the procedure is same as FMIP and the FBU (Fast Binding Update) message has more information to join multicast tree.

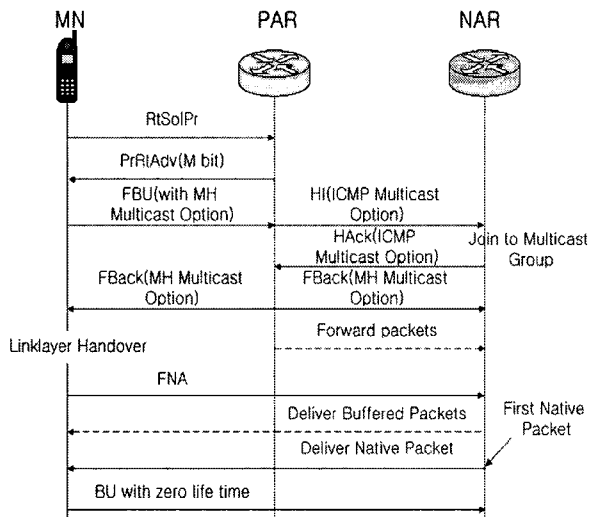


Fig. 2. M-FMIP Predictive mode.

PAR sends HI (Handover Initiate) message to NAR that contains multicast option of FBU message, then NAR joins to multicast tree based on HI message and then, NAR sends Hack (HI Acknowledgement) to PAR, PAR sends FBack (Fast Binding Update Acknowledgement) message to NAR and MN.

After receiving FBack message, the MN performs Linklayer Handover and PAR sends multicast packet to NAR.

Then, the MN receives multicast packet (Native Packet) from NAR by sending FNA (Fast Neighbor Advertisement) message to NAR, then MN sends BU (Binding Update) with Zero

lifetime message to PAR to terminate tunneling. Native packet means that the packet is not received the buffered packet of AR, but received directly from multicast sender.

M-FMIP has best efficiency at predictive mode, but its performance is decreased by retry of sending BU when MN cannot receive FBack message when performing handover. In addition, if MN moves narrow area frequently, performance degradation is occurred because it takes much time to join multicasting tree.

2.3 M-HMIP

In order to support multicast in HMIP, the M-HMIP uses M-MAP (Multicast Mobile Anchor Point). Basically, M-HMIP has an advantage that does not need to send BU to HA and CN (Correspondence Node) when MN moves within MAP domain.

According to HMIP specification, M-HMIP also supports the macro handover and the micro handover.

2.3.1 M-HMIP Micro Handover

Figure 3 shows the M-HMIP micro handover. M-HMIP works micro handover when MN moves between M-MAP domains.

In the micro handover, MN registers RCoA (Regional Care of Address) and LCoA (Local Care of Address) to NM-MAP (New M-MAP), also uses MLD (Multicast Listener Discovery) membership report to join multicast tree[7]. And, before MN joins to multicast tree, MN receives multicast packets through tunnel between PM-MAP (Previous M-MAP) and NM-MAP. After MN have finished join to multicast tree, NM-MAP sends multicast packet to MN and MN sends MLD done report message to PM-MAP to terminate tunneling with BU.

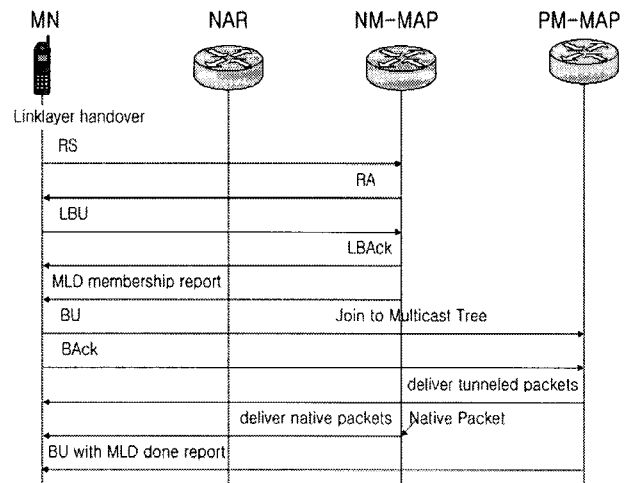


Fig. 3. M-HMIP micro handover

2.3.2 M-HMIP macro handover

Figure 4 shows the M-HMIP macro handover. In the macro handover, an MN doesn't need to exchange MLD report message, it just sends LCoA of AR2 to M-MAP through LBU (Local BU) message. MAP receives LBU message and updates binding cache and sends LBack (LBU acknowledgement) to MN. Then MAP sends multicast packet to MN using NLCOA (New LCoA).

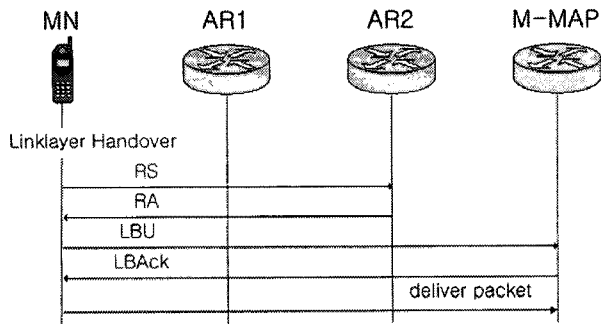


Fig. 4. M-HMIP macro handover.

An advantage of M-HMIP is that it does not need to join multicast tree at intra M-MAP domain and it just needs to update LCoA of AR2 to M-MAP, so it can perform fast handover in intra M-MAP domain, and it can reduce BU time using macro handover if distance between M-MAP and multicast sender is far.

### 3. PROPOSED M-FHMIP MECHANISM

#### 3.1 M-FHMIP

The proposed M-FHMIP integrates the advantages of M-FMIP predictive mode and M-HMIP local area mobility management. Basically M-HMIP performs L3 handover after L2 handover, but if M-HMIP uses M-FMIP message before handover, M-HMIP can reduce handover latency. So we focus on M-HMIP using M-FMIP message before handover.

##### 3.1.1 M-FHMIP micro handover

Figure 5 shows M-FHMIP micro handover's message flow. In the M-FHMIP micro handover, because of rejoin to multicast tree, MN sends FBU with MLD membership report to PM-MAP, and then PM-MAP sends FBU with MLD membership message to NM-MAP. NM-MAP joins to multicast tree using MLD membership report and sends HAck message to PM-MAP as acknowledge message. When PM-MAP receives HAck, it sends FBack to NM-MAP and PM-MAP, and PM-MAP sends multicast packets to NM-MAP that forwarding to MN. After receiving FBack message, MN performs Link-layer Handover and sends FNA message to NM-MAP, and NM-MAP sends tunneled multicast packets to MN.

After NM-MAP is finished to join of multicast tree, MN receives native multicasting packet from NM-MAP and sends BU with MLD done message to PM-MAP to terminate tunneling.

##### 3.1.2 M-FHMIP macro handover

Figure 6 shows the M-FHMIP macro handover. In the M-FHMIP macro handover, MN does not need to join to multicast tree, and sends FBU message of FMIP with NLCOA to M-MAP to notify that MN is performing handover. Then M-MAP sends HI message to NAR to prepare handover and NAR sends HAck message to M-MAP as acknowledgement. M-MAP, received HI message, sends FBack to MN and NAR, M-MAP starts buffering multicasting packets. After Link-layer Handover, MN

sends FNA to M-MAP, then M-MAP sends buffered multicasting packets to MN.

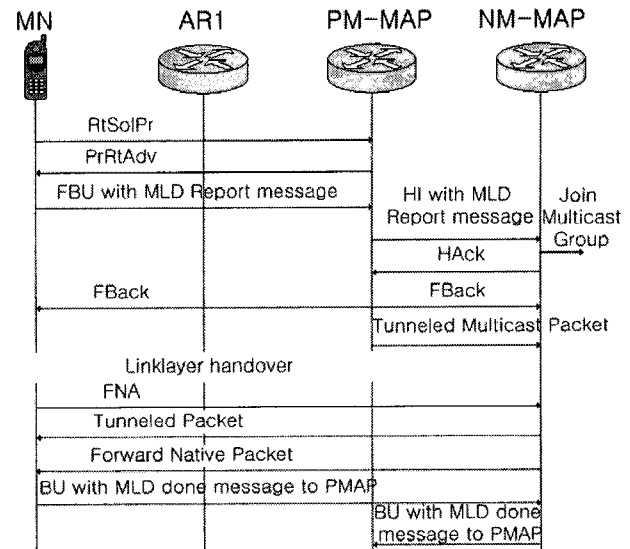


Fig. 5. M-FHMIP micro handover.

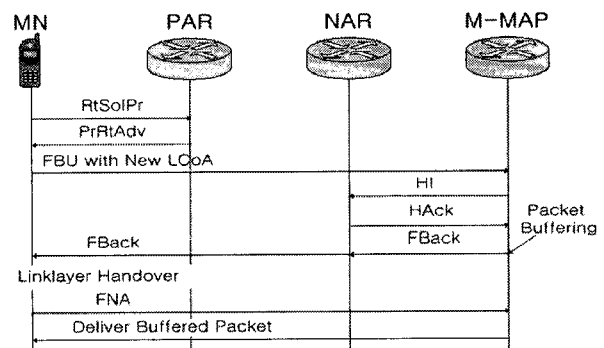


Fig. 6. M-FHMIP macro handover

### 4. PERFORMANCE EVALUATION

#### 4.1 Handover latency analysis

After handover, the most important point that affects handover is delay time to join to multicast tree before receiving multicasting packet from source. Therefore, we analyze the time gap until MN receives native packets after handover in this paper.

Figure 7 analyzes the proposed M-FHMIP message transfer timing according to [8] compare with existing mobile multicast mechanism. To classify handover performance, we define  $T_p$  as a time to receive buffered packet from AR and  $T_D$  as a time to receive native packet from AR. Table 1 shows the packet transfer timing  $T_p$  and  $T_D$  according to figure 7[9]. All acronyms of table 1 are follows.

Table 1. Packet transfer timing,  $T_p$  and  $T_D$ , of MIP, M-HMIP, M-FHMIP

	$T_p$	$T_D$
MIP	$T_L+T_{RA}+T_{DREM}$	$T_L+T_{RA}+T_{DREM}$
M-HMIP micro	$T_L+T_{RA}+T_{LBU}+T_{BU}$	$T_L+T_{RA}+T_{LBU}/2+T_{DREM}$
M-FHMIP micro	$T_L+T_{FNA}$	$T_L+T_{FNA}+T_{DREM}-T_{FMIP}/2$
M-HMIP macro	$T_L+T_{RA}+T_{LBU}$	$T_L+T_{RA}+T_{LBU}$
M-FHMIP macro	$T_L+T_{FNA}$	$T_L+T_{FNA}$

$T_L$  is Link-layer handover time,  $T_{BU}$  is BU time,  $T_{LBU}$  is LBU time,  $T_{FNA}$  is FNA time,  $T_{FMIP}$  is FMIP message processing time,  $T_{RA}$  is RS and RA processing time,  $T_{DREM}$  is a time to join multicast tree. And we ignore time that router and node processing time.

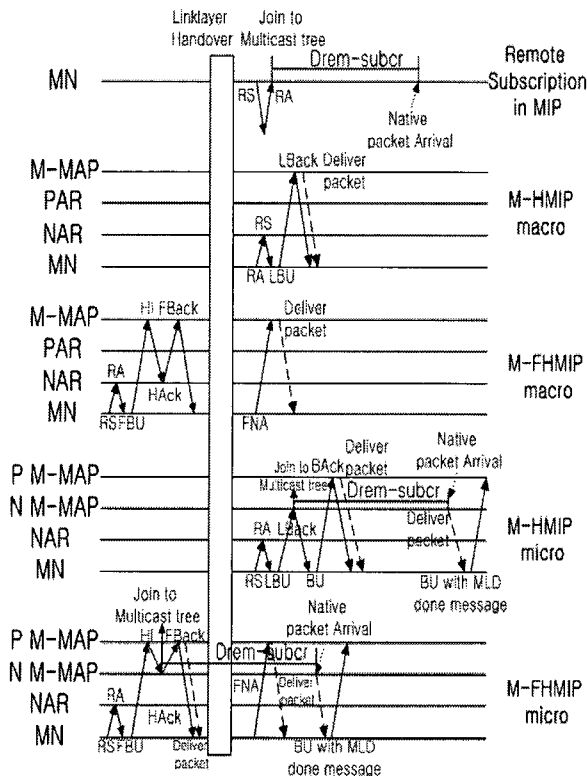


Fig. 7. Packet transfer timing analysis

And we define  $T_{D-micro}$  as a performance gap to receive native packet between M-FHMIP micro handover and M-HMIP micro handover,  $T_{D-macro}$  as a performance gap to receive native packet between M-FHMIP macro,  $T_{p-micro}$  as a performance gap to receive buffered packet between M-FHMIP micro handover and M-HMIP micro handover,  $T_{p-macro}$  as a performance gap of M-FHMIP macro handover and M-HMIP macro handover. So we can get below Eq.(1) to Eq.(4).

$$T_{D-micro} = T_{RA}+T_{LBU}/2-T_{FNA}+T_{FMIP}/2 \quad \dots (1)$$

$$T_{D-macro} = T_{RA}+T_{LBU}-T_{FNA} \quad \dots (2)$$

$$T_{p-micro} = T_{RA}+T_{LBU}+T_{BU}-T_{FNA} \quad \dots (3)$$

$$T_{p-macro} = T_{BU}+T_{LBU}-T_{FNA} \quad \dots (4)$$

5. NUMERICAL RESULTS

To analyze handover latency time, MIP, M-HMIP and M-FHMIP have been analyzed. In this numerical analysis, MIP means MIP based on Remote Subscription method. Each analysis performs based on table 1 and we define system parameters on table 2.

Table2. System parameter based on table 1

System parameters	Description
$T_\alpha$	Packet transfer time between MN and AR
$T_\beta$	Packet transfer time between AR and MAP
$T_\gamma$	Time to performing L2 handover
$T_\delta$	Packet transfer time between MAP and MAP
$T_\epsilon$	Time to join multicast tree

So, we can get below formula about  $T_D$  based on table 1 and table 2 and figure 7.

$$MIP = 2*(T_\alpha + T_\beta) + T_\epsilon \quad \dots (5)$$

$$M-HMIP \text{ macro} = 2*(T_\alpha) + (T_\alpha + T_\beta) \quad \dots (6)$$

$$M-FHMIP \text{ macro} = (T_\alpha + T_\beta) \quad \dots (7)$$

$$M-HMIP \text{ micro} = 2*(T_\alpha) + (T_\alpha + T_\beta) + T_\gamma + T_\epsilon \quad \dots (8)$$

$$M-FHMIP \text{ micro} = (T_\alpha + T_\beta) + T_\gamma - (T_\alpha + T_\beta) - T_\delta + T_\epsilon \quad \dots (9)$$

And we define  $T_L$  as 1000ms according to RFC 2462[10] and define experimental parameters in table 3 according to [11].

Table3. Experimental system parameter values

$T_\alpha$	10ms	$T_\beta$	50ms
$T_\gamma$	1000ms	$T_\delta$	30ms

Figure 8 shows the numerical result of Eq.(5) to Eq.(9) according to  $T_\alpha$  value.  $T_\alpha$  values change 10ms to 110ms. This figure shows the effect of  $T_\alpha$  value to handover latency performance. We can notice that M-FHMIP shows low handover latency compare to other mechanism in irrespective of  $T_\alpha$  values. This means that M-FHMIP has an advantage as a respect of handover latency in irrespective  $T_\alpha$  values.

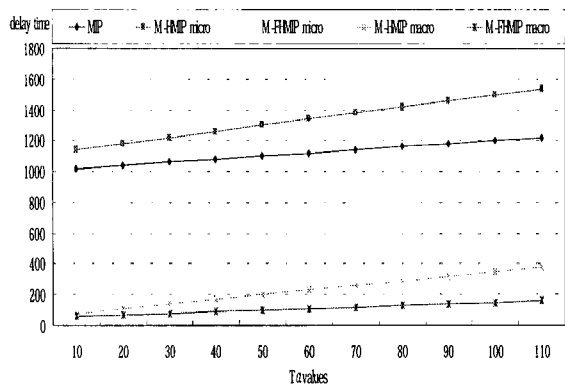


Fig. 8. Numerical result according to Tα value.

And we compare M-HMIP and M-FHMIP in micro mode and macro mode. Figure 9 shows the numerical result that M-FHMIP has an advantage at any values of Tα compare to M-HMIP.

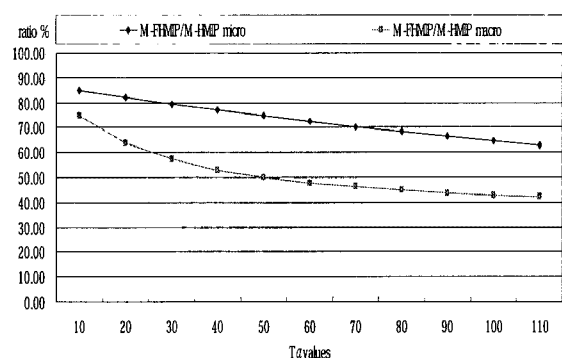


Fig. 9. Numerical result compare to M-HMIP and M-FHMIP.

In addition, we suppose that there are 4 MAPs and each MAP has 5 ARs to compare M-FHMIP and existing M-HMIP. If MN moves to each MAP, we can get accumulated delay latency in figure 10.

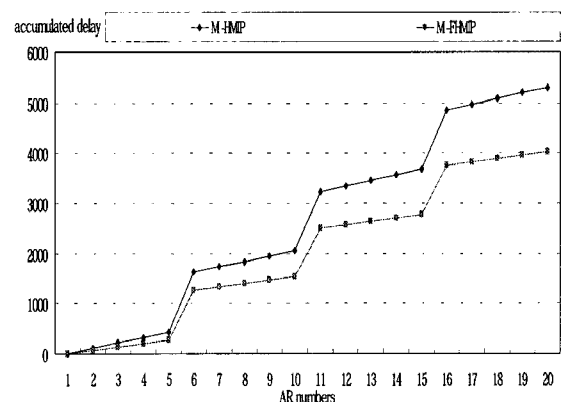


Fig. 10. Accumulated delay latency.

As a result, M-FHMIP has 76% performance dominant in accumulated delay latency compare to existing M-HMIP. This is caused by M-FHMIP uses M-FMIP predictive handover message compare to M-HMIP.

## 6. CONCLUSION

To support mobile multicasting smoothly in wired and wireless convergence communication network, the most important point of handover is that MN needs to reduce delay time to join multicast tree and to perform fast handover.

Remote subscription based multicasting MIP takes large handover latency because it performs L3 handover when L2 handover is finished. So it does not suitable for effective multicasting service. M-FMIP occurs packet deliver latency if it moves many area rapidly because it needs to join multicast tree at every ARs, and M-HMIP have same problem like Remote subscription based MIP because it needs to join multicast tree when it perform micro handover.

Therefore, the proposed M-FHMIP mechanism focused on the time to receive native packet from ARs as fast as possible to solve above problem after handover. The meaning of receiving native packet is that MN can optimize multicast tree in RS when MN moves to any ARs.

The proposed mechanism integrated an advantage of M-HMIP and M-FMIP in MIPv6. It can reduce native packet transfer latency when MN join to multicast tree and, reduce packet transfer latency at buffered packet.

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