# A Dynamic Architecture for Mobility Management in Hierarchical Mobile IPv6

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*Abstract*—**Hierarchical Mobile IPv6 (HMIPv6) is an enhanced Mobile IPv6 for reducing signaling cost of location management. Multi-level Hierarchical Mobile IPv6 (MHMIPv6) can organize mobile region as a multi-level hierarchy architecture, which is more flexible to support scalable services. However, MHMIPv6 will bring additional packet processing overhead, and produce negative impact especially on some mobile nodes (MNs) with relatively low movement characteristics. This paper proposes a dynamic hierarchical Mobile IPv6 (DHMIPv6) management, in which different hierarchies are dynamically set up to minimize the total cost for different MNs according to their movement characteristics respectively. Under such management MNs can select the monolayer or two-layer mobility anchor point(MAP) structure when they occur the handover at any time. Experimental results show that compared with HMIPv6 and MHMIPv6, DHMIPv6 achieves high adaptability with lower total cost under various scenarios.**

*Index Terms* **—Hierarchical Mobile IPv6, Multi-level Hierarchical Mobile IPv6, dynamic hierarchical architecture, Adaptability**

## I. INTRODUCTION

Hierarchical Mobile IPv6 management (HMIPv6) [1] divides mobile node's (MN) mobility [2] into micro-mobility and macro-mobility. When a MN moves within a particularly hierarchical domain, then micro-mobility; In this case, HMIPv6 utilize local mobility management to reduce the amount of signaling generated by the registration to the correspondent nodes (CNs) and to the home agent (HA).when the MN moves out to a new domain, then macro-mobility, the mobility of the MN will be managed by the standard Mobile IPv6 management (MIPv6) [3]. Mobile Anchor Point (MAP) is a substitute of "Home Agent" (HA) in each domain of the network which hides user's mobility from the outer domain. Then the binding updates are sent from MN directly to MAP rather than more distant HA or CNs when the MN stays in a specific region; meaning that MN's exact position is hidden from outer region and the signaling overhead is reduced. The MN needs to register

its position to HA and CNs when it moves out of the specific region, just like the standard MIPv6.

Shengling Wang et al proposed a model to analyze the application scopes of MIPv6 and HMIPv6 [4]. In [4] ,Wang presented HMIPv6 does not always outperform MIPv6 , The analytic model in [4] can choose the better alternative between MIPv6 and HMIPv6 according to the mobility and service characteristics of users and can choose the best mobility anchor point and regional size when HMIPv6 is adopted, addressing how to hierarchize the network..

There are also some works considered the MN's characteristics to get a better performance [5] [6] [7].Xie et al. proposed an analytic model for Mobile IP regional registration which is one of hierarchical mobility management schemes [5]. The proposed analytic model focused on the determination of the optimal size of regional networks, given the average total location update and packet delivery cost. Besides, Ma introduced a dynamic hierarchical mobility management strategy for mobile IP networks, in which different hierarchies are dynamically set up for different users and the signaling burden is evenly distributed among the network [6]. [7] introduced two static MAP selection schemes: the furthest MAP selection scheme, the nearest MAP selection scheme and two dynamic MAP selection schemes: the mobility-based and the adaptive MAP selection schemes. [7] proposed that the dynamic schemes are better than the static schemes since the dynamic schemes can select the serving MAP depending on the MN's characteristics In addition, the dynamic MAP selection schemes achieve better load balancing.

To reduce signaling cost further, Multilevel Hierarchical Mobile IPv6 management (MHIPv6) [8] subdivide mobile region of MNs to multiple levels. The MAPs are placed at all levels of hierarchical structure of network, The MAP of the lower layer is responsible for location management and data delivery of MNs in a smaller range reign, However the higher MAP has a wider service domain through the lower layer MAPs beneath itself. So an MN moves out to another, which MAP Will be selected to register depend to the MN's changing mobility. MHMIPv6 is more flexible than

HMIPv6, and the signaling cost will be reduced even further. But it also presents new problems. First, the high level MAP is responsible for the management and data forwarding of all mobile nodes in a large area. The Center fixed structure may result in high load for the high level MAP, and the failure of the high level MAP cause the communication interrupt for all MNs. Secondly , packets from the communication nodes sent to mobile node need be stored and forward through the MAPs at all levels, that significantly increased the network load.

This paper proposes a dynamic two-level MAP hierarchical mobile IPv6 model (DHMIPv6). The model of physical structure is the monolayer MAP, but can implement the two levels of structure logically. Compare to HMPIv6, the model reduce the number of home registration for the mobile node, so reduce the costs. At the same time it avoids the heavy load and system robustness problems brought by center fixed structure of the MHMIPv6. In this paper, we also introduce a new mathematical model to calculate the smallest overall costs of location registration and packet delivery for determining the proper location registration strategy when a mobile node moves among subnets. This model considers the factors such as various network parameters, movement characteristics of mobile nodes etc.

This paper is organized as follows: In Section II, the introduction of HMIPv6 and MHMIPv6. In Section III, the mobility model (DHMIPv6) is described and a method for deriving the total location update and packet delivery cost is introduced. In Section IV, we analyzed the total costs of location registration and packet delivery in DHMIPv6; determine the proper location registration strategy to minimize the total costs. In Section V. Comparison results of system performance between DHMIPv6 and HMIPv6, MHIPv6 is presents. Section VI gives the conclusions.

## II. HMIPv6 AND MHMIPv6

### A. HMIPv6

The system architecture of HMIPv6 is shown in Fig.1. The HMIPv6 uses the MAP to provide agent service for MNs at foreign subnet, The MN will receive router notice which Contains one or more MAP information option when it moves from one subnet to another. The MN checks if the MAP domain has changed according to the MAP information. If the MAP domain has changed, The MN can obtain a new link care-of address (LCOA) and a regional care-of address (RCOA). An MN needs to register its LCOA with the MAP for the routing purpose, and register the new RCOA to the home agent and correspondent nodes. Then, all packets to MN will through the new MAP forward. If the MN find MAP domain has not changed, it only needs to register its LCOA with the MAP. So the home registration is not need when switchover happened between two subnets of the same MAP domain. In this case, the mobility of MN is transparent to home agent and correspondent node, it reduce relatively registration cost and time delay. [9] proposed an adaptive network mobility support protocol based on hierarchical mobile IPv6. [10][11] improved the performance through reduce the handover latency. In HMIPv6.Hierarchical mobile management is also used in other mobility management scheme, such as Cellular IP [12], HAWAII [13], Wireless Ad Hoc Networks [14] etc.
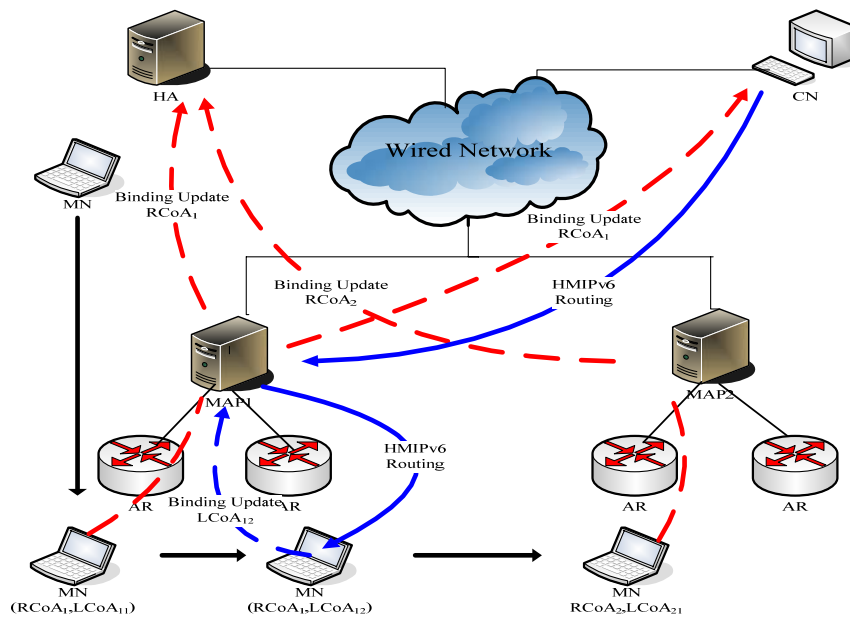


Figure 1.     Position registration and packet routing in HMIPv6

*B.  MHMIPv6*

MAPs are organized into a tree structure in MHMIPv6, as shown in Fig.2, The top MAP of the tree is the root MAP (RMAP). The MAPs at lowest layer are the leaf MAPs (LMAP), When a switchover of a MN happened, the MN register its LCOA with the leaf MAP at first, then the LMAP check if the MN has existed in its binging list. If existed, the LMAP need only to reply the binging update, else the LAMP need to register to the higher level MAP, Analogously, if a MAP has received a binging update, it will check if the MN has existed in its binging list. If the MN has registered, the MAP will finish the registration process after it confirm the binging update, else the MAP send sequentially registration Binding Update to the higher level MAP until RMAP. This process is repeated in each MAP in the hierarchy until a MAP having the MN in its mapping table can be found. In this way, the binding update delivery through multiple levels MAP to RMAP even correspondent nodes and the home agent. Therefore, the first binding update in a foreign network, the BU message is forwarded up to the RMAP in the foreign network and the HA. When a packet is delivered to an MN from a correspondent node, it will carry forwarded by all levels MAPs. It is possible to provide more scalable services and to support a larger number of MNs in MHMIPv6, and the MHMIPv6 is more flexible than HMIPv6 which only divides MN's mobility into two situations: global and regional. However, the MHMIPv6 results in a higher processing cost than the HMIPv6 when a packet is delivered to an MN. This is because the packet goes through more intermediate MAPs and the encapsulation/decapsulation procedures are repeated at each MAP, and if a MAP failed, all the tree structure under the MAP will fail, it will also affect the robustness of the entire network[15].[15] developed an analytic model based on MHMIPv6 architecture to calculate optimal hierarchy too.
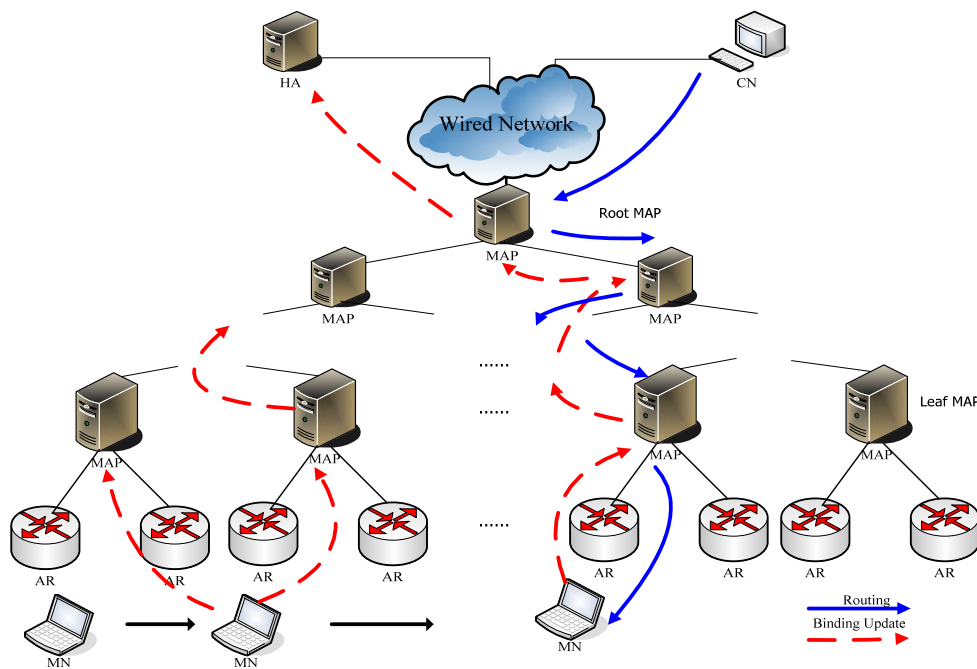


Figure 2.        Position registration and packet routing in MHMIPv6

## III   OUR PROPOSED DHMIPv6

In MHMIPv6, the high level MAP is responsible for packets forwarding of all mobile nodes in a large domain. So, it is likely that they will meet the problem of load. The centralized fixed scheme of the MHMIPv6 has single point invalidation that the failure of a top MAP will lead to communication interrupt of a large area. And the packet sent to the MN from correspondent node through more intermediate MAPs and the encapsulation/decapsulation procedures are repeated at each level MAP which also increased the load on the network .To solve these problems, we propose a new mobility management scheme which has the same physical structure with HMIPv6 but has dynamic two levels MAP logically.In the mobility scheme each MAP can function either as an Root MAP or a leaf MAP or a single level MAP , and an MAP should act as Which types of MAP depends on the user mobility. Thus, the traffic load in a regional network is evenly distributed to

each MAP. Through this approach, the system robustness is enhanced. We also propose how to adjust the number of LMAPs under a RMAP for each MN according to the user-variant and time-variant user parameters in the dynamic scheme. In this dynamic system, there is no fixed regional network boundary for each MN. An MN decides when to perform a home location update according to its changing mobility, packet arrival pattern and the number of correspondent nodes. The detailed analysis will be given in Section IV.

As shown in Fig.3, MN1 First enters the MAP1 domain, Passes through MAP2 domain and MAP3 domain next, finally reaches MAP4 domain. At first MN1 enter the MAP1 domain, it performs a home registration through MAP1, and obtains RCOA (regional care of address) and LCOA (Online care to address).MN1 perform the procedure of location management and packet routing same with the standard HMIPv6 at t-his time.MN1 do not perform the home registration when it enters MAP2 domain or MAP3 domain to reduce the cost of registration. But it registers to the MAP1 with the regional care-of ad-dress obtained in new MAP as a online care-of address domain. Packets from CNs forwarding to current MAP domain of MN1 through MAP1 too and finally submitted to the MN1. So we implement two levels of structure MAP logically. With this method, when MN1 turn crossed k different MAP domain (in this case, the value of k is 3) to reach a new MAP (MAP4) domain, MN1 performs a home registration, and repeat the above steps.

As shown in Fig.3, When MN1 and MN2 in MAP3 domain at the same time. For MN1, MAP1 is MAP3's Upper MAP, but MAP5 is MAP3's Upper MAP for MN2, Such the system assigned functions of upper MAP on o MAP to the two MAPs. So that the influence brought by the failure of MAP1 or MAP5 is relatively limited; And the functions of high-level MAP allocated to each MAP, so that it can avoid single location invalidation and load balancing problem in fixed center structure effectively.

The protocol descriptions of packet delivery and location management in DHMIPv6 are shown in Table I and Table II respectively.

TABLE I

DH-MIPv6 LOCATION DH-MIPv6 PACKET DELIVERY PROTOCOL

if (a correspondent node deliver the packet to an MAP which address registered in the correspondent node with a MN binding?)
  if(The MAP is the LMAP of the MN？)
    Packet submitted  to the  LMAP address registered by MN through the tunnel
  else
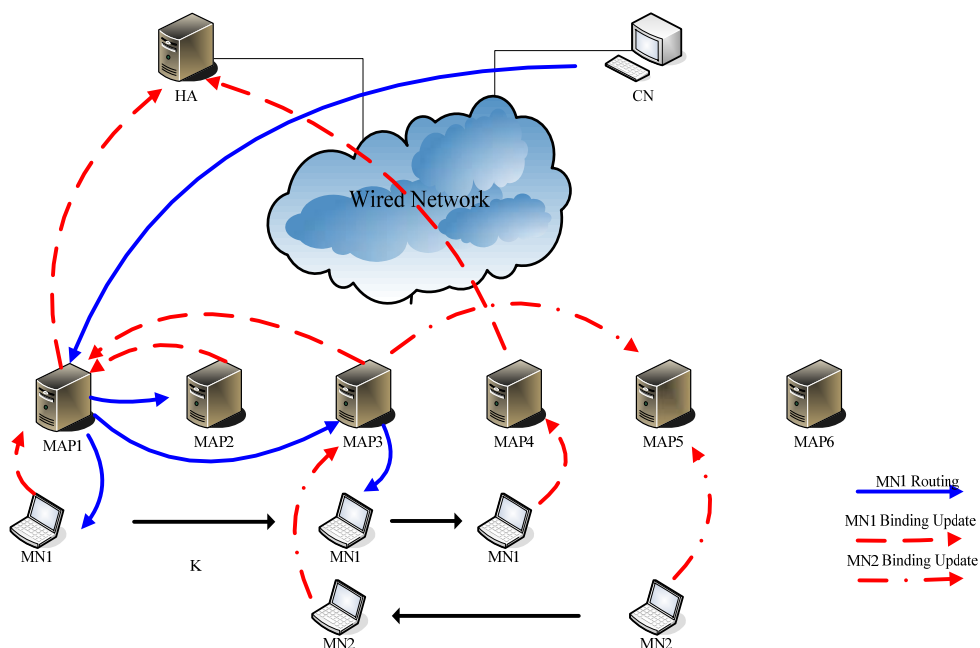    Packet submitted to the MN through the tunnel from the LMAP
end
end.



Figure 3.    Position registration and packet routing in DHMIPv6

TABLE II

DH-MIPv6 LOCATION MANAGEMENT PROTOCOL

if (MN enters a new subnet?)

  if(The MN enters a new MAP domain?)

    compare the address of the new MAP to the addresses in buffer

      if(the new address is one of addresses in buffer?)

     MN perform a regional registration to the selected Previously

     RMAP through the new MAP

  else

      if (The number of addresses in buffer>=Kopt?)

    compute the new Kopt according to the movement characteristics

    of MN

    delete all the addresses in buffer

    Select the MAP as the new RMAP, perform a home registration

    through it

     else

    MN perform a regional registration to the selected Previously

    RMAP through the new MAP

     end

     record the new map address in buffer

    end

else

    Perform a region registration to the Current MAP

  end

end

## IV ANALYTICAL MODE

### A. Location Update Cost

In our model, a MN may perform a home registration or may perform a regional registration to logical RMAP or logical LMAP when it enters a new subnet. Then these location cost can be expressed respectively as Eq. (1), Eq. (2), Eq. (3).

the location update cost of home registration is:

$$C'_{UH} = \omega + \eta(d_{ar-MAP} + d_{MAP-HA}) + 2a_{MAP} + a_{HA}$$

(1)

the location update cost of regional registration to logical RMAP is:

$$C'_{URl} = \omega + \eta(d_{ar-LMAP} + d_{LMAP-HMAP}) + 2a_{LMAP} + a_{HMAP}$$

(2)

the location update cost of regional registration to logical LMAP is:

$$C'_{UR2} = \omega + \eta d_{ar-MAP} + a_{MAP}$$

(3)

the location update cost of registration to CN can be expressed as Eq. (4):

$$C'_{UC} = \omega + \eta(d_{ar-MAP} + d_{MAP-CN}) + 2a_{ar} + 2a_{MAP} + a_{CN}$$

(4)

Where $\omega$ and $\eta$ are the unit costs when a location update procedure is performed in a wireless and a wired link. $d_{ar-MAP}$ denotes a distance between AR and MAP, $d_{MAP-HA}$ denotes a distance between HA and MAP. $a_{MAP}$ is the processing cost of location update at the MAP, $a_{HA}$ is the processing cost of location update at the HA, $a_{CN}$ is the processing cost of location update at the CN, $d_{LMAP-HMAP}$ denotes a distance between upper MAP and lower MAP. $a_{HMAP}$ is the processing cost of location update at the upper MAP, $a_{LMAP}$ is the processing cost of location update at the lower MAP.

We call the action an MN moving out of a subnet "a movement". Define a random variable M so that an MN perform a home registration at movement M. we assume that the total number of MAPs is N, the number of subnets located within a MAP domain is L. In order to facilitate the analysis, we assume the MN will move out to the other subnets with equal probability, so when the MN perform a handover, it moves into the others subnets with equal probability $P = \frac{1}{NL-1}$. For the standard HMIPv6 scheme, the probability of performing a home registration at movement M is:

$$P_M = \frac{NL-L}{NL-1} * (\frac{L-1}{NL-1})^{M-2}$$

(5)

It can be shown that the expectation of M is:

$$E \mid M \mid = \sum_{M=2}^{\infty} M P_M = \frac{2NL-L-1}{NL-L}$$

(6)

For DHMIPv6 system architecture, the MN may not need to perform the home registration when it occur the handover between two MAP domains. A MN take a $MAP_0$ that it passed before as the upper agent to reduce the number of home registrations according to the movement characteristics of the MN. So there are a MAP group that the $MAP_0$ is the center. Then the MN do not need to perform the home registration when it moves into a MAP domain from another MAP domain inside the MAP group domain, but need to perform the regional registration to $MAP_0$. The DHMIPv6 system operates similarly the standard HMIPv6 when the MN stay in the domain of $MAP_0$. But when the MN stay in the domain of the others k-1 MAPs, it operates similarly two level MHMIPv6 that $MAP_0$ is the upper MAP. Define a random variable D so that an MN perform a home

registration at movement D in DHMIPv6 system architecture, in other words, the MN move out of the domain of the MAP group at movement D.

Define the expectation of the number of movements it takes an MN moving from its first MAP domain to its second new MAP domain as $E\mid D\mid_{1\rightarrow 2}$:

$$E\mid D\mid_{1\rightarrow 2}=1$$

(7)

Similarly, when an MN has visited two different MAP domains, define the expectation of the number of movements it takes an MN moving to its third new MAP domain as $E\mid D\mid_{2\rightarrow 3}$:

$$E\mid D\mid_{2\rightarrow 3}=\sum_{n=1}^{\infty}n\cdot(\frac{1}{N-1})^{n-1}\frac{N-2}{N-1}=\frac{N-1}{N-2}$$

(8)

the expectation of an MN moving to its K new MAP domain and an MN moving out of the MAP group domain can be shown respectively:

$$E\mid D\mid_{k-1\rightarrow k}=\sum_{n=1}^{\infty}n\cdot(\frac{k-1}{N-1})^{n-1}\frac{N-k+1}{N-1}=\frac{N-1}{N-k+1}$$

(9)

$$E\mid D\mid_{k\rightarrow k+1}=\sum_{n=1}^{\infty}n\cdot(\frac{k}{N-1})^{n-1}\frac{N-k}{N-1}=\frac{N-1}{N-k}$$

(10)

So the expectation of D be obtained as Eq.(11):

$$E\mid D\mid=E\mid D\mid_{1\rightarrow 2}+E\mid D\mid_{2\rightarrow 3}+\cdots+E\mid D\mid_{k-1\rightarrow k}+E\mid D\mid_{k\rightarrow k+1}$$

$$=1+\frac{N-1}{N-2}+\cdots+\frac{N-1}{N-k+1}+\frac{N-1}{N-k}$$

$$=(N-1)\sum_{i=1}^{k}\frac{1}{N-i}$$

(11)

Define a random variable R to describe the number of the MN stay in the domain of $MAP_0$ before it moves out of the domain of the MAP group , the expectation of R can be obtained as Eq.(12):

$$E\mid R\mid=1+\frac{1}{2}E\mid D\mid_{2\rightarrow 3}+\cdots+\frac{1}{k}E\mid D\mid_{k\rightarrow k+1}$$

$$=\sum_{i=1}^{k}\frac{N-1}{(N-i)i}$$

(12)

Hence, the location update cost in our model can be obtained from the following equations:

$$C'_{LU}=C'_{UH}+(E\mid D\mid\cdot E\mid M\mid-E\mid D\mid+E\mid R\mid)C'_{UR1}$$

$$+(E\mid D\mid-E\mid R\mid)C'_{UR2}+\sum_{j=1}^{y}C'_{UCj}$$

(13)

The total location update cost in standard HMIPv6 can be obtained as Eq.(14):

$$C_{LU}=(E\mid D\mid-1)(C_{UH}+\sum_{j=1}^{y}C_{UC_j})$$

$$+(E\mid D\mid\cdot E\mid M\mid-E\mid D\mid)C_{UR}$$

(14)

Where y is the number of correspondent nodes, $C'_{UCj}$ denotes the location update cost that the MN registered to the jth correspondent Node. So, $\sum_{j=1}^{y}C'_{UCj}$ denotes the location update cost that the MN registered to all correspondent Nodes.

### B. Packet Delivery Cost

The cost for packet delivery procedure through two MAPs or single MAP can be expressed respectively as:

$$C_{P1}=\rho\cdot\alpha\cdot(d_{CN-HMAP}+d_{HMAP-LMAP}+d_{MAP-AR})$$

$$+\beta\cdot\alpha\cdot d_{AR-MN}+P_{HMAP}+P_{LMAP}$$

(15)

$$C_{P2}=\rho\cdot\alpha\cdot(d_{CN-MAP}++d_{MAP-AR})$$

$$+\beta\cdot\alpha\cdot d_{AR-MN}+P_{MAP})$$

(16)

Where $\beta$ the unit transmission cost is in a wireless link, $\rho$ is the unit transmission cost in a wired link. $\alpha$ is the CMR(call-to-mobility ratio) of the MN, In this paper, $\lambda$ is the arrival rate of packets, the average time a MN stays in each subnet before making a movement is $1/\mu$ ,the CMR of the MN can be shown as : $\alpha=\lambda/\mu$.

$P_{MAP}$ is the processing cost at the MAP. The processing cost at the MAP includes a lookup cost and a packet encapsulation/decapsulation cost. It is assumed that the lookup cost is proportional to the logarithm of the number of MNs located in the MAP domain and the encapsulation/decapsulation cost is a constant value. In the DHMIPv6 system architecture, there are a group of lower MAPs under the management of a upper MAP for a MN, but the function of upper MAPs is assigned to all MAPs. So, in addition to manage $o\cdot L$ MNs in its domain, Each MAP manages others $o\cdot L$ MNs through other MAPs too. So $P_{MAP}$ can be expressed as:

$$P_{MAP}=P_{HMAP}=P_{LMAP}=\delta\log 2oL+g$$

(17)

Then, the overall packet delivery cost is the sum of all packet delivery costs can be expressed as:

$$C_P=E\mid M\mid\cdot(E\mid D\mid-E\mid R\mid)\cdot C_{P1}+E\mid M\mid E\mid R\mid\cdot C_{P2}$$

(18)

the total cost is the sum of the location update cost and the packet delivery cost is:

$$C_{total}=C_L+C_P$$

(19)

The average total cost per unit time is:

$$C_T = \frac{(C_L + C_P)}{E|M| \cdot E|D|}$$

(20)

The unit time is the average time an MN stays in each subnet.

The optimal number of MAPs beneath a MAP for a MN, $k_{opt}$ is defined as the value of k that minimizes the total cost. To investigate the impact of the optimal number and CMR, we formulate the total cost as a function of the optimal number and CMR. The difference function is also defined order to find the optimal number as shown in Eq. (21):

$$\Delta(k, \alpha) = C_T(k, \alpha) - C_T(k-1, \alpha)$$

(21)

Using the difference function, it is possible to find the optimal number when the CMR are given:

$$k_{opt} = \begin{cases} 1 & , \quad \Delta(2, \alpha) > 0 \\ \max(k : \Delta(k, \alpha) \leq 0) & , \quad otherwise \end{cases}$$

(22)

## V  EXPERIMENTAL RESULTS AND ANALYSIS

In this section, we demonstrate the performance improvement of the DHMIPv6 scheme to HMIPv6 scheme and MHMIPv6 scheme of two levels. We have compared our DHMIPv6 scheme with HMIPv6 scheme and MHMIPv6 scheme in terms of Location update cost and packet delivery cost. Table III lists some of the parameters used in our performance analysis. Compared to HMIPv6 scheme, our DHMIPv6 scheme reduces the location update cost but bring the increase of the packet delivery cost. The total costs are affected by several factors: in the case of the unit location update cost, which

procedures are performed for location registration determines the update cost. On the other hand, in the case of packet delivery cost, the unit transmission cost is one of the important factors to be considered. Therefore, we analyze various results for different cost sets. Table IV shows the different cost sets.

Fig.4 plots the Kopt as a function of CMR for the DHMIPv6.As shown in the figure, Kopt decreases as CMR increases for DHMIPv6 systems. When the CMR is low, Registration cost accounted for a large proportion of the total cost, a MN of DMHMIPv6 can choose a MAP as the higher MAP to manage a large range of MAPs domain (in this case, Kopt is greater) to reduce the number of home registration. When the CMR is high, the packet delivery cost dominates and the saving in packet delivery cost becomes significant. The MN can choose a smaller Kopt  to reduce the packet delivery cost. When the CMR is large enough, the packet delivery cost is far greater than the registration cost .the Kopt can be set to 1 to reduce the packet delivery cost the MN is actually carried out in the standard HMIPv6 management at the time. Fig.4 also shows when the unit cost of the impact on the calculation of Kopt, large unit packet delivery cost or small unit registration costs prompting Kopt to close 1 faster.

TABLE IV

DIFFERENT COST SETS

|      | $\omega$ | $\eta$ | $\beta$ | $\rho$ |
|------|------|------|------|------|
| Se1  | 2.0  | 1.0  | 1.0  | 2.0  |
| Set2 | 10.0 | 5.0  | 1.0  | 2.0  |
| Set3 | 2.0  | 1.0  | 5.0  | 10.0 |

TABLE III

PERFORMANCE ANALYSIS PARAMETERS

| $d_{ar-MAP}$ | $d_{MAP-CN}$ | $d_{MAP-HA}$ | $d_{MAP-HA}$ |
|------|------|------|------|
| 1    | 10   | 10   | 2    |
| $a_{MAP}$ | $a_{HA}$ | $a_{CN}$ | |
| 2    | 4    | 4    | |
| g    | N    | L    | P |
| 2    | 8    | 2    | 5 |



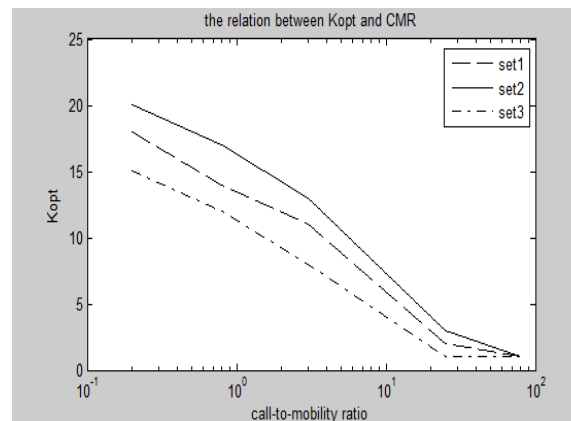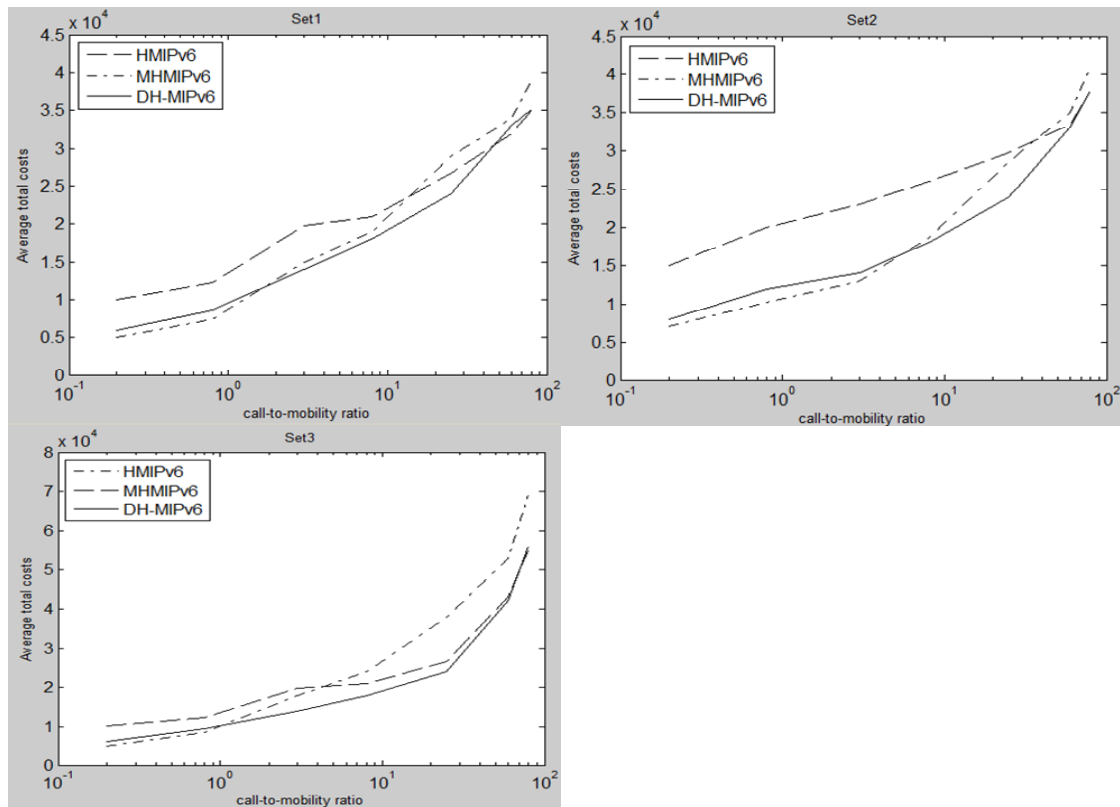Figure 4.     Kopt for DHMIPv6

Figure 5. Comparison of the total costs for different cost parameters.

In Fig.5, We compared the average total cost of DHMIPv6, HMIPv6 and MHMIPv6 in three different network environments. We can observe that the average total cost of MHMIPv6 is smaller than the average total cost of HMIPv6 because of the reduction of home registrations when the CMR is small, at the same time DHMIPv6 choose a logical MAP as the high level MAP of a large area, the average total cost reach or near the average total cost of HMIPv6. With the increase of CMR, the MN can adjust their Kopt to get the better average total cost in DHMIPv6.So we can observe the average total cost of DHMIPv6 is smaller than HMIPv6 and MHMIPv6 sometimes. When CMR is large enough, the location management cost act as a small proportion of total cost, the average total cost of HMIPv6 is smaller than the average total cost of MHMIPv6 because of the encapsulation/decapsulation procedure occurred during forwarding process at each MAP. At this time, DHMIPv6 tend to similitude HMIPv6, it has roughly the same average total cost of HMIPv6. We can also get a Conclusion from the figure, in the three different network environments, DHMIPv6 have a good adaptability in comparison with HMIPv6 and MHMIPv6. It have a relatively good total average cost regardless of the CMR is large or small.

## VI CONCLUSIONS

HMIPv6 using MAPs as the foreign agents for MN, MHMIPv6 divided the foreign network into multiple levels of domains. MHMIPv6 is a more flexible mobility management but it also brings new problems: high-level load and single point of failure problem and the extra cost of forwarding data between multi-level MAPs. This paper proposes a dynamic two-level MAP hierarchical mobile IPv6 model (DHMIPv6), When a MN moved into a new MAP domain, the home registration is not necessarily, the MN may choose the previous MAP as the high-level MAP, and register to it through the current MAP, or may perform a home registration, choose a one level or two levels MAP structure adaptively. Then, it dose not only reduce the number of home registration, but also avoid load and single point of failure problem. In case of large data flow, DHMIPv6 using the monolayer structure, it reduce the packet delivery cost of data forwarding process between multiple MAPs, and Well adapted to the variation of the movement characteristics of MNs.

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