



## Combined Approach for Handover Support in MIPv6

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**Abstract** - In the future generation networks mobile IP is one of the dominating protocols that provide seamless mobility support in the internet. Although Internet Engineering Task Force has standardized various mobility management protocols like MIPv6, FMIPv6, HMIPv6, FHMIPv6 but still there is space for enhancing their performance. MIPv6 suffers from drawback like handover latency & high signaling cost. On the other hand, FMIPv6 aims to reduce handover latency but increases the extra signaling between new Access Router and previous Access Router thereby increasing the cost of the network. To tackle the issue of signaling cost, HMIPv6 introduces a mobility anchor point which aims at reducing the signaling cost but thereby compromising the other factor of handover latency.

In this paper, an effective combination of both FMIPv6 & HMIPv6 i.e. FHMIPv6 has been proposed for optimization of signaling cost as well as handover latency. Also an intelligent mobility support scheme is introduced for selection of best MAP according to changing user's mobility. This scheme also makes a selection between MIPv6 & HMIPv6. By MATLAB simulation it is shown that FHMIPv6 gives overall best results in terms of cost function among the existing host based mobility protocols.

**Keywords** - Mobile IPv6, Fast Mobile IPv6, Hierarchical Mobile IPv6, Mobility Anchor Point, Access Router.

### I. INTRODUCTION

The desire to have seamless connectivity to the internet regardless of the physical location of the user has become indispensable. By keeping the necessity of time in mind, mobile internet protocols were developed by IETF which combines the advantages of both mobile phones and internet. MIPv4 was proposed as the first mobility management solution by IETF in 1993. In MIPv4, as the mobile node (MN) changes its point of attachment, then its address changes dynamically. The address that is dynamically assigned in a visited/foreign network is termed as Care of Address (CoA). Mobile Internet Protocol (MIP), the first viable mobility solution was not free from limitations. MIPv4 may use long paths due to triangle routing (because when corresponding nodes (CNs) have to send packets to MN then these packets have to travel via home agent (HA) of MN). Thus, route optimization was not provided in MIPv4. To reduce the latency and packet loss, many authors have suggested their ideas for optimizing the protocol. Some concentrated on the link-layer to detect the movement of Mobile Nodes (MN) in advance, while others focused on network-layer to speed up the binding update process by buffering the packets. Some of the schemes developed so far related to minimizing the delay and route optimization in Mobile IP are described as follows:

To tackle the issue of triangle routing in MIPv4, another protocol called MIPv6 [1, 2] was proposed. It provided proper route optimization and reduced the extra delay due to longer paths. Mobile IPv6 operates in any location without any special support required from the local router. In MIPv6 a binding option has been defined for mobility support. Binding is the association of the home address (HoA) of a mobile node with a care of address (CoA) for that mobile node. With MIPv6, an MN performs binding update to HA/CNs regardless of its movements to other subnets. Fast MIPv6 is another important improvement over MIPv6, which was proposed to reduce handoff delay and minimize service disruption during handovers pertaining to MIPv6. The Fast Handover Protocol (FMIPv6) [3] allows an access router (AR) to offer services to MN in order to anticipate the layer-3 handover. The movement anticipation was based on the layer-2 triggers. MN has the possibility to prepare its registration with new access router (nAR) and obtain its new care-of-address (nCoA) while still connected to its previous access router (pAR). Moreover, MN can instruct the pAR to forward packets addressed to its previous care of address (pCoA) to its new care of address (nCoA). To resolve the drawbacks occurring in MIPv6, HMIPv6 introduces a new entity called Mobility Anchor Point (MAP) [4]. MAP serves the purpose of local HA (home agent) within a region, MN sends Binding Updates (BU) to MAP rather than the CNs and HA which are farther away from MN. Thus, HMIPv6 aimed to reduce the amount of signaling between the MN and its CNs during a handoff process. Although improvisation has been done in FMIPv6 and HMIPv6 but still these are having drawback of high signaling load and handover latency respectively.

In this paper, FHMIPv6 (effective combination of FMIPv6 & HMIPv6) has been introduced which aims at reducing the ongoing problem of hand over latency & signaling load in HMIPv6 & FMIPv6 respectively. The rest of the paper is organized as follows. Section II gives an overview of related work of these protocols. Section III presents an overview of some of the mobile IP protocols. Section IV gives analytical model for calculating cost function & IMS scheme. Section V demonstrates the numerical analysis & discussion. Conclusion & future work are given in section VI.

## II. RELATED WORK

Analytical model for calculation of handover latency of FMIPv6 and HMIPv6 [5] has been proposed and IEEE 802.11 - based Wireless Local Area Networks ( WLANs) have been employed as the wireless access network. J. Xie. and I.F.Akyildiz [6] have introduced a novel distributed and dynamic location management scheme where the signaling burden is evenly distributed and regional network boundary is dynamically adjusted according to user's changing mobility .C. Makaya, S. Pierre[7] introduces an analytical framework for performance evaluation of various IPv6 based mobility management protocols(including MIPv6,FMIPv6,HMIPv6 and FHMIPv6). This proposal studies the effects of various network parameters such as packet arrival rate, wireless link delay with respect to handover latency and packet loss .A shadow registration concept [8] is proposed to reduce the macro mobility delay in VoIP service taking mobile IP and SIP (Session Initiation Protocol) into consideration. The effect of domain size and mobile node speed on signaling cost has been analyzed & performance comparison ofMIPv6, HMIPv6, paging extension for MIPv6 and paging extension for HMIPv6has been done[9].HMIPv6 has been proposed as an extension of MIPv6 [4] and this proposal solves the drawbacks of MIPv6 by dividing handover management into inter-MAP mobility and intra MAP mobility. It aims to minimize service disruption occurring at the time of registration. Performance analysis of mobile IP protocols has been done in terms of handover latency [10]. Adaptive retransmission technique is proposed in this paper to optimize the handover latency. A comprehensive analytical Framework for IPv6-based mobility protocols like MIPv6, HMIPv6, FMIPv6 and FHMIPv6 has been proposed in order to analyze the impact of wireless link delay on handover latency and the numerical results shows that FHMIPv6 has best results among the existing protocols [21].

## III. MOBILE IP PROTOCOLS: AN OVERVIEW

Mobility management enables a system to perform location management and handover management effectively. Location management means to trace roaming users for delivering data packets while handover management is to maintain connection between roaming users while moving to a new IP subnet. Several mobile IP protocols have been proposed for carrying out these tasks, some of the Mobile IP (MIP) protocols are briefly discussed in this section.

A handover or handoff can be defined as the process of terminating existing connectivity and obtaining a new one. Seamless handover i.e. with minimal signaling overhead, packet loss, handoff latency and service continuity [11] is indispensable for an IP network.

Time interval during which an MN (Mobile Node) can neither send nor receive any packets is termed as handover latency. It comprises of link layer (L2) and IP layer (L3) handover latencies.

### A. Mobile IPv6 (MIPv6)

MIPv6 is aimed at providing mobility management at IP layer so that MN remains reachable to CN's even after movement within that IP network[12] .Each MN is having two types of address - HoA (home address which is permanent) and CoA (care of address which is temporary). CoA presents the information about MN's current location. Router solicitation/Advertisement (RS/RAd) messages are exchanged for discovery of nAR (new access routers). For the assurance of uniqueness of configured CoA, DAD (Duplicate Address Detection) procedure is performed. DAD procedure comprises of network solicitation/advertisement (NS/NA) messages exchange. After getting CoA, binding update(BU) procedure is performed by MN by exchanging BnUP & BnAck messages between MN and HA (home agent). For route optimization, BU procedure is also performed to all CN's.Before executing a binding update process at CN, return routability (RR) procedure must be performed so as to ensure the authenticity of BU message.The return routability procedure comprises of home address test and care of address test. It consists of exchange of four messages - Home Test(HT), Home Test Init (HTi), Care of test (CT), Care of Test init (CTi). Although RR procedure provides authenticity of BU messages but it increases the delay unnecessarily. MIPv6 is having disadvantages of overhead signaling traffic, high handoff latency and packet loss. Signaling messages exchange in MIPv6 is given by fig 1.

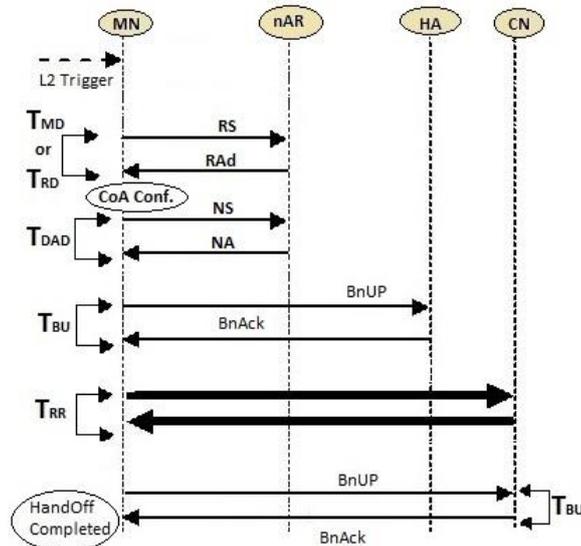


Figure 1: Signaling Flow in MIPv6

TABLE 1 ACRONYMS USED IN SIGNALING DIAG. OF MIPv6 PROTOCOLS.

Symbol	Definitions
T <sub>MD</sub>	Movement detection delay
T <sub>RD</sub>	Router discovery delay
CoA conf.	Care of Address configuration
T <sub>BU</sub>	Binding update delay
T <sub>RR</sub>	Return routability delay

**B. HMIPv6 (Hierarchical Mobile IPv6)**

For solving the higher signaling delay problem in MIPv6, a new scheme called HMIPv6 was proposed. To resolve the drawbacks occurring in MIPv6, HMIPv6 introduces a new entity called Mobility Anchor Point (MAP) [13]. MAP serves the purpose of local home agent (HA) within a region. Each MAP consists of a set of Access Routes (AR's) and their number determines the regional size. An MN residing in a MAP domain is having two addresses - Regional care of Addresses (RCoA) which indicates the MAP to which an MN is attached and on link care of address (LCoA) indicating the AR that the MN attaches to. Mobility in HMIPv6 comprises of two perspectives – micro mobility (mobility within a MAP region) and macro mobility (mobility outside a MAP region). In HMIPv6, macro mobility is still managed by MIPv6 as MN needs to launch both regional registration & home registration, but micro mobility is managed by hierarchical MIPv6. In case of micro mobility, there is no need to transmit BU messages to HA/CN's but only to MAP when LCoA changes. So, the movement of MN within a MAP region is hidden from HA/CN's. Due to double registration process in macro mobility, HMIPv6 suffers from handover latency. HMIPv6 procedure is shown in fig 2.

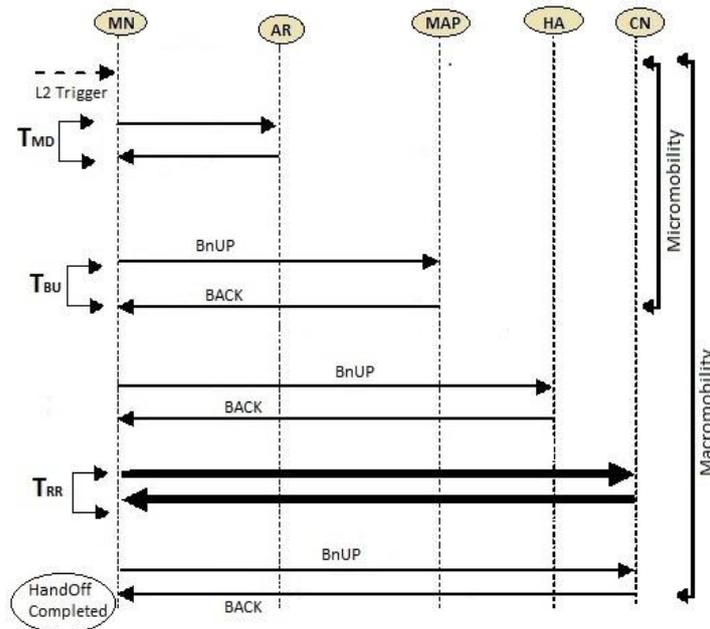


Figure 2: Signaling Flow in HMIPv6

**C. FMIPv6 (Fast Mobile IPv6)**

FMIPv6 exploits the anticipation of L3 (IP layer) handoff based on L2 (link layer) triggers [14] by MN. On receiving L2 trigger, MN sends a router solicitation for proxy (RtSolPx) to pAR (previous Access Router) and pAR responds with Proxy Router Advertisement (PxRtAdv) which contains a new CoA (nCoA). L3 handoff is initiated by MN on sending a FBU (Fast Binding Update) message to pAR so that the packets can be forwarded to nAR. FBU contains MN's new CoA. In order to check the uniqueness of new CoA, pAR sends a HI messages to nAR. Thereafter, a temporary bidirectional tunnel is setup between pAR and nAR to redirect the packets. Now, nAR sends Hack message to pAR to report status about uniqueness of new CoA and successful tunnel establishment. After receiving Hack message, pAR sends FBack message to MN on both pAR and nAR's Link.

Now, binding is established between previous CoA (pCoA) and new CoA (nCoA) by pAR and tunneling of packets towards nCoA is done through nAR's link. nAR buffers these packets until MN gets attached to nAR's link. MN's presence is detected by nAR on receiving router solicitation (RS) message with fast neighbor advertisement (FNA).

Thereafter, nAR declines these packets stored in the buffer to MN. Although FMIPv6 is having advantage of low handover latency [15] and packet loss but it still suffers from drawback of increasing signaling load and complexity of protocol design.

FMIPv6 process is illustrated in figure 3.

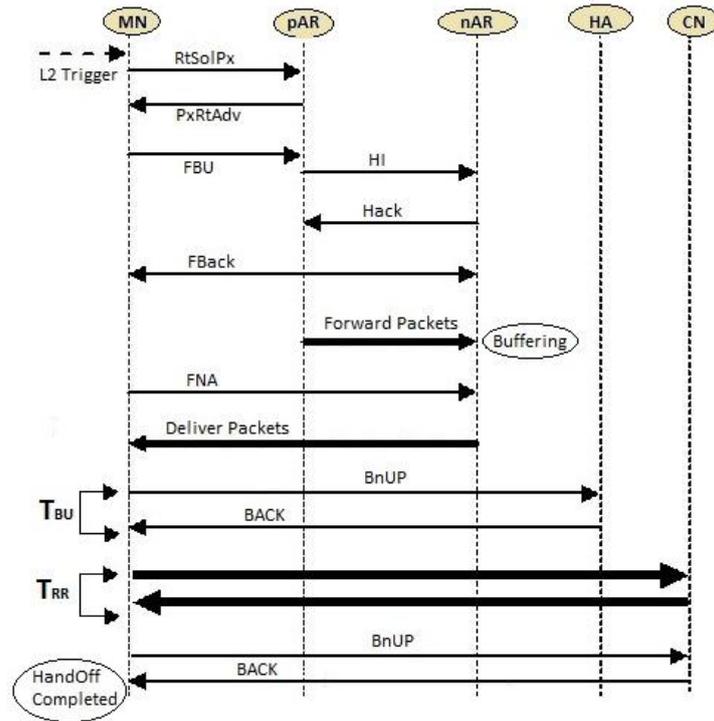


Figure 3: Signaling Flow in FMIPv6

**D. FHMIPv6 (Fast Hierarchical Mobile IPv6)**

FHMIPv6 employs the advantages of HMIPv6 and FMIPv6 for performance improvement and optimization of cost function. This protocol allows high efficiency in network bandwidth usage similar to HMIPv6 and reduces the handover delay and packet loss similar to FMIPv6. A bidirectional tunnel is formed between MAP and nAR in case of FMIPv6 instead of pAR and nAR as in case of FMIPv6. FHMIPv6 process is illustrated in figure 4.

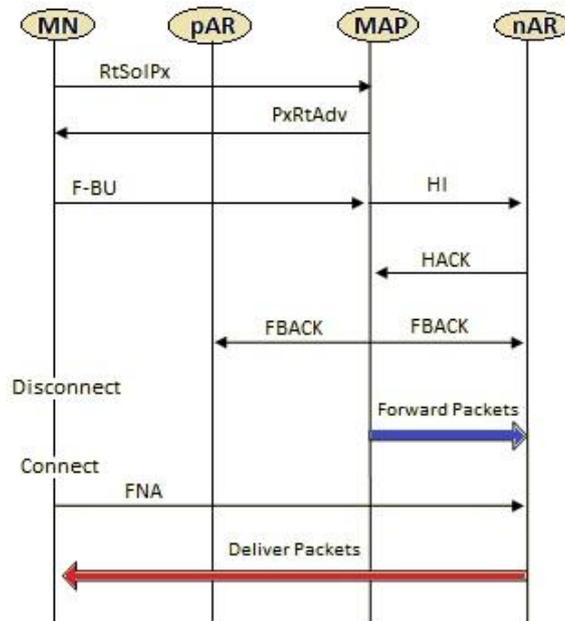


Figure 4: Signaling Flow in FHMIPv6

**IV. ANALYTICAL MODEL FOR CALCULATING COST FUNCTION & IMS SCHEME**

An analytical model has been proposed in this section which considers both registration and packets delivery performance for analysis. Internet architecture has been used for modeling the mobile IP network which is spatial oriented [16].

**A. Registration Time Delay Analysis**

*Definition1:* Registration delay cost, denoted as  $R_T$  is defined as average registration time delay of MIPv6 compared with HMIPv6.  $R_T$  may be positive or negative.  $R_T > 0$  means that average registration time delay of MIPv6 is less than HMIPv6 & vice versa.

TABLE2 SYMBOLS USED IN REGISTRATION TIME DELAY ANALYSIS

Symbols	Definitions
$R_{RM}$	Average registration delay of MIPv6
$R_{AM}$	Average registration delay of signaling between AR & MN
$R_{HA}$	Average delay of delivering registration signaling between HA & AR
$R_H$	Average registration signal processing latency of HA.
$R_{intra}$	Average delay of registration process in HMIPv6 during an intra MAP handover.
$R_{inter}$	Average delay of registration process in HMIPv6 during an inter MAP handover.
$R_{MA}$	Average delay of delivering registration signaling between MAP and AR.
$d_{MA}$	Average distance between MAP & its reachable ARs
$d_{HA}$	Average distance between HA & AR
$\mu$	Unit distance signaling transmission cost of wire link.
T	Average dwell time that HN stays in AR
$R_M$	Average registration delay in HMIPv6

In case of HMIPv6 there are two registrations namely regional registration & home registration while in case of MIPv6 there is only home registration[10].

$R_{RM}, R_{intra}, R_{inter}$  can be calculated as:-

$$R_{RM} = 2 R_{AM} + 2 R_{HA} + R_H \quad (1)$$

$$R_{intra} = 2 R_{AM} + 2 R_{MA} + R_M \quad (2)$$

$$R_{inter} = 4 R_{AM} + 2 R_{MA} + 2 R_{HA} + R_H + R_M \quad (3)$$

Let n be the number of handovers needed by an MN to move out of a region where ( $n \geq 1$ ). This means at  $n^{th}$  handover MN will enter to a new region. Thus total average delay ( $T_{IT}$ ) required by an MN for n handovers in HMIPv6 & MIPv6 [16] is given by:-

$$R_{IT} = (n - 1) R_{intra} + R_{inter} \quad (4)$$

$$R_{AT} = n R_{RM} \quad (5)$$

Now,  $R_T$  can be calculated by using above definitions and equations as follows:-

$$R_T = \frac{\mu(2\theta + 2nd_{MA} - 2d_{HA}(n-1) + n(R_M - R_H) + R_H)}{nT} \quad (6)$$

Where  $\theta \cdot \mu$  is the average signaling delivering delay of wireless link and  $\theta > 1$ .

In the above formulae, HM IPv6 gives greater registration revenue only when  $R_T < 0$  and it is possible when the distance between MN & MAP is shorter and distance between HA & MN is greater.

Now, we can deduce following two theorems.

**Theorem 1:-** HMIPv6 outperforms MIPv6 in terms of registration delay cost  $R_T$  when MN roams with in a region (micro mobility) for this case  $R_T$  can be calculated as

$$R_T = \frac{2\mu(d_{MA} - d_{HA}) + R_M - R_H}{T} \quad (7)$$

**Theorem 2:-** For regional size K and N as the number of access routers, macro mobility (mobility of MN outside a region) can be calculated as

$$R_T = \frac{(2\mu\theta + R_H) \cdot (2N - 2K - 1) + 2\mu d_{HA}(1 - 2K)}{(2N - 2)T} + \frac{4\mu(N - 1) \cdot d_{MA} + 2(N - 1) \cdot (R_M - R_H)}{(2N - 2)T} \quad (8)$$

### B. Average Packet Delivery Analysis

**Definition 2:-** Average packet delivery cost, denoted by  $P_T$ , is defined as the average time that can be saved by using MIPv6 instead of HMIPv6 for delivery from CN to MN.

TABLE3 SYMBOLS USED IN AVERAGE PACKET DELIVERY DELAY ANALYSIS

Symbols	Definitions
$P_{PM}$	Average packet delivery delay of MIPv6
$\lambda$	Average packet arrival rate
$P_H$	Average packet processing latency of HA
$P_{CH}$	Average delay of performing packet from CN to HA
$P_{HA}$	Average delay of performing packet from HA to AR
$P_{AM}$	Average delay of performing packet from AR to MN
$P_{PH}$	Average packet delivery delay of HMIPv6
$P_M$	Average packet processing delay of MAP
$P_{HM}$	Average delay of forwarding packets from HA to MAP
$D_{HM}$	Average distance between HA & MAP

The average delay of forwarding packets from CN to MN in MIPv6 & HMIPv6 can be calculated as

$$P_{PM} = \lambda \cdot (P_H + P_{CH} + P_{HA} + P_{AM}) \quad (9)$$

$$P_{PH} = \lambda \cdot (P_H + P_M + P_{CH} + P_{HM} + P_{MA} + P_{AM}) \quad (10)$$

As per definition (2), the average delivery cost,  $P_T$  is given by

$$P_T = P_{PH} - P_{PM} = \lambda \cdot (P_M + P_{HM} + P_{MA} - P_{HA}) \quad (11)$$

Let  $\delta$ , be the average delay of encapsulating a packet in MAP, so  $P_M$  can be formulated as

$$P_M = A \cdot w \cdot k + B \cdot \lg k + \delta \quad (12)$$

Where  $A > 0$ ,  $B > 0$  ( $A$  &  $B$  are positive coefficients).

Assumes that average packet delivery delay of wired link is proportionality constant  $\eta$ . Then equation (11) can be transformed as

$$P_T = \lambda \cdot (A \cdot w \cdot k + B \cdot \lg k + \delta + \eta \cdot (d_{HM} + d_{MA} - d_{HA})) \quad (13)$$

Where  $\lg$  is logarithmic function,  $w$  is the average number of AR in a region assuming that an AR can serve  $w$  MNs.

Since  $d_{HM} + d_{MA} \geq d_{HA}$ , equation (13) concludes that the average packets delivery cost,  $P_T$ , is positive. If  $P_T$  positive. If  $P_T > 0$ , it states that average packet delivery delay of HMIPv6 is greater than that of MIPv6 [10].

### C. Total Cost Function

*Definition 3:* Total cost function denoted as  $C_t$ , determines the overall performance of HMIPv6 against MIPv6 in terms of both registration and packets delivery,  $C_t$  is given by following formula where  $n_1$  &  $n_2$  are positive coefficients.

$$C_t = n_1 \cdot R_T + n_2 \cdot P_T \quad (14)$$

As per definition 3, if  $C_t < 0$ , HMIPv6 will be adopted as mobility management solution otherwise MIPv6 is adopted.

Now, for FMIPv6

Considering  $P_{CM}$ ,  $P_{MA}$ ,  $P_{AA}$  as the packet delivery delay between CN and MAP, MAP and AR and AR's respectively and  $P_{BU}$  as the binding update delay.

If  $0 < t < P_{BU}$  (Till Binding update),

Then average packet delivery delay =  $P_{MA} + P_{AA}$

Since  $P_{AA} = 2 P_{MA}$  (If MAP is the aggregator router) for  $P_{BU} < t < P_{MT}$  ( $P_{MT}$  is measuring time for delivery delay)

Packet delivery delay =  $P_{MA}$

So, average packet delivery delay =  $\frac{P_{BU} * 3P_{MA}}{P_{MT}} + \frac{(P_{MT} - P_{BU})P_{MA}}{P_{MT}} = P_{MA} + \frac{P_{BU}}{P_{MT}} * 2P_{MA}$

If  $P_{BU} = 4(P_{CM} + P_{MA})$  in FMIPv6

Then, Average delivery delay =  $P_{MA} + \frac{8P_{MA}}{P_{MT}} (P_{CM} + P_{MA})$

Whereas, in case of FHMIPv6

Average delivery delay =  $P_{MA}$

Now, its cost function can be calculated as  $C_t' = C_t - \frac{8P_{MA}}{P_{MT}} (P_{CM} + P_{MA})$

#### The IMS Scheme

The case of HMIPv6, when  $k$  increases, it may gain more average registration cost while compromising with average packet delivering cost. But regional size  $K$  cannot increase indefinitely due to processing bottleneck of MAP [7]. The total average packet processing latency of MAP is given by  $\lambda \cdot (A \cdot w \cdot k + B \cdot \lg k + \delta)$ , which depends on its load.

Thus, an optimal value of  $k$  that minimizes  $C_t$  will optimize the total performance of HMIPv6 against MIPv6. We denote such  $k$  as  $k_{opt}$ , which can be solved as follows

Min  $C_t(k)$  such that

$$\lambda \cdot (A \cdot w \cdot k + B \cdot \lg k + \delta) < \psi \quad (15)$$

Where,  $\psi$  is a constant restricting the total packet processing latency of MAP.

*Definition 4:-* Cost function of HMIPv6, called  $C_{HMIPv6}$  calculates the absolute performance of HMIPv6 in terms of average registration cost and average packet delivery cost. It is given by

$$C_{HMIPv6} = \frac{n_1(n-1)R_{intra} + n_2 P_{PH}}{nT} \quad (16)$$

IMS scheme: Intelligent mobility support scheme determines the applicability between HMIPv6 and MIPv6 according to changing user's mobility. It also selects the best MAP (mobility anchor point) on the basis of total cost function.

*Intelligent Mobility Support Scheme (IMS) Algorithm:-*

- 1) Begin
- 2) If  $\lambda$  or  $T$  changes (MN leaves current MAP), then go to next steps, otherwise go to step 10.
- 3) Compute  $K_{opt}[i]$  &  $C_t[i]$  where  $i=1,2,-----M$
- 4) Initialize OC .
- 5)  $OC = \min \{C_t(i)\}$ .
- 6)  $OK_{opt} = K \min \{C_t(i)\}$ .
- 7) If  $OC < 0$ , then HMIPv6 is adopted as mobility management solution and MN selects the MAP whose sequence number is OC.
- 8) The selected MAP's optimal regional size is  $OK_{opt}$

- 9) Else  $OC \geq 0$ , then MIPv6 is adopted as mobility management solution.
- 10) MN gets no information on handover.
- 11) END.

### V. NUMERICAL ANALYSIS & DISCUSSION

Using MATLAB simulation Figure 5& 6 compare the performance of IPv6 protocols (MIPv6, HMIPv6 & FHMIPv6) using cost function as the metric. The variation of cost function against key parameters i.e. average packet arrival rate and average dwell time has been observed. Further the effect of some key parameters on cost function has been studied in figure 7, 8 and 9. The parameters used in this simulation are taken from existing literature[10]. The estimated value of  $\lambda$  (average packet arrival rate) can be found in [18,19] whereas T (dwell time) is taken as 100 [17]. Value of the 'w' and N are taken to be 15 and 30 respectively and the approximate value of  $d_{HM}$ ,  $d_{HA}$  and  $d_{MA}$  are taken as 18, 23 and 6 respectively [20].

Figure 5 and 6 depicts how the cost function changes with  $\lambda$  (average packet arrival rate) and T (average dwell time) for Mobile IP protocols. From figure 5, it can be observed that cost function gradually increases with increase in average packet arrival rate. FHMIPv6 is having lowest cost function among other protocols.

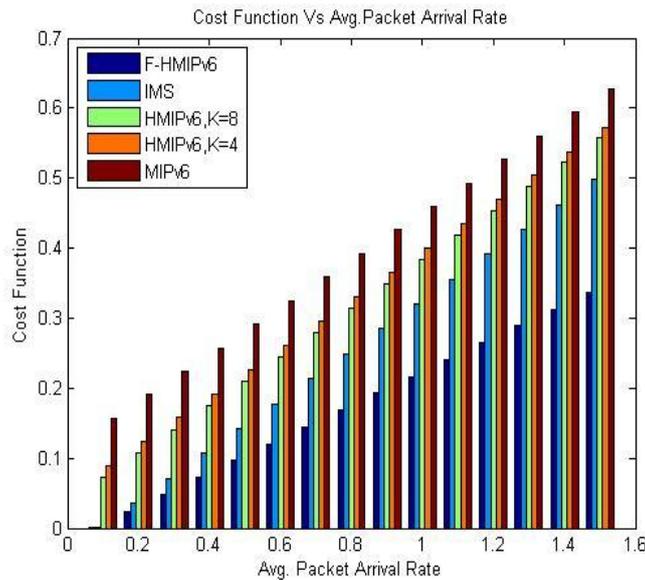


Figure 5: Cost Vs Avg. Pkt. Arrival Rate

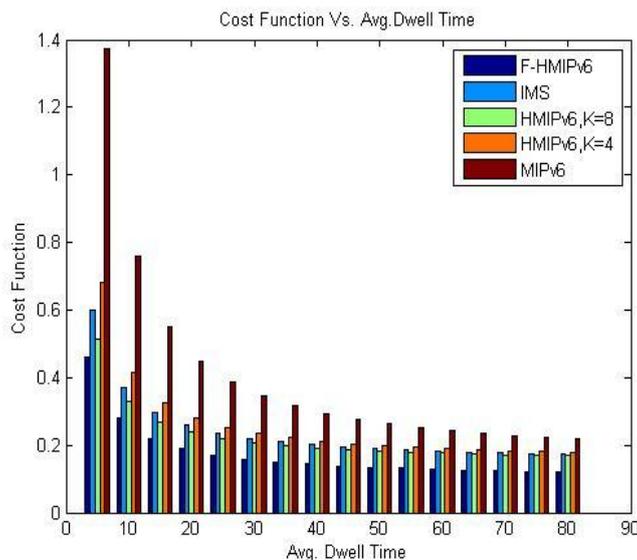


Figure 6: Cost Vs Avg. Dwell Time

From figure 6 an exponential form of graph can be observed, cost function decreases as the average dwell time increases FHMIPv6 is having best results in this regard too. From the above two graphs it is clear that MIPv6 and HMIPv6 have worst results among all protocols followed by IMS and FHMIPv6. FHMIPv6 is having best results. In MIPv6 and HMIPv6, return routability (RR) procedure accounts for a larger portion of handover delay. So, FHMIPv6 has been proposed for minimization of handover delay due to RR.

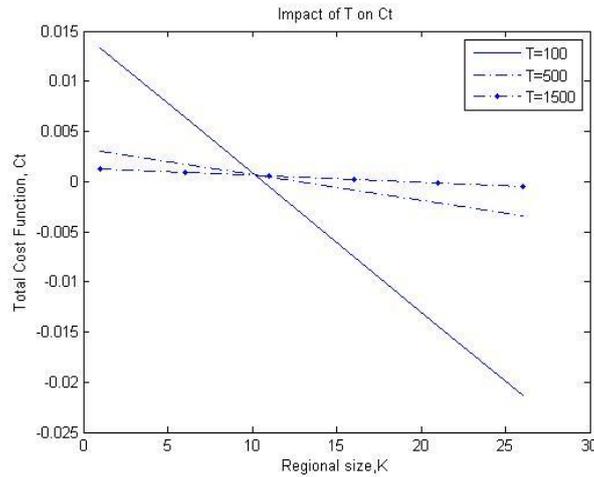


Figure 7: Impact of T on Ct

Figure 7 depicts the impact of T (average dwell time) on Ct. It is clear from the figure 7 that for  $K \leq 9$ , Ct is greater than 0. This is because when K (regional size) is smaller, the rate of movement of MN outside a region is larger, leading to double registration. Whereas, when K is larger i.e.  $K > 9$ , most of the mobility belongs to micro – mobility, hence Ct is less than zero.

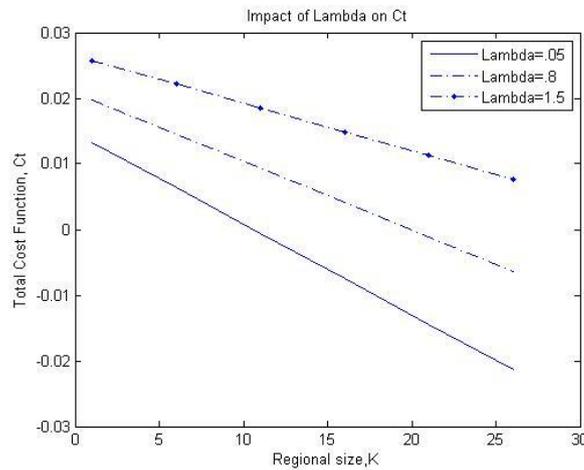


Figure 8 : Impact of Lambda on Ct

Figure 8 depicts the impact of  $\lambda$  (average packet arrival rate) on Ct. This figure illustrates that Ct increases as  $\lambda$  increases. This is because as the  $\lambda$  increases, the average packet delivery cost will increase thereby leading to increase in Ct.

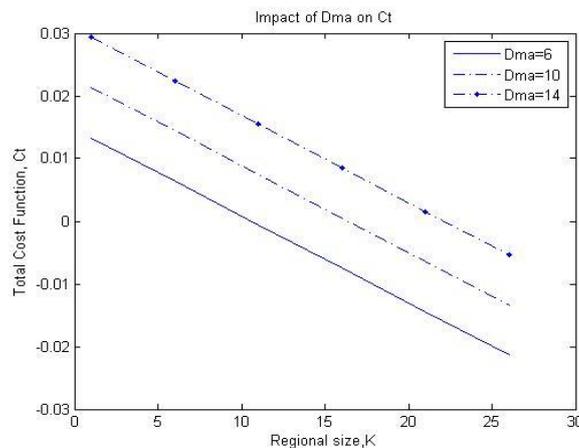


Figure 9 : Impact of Dma on Ct

Figure 9 illustrates the impact of Dma (distance between MAP and AR) on Ct. From figure 9 it can be observed that Ct increases with increase in Dma. This is due to the fact that as Dma increases both the average registration cost and average packet delivery cost increases, leading to increase in Ct.

## VI. CONCLUSION & FUTURE WORK

In this paper, an analytical model for IPv6 based mobility protocols like MIPv6, FMIPv6, HMIPv6 and FHMIPv6 has been proposed in order to analyze the performance in the terms of cost function taking average packet arrival rate and average dwell time into consideration. The numerical result shows that FHMIPv6 enables improvement in terms of cost function rather than other protocols which we have discussed. However, the improvement of cost function is compromised by the factor of buffer space requirement in FHMIPv6. Also an intelligent mobility support scheme has been introduced for selection of best MAP according to changing user's mobility. This scheme also makes a selection between MIPv6 & HMIPv6. Further work can be done in improving the buffer space requirement in FHMIPv6.

## REFERENCES

- [1] I.F. Akyildiz, J. McNair, J. Ho, H. Uzunalioglu, and W. Wang, "Mobility management in next-generation wireless systems", in Proc. of IEEE, vol.87, no.8, pp.1347-1384, 1999.
- [2] J. D. Solomon, *Mobile IP, The Internet Unplugged*. (Upper Saddle River, NJ: Prentice-Hall, 1998.)
- [3] Koodli R, "Fast Handovers for Mobile IPv6", Internet Draft, IETF, draft-ietf-mipshop-fast-mip6-03.txt, RFC 4068, July 2005.
- [4] Soliman H., "Hierarchical Mobile IPv6 Mobility Management", Internet Draft, IETF, draft-ietf-mipshop-hmip6-04.txt, RFC 4140, August 2005.
- [5] Xie, J., I. H., I. S., "IEEE 802.11-based Mobile IP Fast Handoff Latency Analysis." in IEEE conference pp.6055-6060, 2007.
- [6] J Xie. and I.F. Akyildiz. "A Novel Distributed Dynamic Location Management Scheme for Minimizing Signaling Costs in Mobile IP". IEEE Transactions on Mobile Computing, vol.1, no.3, pp.163-175, 2002.
- [7] C. Makaya, S. Pierre, "An Analytical Framework for Performance Evaluation of IPv6 Based Mobility Management Protocols", IEEE Transactions on Wireless Communication, vol.7, no.3, pp.972-983, March 2008.
- [8] T. T. Kwon, M. Gerla, and S. Das, "Mobility management for VoIP service: Mobile IP vs. SIP", IEEE Transactions on Wireless Commun., vol. 9, no. 5, pp. 66-75, Oct. 2002.
- [9] B. Hu, Y. Shi, X. Chen, and S. Li. "Analysis of Location Management Schemes in Mobile IPv6". Proc 6th International Conference on ITS Telecommunications, pp:1067-1070, 2006.
- [10] Shengling Wang, Yong Cui, Sajal K. Das "Intelligent Mobility support for IPv6", IEEE, pp:403-410, 2008.
- [11] C. Perkins, "Mobile IPv4 Fast Handovers", IETF draft, RFC 4988, June 2007.
- [12] Johnson D., Perkins C. & Arkko J., "Mobility Support in IPv6", Internet Draft, IETF, draft-ietf-mobileip-ipv6-24.txt, RFC 3775, June 2004.
- [13] S. Pack and Y. Choi, "Performance analysis of hierarchical mobile IPv6 in IP-based cellular networks", in Proc. IEEE PIMRC 2003, Beijing china, pp.2818-2822, September 2003.
- [14] Perkins C. & Wang K.Y., "Optimized smooth handoffs in Mobile IP", Proceedings of IEEE Symposium on Computers and Communications, Egypt, July 99.
- [15] M. Torrent-Moreno, X. Perez-Costa, and S. Sallent-Ribes, "A performance study of fast handovers for Mobile IPv6", in Proc. IEEE International Conference on Local Computer Networks (LCN 2003), pp. 89-98, 2003.
- [16] Shengling Wang, Yong Cui, Sajal K. Das, Wei Li, and Jianping Wu, "Mobility in IPv6: Whether and How to Hierarchize the Network?", Issue No.10 - Oct. (2011 vol.22) pp: 1722-1729, 2011 IEEE.
- [17] Y. Chen and M. Huang. "A Novel MAP Selection Scheme by Using Abstraction Node in Hierarchical MIPv6". Proc. IEEE International Conference on Communications, pp:5408-5413, 2006.
- [18] H. Xie, S. Tabbane, and D.J. Goodman. "Dynamic Location Area Management and Performance Analysis". Proc. 43rd IEEE Vehicular Technology Conference, pp:536-539, 1993.
- [19] M. Yabusaki. "Mobility/Traffic Adaptive Location Management". Proc. IEEE 56th Vehicular Technology Conference, Vancouver, pp:1011-1015, 2002.
- [20] W.R. Stevens, TCP/IP Illustrated, Volume 1: *The Protocols*. Addison-Wesley Longman, Inc., 1994.
- [21] Varun Goel and Satyajit Sen Purkayastha, "A Comparative Handoff Latency Evaluation in IPv6 Based Mobility Management Protocols" Volume 2, Issue 11, November 2012.