Optimum Efficient Fast Handover Support for IPv6

Virender Kumar, G. C. Lall, Rishipal

Abstract----International Engineering Task Force (IETF) proposed MIPv6 and HMIPv6 both mobility management solutions to support the IP mobility. Although HMIPv6 is an extension of MIPv6 still there is handover latency and packet loss in HMIPv6.In this paper a scheme is presented that supports a fast handover efficiently in hierarchical mobile IPv6 networks (HMIPv6). In HMIPv6 when a mobile node (MN) moves from a one MAP region to another, then there is a interruption of connection as well as packet loss due to long handover latency. To overcome these problems, an efficient fast handover scheme is adopted from FMIPv6 to optimize the performance of the inter-MAP handover. In this paper the handover latency for MIPv6 & HMIPv6 is compared to the proposed scheme with analytical model. By analysis and by simulations, we show that the proposed scheme has better performance compared to MIPv6 & HMIPv6 in terms of handover latency and packet loss.

Keywords— Access Route, Fast Mobile IPv6, Hierarchical Mobile IPv6, Mobile IPv6, Mobility Anchor Point.

I. INTRODUCTION

Internet Engineering Task Force (IETF) has proposed Mobile IPv6 (MIPv6) [1] protocol to provide routing support to permit IP hosts using IPv6 while permitting session continuity. Due to long handover latency, in MIPv6, the mobile nodes (MNs) can experience not only packet loss but also interruption of connection. Various extensions of MIPv6 have been proposed by IETF to overcome the problems which occurs in MIPv6. Hierarchical MIPv6 (HMIPv6) [2] and Fast MIPv6 (FMIPv6) [3] are such extensions of MIPv6. FMIPv6 provides seamless fast handover for the MN changing its movement from one AR to another AR in the same IPv6 network. HMIPv6 is a location management protocol that can reduce the handover latency and signaling overhead by introducing a new entity known as Mobility Anchor Point (MAP). In [2] and [4] fast handover methods have been proposed using FMIPv6 to perform handover in the same MAP domain. The schemes presented in [2] and [4] experience a long handover latency when the MN moves from one AR in the same MAP domain A to another AR belonging to MAP domain B due to change in both regional care of address (RCoA) and on link care of address (LCoA).

Another limitation of [2] and [4] is that there is no establishment of path between previous AR to new AR to minimize the packet loss. In order to reduce the packet loss and perform the handover efficiently in the inter-MAP mobility we need to support fast handover. This paper reveals an inter-MAP handover scheme by supporting a fast handover in inter-MAP mobility in HMIPv6.

II. HANDOVER IN MIPv6

In MIPv6, router solicitation (RS) messages or Router Advertisement (RA) messages initiate the movement of a MN. Then, based on the prefix of new AR, the MN generates a new CoA.

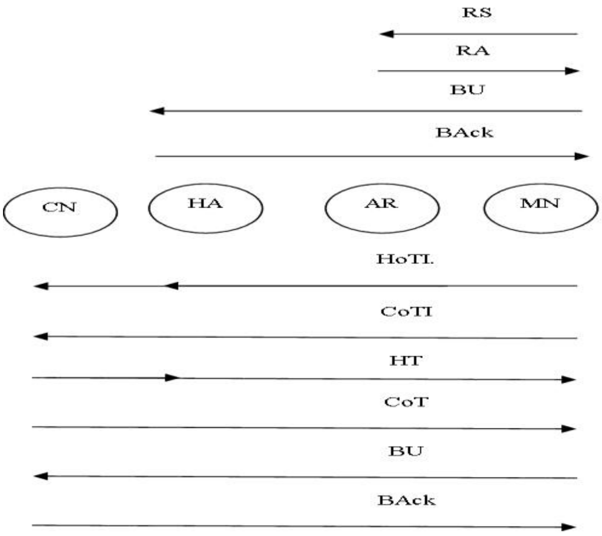

Fig.1 Handover of message in MIPv6

The MN sends a Binding Update (BU) message to the Home Agent (HA) in order to inform its new CoA. The Home Agent sends a Binding Acknowledgement (BA) message in response to the Binding Update message and binds its new CoA. Further, a new address registration process is done by the MN with the Correspondent Node (CN). As per the rule defined by [1] the MN should perform a return routability (RR) procedure by using home test init (HoTI)/home test (HoT) messages and care of test init (CoTI)/care of test (CoT) messages. Further after completing the RR procedure, the MN will perform the address registration with the CN by exchanging of BU and BA messages.

Hence, the total handover will become the addition of the time for exchanging RS/RA messages, the time for performing the layer 2 handover, the time for exchanging BU/BA messages, the time for performing registration with HA and the time for performing registration with CN included the RR procedure. The message flow of handover has been shown in Fig.1.

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III. HANDOVER IN HMIPv6

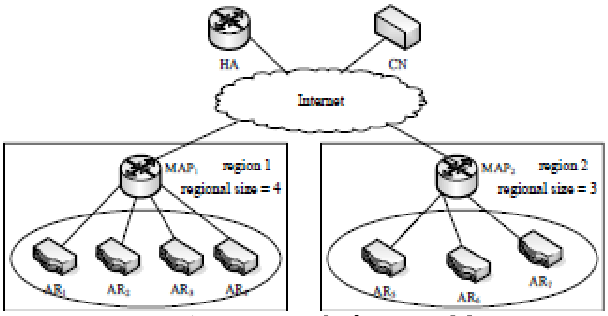

Fig.2 Framework of HMIPv6 [9]

Figure 2 shows the framework of HMIPv6 [9]. In HMIPv6 [2] introduces a new entity called Mobility Anchor Point (MAP) to act as a local HA within a region. Each MAP administers a set of Access Routers (ARs) which form a region. The number of ARs beneath a MAP is defined as the regional size. Within a region, an MN is associated with two addresses: the Regional Care of Address (RCoA), indicating the MN's MAP, and the on-Link CoA (LCoA), indicating the AR that the MN attaches to. When an MN enters into a new region and receives the RCoA and the LCoA, it will initiate a "regional registration" process to the MAP to bind these two addresses. Following a successful regional registration, the MN is requested to offer the binding between its home address and RCoA to the HA by a home registration. Due to serving as a local HA, the MAP intercepts all packets addressed to the MN's RCoA and tunnels them to the LCoA. When the MN moves within the region, it only needs regional registration, thus reducing its interactions with the external networks, obtaining the lower signaling. Thus the MN mobility has been classified in two type's micro-mobility (handover in the same region) and macro-mobility (handover across regions). In this paper we do not focus on the micro-mobility.

The other type of mobility in HMIPv6 is macro-mobility or inter-map handover. When a MN changed its region or map domain in inter-map handover, it means the MN has to generate two types of addresses: RCoA and LCoa as well as perform two types of Binding Updates procedures.

The process of handover of MN initiated by router solicitation (RS) and Router Advertisements (RA) messages. In addition with the information of next MAP domain (i.e. prefix of the MAP and MAP address) remains in RA the MN generates a LBU message having the new addresses to the new MAP. A new binding cache entry for the MN is created by the MAP and binds the MN's LCoA and with the MN's RCoA. Further the MN sends a BU message to the HA having the new RCoA as a CoA in the Binding Update message. Then, the process of new address registration is done to CN with a RR procedure in advance by the MN. In HMIPv6, to reacquire the connection in the inter-MAP mobility the total handover latency is composed of the time for performing the layer 2 handover, the time for exchanging the LBU/LBA message, the time for performing registration with CN included RR procedure and the time for performing registration with HA. The message flow of the inert-MAP mobility handover has been shown in the Figure 3.

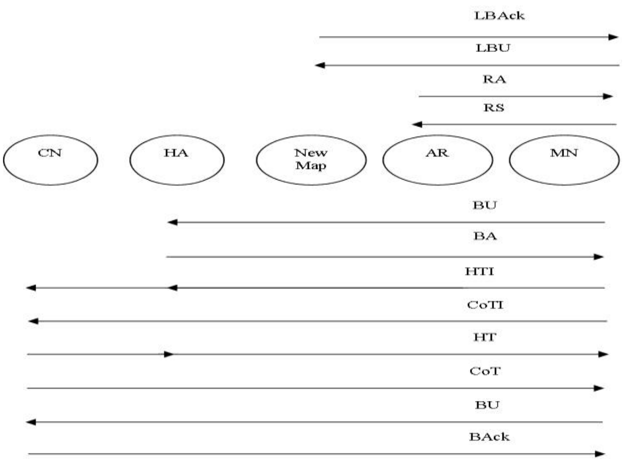

Fig.3 Inter-MAP handover of message in HMIPv6

IV. OPTIMUM EFFICIENT FAST HANDOVER SCHEME

The main reason of the relatively long handover delay between MIPv6 and HMIPv6 is that the layer 2 handover is individually performed as the first phase and not carried out in advance of the movement of the MN to a new AR. To minimize the handover delay we use the same pre-handover mechanism of FMIPv6.In this pre-handover mechanism, when the MN recognizes its movement to new MAP while staying in the current MAP, the MN can prepare itself for the handover in advance.The main reason of long inter-MAP handover in HMIPv6 is that the local movement is not localized in HMIPv6. In order to inform the AR of the mobility is the only requirement for early time of the inter-MAP handover. While performing the inter-AR handover, we assume the pre-handover mechanism procedure which can be carried out simultaneously. We consider that a MAP domain administers a number of ARs and each AR advertises a RA message periodically which contains the information regarding adjoining MAP domains (i.e. prefix of the MAP domain, MAP address) and information about adjoining ARs (i.e. prefix of the AR, new AR address). On receiving the RA messages with new information the MN can recognize its change of MAP domain. The MN gives a new LCoA based on the prefix of the new AR and a new

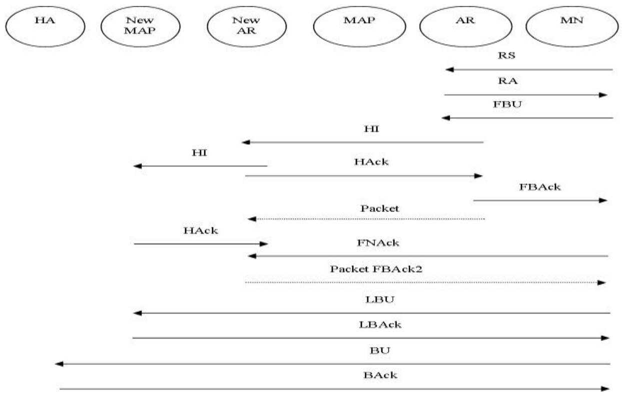

Fig.4 Handover of message in OEFH

RCoA based on the prefix of the new MAP. The MN transmits a fast Binding Update (FBU) message to the current AR. On receiving the BU message, the AR transmits a handover initiate (HI) message to the new AR. This is a request from the MN for the establishment tunnel or path between those ARs. At the same time the MN wants the assurance that the MN must have the unique new LCoA on the AR link. The process of request for the verification of the uniqueness of RCoA of the MN by the new AR is done by sending a HI message to its MAP on receiving the HI message from the previous AR. Further, the MAP gives a handover acknowledgement (HAcK) message to the new AR of the MN. However for the new AR there is no need to wait for receiving the HAck message from its MAP. A neighbor advertisement acknowledgement message is sent to the new AR by the new MAP if the RCoA were not unique. The MNs current AR can receive a handover Acknowledgement message by the new AR after the uniqueness of LCoA is checked to inform that the address verification and the tunnel establishment are completed. The previous AR can receive a NAACK message from the new AR, if the LCoA were not unique, which is then forwarded by the AR to the MN. After receiving the HAcK message, an AR gives a fast Binding Acknowledgement 1 (FBack 1) message to both the MN so as to make familiar with the handover starts. And after that handover of layer 2 is initiated. The previous AR intercepts the packets which are addressed to the old LCoA of the MN during the handover procedure. These intercepted packets are then forwarded by the previous AR to the new AR. After the completion of layer 2 handover, the MN should inform its presence at the new link by giving a fast neighbor acknowledgement (FNA) message. The new AR transfers the buffered packets to the MN after receiving the FNA message. The MN is make aware of the uniqueness/duplication of the RCoA by the packets which contain a piggyback FBack 2 /NAACK. The MN is able to make again internet connectivity when the MN gets the packets from the new AR at the new link. Rest of the procedure of the inter domain handover is the same as of the original HMIPv6. Thus the total handover latency of the proposed OEFH scheme is made up of the combination of the time for executing layer 2 handover and transmitting FNA message, HI/HAck messages, the time for handover initiation using FBU/FBAck and the time for interchanging RS/RA messages.

V.HANDOVER LATENCY ANALYSIS

In this part of paper we will describe the handover latency of MIPv6, inter-domain or inter-MAP movement handover latency of the HMIPv6 and the proposed OEFH scheme to evaluate the handover latency.

Generally, the handover latency is made up of combining the layer 3 handover and layer 2 handover. The layer 2 handover comprises of two steps: an execution phase and a search phase. We assume that a handover latency period is from the exact point of time that the MN gives and gets IP packets from/to the Correspondent Node, besides the queuing time and the processing time are negligible [7]. To analysis the performance we assume that system model in fig. 5 described in [7] and [8] which shows the delays between two objects in the layer 3 handover d_{L2} and d_{Ls} denotes the delay for execution phase and searching phase respectively in the layer 2 handover.

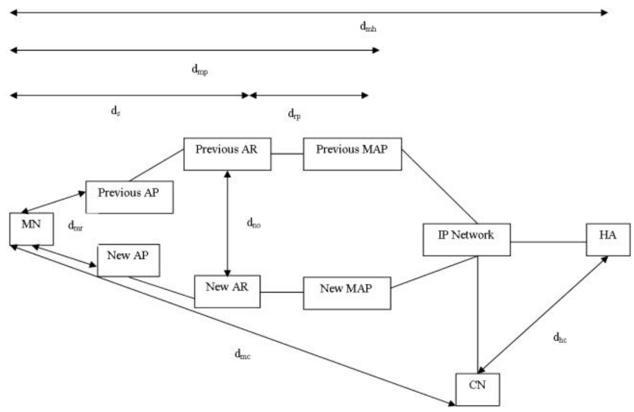

Fig.5 A system model for performance analysis

As shown in fig. 1 which represents the handover in MIPv6, dL2 + dLs is the delay of layer 2 handover. RS/RA messages are exchanged by the MN with a new AR at the new link which takes 2ds. After generating a new CoA by the MN a new address is registered to its Home Agent by using Binding Update/Binding Acknowledgement messages, which takes 2dmh.The MN should go through the RR procedure in order to reacquire the internet connectivity. CoTI/CoT messages and HoTI/HoT messages are executed by the MN through different paths to the Correspondent Node in parallel in the RR procedure. Thus we see that RR procedure takes max.(2(dmh+dhc),2dmc). After the completion of RR procedure, a new BU message can be sent by the MN to the CN, which takes 2dmc. Thus in MIPv6, the total handover delay can be written as

DMIPv6=dL2+dLs+ 2ds + 2dmh + max.(2(dmh+dhc),2dmc) (1)

As shown in Fig. 2 which represents the inter-MAP movement handover of HMIPv6, after the layer 2 handover (dL2 + dls) the MN exchanges the router solicitation/Router Advertisement messages to/from the new access router at the new link. This process takes the time delay of 2ds. After that a new RCoA and a new LCoA should be generated by the MN. These new addresses generated by the MN registers to the new MAP. It is executed with LBA/LBU messages. This process takes the delay time of 2dmp. The new address registration to the CN by Binding Update/Binding Acknowledgement messages takes 2dmc. And the new address registration to its Home Agent with Binding Update/Binding Acknowledgement messages takes 2dmh. The Mobile Node must execute the RR procedure in the address registration process, which takes max (2 (dmh + dhc, 2dmc). The total handover delay of inter-domain or inter-MAP handover in HMIPv6 can be written as

DHMIPv6 = dL2 + dLs +2ds + 2dmp + 2dmh + max (2 (dmh + dhc, 2dmc) + 2dmc (2)

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As shown in fig.4 which represents the proposed OEFH scheme, the MN is able to make aware of the mobility before to the handover of layer 2 with Router Solicitation/Router Advertisement messages with the current access router at the current link which takes 2ds. After generating new addresses like new LCoA and new RCoA, the mobile node transmits a fast Binding Update message to the current Access Router, which takes ds. In the time 2d0, the HI/HAcK messages are exchanged by the current AR with new AR. There is no delay of layer 2 handover due to exchanging of HI/HAcK messages between new MAP and its new AR because the new AR does not wait for HAcK message. In the time ds the current AR sends a feedback message to the MN. Further the handover of layer 2 starts. Now because the search phase is executed in advance, so at this time the layer 2 handover delay is dL2. In the time ds the MN gives a new FNA message to the new AR at the new link after the completion of layer 2 handover.

However, if the MAP of the new AR is not able to send the handover acknowledgment message to its AR till now, so to complete the handover the MN has to wait for the Fast Binding Acknowledge message 2 from the new AR it means we must do the comparison of delay of the handover initiating message sent by the new AR to its MAP till MN gives a FNA message to the AR at the new link with the delay of interchange of HI/HAcK messages between new AR and its MAP. So, the overall handover latency of the proposed OEFH scheme can be written as

$$D_{OEFH}=3d_s+d_{n0}+\max(d_{L2}+2d_s+d_{n0},2d_{rp}) \quad (3)$$

In maximum case

Delay of wired network < Delay of wireless network

i.e. $d_s > drp$

or, $d_{L2} + 2d_s + d_{n0} > 2d_{rp}$

so, the overall handover latency of the proposed OEFH scheme can be further written as

$$D_{OEFH} = d_{L2} + 5d_s + d_{n0} \quad (4)$$

VI. NUMERICALS RESULTS & DISCUSSION

We assume that there is a relative larger delay of wireless network than that of wired network and assuming a low bandwidth in the wireless link [6]. A table is given below in which there is various delays values which are substituted in the system model of fig. 5.

Table I. [10]

d_{mr}	d_{mp}	d_s	d_{n0}	d_{mh}	d_{mc}	d_{hc}	d_{Ls}	d_{L2}
15 ms	18 ms	16 ms	8 ms	152 ms	160 ms	150 ms [8]	250 ms	12 ms [5]

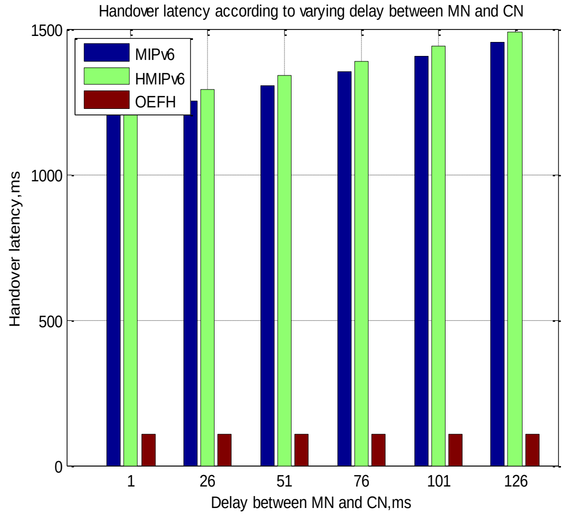

Fig.6 Handover Latency according to varying between MN and CN

Fig. 6 shows the handover latency variation of the MIPv6, HMIPv6 and the proposed OEFH scheme. This figure shows that when the delay between MN and CN increases up to 120ms, the handover latency of MIPv6 and HMIPv6 is larger up to 1400ms. We observe that the handover latency of HMIPv6 is little larger than that of MIPv6 corresponding to the delay between MN and CN. Most importantly we also observe that the handover latency of proposed OEFH scheme is very less than that of MIPv6 and HMIPv6 and independent of the delay between MN and CN. The results also shows that registration with CN also effects the handover latency and the MN has to wait for receiving packets due to the delay augment between MN and CN.

Fig. 7 shows that because the MN in OEFH scheme can achieve connectivity earlier so the handover latency of the proposed OEFH scheme is smaller than that of the MIPv6 and HMIPv6 and is independent of the delay between the MN and HN

Fig. 8 shows the graph in which it has been shown that when we increase the wireless link delay then the OEFH scheme also shows the smaller handover latency than that of MIPv6 and HMIPv6

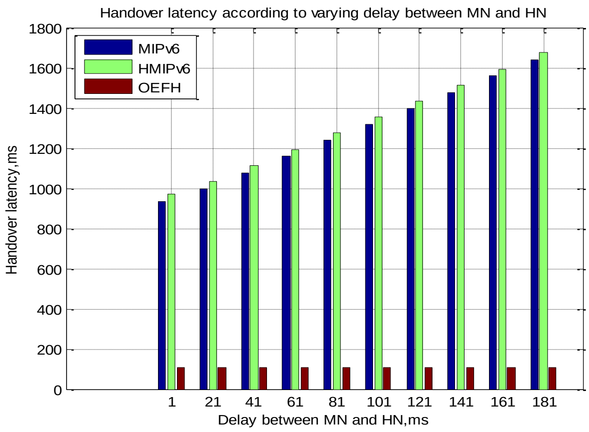

Fig.7 Handover Latency according to varying delay between MN and HN

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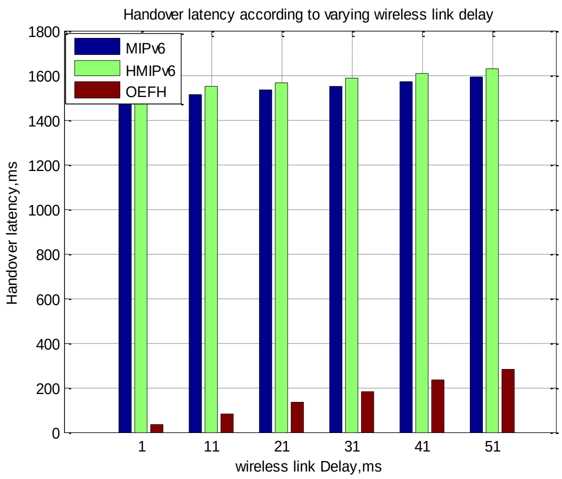

Fig.8 Handover Latency according to varying wireless link delay

VII. CONCLUSION

In this paper, we present an OEFH scheme which demonstrates that when a MN moves from one MAP to other MAP, then the packet loss and interruption of the connection of the MN are reduced to a remarkable extent by adopting a fast handover scheme from FMIPv6. The graphical results show that the proposed scheme supports the fast inter-domain or inter-MAP handover due to the smaller handover latency than that of the MIPv6 and HMIPv6.

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