# An improved BU scheme for inter-domain signaling in Hierarchical Mobile IPv6 networks

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1- Mobile computing

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## Dedication

*This thesis is dedicated to Allah almighty, who is with me in every moment of my life and dedicated to my affectionate parents who are next to Allah.*

**A dissertation Submitted To**

**Department of Computer Science,**

**Faculty of Basic and Applied Sciences,**

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**As a Partial Fulfillment of the Requirement for the Award of the**

***Degree of MS in Computer Science***

# Declaration

We hereby declare that this research project "*An improved BU scheme for inter-domain signals in Hierarchical Mobile IPv6 networks*" neither as a whole nor as a part has been copied out from any source. It is further declared that we have done this research with the accompanied report entirely on the basis of our personal efforts, under the proficient guidance of our teachers especially our supervisor [Mata Ur Rehman and Dr. Farrukh Aslam]. If any part of the system is proved to be copied out from any source or found to be reproduction of any project from any of the training institute or educational institutions, we shall stand by the consequences.

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# Acknowledgement

First of all we are obliged to Allah Almighty the Merciful, the Beneficent and the source of all Knowledge, for granting us the courage and knowledge to complete this Project. I have no words

This research project would not have been possible without the support of many people. The author wishes to express her gratitude to her supervisor, Mata Ur Rehman as well as to co supervisor Dr. Farrukh Aslam who were abundantly helpful and offered invaluable assistance, support and guidance.

Special thanks to Muhammad Wasim who has done research in same area, he guided and helped me as and when I approached him.

Then I cordially regard the inspiration prays, encouragement and financial support of our parents and family for their motivation in every aspect of our study enabling us to complete this project.

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# Project In Brief

| | |
|---|---|
| **Project Title:** | An improved BU scheme for inter-domain signaling in Hierarchical Mobile IPv6 networks |
| **Objective** | To propose and efficient Binding Update Scheme that reduce the delay in handover process of HMIPv6 |
| **Undertaken By:** | Afshan Ahmed<br>Registration# 523-FBAS/MSCS/F08 |
| **Supervised By:** | Supervisor: Mata –ur- Rehman<br>Co-supervisor: Dr. Farrukh Aslam Khan |
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# Abstract

As the number of mobile users is increasing day by day, we need to pay attention to support mobility and its management. Mobile IP is used to maintain mobility information when a mobile user moves from one location to the other while its permanent address remains unchanged. However, when Mobile Node changes its point of attachment so frequently, it reduces handover performance of this protocol. Hierarchical Mobile IPv6 is one of protocol proposed for handling such issue by localizing the mobility. But the handover process in inter domain mobility brings a long delay, and take long time to start proper communication. To reduce this delay in registration process, an Advance- Binding Update Scheme (A-BU) is proposed for macro mobility handovers in HMIPv6 network. This well-organized scheme minimizes handover delay as well as packet loss. A mathematical model is designed for evaluation and MATLAB is used to obtain results.

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# 1

# INTRODUCTION

## 1.1 Introduction

As number of mobile users is increasing; it needs to pay intention to support mobility. The main goal is to provide these mobile users a seamless connectivity, with minimum delay in communication during visit the mobile networks. Mobile IP is most often found in wired and wireless environment to provide communication to users who need to carry their devices across multiple LAN subnets. MIP provides seamless and continues connectivity in internet for many applications such as VPN, VOIP, and Radio/TV on internet etc. MIPv6 and HMIPv6 are the enhancement in MIP to improve mobile communications in certain circumstances by making the whole process more efficient.

In this chapter, we discussed in detail the Mobile IP protocols, their working and their comparisons. Registration process and packet delivery process of HMIPv6, a brief discussion on problem domain and proposed solution are also examined in this chapter.

## 1.2 Mobile IP

As new technologies are being inventing, the era of mobile computing is getting more intention. Number of mobile users is increasing day by day. Thus to facilitate them, IETF introduced mobile IP, which allows mobile nodes with all necessary resources to change quickly their location which continuing the ongoing session. Mobile IP is an enhancement in IP which allows Mobile node to roam freely anywhere on internet while maintaining its current IP address.

Mobile IP [43] or IP mobility is an Internet Engineering Task Force (IETF) standard communications protocol which is designed for mobile user to move from one network to any other network, without changing its permanent address. Mobile IP protocol is location-independent protocol allows IP datagram to route on the internet. MIP is mostly found in wireless WAN, where users need to take their mobile device across several LANs with different IP address. Mobile IP provides such an efficient mechanism for roaming within the internet, which allows mobile node to change its point-of -attachment without chaining its permanent home IP address. This mechanism lets the mobile nodes to maintain transport and higher-layer connection even as roaming.

## 1.3 Introduction

### 1.3.1 Mobile IPv4

Mobile IPv4 allows mobile nodes to continue ongoing session with corresponding nodes when they change their current point of attachment, without changing their permanent address. When mobile node moves to the other network, it has two addresses one is of its home network, called permanent address and the other is of foreign network to which mobile node moves, called care-of address.

Then mobile node needs to have an agent, a home agent and a foreign agent which makes the change of address transparent to the rest of the Internet. Home agent is a router attached to the home network, and it stores all information related to the mobile node as its permanent addresses etc. And same like the home agent, the foreign agent is also a router attached to the foreign network or network where mobile node moves to. It store information of mobile node as its care-of address and its current location etc and also advertises its care-of address. There are two ways to finding and selecting an agent [35]. First is through Router advertisement (RA) message, which is sent continually from a foreign agent. RA contains all necessary and basic information. Second method for agent discovery is Routing solicitation (RS) message which is periodically sent by MN until it receives response from mobility agent.

After moving to foreign network, MN needs to start registration process through exchange of Registration Request and Registration Reply messages [35]. An MN registers its care-of address with its home agent, which inform home the agent about current attached location of MN. After successful completion of registration, MN is able to communicate with its home agent. When a corresponding node wants to communicate with mobile node; it first sends packets to home network using its permanent address. The home agent send packets through IP tunnelling by encapsulating the datagram with a new IP header using mobile node's care-of address [10][35]. Acting as transmitter, Mobile node doesn't communicate directly with corresponding node using its permanent address. Figure 1 shows the basic operation of MIPv4:

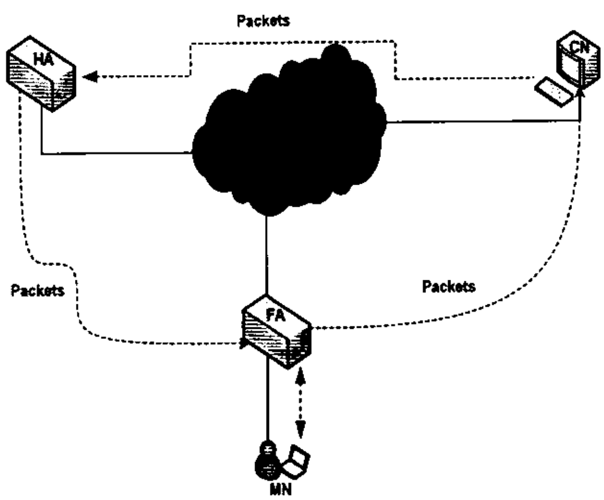


Figure 1.1: MIPv4's Basic Operation

### 1.3.2 Problems with MIPv4

The main problems faced by MIPv4 are:

i) Triangle routing: This problem occurs when a remote host communicates with the mobile host. There is no inefficiency, when mobile node sends a packet to remote host. However, when remote host sends packet to mobile host, it first sends to home agent and then home agent transmits it to the mobile host. The packet travels two sides of a triangle, instead of just one side.

ii) Double crossing: Double crossing problem occurs when remote host communicates with mobile node that has moved to the same network as remote host. When mobile node communicates with remote host, there is no inefficiency. But when remote host sends packet to the mobile host, it crosses the internet twice, although they are at same site.

iii) Reliability issue: In MIPv4 there is single HA (home agent) model, and whole traffic is controlled by this single HA; so failure of single HA can discontinue overall transmission.

iv) IP within IP: The datagram is encapsulated for transmitting to the destination. To encapsulate an original IP datagram put in another IP envelop. Thus the whole packet consists of outer IP header plus the original datagram [10]. As a result, packet will be too big, and wastage of unnecessary space.

v) Security issue: Security is most challenging problem of mobile IP [10]. Attacks that can possibly hit the MIP's security are: insider attack, denial-of-service attack, replay attacks, theft of information includes: passive eavesdropping and session-stealing attacks, other active attacks [24].

## 1.4 Introduction

### 1.4.1 Mobile IPv6

Mobile IPv6 is enhanced version of mobile IP which allows IPv6 nodes to be mobile, to arbitrarily change their location on network, while maintaining existing connections. Mobile ipv6 protocol is almost same as mobile ipv4 with some improvements like route optimization, registration, security, authentication, and address configuration, agent and neighbour discovery [27][10]. In mobile ipv6, a mobile node is always addressable with its home address, which is ipv6 address, assign to a mobile node within its home network. When a mobile node is away from its home network, packet can still be routed to it using its home addresses.

When mobile node moves to any other foreign network or links away from home, one or more care-of address are assigned to it. A mobile node can configure its care-of address using Stateless Address Auto Configuration [27] [40] or state manner like DHCP. Packets are routed to the mobile node as long as they stayed on this location. An association between mobile node's home address and care of-address is known as Binding for the mobile node [27]. Mobile node registers its primary CoA to home agent sending 'binding update' to the home agent. Home agent sends back 'binding acknowledgment' message.

In mobile IPv6, mobile node can communicate directly with CN, using method named as 'Route optimization'. Route optimization make able to mobile node that inform CN about its care of-address each time it configures, sending binding update message. The CN maintain a binding cache, and update it on receiving MN's new care of-address. Therefore, CN can directly send packets to MN without involving home agent.

Route optimization is fundamental part in mobile ipv6 [10]. This allows any CN to communicate directly to any MN, and so it solves the problem of triangular routing. CN can directly communicate with MN, and also multiple HA can be maintained thus impact of possible failure of HA can be reduced. Mobile ipv6 nodes are more authenticated and secure, because authentication is implemented on all nodes; so that they may send only authentic binding updates. Basic operation of MIPv6 is shown in Figure 2:

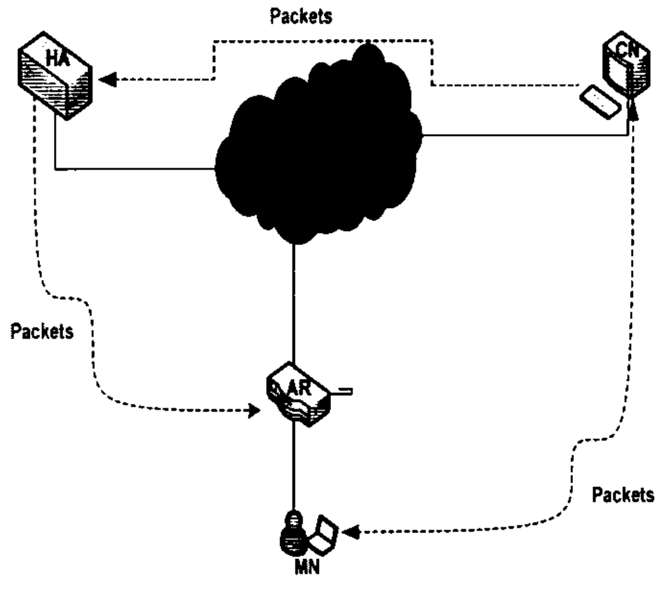


Figure 1.2: MIPv6's Basic Operation

### 1.4.2 Problems with MIPv6

i) Signaling overhead of MIPv6 is more than MIPv4, because it sends binding updates not only HA but CN as well.

ii) Authentication binding update requires approximately 1.5 round trip time. Signal exchange needed to update location may always cause of active connection disruption.

iii) MIPv6 supports macro mobility but extremely poor for micro mobility. If MN utilizes route optimization, additional delay may occur.

iv) Handover delay arises during handover procedure. Handoff latency and packet loss in the intra-domain mobility may decrease overall performance.

### 1.5 Hierarchical mobile IPv6

Hierarchical mobile IPv6 [5] is same as MIPv6 with minor extension, but main difference is of MAP, that is new function added in it called Mobility Anchor Point (MAP). Home agent and its operation, corresponding node and mobility between different types of network are same as MIpv6.

Problems of mobile IPv4 are solved by Mobile IPv6, and then mobile IPv6 problems are removed by developing Hierarchical mobile IPv6. Hierarchical mobile ipv6 is simply an extension of mobile IPv6. Mobile IPv6 allows modes moves within the internet topology and or maintaining reachability and ongoing connection between mobile and corresponding node, it sends Binding updates (BU) to its home agent (HA) every time it moves. Route optimization brings additional delay. For location updating signalling exchange may cause of active connection interruption, some packets will be lost, upper-layer protocol may be affected with the connection setup delay in link layer and IP layer, handover delay may cause overall performance. For these delays, a new mobile IPv6 node is used, and placed at any level in a hierarchical network of routers, that is called Mobility Anchor Point (MAP) [5]. Access Routers are also included with it. MAP is designed to reduce the signalling cost of MIPv6, between the mobile node, corresponding nodes, and its home agent. But outside the local domain, signalling amount of MIPv6 will be limited by MAP.

A mobile node enters in a MAP domain on receiving Router Advertisement (RA) message which contains all related information about MAPs. Hierarchical mobile IPv6 used two addresses: Regional care-of address(R-CoA) and On-link care-of address (LCoA). When a mobile node enters in a MAP domain, a Router advertisement having information about one or more local MAP will be received. The mobile node can bind its on-link CoA which is its current location, with RCoA. MAP acts like local HA, so it will receive all packets and forward to the mobile node. When mobile node changes its current address within local MAP domain, only its LCoA will be change, RCoA remains same until it moves to the other MAP domain.

So only LCoA will need to register with CN and HA, RCoA doesn't change until MN moves within local MAP domain. This makes the transparent mobility of mobile node to CN to whom it communicates with. Access Routers (ARs) define boundaries of MAP by advertising the MAP information to the attached MNs [5] [22]. HMIPv6 is simply an extension of MIPv6, if HMIPv6- aware mobile node doesn't discover the capability of MAP in visited network; it will prefer to use simply MIPv6. Then HA is located near the network, and it work instead of MAP, and only need to update HA whenever mobile node moves to new location. HMIPv6 architecture is shown in figure 3:

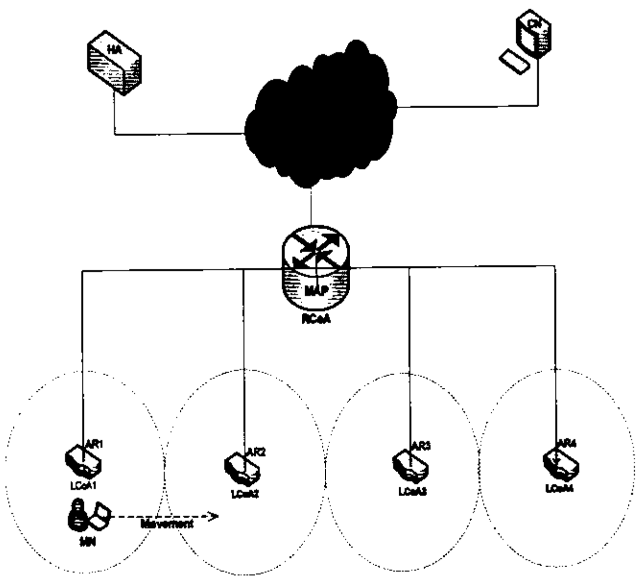


Figure 1.3: HMIPv6 Architecture

### 1.6 Handover in Hierarchical mobile ipv6

Handover or handoff is process when a MN moves from one domain or location to other domain or location. It has to perform many tasks to continue its on-going communication. Two main operations that it must perform are registration process which includes location updating in which a MN has to register and update its new location by BU process. Second is packet delivery for sending and receiving packets to and from CNs [5] [22].

### 1.6.1 Registration Process

There are two types of mobility in HMIPv6: intra site mobility and inter site mobility [5] [22]. Movement of MN within a same domain from one AR to other AR is Intra site mobility that is local mobility and movement from one MAP domain to other MAP domain is Inter site mobility and its global mobility. Registration process in Intra mobility needs only register LCoA of AR to MAP; there is no need to send BU to HA and CN. But in Inter mobility whole process of BU needs to carry out for LCoA as well as for RCoA.

#### 1.6.1.1 Intra-Domain mobility

When MN moves from one AR to other AR within same MAP domain (intra/micro handover), the BU process is:

1. MN moves to new AR on receiving RA message, within same MAP domain.
2. MN configures new LCoA and sends BU message to MAP via new AR.
3. MAP receives LCoA, and performs DAD.
4. After successful completion of DAD, MAP sends BA with packets back to MN via new AR.

MAP receives periodically binding updates from MN or when MN changes its LCoA, and maintains its cache. HA and CN are not informed when MN change its LCoA, but periodically binding updates are received form MN.

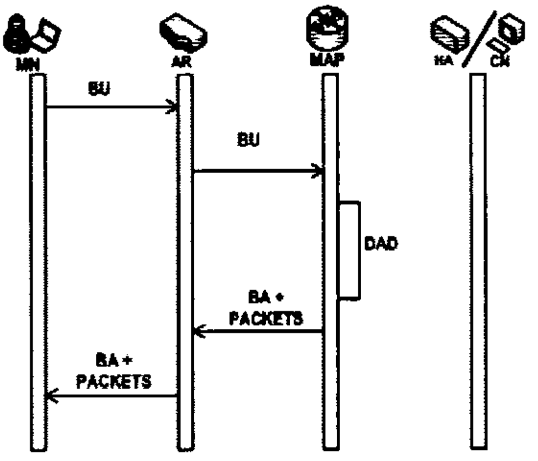


Figure 1.4: BU procedure for intra-domain mobility

### 1.6.1.2 Inter- Domain Mobility

When MN moves from MAP1 to MAP2 (inter/macro handover) after detecting movement, it performs following BU operation:

1. MN first configure two addresses: LCoA and RCoA
2. For binding LCoA to RCoA, MN sends Local Binding Update (LBU) message to MAP via currently attached AR.
3. MAP receives BU message and performs Duplicate Address Detection (DAD) to verify the uniqueness of the newly configured address.
4. After successful completion of DAD, MAP sends Binding Acknowledgment (BA) message back to MN. MN then sends BU message to HA and CN via MAP.
5. HA/CN store address of MN to their binding cache, if binding is successful and start sending packets to MN using its RCoA (as HA/ CN knows only about RCoA).
6. MAP2 receives packets and tunnels them to MN using its LCoA.
7. MN receives packets, de-capsulate them and process in normal way.

### 1.6.2 Packet Delivery Process

There are two possible modes for communication between MN and CN: bi-directional tunnel and route optimization. First mode is available even when MN is not registered its current location with CN. CN sends packet to HA, using MN's home address, HA encapsulates packet and sends packet to MAP using RCoA as it knows only RCoA. MAP receive packet from HA, encapsulate packet and send it to MN using its LCoA. MN de-capsulate packet and process it in normal way. When MN transmits packet to CN, it first sends to MAP, MAP sends it to HA, then HA send it to CN. Second way is Route optimization, which establishes after receiving packet from CN to MN. It requires registering MN's current LCoA with CN sending binding updates. Now CN can directly communicate with MN using its current location's address. CN sends packet to the MAP, and MAP tunnels this packet to the MN. Same as, when MN will send packet to CN, it transmits to MAP and MAP sends packet to the CN. When MN moves toward next AR (e.g. from AR1 to AR2) packet transmission will deliver via new tunnel established between MAP and MN on AR2. This action will be hidden from HA and CN.

## 1.7 Research Domain/Problem Domain

MIPv6 is less efficient for local mobility that is micro mobility for which it doesn't give outstanding performance. Therefore, to resolve this problem, HMIPv6 introduced which adds up a new function MAP. But it couldn't improve the performance in case of global mobility when a MN handoff from one MAP domain to other MAP domain. Because MN has to send BU to MAP to register its LCoA, and in additions it also register new MAP's RCoA with HA and CN. It takes long time to start proper communication again and transmission delay occurs between MN and HA/CN. As a result, longer handover latency and packet loss is faced to HMIPv6 than MIPv6. That's why its location cost and packet delivery cost is high in case of inter domain mobility as compared to MIPv6 and other protocols like Proxy Mobile Ipv6[1]. Many schemes are proposed to reduce inter-domain mobility cost, but still this problem affecting the overall performance of HMIPv6.

### 1.8 Proposed Solution

In our proposed approach, we have first identified the necessary components involved in handover process. We have proposed a new BU scheme, with some modifications in existing BU scheme of HMIPv6. New BU scheme is frequent and speedy because BU procedure is done in advance, as well as with less number of messages. The next visited MAP complete all BU procedure before MN's actual handoff and MN immediately starts communication as connect to new AR in new domain. This scheme reduces the impact of BU process on handover delay for handover outside a MAP domain. Performance of our proposed scheme with current approach used by HMIPv6 is analysed through simulation.

### 1.9 Thesis Structure

The rest of thesis is organized as follows: in chapter 2, related work is presented; in chapter 3 problem domain and proposed solution, the simulation designs is in chapter 4, in chapter 5, performance metrics and detailed simulation results are presented and the last chapter 6 is about conclusions and future work.

# 2

# Literature Survey

## 2.1 Introduction

This chapter presents an extensive literature survey on Macro BU procedure in HMIPv6. The literature survey is organized and presented concept wise, in bottom up approach starting from basic concept to advance. This survey mainly focused on different schemes related to BU process of Macro Mobility in HMIPv6 networks, which focus latencies associated with handover process. Researchers proposed lot of solutions to overcome these latencies faced by handover process in HMIPv6. They identified many bad sectors which affects the performance and tried to fix these problems. But still HMIPv6 couldn't out perform for Macro mobility and its signalling cost is high even than MIPv6 when move outside the domain. Therefore, there is need to pay attention to maximize the performance of this protocol by reducing handover delay and improving its registration process. In this literature survey, impact of BU process is focused which plays an important role in handover process but facing significant delays during handover process. This chapter is presenting almost all useful contributions that have been undertaken by various researchers to minimize this delay. The investigation is carried out for Macro mobility handover outside an access domain, when MN moves from one access domain to other access domain.

**2.2 Related Research**

The following papers survey is carried out for our related work on Hierarchical Mobile IPv6 handover optimization and approaches used for Binding Update schemes.

There are five major components involved in handover process, Movement Detection, Router Discovery, Address Configuration, Duplicate Address Detection, and Binding Update Completion. Some delay in overall handover process is associated with each of these steps. Increasing the performance of one of them may leads to improve overall handover process. BU process has a vital effect on handover process and affects the handover performance badly. A detailed study about different Binding Update schemes is carried out in this chapter and some most famous approaches for BU are discussed in this next section.

1- Fast Handover Algorithm [30], re-establishes the communication traffic flow quickly, as well as minimizes the service disruption delay of macro handover in HMIPv6. This handover algorithm uses a multicast technique concept which enables a MN to receive packets faster when moves to other MAP domain. The service disruption delay occurs during the registration, a multicast technique is introduced to minimize this delay. The MN is within MAP1 and attaches to the AR, and CN is currently sending packet to the MN. When MN reaches to the edge of the MAP1 coverage area, then for building multicast group it sends control message to the MAP1. MAP1 receives message and construct a multicast group for a mobile node and then sends a message to the adjacent ARs to join this multicast group. Thus packets will multicast to adjacent ARs as well when sends to MN. When MN receives the router advertisement message from new AR of other MAP, it obtains two addresses: LCoA of new AR and RCoA of new MAP. And it has to register its presence with the HA and CN. The registration operation of this scheme is that MN sends BU and request message to new AR to forward the packets. AR receives MN request and BU and forward multicast packets based on MN's unique interface identifier. At the same time, AR sends BU to MAP for DAD check. Map receives BU and performs DAD check. Until registration operation complete, MN receives temporary multicast from AR. MAP finishes the DAD process, after successful DAD process ,MAP changes the destination address of the MN, from old AR to new AR's LCoA and MAP1' s RCoA to MAP2 RCoA, it sends binding acknowledge message back to MN. MN receives message containing validation of RCoA and LCoA and sends BU message to CN for informing about its new, address, via MAP. CN receives BU message and change MN's old RCoA1 to RCoA2 and sends packets to the MN. In this scheme, new AR has copy of on-going packets even when MN is within old AR, and whenever MN moves to new AR, it starts forwarding packets to MN during the registration process.

2-New Binding Update Method using GDMHA in HMIPv6 [16], provides macro mobility between the MAP, which enables a MN to perform Binding Update with the nearest home agent, for the purpose of reducing binding update delay. While, these HAs have same Any-cast address, and the nearest HA can be chosen easily.

In GDMHA mechanism MN performs BU with the nearest home agent, and this is done using GIA (global IP Any-cast). GIA uses to find the HAs among several HAs which are geographically distributed. These HAs belong to the same Any-cast group. When a packet sent to an Any-cast address is delivered to the closest member in the GIA group. Likewise, when MN performs BU, it performs to nearest HA by using GIA method. Mobility management of MN in HMIPv6 is noticeable issue when it moves to other MAP domain. When MN enters into other MAP domain, it must carry out BU with AR, MAP, as well as HA. In this case, if distance of MN and HA is far away, then a longer delay may occur during BU from MN to HA. However, if HAs are distributed belonging to the same Any-cast group, this issue should be handled. Geographically distributed multiple HAs will have same Any-cast address. Thus, BU perform with the HA which is geographically closest to the MN.

3- According to Pre- Binding Update scheme is proposed in [14], each AR and MAP knows about the neighbour ARs and MAPs. Thus, MN can perform handoff procedure in advance using this scheme. In mobile ipv6 and Hierarchical mobile ipv6, no information exchange between ARs before actual handoff. In proposed mechanism, an AR can have related information about its geographically adjacent ARs, typically global address, L2 identifier and the prefix information of ARs that are currently being advertised. The AR, on which MN is currently attached, is able to inform MN about prefix information of ARs to which it is expected that MN will handoff. After completion of the Address Auto configuration (AA) process, the MN transmits binding update to MAP which is in incomplete state. MAP then performs DAD process using this message and will store in incomplete state of the MN's address. When MN actually moves to new AR, this incomplete state is changed into complete state and routing starts directly. BU process of new MAP is completed depending on MAP1, and packets are also delivered to MN on new MAP via this route. When MN moves to MAP3 from MAP2, MAP1 discard MAP2 cache entry and stores MAP3 RCoA. Now MAP3 will perform BU and communication via MAP1.

4- An Efficient Binding Update scheme [13] has been proposed, in which a signal message from the MN contains another signal message, allowing MN to originate only the half of signal messages in home registration process, as compared to original protocol. In this scheme, local binding update message piggybacks binding update message. MAP sends binding updates to HA and CN instead of MN. The MN generates an LCoA and RCoA using information from AR and MAP. Then MN sends the LBU message to MAP, MAP receives this BU message and bind the LCoA with RCoA. DAD process is then performed by MAP to check the uniqueness of the new configured address. After successful completion of the DAD, MAP sends back acknowledge message to MN. A bi- directional tunnel is established between MN and the MAP. Now MAP sends this BU message to the HA. As HA receive this BU message from MAP, it verifies and updates its binding cache. After doing that HA sends back acknowledge message to the MAP.

5- A Macro Mobility Handover Performance Improvement scheme [15] is based on FHMIPv6. When MN wants to move to AR3 in MAP2 domain from AR2 in MAP1 domain, it First MN sends an RtSolPr to the AR2.AR2 generates PrRtAd message in which prefixes of MAP1 and MAP2 are included. MN in MAP1 domain creates a new RCoA based on MAP2 prefix and new LCoA based on prefix of AR3 in RA message. MN then sends FBU message that includes new RCoA and LCoA, to AR2. HI message is sent to AR3 in MAP2 domain from AR2. On receiving HI message, AR3 performs DAD on new LCoA to verify the uniqueness in its subnet. After this, AR3 sends a HI message to MAP2 to verify the uniqueness of MN new RCoA in its domain. On successful completion of DAD, HAck message is sent to AR2 which informs that new address are stored and fast macro mobility handover is ready, AR3 stores new RCoA and LCoA in its Proxy neighbour Cache. A tunnel is created between AR2 and AR3 through which AR2 send all packets destined to MN to AR3. FBAck message is sent to AR3 and MN when fast macro mobility handover is ready. During L2 handover, all packets sent by CN are intercepted by MAP1 and MAP1 sends to AR2 via tunnel and AR2 sends these packets to AR3 via tunnel where AR3 buffer them until handover of MN ends. After completion of handover process, FNA message is sent to AR3 that MN in on-link of AR3 subnet. AR3 send all packets to MN on receiving FNA message. MN then generates a FNA message including LBU and sends to MAP2. MAP2 bind new RCoA and new LCoA of MN on receiving FNA message. After successful registration with the MAP2, MN can perform location update with it's HA and CN.

6- An Efficient Macro Mobility Scheme Supporting Reactive Fast Handover Mode [11] plays an efficient role when MN doesn't receive FBACK message on the previous MAP domain. No new tunnel is established with new MAP if MN doesn't receive FBACK message. Previous MAP forwards the packets of MN to AR within same MAP domain. The access router stores this packet of MN and sends it on MN after its movement to the new MAP. After macro mobility, MN sends Fast Neighbour Advertisement (FNA) with Fast Binding Update (FBU) to the new MAP when arrives to new MAP domain for informing that MN doesn't receive FBACK on FBU message. New MAP establishes a tunnel for packet forwarding with previous MAP until MN completes registration process for new location at HA. MAP2 sends HI message to MAP1 to establish a tunnel. MAP1 sends a Handover Acknowledgement (HACK) message on receiving Handover Initiate (HI) message from MAP2. Then tunnel established between the MAP1 and MAP2. MAP2 sends a FBACK message to MN. Packets stored at the AR on previous MAP are forwarded to the MN via new MAP. Therefore, the packet loss is reduced during L3 handover. The MN sends a LBU message to the MN to register two addresses RCoA and LCoA. After successful registration, MAP2 sends LBACK message to the MN. MN then sends BU message to the HA to register a new RCoA, and HA sends a BA message back to MN after successful registration.

7- Cost-Reduce Inter-MAP BU [7] uses two different MAPs: primary and secondary MAP. The aim of this scheme is enhancing the HMIPv6 method by providing a fault tolerance mobile service, and reducing cost of binding update as well as the communication overhead. The proposed cost-reduce binding update scheme allows MN registers the first-try MAP and in the second registration MN only sends a BU for registering the P-MAP, and it has the information of the previous P-MAP on behalf of the S-MAP.

1) Improved RH-MIPv6 (IRH-MIPv6): In improved RH-MIPv6 scheme, only one message is sent for the registration of the two MAPs and the CN. MN sends binding

update message to P-MAP, in which S-MAP is for registration of the secondary MAP and P-MAP for the primary MAP. It sends BU with RCoA to CN. This BU procedure shows better performance when carried out in wired network as compares to wireless network. For registration of the CNs, a second RCoA included within an Alternate care-of address (ACoA) option is sent to CN form MN, which reduces the signalling cost. This reduces the cost between the distributed MAPs. IRH-MIPv6 also required additional BU cache. And failure detection mechanism and time required for recovery is same as RH-MIPv6.

2) Cost reduce inter-MAP BU scheme: Cost reduce RH-MIPv6, first- try MAP registration is same as IRH-MIPv6.when MN enters in new MAP domain, it receives several router advertisements (RA) message, and choose two exchangeable MAPs. Only one BU message is send form MN for the registration of both MAPs that are primary and secondary MAP, and CNs. It reduces the signalling cost in the distributed MAP environment. The two MAPs send back binding acknowledge message to the MN for completion of the binding update procedure. MN sends binding update message to CN for registration including P-RCoA and S-RCoA. After MN moves to the other MAP, this scheme can skip the S-MAP registration when MN registers new P-MAP. It means that P-MAP work as the S-MAP. Then MN hold information of the location of previous P-MAP, and sends it BU. MN can communicate with previous MAP, if current MAP is failed. When MN registers to its new CNs if there is the secondary RCoA inside the BU message for registering previous P-MAP show the failure has occurred. The Cost-reduce RH-MIPv6 also needs to add an additional entry in the binding cache, and also a new flag to the binding update message.

8) Fast Macro Handover (FMHS) in HMIPv6 [3] is another scheme according to which, when MN makes handover to the other MAP domain, it obtains new RCoA by new MAP and registers it to the previous MAP. When MN moves to other MAP, it registers with

pervious MAP which is geographically close, instead of HA. A tunnel is established between previous MAP and new MAP. Thus, as MN attaches access link in new AR, it immediately receive packets routed to the new RCoA. MN sends FBU message to MAP1, which contains MAP2 network prefix information. And also inform MAP1 about its movement to different MAP domains. On receiving message from MN, MAP1 performs the MAP discovery and exchanges HI/HACK message for establishing a tunnel between MAP1 and MAP2. MAP1 stores RCoA2 in its proxy binding cache and update it and forward packets to MAP2 which are addressed to RCoA1 through the tunnel established between MAP1 and MAP2. As MAP is elected as agent for MN, so MAP2 will receive all packets on behalf of the MN and buffer the packets until finishing the L2 handover of the MN. After L2 handover of the MN, MAP2 will encapsulate and forward all packets to the MN's current address that is LCoA2 directly. The basic purpose of this scheme is to localize the macro handover in HMIPv6.

9- An Efficient Scheme Fast Handover over HMIPv6 (ES-FHMIPv6) [4] is designed to be efficient with the data transport feature. A dual buffer is added in Access Point (AP) for the purpose of storing messages received from Previous Access Router (PAR). A scheme is designed with the combination of FMIPv6 and HMIPv6 to reduce the handover latency in macro mobility of HMIPv6, but its processing overhead is more for re-tunnelling at the previous access router (PAR), and inefficient usage of network bandwidth is also drawback of this scheme. Thus, there is still need of fast handover scheme for HMIPv6 based networks. ES-FHMIPv6 overcomes the deficiencies of the combination of FHMIPv6 and HMIPv6 to improve the handover latency time of message transmission. According to this scheme, a MN wants to move from previous access router (PAR) to new access router (NAR), in the previous access point (PAP) region. And NAR has already information about the link layer address and network prefix, also sends the router advertisement (RA) to the New Access Point (NAP). NAP has a dual buffer which stores the received message of AR sent by NAR. A NAP sends a beacon message periodically to MN in every 100ms. L2 Association Request to NAP is sent by MN, NAP sends an association request with stored router advertisement. MN sends LCoA and RCoA to NAR where address configuration confirmation with 1000ms has been established for RCoA, New Enhanced-Binding Update for LCoA and RCoA, HA/CN response to MN with New Enhanced Binding Acknowledgement.

### 2.3 Performance comparison

Performance comparison of all discussed schemes is given in this table:

| Schemes | Signalling Cost | Latency | Overhead |
|---|---|---|---|
| **Fast Handover Algorithm** | Update MN's current location every time increase SC | Latency during BU in macro domain mobility is decreased | Overhead of sending unnecessary messages and resending of packets in Multicast |
| **New Binding Update Method sing GDMHA in HMIPv6** | Number of BU messages may cause of more signalling cost | BU latency and handoff latency is decreased | Maintaining multiple HAs is and sending BCRA message is overhead of this scheme, |
| **Pre- Binding update scheme** | Save signalling cost | Decrease inter-domain handoff latency | More overhead for more number of messages |
| **An efficient binding update scheme** | Reduce signalling cost by sending single BU message | Decrease packet delivery latency | Overhead for MAP to hold and manage both BU messages at same time |

| | | | |
|---|---|---|---|
| **A macro Mobility handover performance** | Signal cost is more to send more number of messages. | Reduced packets transmission latency as well as handover latency is reduced. | Buffering all packets by AR until MN moves to other AR, and tunnelling between PAR and NAR is over head of this scheme. |
| **RH-MIPv6** | Signalling cost incurred to send more messages in registration | Macro Handover latency is reduced, Faster recovery of MAP | Maintain P-MAP and S-MAP, and overhead of additional cache entry |
| **Fast Macro Handover in Hierarchical Mobile IPv6** | Moderate | Shorten Macro handover latency , Doesn't improve wireless latency as wired | Little overhead for MAP2 to buffer all packets of MN until it finishes L2 handover |
| **ES-FHMIPv6** | Moderate | Minimize message transmission latency' total handover latency is reduced as well | Overhead for managing old and new MAP s. maintaining dual buffer table is additional overhead for PAR |

Table 2.1: Performance comparison

### 2.4 Concept Matrix

The following table summarizes the investigation of different Binding Update Schemes.

| Paper/Draft/RFC | Concept | Findings |
|---|---|---|
| **Fast Handover Algorithm** | Fast handover algorithm is based on modification of the HMIPv6 protocol including the multicast technique concept | BU delay and packets delivery delay is decreasing using this scheme.<br>MN registers its location every time it moves for becoming member of |

| | | |
|---|---|---|
| | | multicast group may cause of overhead, wastage of network resources and packet loss because of unnecessary sending and resending of packets in multicasting. |
| **New Binding Update Method sing GDMHA in HMIPv6** | MN performs BU with the nearest HA belonging to an identical Any-cast group. | Delay during Binding update is reducing with this scheme. Maintain multiple HAs is overhead of this scheme, binding cache entry exchange may cause of extra load. This scheme is useful within the single administrative domain. |
| **Pre- Binding update scheme** | This scheme Perform BU in advance before actual handoff of MN, through sending pre-BU message. | This scheme saves signalling cost, improve inter-domain BU process, and decrease the handoff latency.<br>Overhead is more of this scheme because of the number of messages, failure of MAP1 may stop the communication. |

| | | |
|---|---|---|
| **An efficient binding update scheme** | MN sends LBU+BU in single message to MAP and MAP (instead of MN) sends BU message to HA/ CN, and acknowledge back to MN within a single message. | performance of BU procedure is increased, MN sooner receives packets as moves to other MAP, and number of packet loss is decreased. Holding and managing for both BU messages at the same time may little over headed for MAP until it sends back binding acknowledge message for local BU to MN . |
| **A macro Mobility handover performance** | Fast handover mechanism is used, a tunnel is using between edge ARs and perform the L3 handover earlier. | Reduced handover latency and packet loss cost can be reduced to 82%. Overhead is more because of tunnel, holding packets and using proxy function till completion of handoff process of MN. |
| **RH-MIPv6** | Two MAPs are used to overcome the delay, and single BU message is sent to register both MAPs. | Improved performance for handover latency, Its major benefit is faster recovery of MAP failure. Overhead is more to maintain P-MAP and S-MAP, cost reduce RH-MIPv6 also needs additional cache entry for binding update and for flags as well, good in wired but not as in wireless |

| | | |
|---|---|---|
| **An Efficient Macro Mobility Scheme Supporting Reactive Fast Handover Mode in HMIPv6** | MAP1 sends packets to AR on same MAP domain, AR hold these packets until MN moves to new MAP. A tunnel is established between MAP1 and MAP2, and all packets forwarded to MN on its new location. | Handover latency is reduced, but main advantage is to reduce packet loss. Signalling overhead is more because of number of messages for registration, also for establishing tunnel between MAP1 and MAP2. AR stored packets for MN until it doesn't register to the new location, additional load for this AR. |
| **Fast Macro Handover in Hierarchical Mobile IPv6** | MN sends BU message including newly acquired RCoA to the previous MAP that is geographically close to new MAP, instead of its HA | It shortens the macro handover latency of HMIPv6. FMHS doesn't improve wireless latency, as well as when previous MAP is failed, connection can be terminated and longer handover latency in this case may occur |
| **An Efficient Scheme Fast Handover over HMIPv6** | ESF-HMIPv6 is designed including a dual buffer in Access Point (AP) which stores PAR's received messages. | Inefficiencies of FHMIPv6 that are unnecessary processing overhead and inefficient use of network bandwidth, are overcoming by this proposed scheme. Overhead is more of this |

| | | |
|---|---|---|
| | | scheme for managing new and old AR and extra signalling, as well as maintaining dual buffer table is additional overhead for PAR. |

Table 2.2: Concept Matrix

## 2.5 Factors affecting performance of HMIPv6 handover process

In the handover process, following factors affect the performance of HMIPv6:

- Arrival Rate of MNs entering a domain
- Speed of MN
- Address Configuration
- Movement detection
- Number of ARs within a MAP domain
- Duplicate Address Detection (DAD) time
- Binding Update completion time
- Link Delays
- Handover Frequency

## 2.6 Limitations

From literature survey, it's obtained that different schemes are proposed by many researchers to improve the BU procedure for minimizing handover delay in HMIPv6 protocol. Most of the schemes start registration process after MN actually enters in new domain. MN sends BU message to new MAP, MAP sends back acknowledgment after performing DAD mechanism, then MN again sends BU message to new MAP for HA and CN. MAP receive this BU and forward to HA and CN, they store new address of MN in their caches and send packets for acknowledge. New MAP receives packets destined for MN, and forward packets to MN via its currently attached AR. This process takes a long time and MN has to wait till completion of whole registration process for starting proper communication, which affects the handover performance badly and heavy packet loss too.

## 2.7 Summary

In this chapter, we have presented the related research of our work. Many researchers proposed different scheme as the solution for minimizing the delay in BU time and to improve the handover performance. These proposed schemes are doing well in some particular scenarios but there is still of some more efficient techniques to be developed that overall performance of handover can be improved. We have highlighted the limitations of some existing schemes, compare them, which shows the current requirement for the BU procedure in handover process.

# 3

# Requirement Analysis

## 3.1 Introduction

With the rapid usage of portable devices and wireless networks, managing mobility in IP networks becomes a hot research issue. Mobile IP is introduced to reduce mobility issues, which provides transparent mobility by hiding the change of IP address when mobile node moves between IP subnet. However, when Mobile Node changes its point of attachment so frequently, it reduces handover performance of this protocol. Hierarchical Mobile IPv6 is one of protocol proposed for handling such issue by localizing the mobility. HMIPv6 separates micro mobility and macro mobility with the introduction of MAP. Handover performance in micro mobility has been significantly improved, but there is still issue in case of macro mobility because it managed in manner as MIPv6 does. When MN moves from one MAP domain to the new MAP domain, it changes both addresses. This need to register it LCoA and RCoA to the new MAP, as well as new MAP registers new RCoA to MN's HA. This process takes long time to start proper communication again and as result longer handover latency is faced by this protocol. Many schemes are proposed to minimize handover delay but still researchers are focusing it to improve handover performance in macro mobility.

Following figure shows a HMIPv6 Macro-Mobility domain:

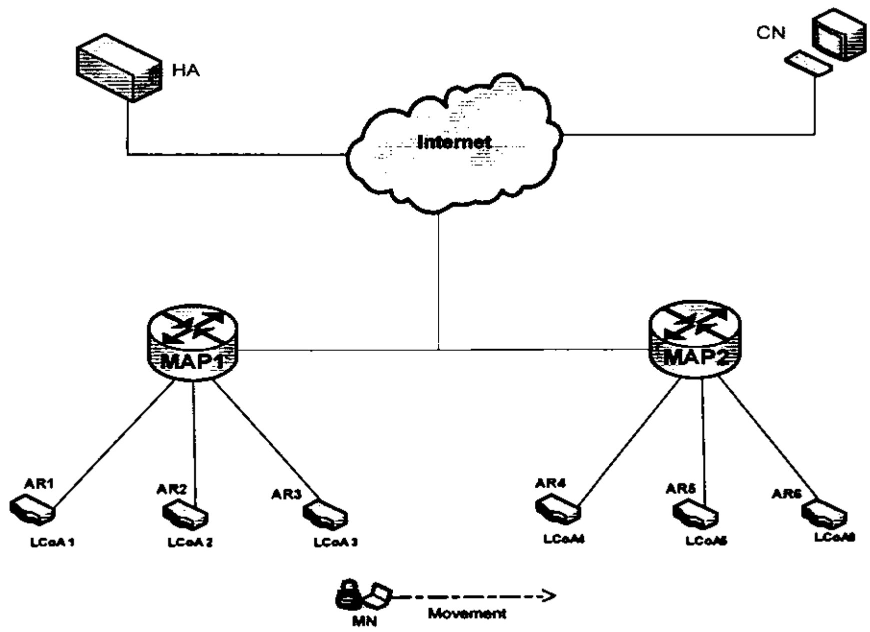


Figure 3.1: HMIPv6 Macro-Mobility Domain

### 3.2 Handover delay

MN performs different tasks while moving from one domain to other domain by exchanging information with his HA and CN. In HMIPv6 network, handover process mainly consists of five major components. These are: Movement Detection, Router Discovery, Address Configuration, Duplicate Address Detection and Binding update Completion. Total handover delay is based on these five components and if one of them is improved, can have major effect on overall performance of protocol.

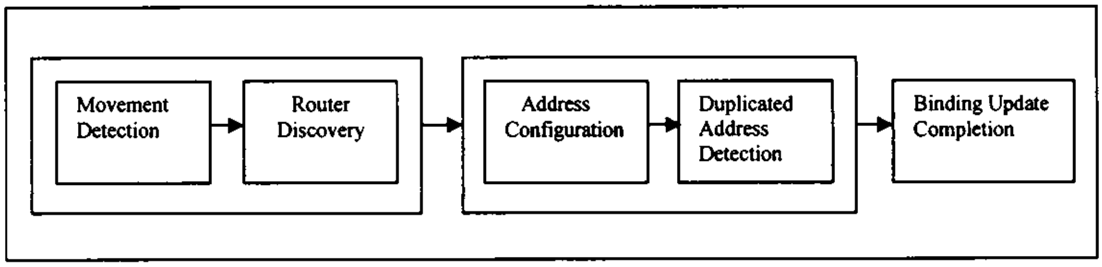


Figure 3.2: Steps in HMIPv6 handover delay

Movement detection in IPv6 based network is usually relies on reception of router advertisement (RA) message from new AR. According to [4861] router advertisements contains the list of prefixes which tells the MN that it moved to the new network. Every time a MN detect movement, it also detect that either it is in same MAP domain or have to move other MAP domain. The MAP discovery process continues up till MN moves from one subnet to other. Router advertisement also detect that MN moves to the next MAP domain or still in the same through neighbour discovery [6] and MAP option. If MN moves with in same MAP domain to other AR, it will receive same MAP option so there is no issue only it's on- link care- of address. But when it will receive change in advertised MAP's address, then it has to be move to other MAP domain. Moving to other MAP domain needs to binding update from start.

Router Discovery is procedure of discovering a router to which a MN must attach when moved to foreign network. The decision is to which router a MN is going to attach in foreign network is carried out through ICMP router discovery procedure described in [8] [44].

After choosing a router to attach with, MN then configures CoA from the prefix information. This new CoA is generated using IPv6 stateless address auto-configuration [40] and uniqueness of CoA is verified by using DAD procedure.

After successful completion of all above components, finally HA and CN are informed about the change of MN's address and register new address through Binding Update Message [8].

**3.3 Problem Statement**

Based on drawbacks and limitations which come out from literature survey, we have developed our problem statement.

Handover process is completed with Binding Update procedure. When MN moves from one AR to other AR within same domain, only LCoA is changed and DAD verify the uniqueness of newly configured address. This LCoA register only with MAP, but HA and CN are not informed because they only need of RCoA. Therefore, no performance issue in case of micro mobility.

When MN moves to other MAP domain, it first configures two new addresses (LCoA and RCoA) and then performs DAD procedure to verify the uniqueness of new addresses. After successful completion of DAD checking, MN sends BU message to HA and CN to inform them about its new location and also register new RCoA to them. HA and CN sends back Binding Acknowledge (BA) to MN and then communication is started.

It takes long time to start proper communication again because MN is not able to send or receive packets until successful completion of Binding Update process, so transmission delay occurs between MN and HA/CN. As a result, longer handoff latency and packet loss are faced to HMIPv6 than MIPv6. That's why its location cost and packet delivery cost is high in case of macro domain mobility as compared to MIPv6 and other protocols like Proxy Mobile Ipv6[1].

Registering new RCoA to MAP and then HA and CN is time taken procedure, which affect overall performance of protocol. To enhance the performance of handover process, delay of BU procedure must be reduced.

### 3.4 Proposed solution

To reduce delay in registration process, BU process must be improved. To accomplish this task, we are taking place BU process in advance before actual handoff as well as reducing number of messages. We are going to propose an Advance- Binding Update Scheme (A-BU) for macro mobility handovers in HMIPv6 network.

In this scheme, we have modified the actual binding update procedure in which a MN can perform BU procedure in advance before making actual movement. MN can carry out BU procedure in advance with MAP to which it's ready to move while continuing communication in current MAP domain. First we describe actual BU procedure and then the A-BU scheme.

#### 3.4.1 BU process in HMIPv6

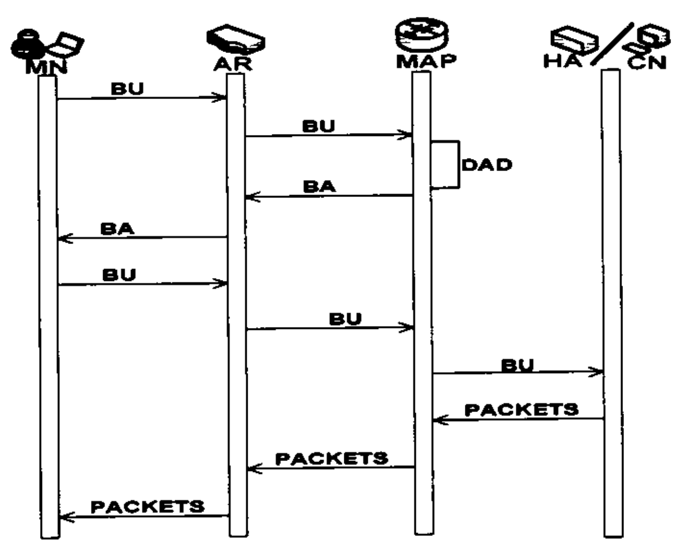


Figure 4.3: BU Procedure in HMIPv6

When MN moves from MAP1 to MAP2 (inter/macro handover) after detecting movement, it first configures two addresses: LCoA and RCoA. For binding LCoA to RCoA, MN sends Local Binding Update (LBU) message to MAP via currently attached

AR.MAP receives BU message and performs Duplicate Address Detection (DAD) to confirm the uniqueness of the recently configured address. After successful completion of DAD, MAP sends Binding Acknowledgment (BA) message back to MN. MN then sends BU message to HA and CN via MAP.HA/CN store address of MN to their binding cache, if binding is successful and starts sending packets to MN using its RCoA (as HA/ CN knows only about RCoA).MAP2 receives packets and tunnel them to MN using its LCoA. MN receives packets, de-capsulate them and process them in normal way.

This entire BU process carried out when MN has moved into new domain. Thus, MN has to wait and communication cannot start until whole BU process complete successfully, which cause of long delay.

### 3.4.2 Proposed Binding Update Scheme

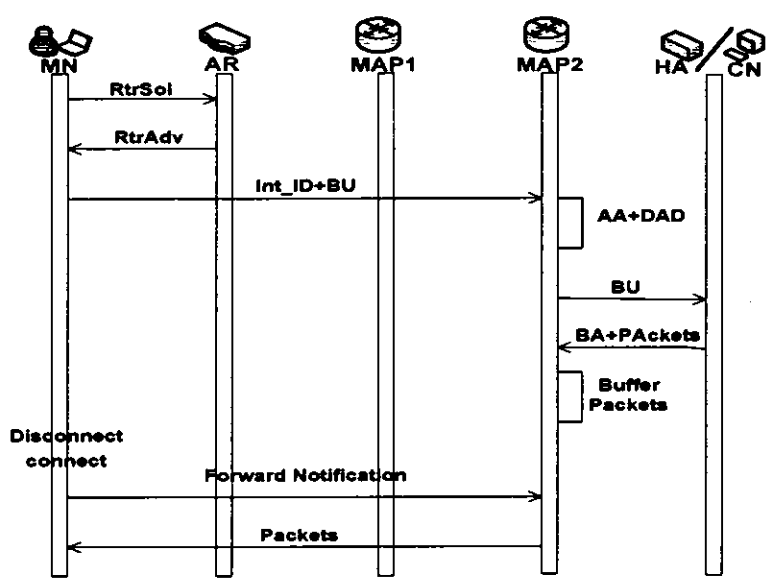


Figure 3.4: BU procedure in A-BU

When MN is in MAP1 domain and communicating with CN, it senses through router advertisement message that it will perform handoff. MN sends BU message to MAP2 via its currently attached AR. MAP2 receives this BU message and performs AA and DAD on new RCoA2. In original HMIPv6 scheme, AA is performed by MN. After successful completion of DAD, MAP2 sends BU message to HA/CN for informing them about new RCoA of MN. HA/CN stores MN's new RCoA in binding cache, and after successful completion CN starts sending packets to MAP2. MAP2 receives packets and buffers them for MN. MN is still in MAP1 and there is no delay in communication, both MAPs are working simultaneously. When MN node enters in MAP2's domain, MAP2 start sending buffered packets to MN. MN doesn't have to wait for BU processing for MAP2 and for communication as well. Same procedure will be followed if MN moves from MAP2 to MAP3. This scheme saves 1 round trip time.

Steps involved in Advance_BU procedure:

- MN sends its Interface_ID to MAP2, when MN is in MAP1 domain.
- MAP2 configures RCoA for MN.
- MAP2 performs DAD on new RCoA for verifying its uniqueness.
- MAP2 stores new RCoA in its binding cache and informs HA/CN about MN's new RCoA.
- HA/CN stores new RCoA2 in their binding cache and sends Acknowledge back (BAck) along packets on MN's new RCoA2.
- MAP2 intercept packets destined for MN and start buffering those packets.
- When MN disconnects from MAP1 and connects on new MAP's link that is MAP2, it informs MAP2 about its presence by sending a forward notification message.
- MAP2 starts sending buffered packets to MN.

### 3.5 Contribution

The main contribution of this thesis can be summarized as follows:

- A detail understanding of Mobile IP, Mobile IPv6 and Hierarchical Mobile IPv6.
- Management of Micro and Macro mobility in Hierarchical mobile IPv6.
- Handover procedure and its related issues faced by Macro mobility in HMIPv6 network.
- A modified Binding Update scheme, which bring efficiency in actual Macro handover procedure.
- Influence of proposed BU scheme on the conventional HMIPv6 scheme is analyzed by using different metrics.

### 3.6 Summary

A detail study of problem domain, our problem statement and proposed solution for problem is discussed in this chapter. As number of mobile users increased, MIP is getting active intention. But it suffers from many issues, in which handover is one of them needs to pay intention to improve mobility. It is clearly observed from the problem statement that BU procedure affects the performance of handover procedure badly. As BU procedure is time taken which cause of longer delay when MN moves to other domain. The main idea of our proposed solution is to complete registration process in advance, minimize the number of messages to make handover process fast when MN moves outside a MAP domain.

# 4

# System Design

## 1.1 Introduction

Mathematical modelling plays an important role to analyse and understand the behaviour any system. Mathematical modelling can use in almost every filed, to obtained the numeric results and find the cost. The HMIPv6 consists of hybrid topology and there are hierarchy of nodes, thus to obtain and estimate the cost of protocol mathematical modelling provides a flexible environment.

In this chapter, we will explain MALTAB working and reason to use it, about mathematical modelling that how it helps to observe the behaviour of a system. Then we will present our network model, research methodology and at the end performance matrices will be explained that are used in experiments.

## 1.2 MATLAB Product

MATLAB is a high-level technical computing language having interactive environment for developing algorithms, data analysis, data visualization, and computing numeric of a system [50] [51]. There are many languages that are used to solve problems of system and implementing them but MATLAB is a product that can solve technical problems of a system faster than with traditional programming languages such as C, C++ and FORTRAN. The algorithms and applications developed in MATLAB are organized as stand-alone program or software modules.

For documenting and sharing our work, MATLAB provides a lot of features. MATLAB code can be integrated with other languages and application, as well as its algorithms and applications can be distributed.

There are many key features of AMTLAB including:

- MATLAB is high-level technical computing
- Provides developing environment for managing files, data and code
- Support graphic functions for visualizing data
- Interactive tool for iterative exploration, design and problem solving

### 1.2.1 Why MATLAB?

MATLAB can develop algorithms and programs faster than with other traditional languages, because there is no need of declaring variables, specify data type and allocation memory. In some cases only one line of code can often replace several lines code of traditional languages like C++. Many programming code such as C, C++, FORTRAN, Java and COM object are integrated with our application in MATLAB product, and it can be called from C, C++, or FORTRAN code as well. Numeric algorithms can be implemented for a wide range of applications in MATLAB [51].

In MATLAB generated results can be exported as plots or as complete report. The results generated as plots are supported by all popular graphical program and other Microsoft packages. Simply export plots to graphic file format and then import to Microsoft Word or Microsoft PowerPoint, as well as MATLAB code can easily and automatically publish in HTML, Latex, Word and other formats.

### 1.3 Mathematical modeling

A model which describes the behaviour of a system using mathematical language is termed as mathematical model, and process of developing a mathematical model is called mathematical modelling [54]. Mathematical modelling can be used in almost every field including natural sciences, engineering, computer sciences, and social sciences.

Mathematical modelling can be of different form like dynamical systems, statistical models, differential equations, or game theoretic models, but not limited to them. All types of models can overlap involving a variety of abstract structure with a given model.

Mathematical model usually describe a system using set of variables and a set of equations, and these equations establish relationship between the variables. The values of variables can be real, integer numbers, Boolean values, strings, or practically anything. There are six basic groups of variables [54] which include: decision variables that are sometime known as independent variable, Input variables, State variables, exogenous variables that are sometime known as parameters or constant, Random variables, and Output variables. Each type can have many variables and the variables are usually represented by vectors. These variables are not independent of each other like the state variables are dependent on the decision, random, input and exogenous variables and the output variables are dependent on state of the system.

Variables represent some properties of the system, for example system outputs are often measures in the form of signals, counters, time data and event occurrence that yes or no.

#### 4.3.1 Mathematical modelling and Computer networks

As any other system, mathematical models play a vital role in computer networks for their understanding and controlling. Mathematical models not only allow to attain insight into how network and traffic is actually formed, but also describe how to design mechanism and algorithm to efficiently locate/ circulate/ share information. They are used an essential tool to understand the basic performance limits and trade-offs of computer networks. New applications are emerging as the network infrastructure is changed; the mathematical models need to evolve as well.

## 1.4 Network Model

The Hierarchical Mobile ipv6 network model consists of two level of protocol: the first and higher level is Mobility anchor Point (MAP) and second is Access Routers (AR). ARs are attached with the MAP, and contain both wired and wireless interface. ARs provide connectivity and transmit data to MN. Mobile Node (MN) is a purely wireless node and moves between different wireless domain and their subnet domain area. Our network model is hybrid based wired cum wireless topology. The main entities involved in our network models are given below:

**Mobility Anchor Point (MAP)**

MAP separates micro mobility domain from macro mobility domain. MAP is a router located in a network visited by MN. It acts as a local home agent for the MN and is responsible for keeping track of MN's movement, binding cache's maintenance and other mobility management.

**Access Routers (ARs)**

The AR is Mobile node's default router, and provides connectivity with other nodes of network. ARs have two different interfaces, one is connected to a wired link and other interface is connected to a wireless link. This ability makes AR an important entity for MIP networks because these networks mostly consist of a hybrid topology.

**Corresponding Node (CN)**

CN is a peer node with which an MN is communication; it is source of the traffic. All operations of MN are completely transparent to CN, it encapsulates and tunnel the packets destined for MN to MAP. Corresponding node may be stationary either mobile.

**Mobile Node (MN)**

MN is a receiver of the traffic. MN is wireless node which changes its point of attachment, connects to different routers, and still being reachable via sending BU.

Figure 4.1 shows the scenario of our network model. This scenario consists of two part; first, the wired and second, the wireless part, forming a hybrid topology.

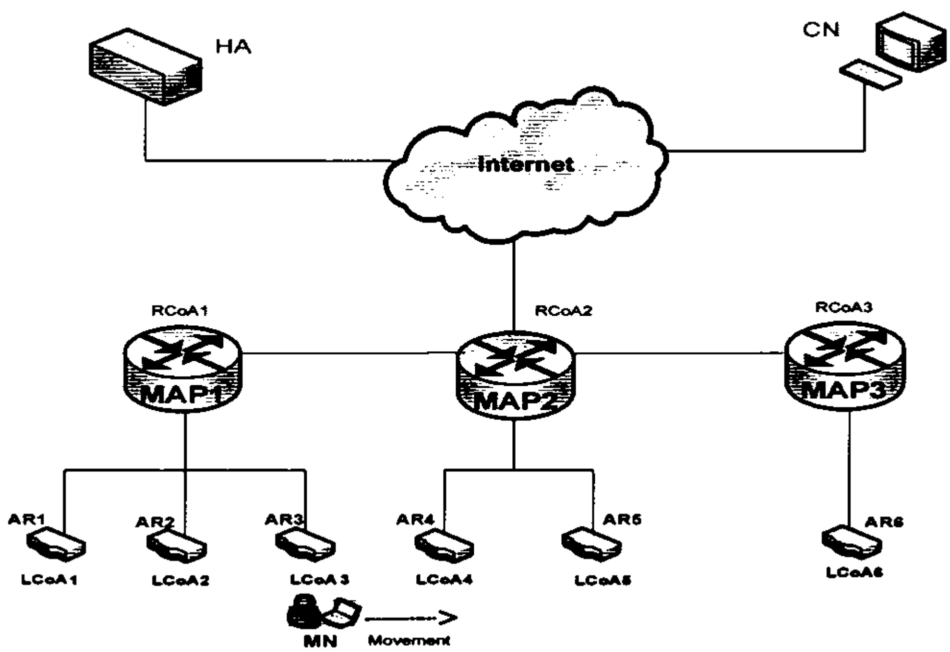


Figure 4.1: The Network Model

### 1.5 Research Methodology

Using four major parameters Subnet Area(S), Domain Area (D), Corresponding Node (CN), and Velocity (V), different experiments are conducted for both handover schemes for location update cost. Two experiments are conducted with one varying parameter, in first other parameters remain same and in second values of other parameters also increased. In first experiment, impact of increasing velocity is analysed with constant value of other parameters, in the second experiment, velocity is varied and value of S and D is also increased. Third experiment in conducted with increasing number of CNs, and other parameters remain same. In fourth experiment, values of S and D are increased with varying number of CNs. In 5th and 6th experiment, domain size D is varied and other parameters remain same in first and increase in second time similar to other experiment.

A cost based evaluation model is proposed to conduct the results for location update and these results are obtained using MATLAB [50] [51]. We adopt Fluid Flow (FF) model [47] [48] for cost analysis, since it is suitable for the mobile user with high mobility, infrequent speed, and direction change. According to this model, number of crossing subnet and number of domain crossing are presented as $\lambda_s$ and $\lambda_d$ respectively, as [1] [53]. Total cost is calculated by adding location update and packet delivery cost, and location update cost is expressed as sending BU through different numbers of hop counts between MN,AR, MAP and CN. These hop counts are presented as a, b and c as [1], and description of these hop counts are presented in table 1 given below. Packet delivery cost is divided into two parts non-optimized route path and the route optimized path and $\omega$ is defined as the indirect packet ratio as in [1] [47]. The total cost is presented as a function of SMR and in FF model SMR is calculated using $S_a$ and $\lambda_s$. Assumption and notation used for our cost analysis and experimental setup is given in sections.

**4.5.1 Assumptions**

The following assumptions are considered for the performance evaluation environment:

- The network model is based on the number of hop counts connectivity, 'a' is the hop between MAPs and 'b' is the hop counts between MAP and its connected ARs.
- The transmission cost *c* is same for both hosts MN and CN from AR.
- The communication session between MN and CN has either a non- optimized route path or an optimized route path.

The system parameters and notations used in calculations are mentioned in table 4.1:

| Notation | Depiction | Value |
|---|---|---|
| BU | The Binding update size (Bytes) | 72 |
| BA | The BA size (Bytes) | 52 |
| $L_s$ | The average session size (KBytes) | 5 |
| $S_a$ | The session arrival rate | 0.01 |
| a | The hop counts between MAPs | 15 |
| b | The hop counts between MAP and AR | 5 |
| c | The hop counts between AR and MN | 1.5 |
| $\tau$ | The tunnel header size (Byte) | 40 |
| $\sigma$ | The session tunnelling weight cost | 1.2 |
| $\omega$ | The ratio of packets on non-opt route | 0.2 |
| $\varepsilon$ | The number of CNs | 1 |

Table 4.1: System Parameters

### 4.5.2 Experimental setup

For every parameter, two experiments are conducted to obtained results for location update cost. The complete detail of our experimental setup for location update cost is given as follows:

#### 4.5.2.1 Experiment for varying Velocity

Some parameters and variables are involved in every experiment. Main variables are used in all experiments are S as area of subnet, D as domain size, and C is the number of CNs. We conduct two experiments with varying Velocity, in first experiment number of CN and domain size remains the same but velocity is varying. The experiment is conducted for both the schemes and detail of experiment 1 is in table 4.2.

**Table 4.2 Parameters for Experiment No.1**

| Variables | Values |
|---|---|
| Experiment | Impact of increasing Velocity |
| Area of Subnet (S) | 150 $m^2$ |
| Area of Domain (D) | 300 $m^2$ |
| Velocity | 20,40,60,80,100,120,140,160,180,200,220,240 m/s |
| Number of CN | 1 |

In second experiment, sizes of S and D are also increased with varying velocity but number of CN is same. This experiment is also conducted for both schemes and details are given in table 4.3.

**Table 4.3 Parameters Experiment No.2**

| Variables | Values |
|---|---|
| Experiment | Impact of increasing Velocity |
| Area of Subnet (S) | 300 $m^2$ |
| Area of Domain (D) | 600 $m^2$ |
| Velocity | 20,40,60,80,100,120,140,160,180,200,220,240 m/s |
| Number of CN | 1 |

#### 4.5.2.2 Experiments are based on No of CN

In this experiment, impact of number of CNs is analysed and conducted same as above experiment. In first part of this experiment, Numbers of CN are increased, while S, D and V remain same. The complete view of this experiment is in table 4.4:

**Table 4.4 Parameters for Experiment No.3**

| Variables | Values |
|---|---|
| Experiment | Impact of increasing No of CN |
| Area of Subnet (S) | 150 $m^2$ |
| Area of Domain (D) | 300 $m^2$ |
| Velocity | 100 m/s |
| Number of CN | 1,2,3,4,5,6,7,8,9,10,11,12 |

In the second part of this experiment, number of CN is increased as well as area of subnet S and area of domain D are increased, but velocity remains same. Area of S is increased 300 from 150 and domain area D is increased 600 from 300. Both schemes are compared on basis of these varying values of parameters. The detail of this experiment is given in table 4.5.

**Table 4.5 Parameters for Experiment No.4**

| Variables | Values |
|---|---|
| Experiment | Impact of increasing Velocity |
| Area of Subnet (S) | 300 $m^2$ |
| Area of Domain (D) | 600 $m^2$ |
| Velocity | 100 m/s |
| Number of CN | 1,2,3,4,5,6,7,8,9,10,11,12 |

**4.5.2.3 Experiment for increasing Domain size**

In this experiment, the impact of increasing area of domain on location update cost is analysed. As size of domain is increased while subnet size, velocity and number of CN are same. The impact of this parameter is investigated for both schemes and results are obtained. The details of this experiment are given in table 4.6.

**Table 4.6 Parameter for Experiment No 5**

| Variables | Values |
|---|---|
| Experiment | Impact of increasing domain size (D) |
| Area of Subnet (S) | 150 $m^2$ |
| Area of Domain (D) | 150,300,450, 600,750,900,1050,1200,1350,1500,1650,1800$m^2$ |
| Velocity | 100 m/s |
| Number of CN | 1 |

In second experiment using varying values of parameter, the values of Velocity and CN is increased while size of subnet is remained same as in above experiment. Table 4.7 is showing the detail of this experiment.

**Table 4.7 Parameters for Experiment No. 6**

| Variables | Values |
|---|---|
| Experiment | Impact of increasing domain size (D) |
| Area of Subnet (S) | 150 $m^2$ |
| Area of Domain (D) | 150,300,450, 600,750,900,1050,1200,1350,1500,1650,1800$m^2$ |
| Velocity | 140 m/s |
| Number of CN | 3 |

### 1.6 Summary

In this chapter, we described detail about working and role of MATLAB and mathematical modelling. Then we presented our network model and its required entities used for modelling. Moreover, we have presented the detail study of experimental setup and parameters that are used for performance assessment of our proposed scheme.

# 5

# Performance Evaluation

## 5.1 Introduction

In this chapter, we have analysed the simulation results, and presented the performance analysis of current HAMIPv6 handover scheme and our proposed one. We performed 6 tests on four main parameters which are Area of Subnet (S), Area of Domain (D), Velocity on MN (V), and No, of Corresponding Nodes (CN). Then total cost is presented by calculating Session to Mobility Ratio (SMR). Both handover schemes are compared on the basis of the results collected from these metrics. The results obtained through each experiment under same environment and conditions are represented. There is clear difference between both handover schemes and their efficiency as shown in graphs. First section of this chapter describes, as to how the metrics are calculated, then we presented our results, and at the end we analysed both scheme according to given results.

### 5.2 Cost Analysis

We perform some experiments to obtain results for location update cost, and the parameters used to calculate these results are Varying Velocity, No. of CN, and increasing Domain size.

#### 5.2.1 Number of Subnet Crossing

The number of subnet crossing in both handover schemes is denoted as $\lambda_s$ and expressed as:

$$\lambda_s = [\frac{2.v}{\sqrt{\pi .S}}] \qquad (1)$$

where $v$ is velocity and S is the Subnet area.

#### 5.2.2 Number of Domain Crossing

The number of subnet crossing in both handover schemes is denoted as $\lambda_d$ and expressed as:

$$\lambda_d = [\frac{2.v}{\sqrt{\pi .D}}] \qquad (2)$$

where D is denoted for Domain area [1].

#### 5.2.3 Total Cost

Total cost (TC) for both schemes is obtained adding location update cost (LU) and packet delivery cost (PD) together. Thus TC is defined as follows:

$$TC_h = LU_h + PD_h \qquad (3)$$

$$TC_a = LU_a + PD_a \qquad (4)$$

Where '$h$' is indicator for HMIPv6 and '$a$' is indicator for A-BU. First ,we will find location update cost , then packet delivery cost ,and at the end we will have total location update cost.

### 5.2.4 Location Update Cost

The location update cost is divided into three parts, which includes $LU^i$, $LU^s$, and $LU^d$ where:

$$\boldsymbol{LU^i} = BU_{map} + BU_{ha} + (\epsilon . BU_{CN})$$

$$\boldsymbol{LU^s} = (\lambda_s . BU_{map})$$

$$\boldsymbol{LU^d} = \lambda_d . [\, BU_{ha} + (\epsilon . BU_{CN})]$$

$LU^o$ is the initial location update cost when MN enters in MAP domain at first time, $LU^a$, and $LU^e$ are the location update cost for MN's intra-domain handoff and inter-domain handoff respectively [1].

Then the Location update cost is given as below:

$$LU = BU_{map} + BU_{ha} + (\epsilon . BU_{cn}) + (\lambda_s . BU_{map}) + \lambda_d . [\, BU_{ha} + (\epsilon . BU_{cn})] \quad (5)$$

### 5.2.5 Location Update Cost for original HMIPv6 Scheme

The Location update cost for HMIPv6 ($LU_h$) where *h* is indicator for HMIPv6, is given as below:

$$LU_h = BU_{map} + BU_{ha} + (\epsilon . BU_{cn}) + (\lambda_s . BU_{map}) + \lambda_d . [\, BU_{ha} + (\epsilon . BU_{cn})]$$

Now to obtain cost for $BU_{map}$, $BU_{ha}$ and $BU_{cn}$, the calculations as follow:

$$\boldsymbol{BU_{map}} = [BU . (b + c)] + [\, BA . (b + c)] \quad (6)$$

BU is from MN→MAP, BA is from MAP→MN

"→" *indicates* to "*to*", e.g. MN to MAP (MN→MAP). It is one directional.

$$\boldsymbol{BU_{ha}} = [BU . (b + c)] + [\, BU . (a + b)] + [BA . (a + b) + BA . (b + c)] \quad (7)$$

BU is from MN→MAP→HA, and BA is from HA→MAP→MN

$$\boldsymbol{BU_{cn}} = [(BU + \tau\,.(b + c) + BU\,.(a + b + c)] \qquad (8)$$

BU is from MN→MAP→CN, BA is not compulsory required operation for CN.

Where τ is an additional IPv6 packet header size, which represents the tunnelling overhead per packet. BU is from MN→MAP→CN, BA is not compulsorily required operation for CN. These equations for HMIPv6 are taken from [1] [47].

### 5.2.6 Location Update Cost for Advance-BU Scheme

Now, we present following model for our proposed scheme.

LU cost for A-BU is calculated same as HMIPv6, using equations below. Where *a* indicates A-BU.

$$LU_a = BU_{map} + BU_{ha} + (\epsilon.BU_{cn}) + (\lambda_s.BU_{map}) + \lambda_d.[\,BU_{ha} + (\epsilon.BU_{cn})] \qquad (9)$$

However, $BU_{map}$, $BU_{ha}$, and $BU_{cn}$ for A-BU are calculated as follows:

$$\boldsymbol{BU_{map}} = [BU\,.(b + c + a)] \qquad (10)$$

BU from MN→MAP

$$\boldsymbol{BU_{ha}} = [BU\,.(a + b)] + [\,BA.(b + a)] \qquad (11)$$

BU from MAP→HA, BA from HA→MAP

$$\boldsymbol{BU_{cn}} = [(BU + \tau\,.(b + c) + BA\,.(c + b)] \qquad (12)$$

BU from MAP→CN, BA from CN→MAP

### 5.2.7 Packet Delivery

Packet delivery cost is calculated using equation below:

$$\boldsymbol{PD} = \mu_o^{\epsilon}\,.[(\omega.L_s.R^{nro}) + ((1-\omega).L_s.R^{ro})] + \mu_i^{\epsilon}\,.[L_s.R^{ro}] \qquad (13)$$

Where $\mu_o^{\epsilon}$ is the rate of communication before entering in the MAP domain and $\mu_i^{\epsilon}$ is the communication rate starting within the MAP domain. $R^{nro}$ and $R^{ro}$ represent Non-Optimized route path and Optimized route path , respectively.

Non-Optimized route path and Optimized route path are calculated as follows:

$$R^{nro} = (a + 2b + c) + (\sigma.(a + b)] + [2\sigma.(b + c)] \qquad (14)$$

From CN→HA→MAP→MN

$$R^{ro} = (a + b + c) + [\sigma.(b + c)] \qquad (15)$$

From CN→MAP→MN

We are using same equation for both schemes, because of their same procedure of packet delivery. Cost will same for both schemes and it is obtained to calculated total location update cost. However, the difference will be seen in total cost for both schemes.

### 5.2.8 Session to Mobility Ratio

The SMR is ratio of the session arrival rate to the mobility rate, and it is used to present total cost. SMR is calculated as:

$$SMR = S_a/\lambda_s \qquad (16)$$

Where

$S_a$ = the session arrival rate

$\lambda_s$= the number of crossing subnets

## 5.3 Numeric Result

The simulation results of the mobility models are given as follow:

### 5.3.1 Results Based on Varying Velocity

First, the impact of mobile user velocity is investigated. Two experiments are conducted for varying velocity, one with area of subnet $150m^2$ and domain area $300m^2$, and number of CN is 1 and other is with area of subnet and domain size increases to 300 and 600, respectively. The MN frequently handoff between subnets in high velocity, thus its location update cost is increased. As in increased number of velocity, MN performs the increased number of movement and with larger subnet less number of movements is performed by MN but it affects the location update cost too. It is seen from the figure 5.1 and 5.2 that during low velocity, both handover schemes consumes similar location update cost. However, it is observed that our proposed A-BU scheme provides an improved performance than original HMIPv6 scheme, as velocity increases.

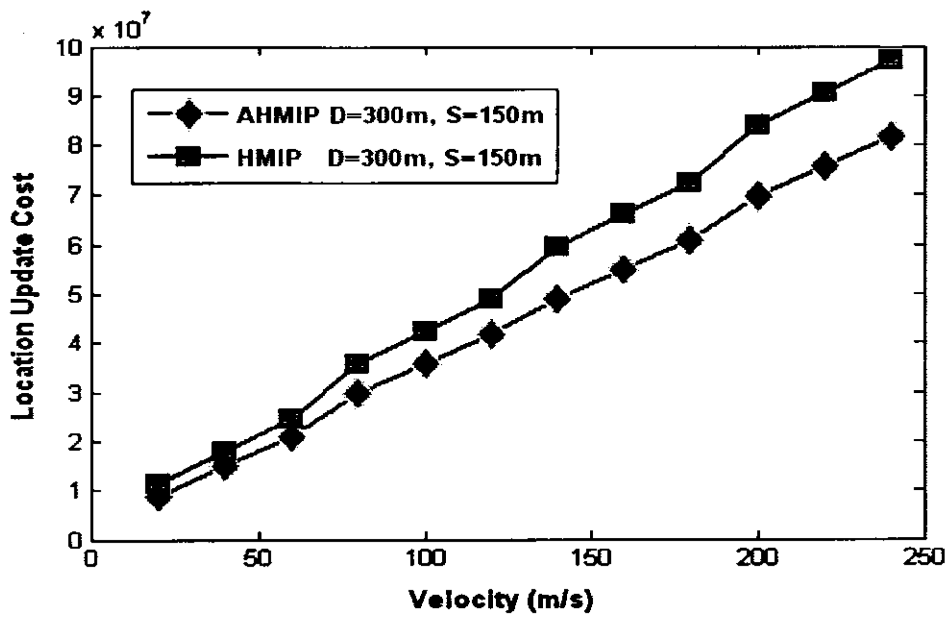


Figure 5.1 LU cost for varying Velocity (v)

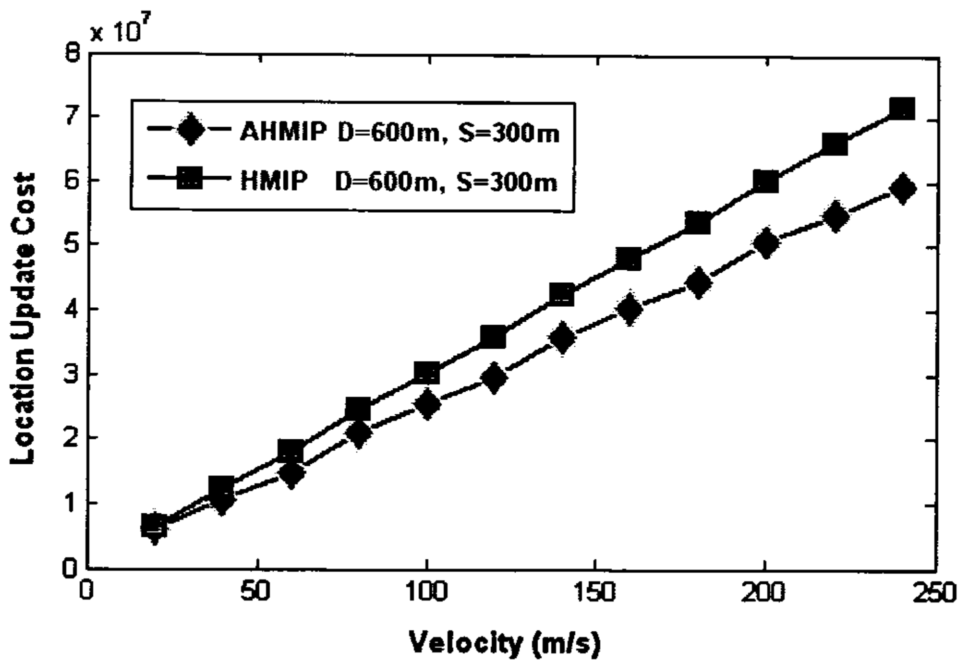


Figure 5.2 LU cost for varying Velocity (v)

### 5.3.2 Results Based on No. of Corresponding Nodes

Impact of increasing number of CN is shown in figure 5.3 and 5.4. Two experiments are conducted, one with increasing number of CN from 1 to 12, S set as 150, D as 300 and v set as 100. And other with same number of CN as in first from 1 to 12, with increasing value of S and D to 300 and 600 ,respectively and v remains same as 100. The graph below shows the gradual increase of location up date cost as number of CNs increases. However with comparison of both schemes, it is clear that our proposed scheme is performing very well and location update cost is much less than actual HMIPv6 scheme. The results are shown in figure 5.3, 5.4 given below.

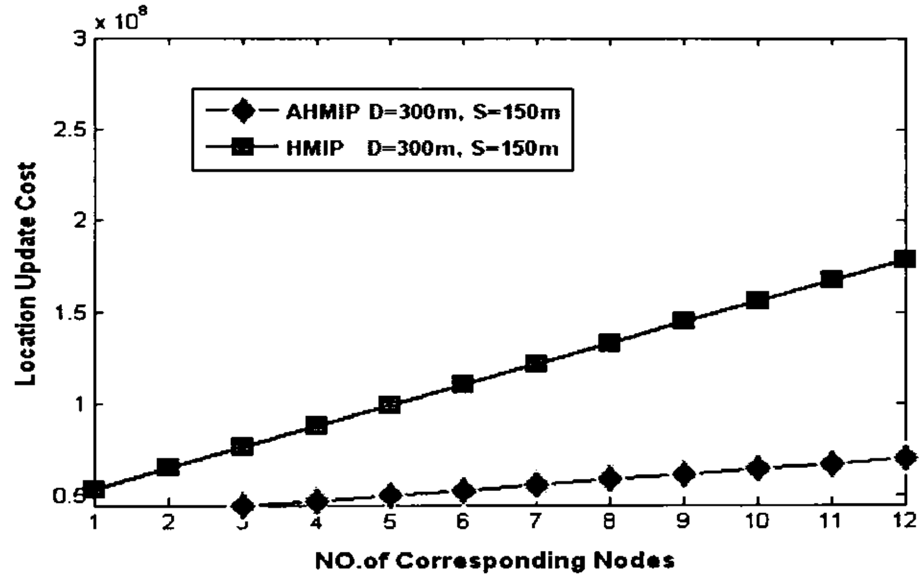


Figure 5.3 LU cost with increasing No. of CN

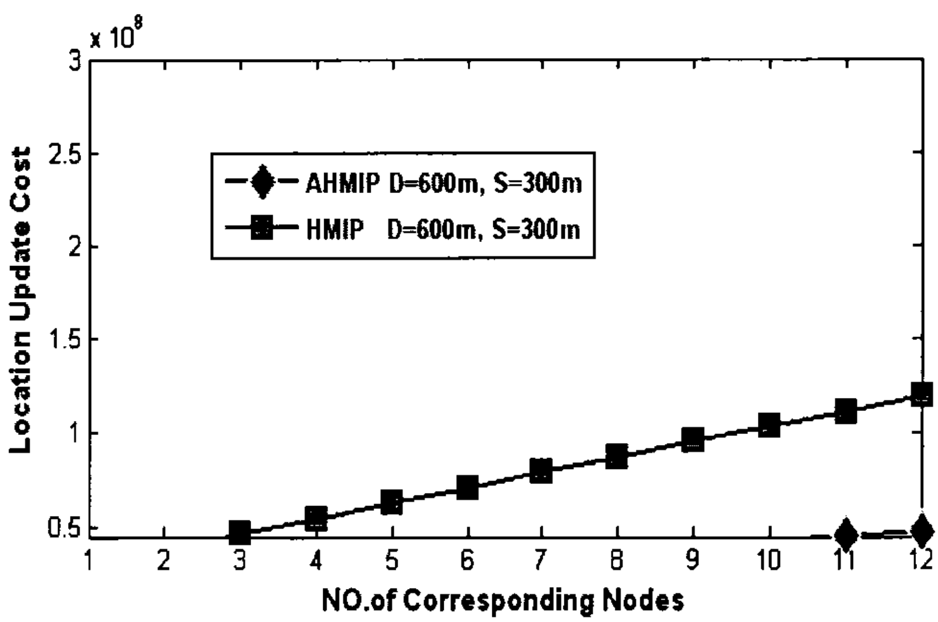


Figure 5.4 LU cost with increasing No. of CN

### 5.3.3 Results based upon increasing Domain Size

The impact of increasing domain size is investigated and shown in figure 5.5 and 5.6 below. In this experiment, size of domain is increased up to 1800 from 150, with v set as 100 m/s, and second time set as 140 m/s, CN vary from 1 to 3, and S remains same in both cases as $150m^2$. The variation in location update cost is seen from the graph below as domain size is increased. Both schemes consume almost same cost as domain size increased, especially when CN is set as 1. However, it is seen that for the small domain size i.e. D < 600 consume high location update cost, which means that size of domain has to be designed carefully in network. As comparing both handover schemes, results in graph 5.5, 5.6 below show that location update cost of our proposed scheme is less than original MIPv6 handover scheme.

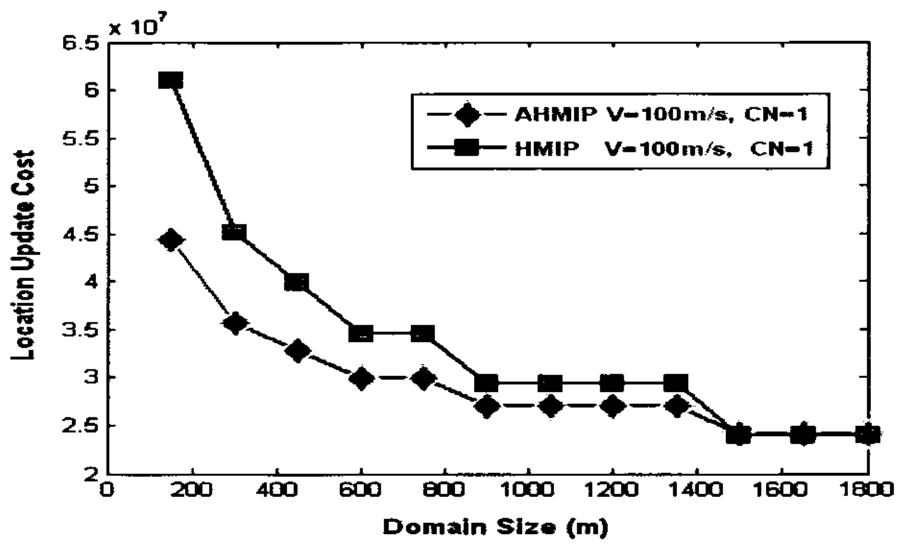


Figure 5.5 LU cost for increasing Domain Size (D)

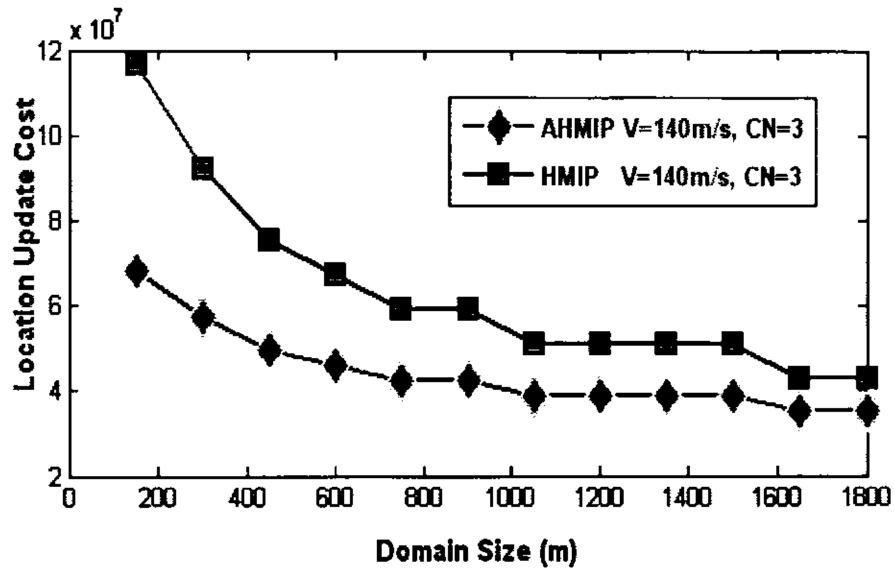


Figure 5.6 LU cost for increasing Domain Size (D)

### 5.3.4 SMR vs. Total Cost

The total cost is presented based on previous investigations, as a function of Session to Mobility Ratio (SMR). For this experiment, D size is set as 300, V as 140, No. of CN is 5, value of $\lambda_s$ is varied from 5 to 25, and $S_a$ is fixed as 0.1. Higher value of SMR shows low mobility, and low mobility consumes low location update cost, similarly when cost of SMR is low mobility rate is relatively high. It is observed from the figure 5.7, that the value of SMR increases the total cost of both schemes are decreased. The graph below is indicated that total cost is very low in our scheme than the HMIPv6 original scheme. The results are given below in figure 5.7.

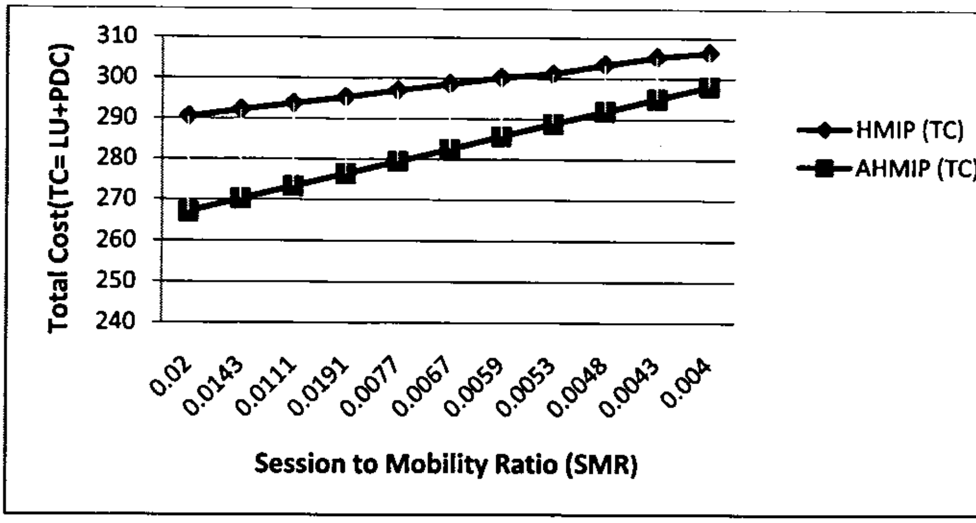


Figure 5.7: The impact of SMR on total cost

### 5.4 Summary

In this chapter, cost analysis and numeric results have been presented in detail. Domain area, Subnet Area, Velocity and No. of CNs have been chosen as performance metrics and different experiments are conducted to obtained results using these metrics. Then we have illustrated our results in detail to compare the performance of both schemes.

# 6

# Conclusion and Future Work

This chapter will present our achievements and conclusions about the thesis work and future dimensions of this work.

## 6.1 Achievements

The main achievements of this research project can be summarized as follows:

- The main contribution of this research project is to reduce the handover latency of macro mobility in Hierarchical Mobile IPv6 networks.
- To reduce this macro handover delay in HMIPv6, we proposed an efficient scheme for achieving our goal.
- We have been given a BU scheme by some modification in actual handover process of HMIPv6, which reduce BU delay during handover from one MAP domain to other MAP domain with less number of messages and advance BU procedure.
- We have analyzed the performance optimization of HMIPv6 protocol by comparing both schemes, actual and proposed one.
- Some performance metrics are tested and calculated for both schemes and detailed useful results are presented.

- A mathematical model is used to obtain our numerical results, and these results can be viewed as graphic mode.

### 6.2 Conclusion

The handover process for macro domain of the HMIPv6 is investigated and it is realized that HMIPv6 protocol is less efficient and couldn't out perform for global handovers outside a particular domain. The main reason is that when MN moves in local domain, it has to register its current address only with current domain's MAP. It doesn't take much long time and communication is continued. However, when MN moves to other MAP domain it has to configure two new addresses, verify them and then register them to MAP as well as to CN and HA. This BU process takes very long time to complete and noticeable delay occurs to stat proper communication. We focus this problem of handover process which cause of poor performance and proposed another scheme for inter domain mobility handovers called Advance-BU (A-BU) scheme. We carried out several tests using MATLAB for presenting performance optimization of our proposed scheme against the actual handover scheme. A number of experiments are conducted to obtain results on the basis of four main performance metrics which include Area of Subnet (S), Area of Domain (D), Velocity (v), and Number of CN. The results are obtained by conducted these experiments for both schemes and on the basis of these results both schemes are compared. According to numeric results and calculated performance metrics it is observed that our proposed scheme is doing better and increasing handover performance in case of location update cost than current actual HMIPv6 handover process.

The only drawback of our proposed scheme is that both MAPs are working simultaneously, if number of MN increases and want to connect at same time with MAP2 which is working on advance BU. It will be extra overhead for this MAP to manage and buffer packets for more than one MN at a time.

### 6.3 Future Work

We have presented a mathematical model to obtain the numeric results for performance optimization of our proposed scheme.

- In future, we will implement our scheme in NS2 and will perform simulation to obtain results to check the behavior and performance of our proposed scheme.
- The behavior of proposed scheme will be checked by increasing number of MNs
- This proposed scheme is modified for distributed MAP environment.

Table of Acronym

| | |
|---|---|
| MIPv4 | Mobile Internet Protocol Version 4 |
| MIPv6 | Mobile Internet Protocol Version 6 |
| HMIPv6 | Hierarchical Mobile Internet Protocol Version 6 |
| FMIPv6 | Fast Mobile Internet Protocol Version 6 |
| MN | Mobile Node |
| CN | Corresponding Node |
| HA | Home Agent |
| FA | Foreign Agent |
| MAP | Mobility Anchor Point |
| AR | Access Router |
| PAR | Previous Access Router |
| NAR | New Access Router |
| RtrSol | Router Solicitation |
| RtrAdv | Router Advertisement |
| BU | Binding Update |
| BA | Binding Acknowledgment |
| DAD | Duplicate Address Detection |
| CoA | Care of Address |
| LCoA | Local care of address |
| RCoA | Regional Care of Address |
| FBU | Fast Binding Update |
| FBAck | Fast Binding Acknowledgment |
| AP | Access Point |

# References

1. J. Lee, Y. Han, S. Gundavelli, "A comparative performance analysis on Hierarchical Mobile IPv6 and Proxy Mobile IPv6",1 may 2009
2. X. WU, G. NIE, "Comparison of Different Mobility Management Schemes for Reducing Handover Latency in Mobile IPv6", 2009
3. S. Nam, H. Hwang, J. Kim "Fast Macro Handover in HMIPv6", 2009
4. H. Yoo, R. Tolentino, B. Park, B. Chang, "ES-FHMIPv6: An Efficient Scheme for Fast Handover over HMIPv6 Networks", Vol. 2, No. 2, June, 2009
5. S. Soliman, C. Castelluccia, K. Malik, "Hierarchical Mobile IPv6 (HMIPv6) Mobility Management, October 2008
6. Y. Han, S. Min "Performance Analysis of Hierarchical Mobile IPv6: Does it improve Mobile IPv6 in Terms of Handover Speed?" 26 June 2008
7. J. Jeong, M. Chung, and H. Choo "Cost-Reduced Inter-MAP Binding Update Scheme in Robust HMIPv6", 2008
8. S. Soliman, C. Castelluccia, K. ElMalki, "Hierarchical Mobile IPv6 (HMIPv6) Mobility Management", RFC 5380, Oct 2008
9. M. Khan, M. Bhuyan, ET "Overview and Comparison of Methods for Minimizing Handoff Latency in Mobile IP", Vol.8, March 2008.
10. F. Nada: Performance Analysis of Mobile IPv4 and Mobile IPv6", VoL 4, No. 2, April 2007
11. K. Lee, Y. Lim, " An Efficient Macro Scheme Supporting Reactive Fast Handover Mode in HMIPv6" 2007
12. L. Niesink, " A Comparison of Mobile IP Handoff Mechanisms", 2nd February 2007
13. J. Oh, Youngsong Mun,"An Efficient Binding Update Scheme in HMIPv6", 2006.
14. J. Jeong, M. Chung, H. Choo "Improved Handoff Performance Based on Pre-binding Update in HMIPv6", 2006
15. K. Lee, Y. Lim, S. Ahn, "A Macro Mobility Handover Performance Improvement Scheme for HMIPv6" 2006
16. J. Lee, Y. Han, H. Lim "New Binding Update Method using GDMHA in Hierarchical Mobile IPv6" ,2005
17. M. Siksik, H. Alnuweiri, S. Zahir, "A Detailed Characterization of the Handover Process Using MIPv6 in 802.11 Networks", 2005
18. H. Jung, E. Kim, J. Yi, "A Scheme for Supporting Fast Handover in Hierarchical Mobile IPv6 Networks", Volume 27, December 2005
19. A. Hashim, F. Anwar, S. Mohd, "Mobility Issues in HMIP", March 31, 2005
20. L. Osborne, A. Hamid, R. Ramadugu, " A Performance Comaprison of Mobile IPv6, Hierarchical Mobile IPv6, and Mobile IPv6 Regional Registrations", 2005

21. M. Habaebi, " Macro/Micro-Mobility Fast Handover in Hierarchical Mobile IPv6", 21 December 2004
22. C. Castellucca "A Hierarchical Mobile IPv6 Proposal" INRIA Technical Report 226, November 1998.
23. X. Costa, M. Moreno and H. Hartenstein "A performance Comparison of Mobile IPv6, Hierarchical Mobile IPv6, Fast Handovers for Mobile IPv6 and their Combination", Volume 7, number 4
24. J. Chandrasekaran: Mobile IP "Issues, Challenges and Solutions"
25. H. Soliman. C. Castelluccia, K, El Malik and L. Bellier, "Hierarchical Mobile Ipv6 Mobility Management (HMIPv6)", IFTF RFC 4140, Aug,2005 *Work in Progress*
26. H. Jung, H. Soliman, S. Koh, "Fast Handover for Hierarchical Mipv6", Internet Draft, April 2005.
27. D.Jonhnson and C.Perskins, "Mobility Support in IPv6", IETF RFC 3775,2004
28. J. Ed, M. Ed, "Mobility Related Terminologies", June 2004
29. J. Choi, G. Haley, "Router Advertisement Issues for Movement Detection/Detection of Network Attachment", Internet Draft, October 2003
30. I. Vivaldi, M. Hahaebi, B. Ali, V. Prakash "Fast Handover Algorithm for Hierarchical Mobile IPv6 macro-mobility Management",2003
31. R.Droms, J.Bounds, H. Packard, "Dynamic Host Configuration Protocol for IPv6", RFC 3315, July 2003.
32. M. Yi, C. Hwang, "A Mobility-Based Binding Update Strategy in HMIPv6", 2003
33. Chaskar, H.ED, "Requirements of a Quality of Service (QoS) Solution for Mobile IP", RFC 3585, September 2003
34. X. Costa, R. Schmitz, H. Hartenstein, "A MIPv6, FMIPv6 and HMIPV6 Handover Latency Study: Analytical Approach"
35. C.Perkins.Ed, "IP Mobility Support for IPv4", RC 3344, August 2002
36. M. Bagnula, I. Soto, A.Garcia, "Random Generation of Interface Identifiers", January 2002.
37. T.Narten, E.Nordmark, W.Simpson, "Neighbor Discovery for IP Version 6", RFC 2461, December 1998
38. A. Conta, S.Deering, "Internet Control Message Protocol (ICMPv6) for Internet Protocol Version 6 (IPv6) Specification", RFC 2463, December 1998.
39. S.Deering, R.Hinden, "Internet Protocol Version 6 Specification", IETF RFC 2461, 1998
40. S.Thomas, T.Narten, "IPv6 Stateless Address Autoconfiguration", RFC 2462, December 1998
41. Behrouz A. Forouzan, "TCP/IP Protocol Suit", Second Eddition
42. H. Lee, "Understanding IPv6"
43. C. Perkins, "IP Mobility Support for IPv4", IETF Rfc 2002, Oct 1996.
44. Deering, "ICMP Router Discovery Message" , IETF RFC 1256, Sep 1991
45. N. Dutta, I. Misra, " Mathematical Modeling of Hierarchical Mobile IPv6 Based Network Architecture in Search of Optimal Performance", 2007

46. J. Xie, I. Akyildiz, "A Novel Distributed Dynamic Location Management Scheme for Minimizing Signaling Costs in Mobile IP" , 1 Oct 2002
47. S. Pack, T. Kwon, Y. Choi, " A performance comparison of mobility anchor point selection schemes in Hierarchical Mobile IPv6 networks", 16 September 2006
48. P. Goel, N. Gautam, " On Using Fluid Flow Model for Performance Analysis of Computer Networks"
49. J. Lee, H. Lim, T. Chung, " A competent global mobility support scheme in NETLMM", 20 July 2008
50. Clarkson University, Cyclismo.org, " Matlab Tutorial"
51. MATLAB Overview, "http\\www.MATLAB.htm
52. Francesco Franco, "MATLAB Tutorial"
53. F. Buumann, I. Niemegeers, "An Evaluation of Location Management Procedures", 1994
54. Wikipedia, the free encyclopedia