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A Comparative Study of MIPv6, HMIPv6 & IMS in terms of Cost

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Abstract---- Mobile IPv6 (MIPv6) and Hierarchical Mobile IPv6 (HMIPv6) both are the mobility management solution proposed by the Internet Engineering Task Force (IETF) to support IP Mobility. There are various types of parameters which have been proposed and used to describe the system performance in the form of mobility of MIPv6 and HMIPv6. In this paper a comparative study has been described in which the performance of MIPv6 and HMIPv6 with Intelligent Mobility Support (IMS) scheme in terms of cost has been demonstrated using an analytical model. Numerical results demonstrate the performance of MIPv6 and HMIPv6 when certain parameters are changed.

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

I. INTRODUCTION

With the fast increasing demand for the seamless mobility providers motivate to support seamless connectivity to Mobile Nodes (MNs). To complete this aim, Internet Engineering Task Force (IETF) proposed Mobile IP (MIP) protocol. MIPv4 and MIPv6 both are the mobility management solution to maintain the on-going communication when one MN moves from one subnet to another. MIPv6 become the next generation solution due to the several advantages of MIPv6 over MIPv4. In Mobile IPv6 one MN is identified by two addresses: Home address and Care of address (CoA) [1]. Home Address represents the permanent address of MN and Care of Address (CoA) is the Temporary Address, representing the current location of MN. There is a mobility management entity i.e. Home Agent (HA) which stores the binding information of the MN. Home Agent also receives all the packets on behalf of the MN when the Correspondent Nodes do not know the current location of the MN. In MIPv6 there is a process known as “Home Registration” in which updated location is registered in HA when the MN roams in the visited networks.

But in MIPv6 a frequent handover by MN in a local region leads to a longer signaling delay. In Handover process this longer signaling delay is the main problem of the MIPv6.

To solve this problem, Hierarchical Mobile IPv6 (HMIPv6) is introduced. In HMIPv6 [2] a new entity is introduced known as Mobility Anchor Point (MAP) to act as a local Home Agent with in a region. In HMIPv6 Mobility Anchor Point (MAP) have a number of Access Routers (ARs). The number of ARs under a MAP is known as the Regional Size. In HMIPv6, there are two addresses: Regional care of address.

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(RCoA) representing the MN’s MAP & the on-Link CoA (LCoA) representing the AR that the MN attaches to.There are two types of mobility in HMIPv6: micro-mobility (handover with in a region) and macro-mobility (handover across the regions). In macro-mobility, the MN gets two new addresses: RCoA, LCoA and it will initiate a regional registration process to bind these two addresses. After having successful regional registration, the MN gives its new update of having new RCoA to it’s HA i.e. there is a binding between its Home Address and RCoA to the HA by a Home Registration. In micro-mobility there is only a regional registration because there is no new RCoA of a MN within a region. Now, we see that in HMIPv6 when MN roams from one region to another, there is a double registration: regional registration and home registration. So in HMIPv6 the handover latency is smaller than that of MIPv6 when the MNs roam within the region but the handover latency is larger than that of MIPv6 when the MNs roam inter- region. Besides, in double registration there is a MAP processing delay leading to a longer packet delivery time because all the packets destined to MN are tunneled through MAP. So, Double registration leads to a larger handover latency and longer packet delivery time. So it is an interesting issue to select to find out the performance of MIPv6 and HMIPv6 depending upon certain conditions.

II. PERFORMANCE ANALYSES OF MIPV6 AND HMIPV6

A. *Relative Registration Cost [3]*

Definition 1. (Relative Registration Cost):
Relative registration cost (T_R) is defined as the average registration time saved by using HMIPv6 compared with MIPv6 [3]

T_R may be positive or negative. $T_R > 0$ means the average registration delay of MIPv6 is shorter than that of HMIPv6, otherwise longer.

Main Symbols in Registration Performance Analyses

Symbols	Definitions
T_R	Average registration delay of MIPv6
T_{AM}	Average delay of delivering registration signaling over wireless link between AR and MN
T_{HA}	Average delay of delivering registration signaling between HA and AR
T_H	Average registration signal processing latency of HA
T_{intra}	Average delay of a registration process in HMIPv6 during an intra-MAP handover
T_{inter}	Average delay of a registration process in HMIPv6 during an inter-MAP handover

T_{MA}	Average delay of delivering registration signaling between MAP and AR
l_{MA}	Average distance between MAP and its reachable ARs
l_{HA}	Average distance between HA and AR
T	Average dwell time that an MN stays in an AR
μ	Unit distance signaling transmission cost of wired link

According to RFC3775[1] and RFC4140 [2] in MIPv6 there is only home registration but in HMIPv6 there are to registrations: regional registration and home registration. Hence, T_{RM}, T_{intra} and T_{inter} can be calculated as:

$$T_{RM} = 2T_{AM} + 2T_{HA} + T_H \quad (1)$$

$$T_{intra} = 2T_{AM} + 2T_{MA} + T_M \quad (2)$$

$$T_{inter} = 4T_{AM} + 2T_{MA} + 2T_{HA} + T_H + T_M \quad (3)$$

Let the MN needs m^{th} handover to move out of a region ($m \geq 1$).Then, in new region the MN will enter at its m^{th} handover. So the total average delay (T_{IT}) that an MN spends for m handovers in HMIPv6 and MIPv6 is [3]

$$T_{IT} = (m-1)\, T_{intra} + T_{inter} \quad (4)$$

$$T_{AT} = mT_{RM} \quad (5)$$

Using definition 3.1 and equations (4) & (5), T_R , can be calculated as

$$T_R = \frac{\mu(2.\theta+2.m.l_{MA}-2.l_{HA}(m-1)+m.(T_M-T_H)+T_H)}{mT} \quad (6)$$

Where μ is unit distance signaling transmission cost of of wired link. We also suppose the average signaling delivering delay of wireless link be $\theta.\mu$, where $\theta > 1$. From formulae (6) we can say that if the nearer the distance between MN and MAP and the farther the distance between HA and MN, then HMIPv6 gives higher average registration revenue. i.e. Only when, $T_R < 0$, HMIPv6 obtains the average registration revenue. Two theorems can be deduced.

Theorem 1: HMIPv6 outperforms MIPv6 in terms of registration revenue when an MN roams within a region (intra-region) and the average registration revenue is $|2\mu.(l_{MA}-l_{HA})/ T|$. In micro-mobility T_R can be calculated as [4]

$$T_R = \frac{2\mu\left(l_{MA}-l_{HA}\right)+T_M-T_H}{T} \quad (7)$$

Theorem 2: T_R lies on the regional size, K, when the MN roams across different regions (inter-region). In this T_R can be calculated as on certain conditions as [4]:

$$T_R = \frac{\left(2\mu.\theta+T_H\right).\left(2N-2K-1\right)+2\mu.1_{HA}.\left(1-2K\right)}{\left(2N-2\right).T} + \frac{4\mu.\left(N-1\right).1_{MA}+2\left(N-1\right).\left(T_M-T_H\right)}{\left(2N-2\right).T} \quad (8)$$

B. Relative Packet Delivery Cost [3]

Definition 2. (Relative Packet Delivery Cost)

Relative packet delivery cost (D_P)[3] is defined as the average time wasted by using HMIPv6 instead of MIPv6 to forward packets.

Main Symbols in Packet Delivery Performance Analyses

Symbols	Definitions
D_{PM}	Average packet delivery delay of MIPv6
α.	Average packet arrival rate
D_H	Average packet processing latency of HA
D_{CH}	Average delay of forwarding packets from CN to HA
D_{HA}	Average delay of forwarding packets from HA to AR
D_{AM}	Average delay of forwarding packets from AR to MN
D_{PH}	Average packet delivery delay of HMIPv6
D_M	Average packet processing delay of MAP
D_{HM}	Average delay of forwarding packets from HA to MAP
l_{HM}	Average distance between HA and MA

According to [1] and [2], the average latency of forwarding packets from a CN to the MN in MIPv6 and HMIPv6 are

$$D_{PM} = \alpha.(D_H + D_{CH} + D_{HA} + D_{AM}) \quad (9)$$

$$D_{PH} = \alpha.(D_H + D_M + D_{CH} + D_{HM} + D_{MA} + D_{AM}) \quad (10)$$

According to definition 3.2, the average packet delivery cost is given by

$$D_P = D_{PH} - D_{PM} = \alpha.(D_M + D_{HM} + D_{MA} - D_{HA}) \quad (11)$$

We assume that δ is the average delay of encapsulating a packet in MAP, so D_M can be calculated as:

$$D_M = A.w.K + B.lg.K + \delta \quad (12)$$

Where *A* and *B* are positive coefficients

Assume that the average packet delivery delay of wired link is proportional to the number of hops that the packets travel with the proportionality constant η. Then Equation becomes [4]

$$D_P = \alpha.(A.w.K + B.lg.K + \delta + \eta.(l_{HM} + l_{MA} - l_{HA})) \quad (13)$$

Where α is average packet arrival time, δ is the average delay of encapsulating a packet in MAP, A & B are coefficients, wk is the average no. AR in a region with assuming that an AR can serve *w* MNs on average and *lg* is the logarithmic function.

Equation (13) leads to the conclusion that average packet delivery cost is positive on certain condition [4]. When $D_P > 0$, it means average packet delivery delay of HMIPv6 is longer than that of MIPv6.

C. Relative Cost [3]

Definition 3. (Total Cost Function)

Total cost function denoted as C_T gives the overall performance of HMIPv6 against MIPv6 in terms of registration and packet delivery cost [3].

$$C_T = n_1.T_R + n_2.D_P \quad (14)$$

Where $n_1 > 0$ and $n_2 > 0$ are the coefficients.

As per the eq. (10), when $C_T > 0$, MIPv6 will be more applicable than HMIPv6 otherwise HMIPv6 is adopted.

D. The IMS scheme [4]

When regional size *K* increases, HMIPv6 may gain more average registration revenue while paying more average packet delivery cost. However, *K* cannot increase indefinitely due to the processing bottleneck of the MAP [7]. The total average packet processing latency of the MAP is given by $\alpha.(AwK+BlgK+\delta)$, which depends on its load. Thus, a proper *K* that minimizes C_T will optimize the overall performance of HMIPv6 against MIPv6. Denote such *K* as K_{opt}, which can be solved as follows [4]

$$\text{Min. } C_T(K)$$

$$\alpha.(AwK + B.lg.K + \delta) < \psi \quad (15)$$

where ψ is a constant restricting the total packet processing latency of the MAP.

Definition 4. Cost function of HMIPv6, *called* C_{HMIPv6} *formulates the absolute performance of HMIPv6 in terms of the average registration and packet delivery delay. It is given by*

$$C_{HMIPv6} = n_1 . \frac{(m-1)T_{intra} + T_{inter}}{mT} + n_2 . D_{PH} \qquad (16)$$

where n_1 and n_2 are the same as in Definition 3.

III. COMPARISON OF MIPv6, HMIPv6 & IMS

In this section we propose an algorithm which demonstrates the comparison of MIPv6, HMIPv6 and IMS scheme. Intelligent Mobility Support (IMS) scheme is the scheme in which in all the parameters (mentioned in the above definitions and symbols) is studied and calculates that out of MIPv6 and HMIPv6 scheme which one is better. If HMIPv6 is adopted than it chooses the best mobility anchor point on the basis of cost factor. In this section an algorithm has been proposed which shows that how Cost changes with α and *T*. Finally it is shown that IMS is better than that of MIPv6 and HMIPv6 when the parameters α and *T* are changed in terms of cost.

A. Algorithm for the Performance of MIPv6 & HMIPv6 to show the Changing of Cost with α and *T*

1. Start
2. Input the value of OC, M & all parameters.
3. Input the value of K_{opt}(i) of MAP(i). i.e.(i=1,2………M).
4. If MN gets the information about parameters on handover.
5. Check for α, T or MAP.
6. If α, T, MAP changes then go to step 7, otherwise go to step 13.
7. Calculate C_t (i) of MAP (i) i.e.(i=1,2………M).
8. OC= Min.{C_t(i)} i.e.(i=1,2………M).
9. OK_{opt}=K Arg min.{C_t(i)} i.e.(i=1,2………M).
10. If OC ≥ 0, then MN adopts MIPv6.
11. Else, OC < 0, then MN adopts HMIPv6 and MN chooses the MAP whose sequence no. is OC.
12. The chosen MAP regional size OK_{opt}
13. There is no information about Handover (MN will stay in same AR).
14. END

III. NUMERICALS RESULTS & DISCUSSION

In this section, we demonstrate the performance of MIPv6 and HMIPv6 against some key parameters α and *T*. We employ numerical analysis on MATLAB to show the results. The parameters used in the simulation process are taken from the various existing literature. The estimating value of α can be found in [7,8] while T can be computed by the method introduced in [6]. In addition the value of *w* and *N* are from [10]. The estimating value of l_{HM} and l_{MA} are taken from [9].

The comparison of the performance of IMS, HMIPv6 (the regional size is 7 or 13) and MIPv6 in figures 1 and 2 using cost as the metric. Figure 1 the graph plotted between the total cost function and average packet arrival time. In this graph the comparison of IMS with MIPv6 and HMIPv6 has been shown. From this figure we can also observe that IMS is better scheme than that of MIPv6 and HMIPv6 in terms of cost because it shows the lowest cost when average packet arrival time is increased. In figure 2, it has been studied that IMS shows the lowest cost when average dwell time of MN is increased

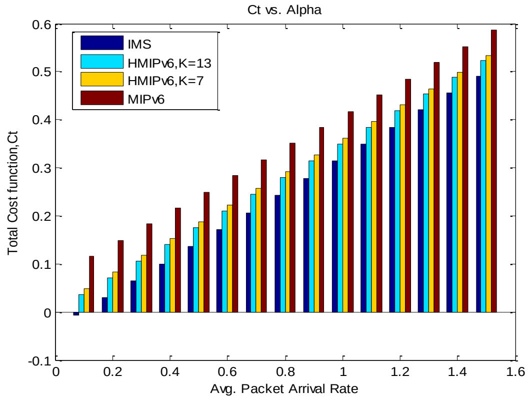

Fig.1 Cost vs. α

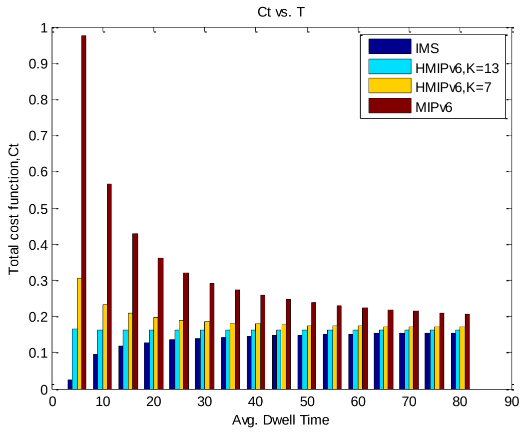

Fig.2 Cost vs. T

The cost of the IMS is taken from the formula (16). Figures 1 & 2 show that how cost changes with α and *T*. We also observe that the cost of IMS is minimum when it is compared with MIPv6 and HMIPv6.

IV. CONCLUSION

In this paper a comparative study has been described in which a performance of MIPv6 and HMIPv6 has been evaluated in the form of certain parameters on the total cost function. It is also evaluated that IMS scheme shows the minimum cost when it is compared with MIPv6 and HMIPv6 in terms of total cost function when certain parameters are changed. Finally, the performance of MIPv6, HMIPv6 and IMS schemes has been simulated in this paper.

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