A Novel Mobility Management Scheme for NEMO Environment

طريقة حديثة لادارة التنقل في الشبكات المتحركة

BY

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ABSTRACT

The frequent change of Mobile Node (MN) location is going to increase rapidly as everything is a mobile presently. In order to achieve seamless mobility, mobility management is considered as very important aspect. The mobile IPv6 (MIPv6) is proposed and standardized by Internet Engineering Task Force (IETF). It is introduced to improve the host mobility management. But, it faces different problems when mobile nodes move between different network infrastructures. To overcome these issues, Proxy Mobile IPv6 (PMIPv6) is introduced. However, PMIPv6 adds additional cost to the network by implementing mobile access gateway and bi-directional tunnel. Network mobility NEMO standardized as extension to MIPV6 to support reachability and session continuity to the Mobile Network Nodes (MNNs) as one unit while they move. But, still there are some issues inherited from MIPv6 such as packet loss and handover latency during the registration of MNNs and handoff of NEMO. This research proposes Binding Update No Sense Drop (BUNSD) Binding Cache Entry (BCE) in Local Mobility Anchor (LMA) schema. The BUNSD-LMA aims to find possible solution to allow MNNs that are roaming in a PMIPv6 domain to perform seamless mobility whiles maintaining their session continuity through mobile router. In this scheme, PMIPv6 is integrated with NEMO BS. In addition, the binding update message format is extended to register the prefix of MNNs in advance with short time. In this Thesis, BUNSD-LMA is evaluated using numerical analysis and simulation using Opnet simulator. The performance metrics considered are handover latency and total packet loss. The analytical result shows that the BUNSD-LMA had better performance in term of handover, and registrations time of MNNs. It showed that the BUNSD-LMA decreases the total packet lost with 38% compared to NEMO BSP.The simulation results provide us with some insight as to the characteristics of the considered NEMO BSP mechanisms. As a result the total packet loss is decreased and seamless mobility of MNNs enhancedin BUNSD-LMA compared to NEMO BS benchmark.

مستخلص البحث

أن التغيير السريع لمواقع النقطة المتحركة (MN) أصبح في تتزايد مستمر وسريع, وذلك لأن كل شئ أصبح متنقلاً في الوقت الحاضر. ومن أجل تحقيق أنتقال سلس وسريع, تعتبر إدارة التنقل مهمة جداً. حيث تم إقتراح وإعتماد برتوكول الإنترنت الإصدار السادس للنقاط المتنقلة (MIPv6) بواسطة فريق عمل هندسة الانترنت (IETF) . تم تقديم هذا البروتوكول لتحسين إدارة التنقل للنقاط المتحركة. ولكن يعاني هذا البروتوكول من عدة أوجه من القصور عندما تتحرك النقاط المتنقلة خلال شبكات مختلفة البنية التركيبية. لحل هذه القضايا تم إقتراح برتوكول وكيل النقطة المتحركة (PMIPv6). ولكن نجد إن PMIPv6 أضاف تكلفة للشبكة وذلك بتطبيق بوابة الوصول المتحركة والنفق ثنائي الإتجاه. ولتدعيم الشبكات المتنقلة تم إعتماد برتوكول الشبكة المتنقلة (NEMO BSP) من قبل IETF كإمتداد لل MIPv6 لدعم الإتصال وإستمرارية الخدمة لنقاط الشبكة المتحركة كوحدة واحدة. ولكن لاتزال هنالك بعض من أوجه القصور الموروثة من (MIPv6) كفقدان الحزم وتأخير زمن الإنتقال أثناء تسجيل نقاط الشبكة المتحركة NEMO BSP. هذا البحث يقترح طريقة تسجيل كل النقاط في الذاكرة المؤقتة لإدارة التنقل المحلية وحذف النقاط التي لاتقوم بعملية إرسال وإستقبال للحزم (BUNSD-LMA) . تهدف هذه الطريقة لإيجاد حل للنقاط التي تتحرك داخل مجال PMIPv6 لتنفيذ عملية إستمرار الخدمة بطرقة سلسة وسريعة من خلال الموجه المتنقل. في هذه الطريقة تم دمج بروتوكول PMIPv6 مع NEMO BSP بالإضافة الى ذلك تم تعديل رسالة تحديث التسجيل لتضمين كل النقاط المتحركة مقدماً بزمن قصير. تم تقييم BUNSD-LMA بإستخدام التحليل الرياضي ونظام المحاكاة Opnet. تم إعتماد فقدان الحزم وزمن التأخير لتقييم الكفاءة. التحليل الرياضي أظهر إن BUNSD-LMA ذو آداء أفضل في زمن الإنتقال لتسجيل نقاط الشبكة المتحركة, كما أظهرت النتائج إن BUNSD-LMA أفضل من NEMO BSP من ناحية فقدان الحزم بزمن أقل من 38%. ونتيجة لذلك إنخفض إجمالي فقدان الحزم وتم تحسين الإنتقال السلس للنقاط المتحركة في BUNSD-LMA مقارنة مع معيار NEMO BSP.

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DECLARATION

I hereby declare that this Thesis is the result of my own investigation, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at Sudan University of Science and Technology or other institutions.

Mohamed Yagoub Geaiger Adam

Signature________________ Date___________________

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LIST OF ABBREVIATIONS

AAA	Authentication Authorization and Accounting
CN	Corresponding Node
CoA	Care of Address
FA	Foreign Agent
FBU	Fast Binding Update
HA	Home Agent
LMA	Local Mobility Anchor
MAG	Mobile Access Gateway
MAP	Mobility Anchor Point
NAR	New Access Router
PBU	Proxy Binding Update
PBA	Proxy Binding Acknowledgement
PAR	Previous Access Router
RCoA	Regional Care of Address
UNA	Unsolicited Neighbor Advertisement
AP	Access Point
AR	Access Router
BA	Binding Acknowledgement
BRep	Binding Reply which is the message delivered from CMAG to MAGs
BReq	Binding Request which is the message delivered from MAGs to CMAG
BU	Binding Update
BuC	Binding Update Cost
BUL	Binding Update List
CN	Correspondent Node
CoA	Care-of-Address
DHCPv6	Dynamic Host Configuration Protocol for IPv6
DMM	Distributed Mobility Management
FMIPv6	Fast Mobile IP version 6
GW	Gateway
HA	Home Agent
HIP	Host Identity Protocol
HMIPv6	Hierarchical MIPv6

HNP	Home Network Prefix
HoA	Home Address
ID	Identifier
IETF	Internet Engineering Task Force
IP	Internet Protocol
IPv6	Internet Protocol Version 6
LM	Location Management
LMA	Local Mobility Anchor
LTE	Long Term Evolution
MAG	Mobile Access Gateway
MAP	Mobile Anchor Point
MIPv6	Mobile IP version 6
MN	Mobile Node
MN-HoA	MN Home Address
MN-ID	MN Identifier
MNN	Mobile Network Node
MNP	Mobile Network Prefix
MR	Mobile Router
ns-2	Network Simulator Version 2
NEMO	Network Mobility
Net	Network
PBA	Proxy BA
PBU	Proxy BU
PDC	Packet Delivery Cost
PMIPv6	Proxy Mobile IP version 6
PoA	Point of Attachment
RA	Router Advertisement
RM	Routing Management
RO	Route Optimization
RRP	Return Routability Procedure
SIP	Session Initiation Protocol
SMR	Session-to-Mobility Ratio
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
VoIP	Voice over Internet Protocol
WiFi	Wireless Fidelity

WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network
3G	Third generation mobile communication networks

GLOSSARY

Access Point (AP): A layer-2 device that offers wireless connectivity to a mobile device using aradio access technology such as the IEEE 802.11 (Wi-Fi).

Access Router (AR): Performs standard IP routing and is the default router for the mobile node. It lies at the edge of the network and provides mobility functionality for visiting mobile nodes.

Base Station (BS): A layer-2 device that offers wireless connectivity to the mobile node.

Bicasting: Involves duplication of packets and routing of duplicated packets to more than one point of attachment.

Care of Address (CoA): A temporary IP address that is assigned by a foreign access router to amobile node as it roams out of its home network.

Correspondent Node (CN): A mobile or conventional fixed node that communicates

(sends/receives packets to/from) to a mobile node.

Duplicate Address Detection (DAD): is a mechanism to verify the MN's IP addressuniqueness to evade IP address conflicts.

Handover: A process whereby an ongoing communication on the MN is transferred to anotherAR (layer-3) or to another AP/BS (layer-2).

Handover operations: These are the procedures that are carried out to attain an effectivetransfer of a mobile node's ongoing communication (handover) from one AP/BS/AR to another.

Handover Initiate (HI): is a message sent from the previous mobile access gateway to the next mobile access gateway regarding the mobile node.

Handover Acknowledgement (HAck): is a response message from the next mobile accessgateway to the previous mobile access gateway to acknowledge the reception of the HI message.

Local Mobility Anchor (LMA): A data packets anchor in the PMIPv6 architecture.

Mobile Access Gateway (MAG): An AR that tracks the mobile node and performs mobility-related signaling for the mobile node.

Mobile Node (MN): is a node that connects to the network wirelessly and hascapabilities of engaging in motion.

Next MAG (NMAG): the MN's tentative AR after the handover.

Previous MAG (PMAG): the MN's default AR before the handover.

Received Signal Strength (RSS): is a measurement of the power present in the radio signal received.

Seamless Handover: A process whereby packet flow migrations from an AR or AP or BS toanother does not cause a perceivable disruption on the service being consumed by the MN.

Transmission Control Protocol (TCP): is a connection-oriented transport layer protocol thatoffers a reliable service by employing handshakes and acknowledgements.

User Datagram Protocol (UDP): is a connectionless transport layer protocol and does notguarantee reliable transmission.

WLAN: is an acronym for wireless local area network

CHAPTER ONE INTRODUCTION

1.1 OVERVIEW

With the increase of wireless network technology, IP faces many short comes to support network addresses. For this the network engineer extends the existing protocol with a new feature that has been gained from previous one. New protocols have been improved called IPv6 to solve networks addressing shortcomings. Besides this, the previous one faces some issues of mobility management. Due to this the researcher extends the existing protocol to mobile internet protocol version six (MIPv6). This protocol used to support the mobile node movement in IPv6 networks. It allows mobile nodes (MNs) user to continual their network connection to previous network whiles they move between different IP networks. MIPv6 is a mobility management protocol, for future all-IP mobile systems are expected to have wide deployment. With the rapid increase in wireless network technology, MIPv6 become very important to researchers to develop powerful mobile devices running mobile applications to get access to multimedia and data services over broadband wireless connections based on IPv6, to reducenetwork costs in IPv6 networks (Gundavelli, 2008).The key benefit of Mobile IPv6 is that even though the mobile node changes domains and addresses during handover, the existing connections through which the mobile node is communicating can be maintained. To do this, connections to mobile nodes has been configured with a specific address that is always assigned to the mobile node interface generated from it is a link layer address, and through which the mobile node is always reachable(Pack, 2008).

Mobile IPv6 faces some limitations in packet loss and latency during handoff operations and binding it is a new address. For this, mobility management protocol proposed to achieve mobile network nodes MNNs as one unit is called network mobility NEMO which is supported by the IETF group as NEMO Basic Support. Mobility management is to continueservices to mobile network nodes MNNswhile mobile router MR change its point of attachments in different networks. One of the important issues of mobility management scheme is the hands-off management. Handoff is how to keep services continue without interruption. When MR changes its point of attachment to another network (Visited network)it needs to update its home agent HA with a new location. The MR acquires Care-of-Address CoA from visited network and sends binding update message to its HA. These messages decrease the performance of NEMO. NEMO which supported by one MR to MNNS have some limitations such as handover delay and low power consummation compared to network mobility management schemes (Pack, 2008) (Calderon, 2012), (Yan, 2010) and (Tsai, n.d.).

However, there is a requirement for seamless handover problem in NEMO environment.

1.2 PROBLEM STATEMENT & ITS SIGNIFICANCE

Today mobile deviceshave become an essential part of our daily life.There is a large-scale deployment of wireless technology in public area, buses, trains, and airplanes. In addition, vehicles, trains and airplanes are equipped with cameras, and sensors for monitoring as mobile networks. For this, the users need to access the Internet and other services anytime and anywhere while they move. The mobile IP protocol enables host mobility support.To enable network mobility, the Internet Engineering Task Force (IETF) has developed Network Mobility Basic SupportProtocol NEMO BSP as extension to MIPv6 (Devarapalli, 2005). NEMO BSP is proposed to achieve mobility to whole MNNs as a one unit. However, NEMO BSP suffers from some problems and challenges, the most important challenges are seamless mobility (handover latency and registration time), signaling overhead and location management.

1.3 RESEARCH OBJECTIVES

This research aims to find a possible solution to allow MNNs that is roaming in a NEMO domain to perform seamless mobility whiles maintaining their session continuity. This research will be conducted to achieve the following objectives:

1- Propose a novel scheme to address handover latency and registration time in NEMO BSP environment in order to achieve seamless mobility.
2- Implement the scheme in a simulation environment.
3- Evaluate the performance of the develop scheme and benchmarked with NEMO BSP standard.

1.4 RESEARCH QUESTIONS AND HYPOTHESES

- Using PMIPv6 to register MNNs on behalf of MMNs, to decrease handover latency.
- Using Extended Binding update message to reduce MNNs registration time as a group.

In this research we will try to answer the following questions:

1. How can we implement PMIPv6 with Extended Binding Update message (EBA) in NEMO environments ?
2. What are the benefits of the integration of PMIPv6 with EBA message in NEMO?
3. Will the implementation of PMIPv6 with EBU message improve the seamless Mobility in NEMO?
4. Will the implementation of PMIPv6 with EBA message improve the mobility and the connectivity MNN?

1.5 RESEARCH METHODOLOGY AND TOOLS

In ordered to achieve the above objectives, the following approaches must be applied.

1. Studies related researches works on network mobility protocols environments.
2. Propose enhanced mobility management mechanism to improve packet loss and handover latency in NEMO BSP environments to ensure seamless mobility.
3. Implement the proposed mobility management scheme.
4. Develop and Design a new mobility management scheme to solve these problems.
5. Evaluate the proposed scheme by using analyses (Matlab) and simulation(Opnet14.5).
6. Benchmarked this proposed developed scheme with standard NEMO BS.
7. Publication of the research results.

1.6 RESEARCH SCOPE

This research concentrate on the development of a novel mobility management scheme to enhance the handoff performance to achieve minimal (delay and packets loss) in NEMO Environments. It deals with the network layer to achieve seamless mobility. This provides transparency to upper layers so no changes is required to the upper layer existing protocols. It uses PMIPv6 to register MNNs on behalf of MMNs, to decrease handover latency. Using extended binding update message by usingthe reserved Gflag bitas with short time, to reduce MNNs registration time as a group. The performance analysis of the proposed scheme is measured through a series of simulations parameters using opnet14.5and benchmarked with the standards.

1.7 THESIS ORGANIZATION

TheThesisis organized into six chapters.

The first chapter provides an overview of this Thesis covering the motivation of the study, the objectives of the study, the research questions, the research methodology and the scope of the study. The rest of the Thesis is organized as follows:

Chapter two outlines the background and discusses some issues of the mobility management protocols and the importance of mobility. In addition, this chapter discusses the proposed schemes techniques. Further, this chapter reviews related studies of seamless mobility management schemes. Lastly, the challenges and open issues were discussed.

In chapter three, the research design and method are described. The description of the research method involves the proposed structure of Binding update no Sense Drop Binding cache Entry of Local mobility Anchor Point BUNSD-BCE-LMA, the operation of BUNSD-LMA, signaling diagram, PSCodes, and flowchart.

Chapter four covers theresults analysis of the proposed BUNSD-LMA compared to NEMO BS Standard.

Chapter five presentsthe simulation resultusing Opnet14.5 modular and summery.

Finally, chapter sixpresent the conclusion and recommendations of the study.

CHAPTER TWO LITERATURE REVIEW

2.1 INTRODUCTION

The frequent change of Mobile Node (MN) location is going to increase rapidly as everything is a mobile presently. In order to achieve seamless mobility, mobility managements are considered as very important. The mobile IPv6(MIPv6) is proposed and standardized by IETF. It is introduced to improve the host mobility management. However, it faces different problems when mobile nodes move between different network infrastructures. To overcome these issues, proxy mobile IPv6(PMIPv6) is introduced. PMIPv6 is a network based mobility management intended to improve handover delay by functioning mobility managements on behalf of mobile node. However, PMIPV6 added additional cost to the network by implementing mobile access gateway and bi-directional tunnel. In addition, network mobility, NEMO is standardized as an extension to MIPv6 to support session continuity to the internet services on behalf of the mobile network nodes. Nevertheless, there are still issues of packet loss and handover delay during the registration of MNNs and handoff of NEMO. The research within this area is very active, trying to solve these problems by integrating different mobility management’s schemes. In this chapter,have evaluated different mobility management’s schemas in NEMO environments. Then, considered most of the current and previous solutions in NEMO. Finally, have presented shortcomings in this area. Some common solutions have been used to solve seamless mobility related problems were briefly investigated and evaluated.

2.2 INTERNET PROTOCOL VERSION FOUR (IPV4)

IPv4 was developed to enable researchers and academics to freely share and communicates in the U.S (Postel, 1981). When the IPv4 was created it supported limited system requirements. These systems lack security and quality of services. However, IPv4 impacts in the developments of Internet revaluations. In todays the needs of networks infrastructure increases to handles the growths of the Internet services. Besides these, enhancements and creation for next generation internet protocol is needed

2.3 INTERNET PROTOCOL VERSION SIX (IPV6)

IPv6 stands for Internet Protocol version 6. IPv6 has been developed based on the rich experience we have from developing and using IPv4. Proven and established mechanisms have been retained, known limitations have been discarded, and scalability and flexibility have been extended. IPv6 is a protocol designed to handle the growth rate of the Internet and to cope with the demanding requirements on services, mobility, and end-to-end security. This technology is designed to replace the existing IPv4 with improved address space, service, and data.

2.4 THE STRUCTURE OF THE IPV6

The header structure of an IPv6 packet is specified in (Deering, 1998). The IPv6 header is easierand leaner than the IPv4 header, allowing for more effective processing and, more flexibility in extending the protocol to future needs. Hence, the IPv4 address space is the 32 bits equal to approximately 4.29 billion addresses. In response to the world population reaches which 6.4 billion people. For this, would not be able to offer an IP address for everybody on the globe. However, small fraction of this address space can be used. Hence, large addresses blocks were allocated without attentions for global routing and address maintenance concerns. These address ranges cannot be reclaimed, accordingly there are several unused addresses that are not obtainable for allocation.

The IPv6 header structure shown in fig2.1. The source and destination address use 128 bits. Additional fields contain information about the version, the Traffic Class (packet priority), Flow Label for QoS, Payload Length and Hop Limit to control the time to live of the packet. Noteworthy is the field Next Header. The header structure of an IPv6 packet could be simplified because of this field.

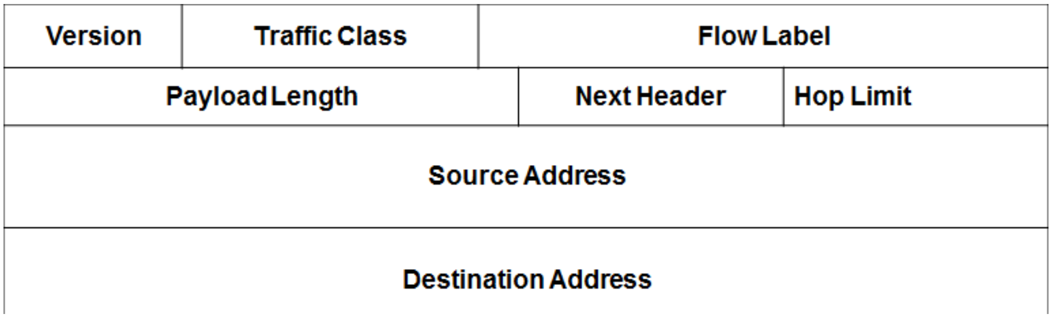


Figure 2.1: IPv6 Header Structure

The Next Header element points to an additional header, thus enabling a header structure which adapts to the current needs of the sent packet. This feature enables routers to process packets faster and with less power, since routers only need to check and adjust header fields which are really needed. The additional headers are contained in the Extension Header field, which has a variable length.

2.4.1 IPv6 Address Types

An IPv6 address can be classified into one of three categories:

Unicast: A unicast address uniquely identifies an interface of an IPv6 node. A packet sent to a unicast address is delivered to the interface identified by that address.

Multicast: A multicast address identifies a group of IPv6 interfaces. A packet sent to a multicast address is processed by all members of the multicast group.

Anycast: An anycast address is assigned to multiple interfaces (usually on multiple nodes). A packet sent to an anycast address is delivered to only one of these interfaces, usually the nearest one.

2.4.2 Link- and Site-Local Addresses

The IPv6 allocated two separate address spaces (scopes) for link- and site-local use, both identified by their prefixes. However, the site-local address has been deprecated. Many problems arise in the application of this address. A link-local address is used on a single link and should never be routed. It doesn't need a global prefix and can be used for Autoconfiguration mechanisms, for neighbor discovery, and on networks with no routers, so it is useful for creating temporary networks.

The replacement for site-local addressesis called unique local IPv6 unicast address, or local IPv6 address for short. It is specified in (Hinden, 2005). These addresses are globally unique but should not be routed to the global Internet. They are designed to be used within corporate sites or confined sets of networks (Kozierok, 2010).

2.4.3 Default Address Selection

The architecture of IPv6 allows an interface to have multiple addresses. The addresses may differ in scope (link-local, global) or state (preferred, deprecated); they may be part of mobility (home-address, care-of-address) or multihoming situation; or they may be permanent public addresses or virtual tunnel interfaces. Dual-stack hosts have IPv6 and IPv4 addresses. The result is that IPv6 implementations that need to initiate a connection are often faced with a choice between multiple Source and Destination addresses.

2.4.4 Neighbor Discovery (ND)

Neighbor Discovery (ND) is specified in(Narten, 1998) . The specifications in this RFC relate to different protocols and processes known from IPv4 that have been modified and improved. New functionality has also been added. It combines Address Resolution Protocol (ARP) and ICMP Router Discovery and Redirect. With IPv4, thereis no means to detect whether a neighbor is reachable. With the Neighbor Discovery protocol, a Neighbor Unreachability Detection (NUD) mechanism has been defined. Duplicate IP address detection (DAD) has also been implemented. IPv6 nodes use Neighbor Discovery for the following purposes:

- For auto-configuration of IPv6 addresses
- To determine network prefixes, routes and other configuration information
- For Duplicate IP address detection (DAD)
- To determine layer two addresses of nodes on the same link
- To find neighboring routers that can forward their packets
- To keep track of which neighbors are reachable and which are not (NUD)
- To detect changed link-layer addresses

2.4.5 Router Solicitation and Router Advertisement

Routers send out Router Advertisement messages at regular intervals. Hosts can request Router Advertisements by issuing a Router Solicitation message. This will trigger routers to issue Router Advertisements immediately, outside of the regular interval. The format is shown in fig 2.2.

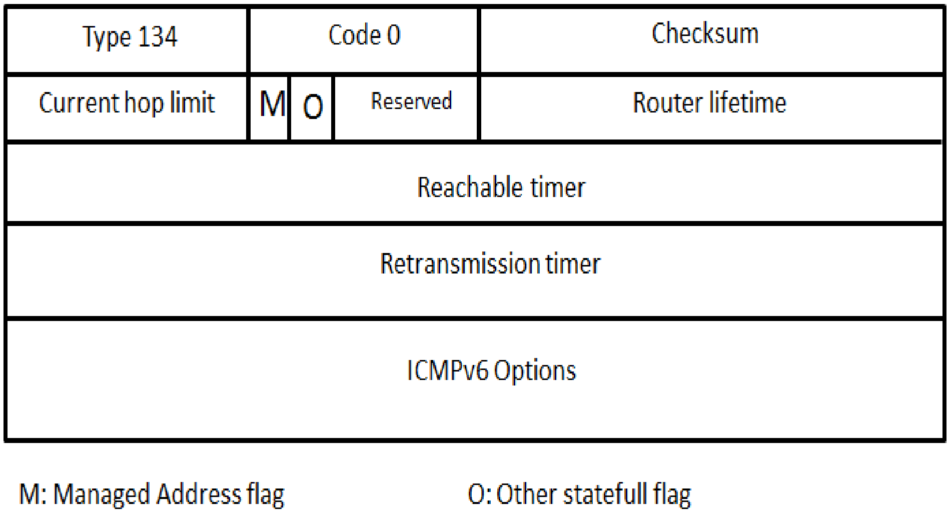


Figure 2.2: ICMPv6 Router Advertisement Message Format

In the IP header of a Router Solicitation message, you will usually see the all-routers multicast address of FF02::2 as a Destination address. The hop limit is set to 255. The ICMP Type field is set to 133, which is the value for the Router Solicitation message. The Code field is unused and set to 0. The following two bytes are used for the Checksum. The next four bytes are unused and reserved for future use. The sender sets them to 0, and the receiver ignores those fields. For a Router Solicitation message, a valid option is the link-layer address of the sending host, if the address of the sending host is known. If the Source address on the IP layer is the unspecified (all-zeros) address, this field is not used. More options may be defined in future versions of ND. If a host cannot recognize an option, it should ignore the option and process the packet.

The next 1-bit field, the M flag, specifies whether statefull configuration is to be used. The statefull configuration refers to what we know as DHCP with IPv4. If this bit is 0, the nodes on this link use Stateless autoconfiguration. If the bit is set to 1, it specifies statefull autoconfiguration. The O-flag configures whether nodes on this link use Statefull configuration other than IP address information. A value of 1 means the nodes on this link use statefull configuration for non-address-related information. The Mobile IPv6 specification (Johnson, 2004) defines the third bit, the home address flag(H-flag). When a router sets the H-flag to 1, it means that it is a home agent for this link. The remaining five bits of this byte are reserved for future use and must be 0.

The Router Lifetime field is important only if this router is to be used as a default router by the nodes on the link. A value of 0 indicates that this router is not a default router and will therefore not appear on the default router list of receiving nodes. Any other value in this field specifies the lifetime, in seconds, associated with this router as a default router. The maximum value is 18.2 hours.

2.4.6 Neighbor Solicitation and Neighbor Advertisement

This pair of messages fulfills two functions: the link-layer address resolution that is handled by ARP in IPv4, and the Neighbor Unreachability Detection mechanism. If the Destination address is a multicast address (usually the solicited node multicast address), the source is resolving a link-layer address. If the source is verifying the reachability of a neighbor, the Destination address is a unicast address. This message type is also used for Duplicate IP Address Detection (DAD).

In the IP header of this message type, the Source address can be either the interface address of the originating host or, in the case of Stateless autoconfiguration and DAD, the unspecified (all-zeros) address. The hop limit is set to 255. The Type field in the ICMP header is set to 135, and the Code field is unused and set to 0. After the two checksum bytes, four unused bytes are reserved and must be set to 0. The target address is used in Neighbor Advertisement and Redirect messages. It must not be a multicast address.

The Options field can contain the link-layer Source address, but only if it is not sent from the all-zeros address. During Stateless autoconfiguration, in a message that uses the unspecified address as a Source address, the Options field is set to 0. The link-layer option must be used in multicast solicitations (link layer address detection) and can be used in unicast solicitations (Unreachability Detection).

Neighbor Advertisement messages are sent as a reply to Neighbor Solicitation messages or to propagate new information quickly. The format of the message is shown in Figure 2.2.

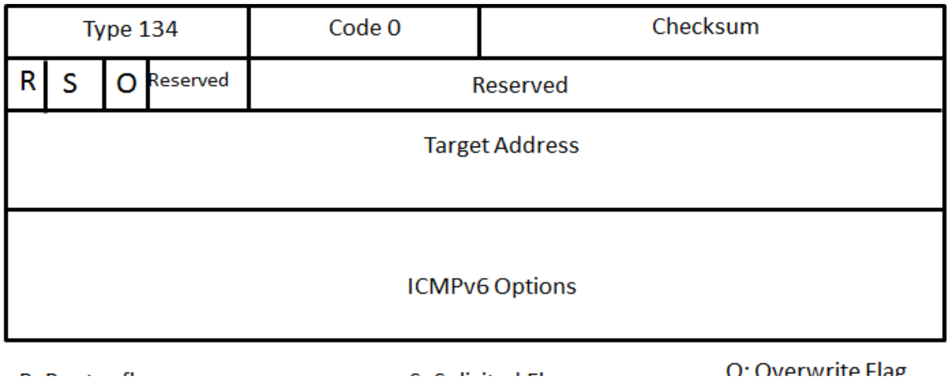


Figure 2.3: Neighbor Advertisement message

2.4.7 The ICMP Redirect Message

Routers issue ICMP Redirect messages to inform a node of a better first-hop node on the path to a given destination. A Redirect message can also inform a node that the destination used is in fact a neighbor on the same link and not a node on a remote subnet. The format of the ICMPv6 Redirect message is shown in Fig.2.3.

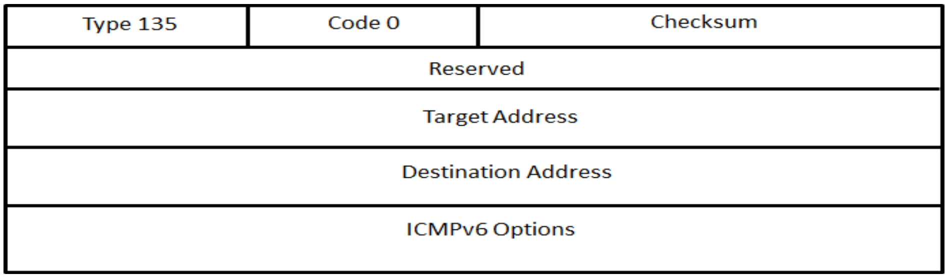


Figure 2.4:ICMPv6 Redirect message

2.4.8 Link-Layer Address Resolution

Link Layer Address Resolutionis the process that happens when a node wants to determine the link-layer address of an interface for which it knows the IP address. With IPv4, this is the functionality of ARP. Link Layer Address Resolution is performed only for nodes that are known to be on the same link (neighbors) and is never performed for multicast addresses.

With IPv6, this is a functionality accomplished with ND messages. A node wanting to resolve a link layer address sends a Neighbor Solicitation message to the solicited node multicast address of the neighbor. This solicitation message contains the link-layer address of the sender in the ND option field. If the destination is reachable, it replies with a Neighbor Advertisement message containing its link-layer address. If the resolving node does not receive an answer within a preconfigured number of attempts, the address resolution has failed.

2.4.9 Neighbor Unreachability Detection (NUD)

A neighbor is considered reachable if the node has recently received a confirmation that packets sent to the neighbor have been received by its IP layer. This confirmation can come in one of two ways: it can be a Neighbor Advertisement in response to a Neighbor Solicitation, or it can be an upper-layer process that indicates the successful connection. In this case, the receipt of TCP acknowledgements implies the reachability of the neighbor.

To keep track of active and reachable connections, IPv6 nodes use different tables. Two important tables relating to ND are the Neighbor and Destination Caches, which will be discussed in the next section.

2.4.10 Neighbor Cache and Destination Cache

IPv6 nodes need to maintain different tables of information. Among these tables, the Neighbor Cache and Destination Cache are particularly important. Depending on the IPv6 stack working with, the implementation and the troubleshooting utilities will be different. But the information must be available on every IPv6 node.

2.4.10.1 Neighbor Cache

The Neighbor Cache maintains a list of neighbors to which traffic has been sent recently. They are listed by their unicast IP addresses, and each entry contains information about the neighbor's link-layer address and a flag that indicates whether the neighbor is a router or host. This can be compared to the ARP cache in an IPv4 node. The entry also contains information about whether there are packets queued to be sent to that destination, information about the neighbor's reachability, and the time the next neighbor unreachability detection event is scheduled to take place.

2.4.10.2 Destination Cache

This table maintains information about destinations to which traffic has been sent recently, including local and remote destinations. The Neighbor Cache can be seen as a subset of Destination Cache information. In case of remote destinations, the entry lists the link-layer address of the next-hop router. The Destination Cache is updated with information received by ICMP Redirect messages. It can also contain additional information about MTU sizes and roundtrip timers.

2.4.11 Autoconfiguration

The autoconfiguration capability of IPv6 saves network administrators a lot of work. It has been designed to ensure that manually configuring hosts before connecting them to the network is not required. Even larger sites with multiple networks and routers should not need a DHCP server to configure hosts. The autoconfiguration features of IPv6 will be a key feature of the protocol when all sorts of devicessuch as televisions, refrigerators, DVD players, and mobile phonesuse IP addresses. These home devices, no need to depend on a DHCP.

An IPv6 address is leased to a node for a certain lifetime. When the lifetime expires, the address becomes invalid. To make sure an address is unique on a link, a node runs the Duplicate Address Detection (DAD) process. The DAD algorithm is defined in (Thomson, 1998). An IPv6 address can have different configuration states:

Stateless and statefull autoconfiguration. Statefull autoconfiguration is what we call DHCP in the IPv4 world. The new with IPv6 is that hosts can autoconfigure their IPv6 addresses without any manual configuration of the host. The second is stateless configuration. In this state no DHCP servers are required for this configuration mechanism.

2.4.12 Routing Protocols

Forwarding an IPv6 datagram beyond a directly attached subnet requires a router. Routers look at the datagram's destination IPv6 address and search for a matching prefix in their local routing tables. The first section of this chapter explains the routing table. It is very important for the router to have all relevant destinations in its routing table. But how do they get there? Entering them manually on all routers would not be very economical. A much more efficient automatic approach can be achieved by deploying routing protocols. Routing protocols define exchange procedures to synchronize the routing table between routers dynamically. Routing information needs to be distributed either within an autonomous system (AS) or between autonomous systems. An AS is defined as a set of networks governed by a single authority. Routing protocols that distribute information within an AS are called Interior Gateway Protocols (IGP). OSPF for IPv6, RIPng, IPv6 support on integrated IS-IS, and EIGRP for IPv6 belong to this category. Protocols that distribute information between ASes are called Exterior Gateway Protocols (EGP). BGP-4 and its extensions for IPv6 represent such a protocol.

2.4.13 Routing Table

Each router maintains a routing table (also known as forwarding table). Each entry represents an IPv6 destination, from now on called an IPv6 route. Each IPv6 route in the table is stored in the form of an IPv6 address prefix and its length. For each IPv6 route, additional information is stored in the routing table. The next hop information, for instance, tells the router where to forward a packet destined for this particular IPv6 route. Another type of information would be the metric of the IPv6 route, allowing the router to select the best path (smallest metric) to each IPv6 route in case of multiple entries.

2.5 MOBILE IPV6

Mobile IPv6 is a protocol that allows a mobile node to move freely from network to another without losing its connections (Johnson, 2004). However, Internet traffic uses TCP connections.A TCP connection is a combination of IP address and port number of the endpoints. If one of these is changed the communication is disrupted and has to be rebuilt. When a mobile node MN connects to a different access point(AP)to the network, itneeds a new IP address. Hence, the Mobile IP addresses the challenge of moving a node to a different connection without changing its IP address by assigning the MNwith two different IP addresses. One of them is the home of address HoA. The second IP address is care-of address CoA. It changes depending on the network to which the node is currently attached.

The objective of developments of Mobile IP is to continue connectivity to IP networks without changing its IP address. It remains reachability whilethe mobile Node moves through different networks infrastructures. Mobile IP gives the nodes freedom to move from its home network to the foreign networks and keep connectivity while Care-of address (CoA) informs about their current locations(Abdalla Hashim, 2012) (Tsai, n.d.). The Mobile nodes (MNs) uses two IP address, home of address (HoA) and Care of Address (CoA).These addresses are used toenable MNs to be roamingwhile still connected to its home network. In Mobile IPv4 (MIPv4), when roaming service enable, the mobile node (MN) gets and assigned its CoA form the Foreign Agent (FA), However, Mobile IPv6 (MIPv6) Aguirre the CoA in different mechanism.In roaming The MN communicates via Access Router (AR) to obtain its CoA (Abdalla Hashim, 2012). However in wireless, handover is performed in link layer while terminal move between different access points. While this issues has been solved in network layer for MIPv6 (Abdalla Hashim, 2012).

2.5.1 Mobile IPv6 Terms and definitions

Here are some definition that are used in MIPv6.

Home of address (HoA): A global unicast address given to a MN. It is permanent address used when the MN in its home link. In normal routing process the packets is delivered to the HoA of the MN.

Home Network prefix (HNP): The IP subnet network prefixes equivalent to a MN HoA.

Home link (HL): The link on which a MNHNP is defined.

Mobile Node (MN): A node which changes its point of attachment from one network link to another while maintain reachability through its HoA.

Correspondent Node (CN): It’s a mobile or stationary device in peer communication with MN.

Foreign Network Prefix (FNP): Its IP subnet network prefix different than the MN HNP.

Foreign Link (FL): A link different than the MN home link.

Care-of address (CoA): A global unicast address givento the MN while it is away from home (in foreign network). MN my usesseveral care-of addresses. The CoAthat registered with its HA is called the primary CoA.

Home Agent (HA): It is a router that resides in a MN home link and the MN register its CoA with it. HA intercepts any packets sent to MN home address.Then HA encapsulates the packets(uses IPv6-in-IPv6) and tunnels them to the MN registered CoAs.

Binding: The association of the HoAwith CoA of a mobile node, in addition to the remaining lifetime.

Registration: The process of sending Binding Update from the MN to its HA or a CN, performing a binding for the MN to be registered in HA or CN. The registration with the CN is nameda Correspondent Registration.

Binding authorization: A registration with a CN needs to be authorized to permit the receiver to confirm that the sender has the right to identify a new binding.

Return routability procedure: A process that authorizes registrations by the use of a cryptographic token exchange.

Keygen token: A number supplied by a CN in the return routability procedure to enable the MN to compute the necessary binding management key for authorizing a Binding Update.

Nonce: Random numbers used internally by the correspondent node in the creation of keygen tokens related to the return routability procedure. The nonces are not specific to a mobile node and are kept secret within the correspondent node.

Nonce index: Used to indicate which nonces have been used when creating keygen token values without revealing the nonces themselves.

2.5.2 How Mobile IPv6 Works

Fig.2.4 shows the components of MIPv6 and how they interact.

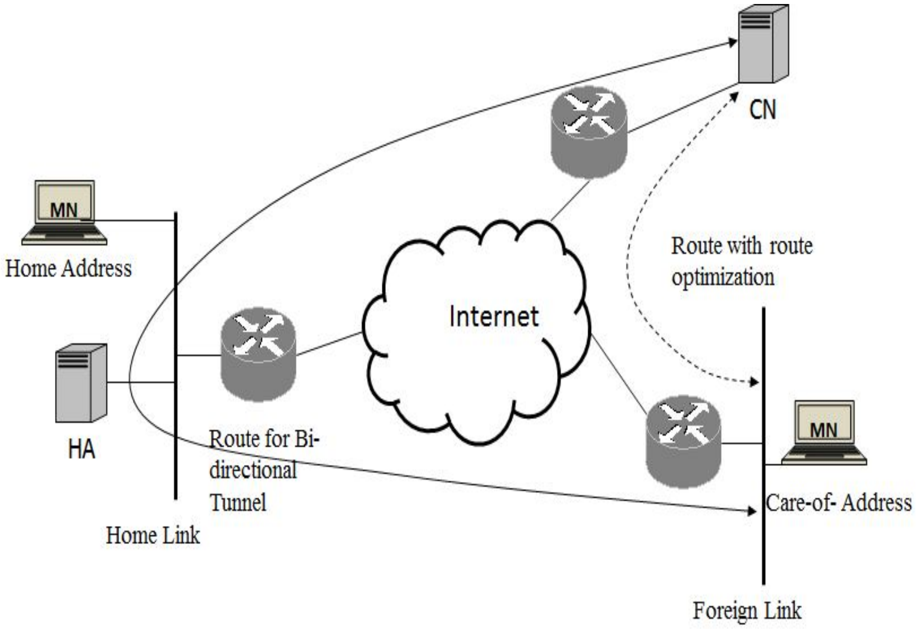


Figure 2.5: Components of Mobile IPv6

The home address is the IPv6 address within the home link prefix of a MN. As long as the MN is at home, it receives packets through regular IP routing mechanisms and works like any other regular IP host. When the MN is away from home, it has an additional CoA. The CoA is created through regular IPv6 mechanisms such as Stateless autoconfiguration or statefull when connecting to the new link.

The association of a home address and a CoA is called a binding. While the MN away from home, the MN registers its CoA with a router on its home link, which called home agent (HA). To register its CoA, the MN sends a binding update (BA) message to the HA. However, The HA responds with a binding BA. Every node communicating with a MN is called a correspondent node (CN). Mobile nodes can also send registrations to the CN directly (called a correspondent registration). A CN can also be a MN.

However, there are two communicationsway for a CN and a MN:

2.5.2.1 Bidirectional Tunneling

In this way Packets from the CN are sent to the HA, the HA encapsulates them in IPv6 packet and sends them to the CoA of the MN. Packets from the MN are sent through the reverse tunnel to the HA that forwards them to the CN through regular routing mechanisms. This mode does not require any MIPv6 support on the CN and works without correspondent registration.

2.5.2.2 Route Optimization

The communication between MN and CN can be direct. Hence, RO requires correspondent registration. The CN uses a special routing header called type 2 when it delivers packets to the MN directly.This mechanism takes advantages of MIPv6 over Mobile IPv4. The main improvement of route optimization is that the directpath between CN and MN. This process can reduces the load on the HA and the home link. This process has high effect if there are many MNs moving together and accessing a real time servicelike Voice over IP or video applications.

MIPv6can supports multiple home agents, and the MN can studythe reconfiguration of its home link or a modify of IP address of its HA through Dynamic Home Agent Address Discovery (DHAAD) mechanism. When the prefix of its home link change, the MN uses the Mobile Prefix Discovery (MPD) mechanism to study about the new prefix.

The following sections describe the protocol and new messages, options, and flags in more detail.

2.5.3 The Mobile IPv6 Protocol Components

This section describes the components, messages, and options for Mobile IPv6.

2.5.3.1 Mobility Header and Mobility Messages

The Mobility Header (MH) has been defined for Mobile IPv6. It is an Extension header used by MN, CN, and home agent. It is used in all messages that are related to establishing and maintaining bindings.A Mobility Header is specified by the Next Header value 135 in the preceding header and has the format shown in Fig.2.5.

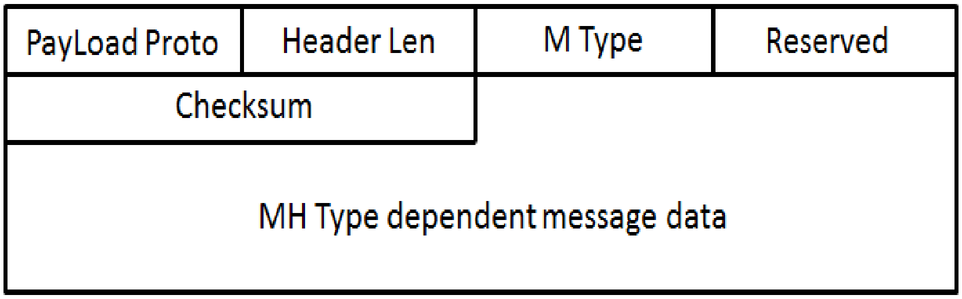


Figure 2.6: IPv6 Mobility Header

The Payload Proto field corresponds to the Next Header field and identifies the following header. It can therefore contain the same values. The current specification sets the value in this field to 59 decimal, which means "no next header". It is designed to be used for future extensions. The Header Length field contains the length of the Mobility header in 8-byte units. The first 8 bytes are not counted. The length of the Mobility header is always a multiple of 8 bytes. The Checksum field contains the checksum for the Mobility header. It is calculated based on a pseudoheader and follows the rules defined in (Deering, 1998). The addresses used in the pseudoheader are the source and destination address in the IPv6 header. If the Mobility message contains a Home Address Destination option, the home address is used for the calculation of the checksum. The MH Type field identifies the type of Mobility message. The messages defined are listed in Table 2.1. The Data field is variable; it depends on the type of message.

Table 2.1: Mobility messages

Value	**Message type**	**Description**
0	Binding Refresh Request	Sent by CN requesting the MN to update its binding.
1	Home Test Init	Sent by the MN to initiate the Return Routability Procedure and request a Home Keygen token from a CN. Sent to the CN through the tunnel via HA.
2	Care-of Test Init	Sent by the MN to initiate the Return Routability Procedure and request a Keygen token from a CN. Sent to the CN directly.
3	Home Test Message	Response to a Home Test Init message (type 1). Sent from the CN to MN. Contains a cookie and a Home Keygen token for the authorization in the Return Routability Process. Sent through the

Value	**Message type**	**Description**
		tunnel via HA.
4	Care-of Test Message	Response to Care-of Test Init message (type 2). Sent from CN to MN. Contains cookie and a Care-of Keygen token for the authorization in the Return Routability Procedure. Sent to the MN directly.
5	Binding Update	Sent by MN to notify a change of its care-of address.
6	Binding Ack	Sent as acknowledgement for receipt of a Binding Update message.
7	Binding Error	Sent by CN to signal an error related to mobility, such as an inappropriate attempt to use the Home Address destination option without an existing binding. The status field can have the following values: 1 = unknown binding for Home Address Destination option 2 = unrecognized MH type value
8	Fast Binding Update	Identical to binding update message, only with slightly different processing rules.
9	Fast Binding Ack	Sent as acknowledgement for receipt of a Fast Binding Update message.
10	Fast Neighbor Advertisement	Sent by MN to announce itself to its new access router.

Values 8, 9, and 10 have been assigned in (Koodli, 2005).

2.5.3.2 The Binding Update Message (BU)

The Binding Update message is used by the MN to inform the home agent or a CN about a new care-of address. The message is also used to extend the lifetime of an existing binding.

The Binding Update message is of MH type 5 and has the format shown in fig.2.6.

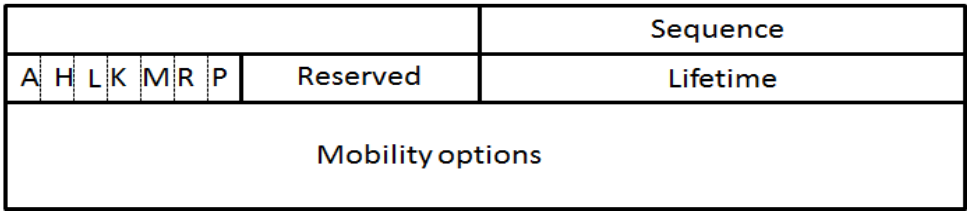


Figure 2.7: Binding Update Message

Sequence Number (2 byte field): It is used for sequencing control to control binding updates and acknowledgements.

5 bits (A, H, L, K, and M): A Acknowledge bit.

: H Home registration bit.

: L Link local address capability bit.

: K Key management’s mobility capability.

: M Map registration.

Reserved (11 bit) : Future used.

Lifetime (2 byte) : Remaining time in which binding is valid (one time unit= 4 second).

0 time = binding expired.

Options (variable) : Binding authorization data option

Nonce indices option, alternative Care-of-Address option

The Sequence Number is used by the receiving node for sequencing Binding Updates. The sending node uses it to verify whether the Binding Acknowledgements received correspond to its Binding Updates. The Acknowledge bit (A-bit) is set by the MN if it expects an acknowledgement in answer to its Binding Update. The Home Registration bit (H-bit) is set by the MN to request the receiver to act as home agent for this node. This is possible only if the receiver is on the home link of the MN. The Link-Local Address Compatibility bit (L-bit) is set if the home address has the same Interface Identifier as the link-local address of the MN. The Key Management Mobility Capability bit (K-bit) is valid only in Binding Updates sent to the home agent. IPsec Security Associations should survive the move of the MN to another network. If that is the case, the K-bit is set. If that is not possible, the K-bit is set to 0. Correspondent nodes ignore the K-bit. The Lifetime shown in four-second units for how long the binding for the care-of address is valid. If the Lifetime is set to 0, the receiver must delete the entry in its Binding Cache. In this case, the MN must be on its home link, and the CoA is the same as the HoA.

The M-bit shown in fig2.6 has additionally been created to identify Local Binding Updates sent to a local Home Agent called a Mobility Anchor Point (MAP). This new node is used to improve Mobile IPv6 handover performance, to obtain efficient routing between the MN and correspondent nodes within the same geographical area, and to achieve location privacy. The mechanism is defined in (Soliman, 2005). When the M-bit is set, the H-bit cannot be set and vice versa.

A Binding Update can have the following options:

- Binding Authorization Data option (this option is mandatory in Binding Updates sent to a CN)
- Nonce Indices option
- Alternate Care-of Address option

2.5.3.3 The Binding Acknowledgement (BA)

The BA is sent to confirm receipt of a Binding Update (BU). It has to be sent if the A-bit is set in the BU. If the A-bit is not set (which means the sender of the Binding Update does not require an acknowledgment), the BA is sent only if there is a problem in the BU. If the receiver accepts the BU and the A-bit was not set, no acknowledgment is sent.

A Binding Acknowledgement can have the following options:

a) Binding Authorization Data option (this option is mandatory in Binding Acknowledgements sent by a CN)
b) Binding Refresh Advice option

2.5.3.4 Mobility Options

A mobility message can contain zero, one, or more options. These options are included in the variable data field of the mobility header.

The presence of options is indicated in the header length field of the mobility header. They have the known TLV format (Type 1 Byte, Length 1 Byte, Value variable).

With the exception of the Binding Authorization Data option, these options can appear in arbitrary order. The Home Address option is an exception, as it is carried in a Destination Options header and not in the Mobility Header (MH).

In (Patel, 2005), extends the original specification to allow MIPv6 nodes (HA, CN, MN) to use identifiers other than an IP address. It defines an option with a subtype number to specify the identifier type. The identifier type can be a Network Access Identifier (NAI)in (Aboba, 2005), an International Mobile Station Identifier (IMSI), or an application/deployment specific opaque identifier.

2.5.3.5 Routing Header Type 2

A new Routing header has been defined for Mobile IPv6. This Extension header allows the data exchange between the CoA of a MN and a CN without being routed through the home agent.

In addition to the Type 0 Routing Extension header is detailed in (Johnson, 2004). It allows, among other things, the configuration of specific rules for Mobile IPv6 packets on firewalls.

When a CN sends an IPv6 datagram to a MN using route optimization, the Destination Address field in the IPv6 header contains the CoA of the MN. The Routing Header Type 2 inserted contains the HoA of the MN. The Routing Header Type 2 can only contain one unicast address. IPv6 nodes that process these Routing headers must verify that the IPv6 address contained corresponds to the home address of the MN.

The Header Extension Length field has the value 2; this header does not have a variable length, as it only contains one address. In the Routing Type field, the value 2 is indicated, and the Segments Left field is set to 1 for one address. The Home Address field carries the HoA of the MN.

If an IPv6 datagram carries two Routing Headers, the Type 0 routing header must be first, followed by the Type 2 routing header.

2.5.3.6 ICMPv6 and Mobile IPv6

This section describes ICMPv6 message.

2.5.6..1 *Home Agent Address Discovery (HAAD)*

The Home Agent Address Discovery mechanism is used by the MN to determine the address of its HA on its home link. There are two ICMPv6 message pairs and the home agents list, which is a list to be maintained by each home agent.

2.5.6..2 *ICMPv6 Home Agent Address Discovery messages*

This message pair consists of a Home Agent Address Discovery Request and Reply message. As the name implies, the MN uses these messages to find its home agent on the home link dynamically. Normally mobile nodes are configured statically with a home agent address. In the case where a home agent is renumbered or goes down and is replaced by another home agent with a different IP address, dynamic discovery of the home agent address may be a useful mechanism.

The MN sends a Discovery message to the Home Agent Anycast address (Anycast ID decimal 126, hexadecimal 0x7E) on its home link. The Source address field in the IPv6 header carries the care-of address of the MN.

The home agents on the home link that are configured for the Home Agent Anycast address respond with a HAAD Reply message.

The Discovery message has a type value of 150; the Reply message has a type value of 151. The Code field is always set to 0. The Identifier field is inserted by the MN and copied over by the home agent for the Reply. This allows identifying corresponding messages. The Reply carries a Home Address field, which can carry one or more home agent addresses. This address or list of addresses is generated from the home agents list.

2.5.6..3 *Home agents list*

Every home agent needs to maintain a home agents list. In this list, every router must be listed that sits on the same link and provides home agent services. A router advertises itself as a home agent by setting the H-bit in the Router Advertisement. A router maintains a home agents list for each link on which it acts as a home agent. The list is updated through Router Advertisements and contains the following information:

1. Link-local address of the HAs on the link. This address is learned from the Source address field in the IPv6 header of Router Advertisements.
2. One or more global IPv6 unicast addresses for these HAs. These addresses are learned from the Prefix Option in the Router Advertisements.
3. Remaining lifetime for this HA entry. When the lifetime expires, the HA has to be deleted from the list.
4. Preference for this HA. A higher value means higher preference. This value is learned from the Home Agent Preference field in the Home Agent Information option in a Router Advertisement (if present). If not present, this value is set to 0. A HA uses this preference to sort the HA list when sending out an Home Agent Address Discovery Reply message.

The HA sending out a Home Agent Address Discovery Reply must list all HAs on the link, sorted by preference. Only the global IPv6 unicast addresses of the home agents are contained in the home agent address field of the home agent address discovery reply message. The reply must not be larger than 1280 bytes. Sorting by preference ensures that HAs with a high priority are listed in this packet.

2.5.4 Mobile IPv6 Communication process

This section discusses Mobile IPv6 terms and goes into more details on the communication processes.

2.5.4.1 Binding Cache

Every correspondent node and home agent maintains a Binding Cache for each of its global IPv6 addresses. It lists all mobile nodes for which it has a binding. If it wants to send data to a certain destination, it first searches its Binding Cache, and after this, the Destination Cache for an address.

A Binding Cache entry carries the following information:

1. Home address of the mobile node for the entry. This field is the key to determining the destination address when sending a packet.

2. Care-of address for the mobile node indicated by the Home Address field in this binding cache entry.
3. Lifetime value for the binding.
4. A flag indicating whether this entry is a home registration entry. Present only on a node that acts as a home agent.
5. Maximum value of the Sequence Number field of all previous Binding Updates received for this home address.
6. Information on the use of this entry.

2.5.4.2 Binding Update List

Every mobile node maintains a Binding Update List. The list has an entry for each Binding Update the mobile node has sent to its home agent(s) and to correspondent nodes for which the lifetime has not expired. If it has sent more than one Binding Update, only the last message with the highest Sequence number is listed.

A Binding Update List carries the following information:

1. IPv6 address of the node to which the Binding Update has been sent
2. Home address for which the Binding Update has been sent
3. Care-of address that was indicated in this Binding Update
4. Lifetime that was indicated in the Binding Update
5. Remaining lifetime for the Binding
6. Highest used Sequence number for this Binding
7. Time when Binding Update was sent
8. State of any retransmissions needed
9. A flag indicating whether further Binding Updates have to be sent to this destination

2.5.5 Home Agent Operation (HAO)

When the MN is away from home, the HA must intercept all packets destined to the MN and tunnel them to the CoA of the MN. It uses Proxy Neighbor Discovery to do this process.

2.5.6 Proxy Neighbor Discovery (PND)

In order to intercept packets destined to the MN on the home link, the HA must pretend to be the MN. The HA sends Neighbor Advertisements to the All-nodes Multicast address, providing its own link-layer address as link-layer address for the home address of the MN. The ND message has the following information:

1. The Source address in the IPv6 header of the Neighbor Advertisement is the address of the HA.
2. The Target Address field in the ND message carries the IPv6 address of the MN.
3. The ND Advertisement contains a Target Link-layer Address option carrying the link-layer address of the HA.
4. The Router Flag (R-flag) must be set to 0.
5. The Override Flag (O-flag) must be set. All nodes on the link will update their Neighbor Caches and store the link-layer address.

The HA receives all packets on this link that are destined to the IPv6 address of the MN. The HA acts as a proxy for the MN. It must inspect all Neighbor Solicitations it receives and verify whether the Target Address field corresponds to a Home Registration entry in its Binding Cache. If so, it replies with a Neighbor Advertisement indicating its own link-layer address as the link-layer address for the MN.

2.5.7 Bidirectional Tunneling (BT)

To forward packets destined to the home address of the MN, the HA uses an IPv6 tunnel. It inserts an additional IPv6 header called the Tunnel header. The Source address in the Tunnel header is the IPv6 address of the HA. The destination address is the primary CoA of the MN. The MN processes the Tunnel header and forwards the decapsulated packet internally to the upper-layer protocols and applications.

In order to receive multicast packets when away from home, the MN must register for these group memberships. There are two ways to complete this:

1. The MN can register with local routers on the Home Link using its CoA. In this case, it can receive multicast packets directly. These

memberships will not survive if the MN moves to another foreign network.

2. The MN can register for multicast group memberships on its Home Link by sending MLD registrations to its HA, which in turn will forward multicast packets to the MN using the tunnel. This will always work no matter how many times the MN changes the network.

The following packets are not forwarded to the MN:

1. Packets sent to the link-layer address of the MN. These packets are answered with an ICMPv6 Destination Unreachable message.
2. Packets sent to the site-local address of the MN.
3. Multicast packets sent to a link-local, site-local, or organization-local scope.

Packets sent through the Reverse Tunnel from the MN to the HA are decapsulated by the HA and forwarded to their destinations through regular routing mechanisms.

When the HA itself sends data to the MN, it behaves like a regular CN, which means it does not use the tunnel, but inserts a Routing Header type 2, which carries the Home Address of the MN.

2.5.8 Mobile Node Operation (MNO)

When the MN is at home, no needs for Mobile IPv6 mechanisms. If the MN is away from home, it uses its HoA as well as its CoA. For each communication, it must choose which address to use. Applications and processes above the IP layer usually communicate using the HoA of the MN.

If a communication has to support a change of the MN to another network, the HoA must be used. As soon as the MN has a communication with a CN for which there is a Binding, the communication can be routed directly. If there is no Binding, all data will be tunneled through the home agent. For certain communications, the MN can also choose to use its CoA without Mobile IPv6 functionality, just as a regular unicast address. When the MN communicates with local nodes in a foreign networkit should communicate directly and not use the Home Address Destination option.

The choice of the best communication path and the corresponding address depends on the requirements of the application, and that is where the choice has to be made.

2.5.9 Communication with Bidirectional Tunneling (CBT)

If the MN wants to communicate with a CN for which it does not have a Binding, it uses the Reverse Tunneling mechanism. In this case, the packet is sent through the tunnel via the HA. The Source address in the original packet carries the HoA of the MN and the correspondent node's address as a destination address. This packet is encapsulated in another IPv6 header carrying the CoA of the MN in the Source address field and the IPv6 address of the home agent in the Destination address field. The HA processes the first header and forwards the original packet to the CN. Fig.2.7 shows the header information.

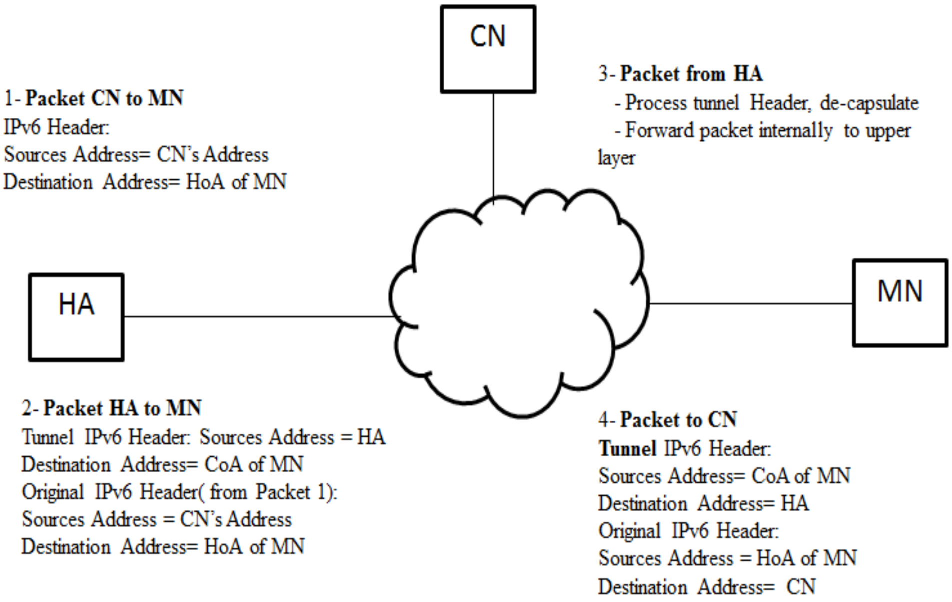


Figure 2.8: Header information with Bidirectional Tunneling

2.5.10 Movement Detection (MD)

Movement Detection is the mechanism used by MN to detect that it has moved to another network. The MD is based on the process of Neighbor Unreachability Detection (NUD). Using NUD, the MN detects when its default router is no longer available. In this case, the MN tries to find a new default router. It performs Duplicate

Address Detection (DAD) for its link-local addresses, chooses a new default router based on the Router Advertisements, and builds new CoA based on the Router prefixes advertised. When the new addresses are initialized, it performs a BU with its home agent first and then with all correspondent nodes for which it has Bindings.

Procedures have to be defined to prevent an MN from unnecessarily updating all Bindings when it has not moved to another network. The following procedures have been defined so far:

1. If the MN receives RAs from new routers with new prefixes but its default router is still reachable, it will not perform any Binding Updates. It uses NUD to detect whether its default router is still available.
2. RAs can carry an Advertisement Interval Option. This allows the MN to detect whether this router is still available based on the comparison of the interval in different RAs.
3. If the default router does not reply to a Neighbor Solicitation, the MN should perform a Multicast Router Solicitation.

2.5.11 Returning Home (RH)

When the MN detects that it is back on its home link, it sends a Binding Update to the home agent to inform it that it is back home and that the HA no longer needs to forward packets through the tunnel.

This Home Registration looks as follows:

1. The A-bit (Acknowledge) and the H-bit (Home Registration) must be set.
2. The Lifetime field is set to 0.
3. The care-of address must be the same as the home address.
4. The Source address in the IPv6 header must be the home address of the MN.

2.6 Mobility Managements

Since the creation of Internet, protocol (IP) 80s without care of mobility management (MM) in mind. For this IP address is used only for locator to determine the destination address, by mean of route. Second is an Identifier that uses TCP to identify the communication end. In MM, this concept is so far different. However, the IP address of mobile node (MN) never change, but the location of MN in respect to IP address change any time MN changes its access connection. Besides, mobility management it has been classified into two Types. The host mobility and network mobility management. In the following, different mobility management schemes are studied with deep focus on their strengths and limitations.

2.6.1 Host Mobility Management

Host mobility management is the method by which the mobility of every mobile node (MN) is managed independently. However, the host mobility is not sufficient for true mobility due to handoff latency and exchange of messages between MN and home agent (HA). In addition to this, host mobility enhanced in different schema to improve the performance of MNs by mean of localized mobility domain(LMD), in which the home agent is closer to MN to get faster signal exchange (Koodli, 2005) (Gundavelli, 2008). In order to achieve seamless mobility, mobility managements are considered as very important. The MIPv6 was proposed and standardized by IETF. MIPv6 introduced to improve the host mobility management. But, it faces different problems when mobile nodes move between different network infrastructures.

2.6.1.1 Fast Handovers for MIPv6 (FMIPv6)

FMIPv6 reduces the handover latency and packet loss during handover of MN through providing all necessary information aboutthe next AR from Layer 3 handover before going to the part of its subnet. Besides these, the FMIPv6 gives the flexibility to buffer all the packets destined to MN during the handover process by setting up a temporary tunnel between Previous Access Router (PAR) and New Access Router (NAR) to forward packets to the new location. Fig.2.12 shows the scenario of fast handover operation.

When the MN discovers high signal strength form near an access point, the MN sends a proxy Router solicitation (RtSolPro) to its PAR request information for a possible handover to NAR. Then PAR replays with proxy router advertisement (ProRtRa) to MN. Then MN constructs tentative new CoA (NCoA) and performs DAD to NCoA. After finishing DAD, the MN sendsa Fast Binding Update (FBA) to PAR to initiate Bi-directional tunnel, after binding NCoA and PCoA. The limitation of this schema is discovering the next candidate AR and the process of DAD to get NcoA (Koodli, 2005).

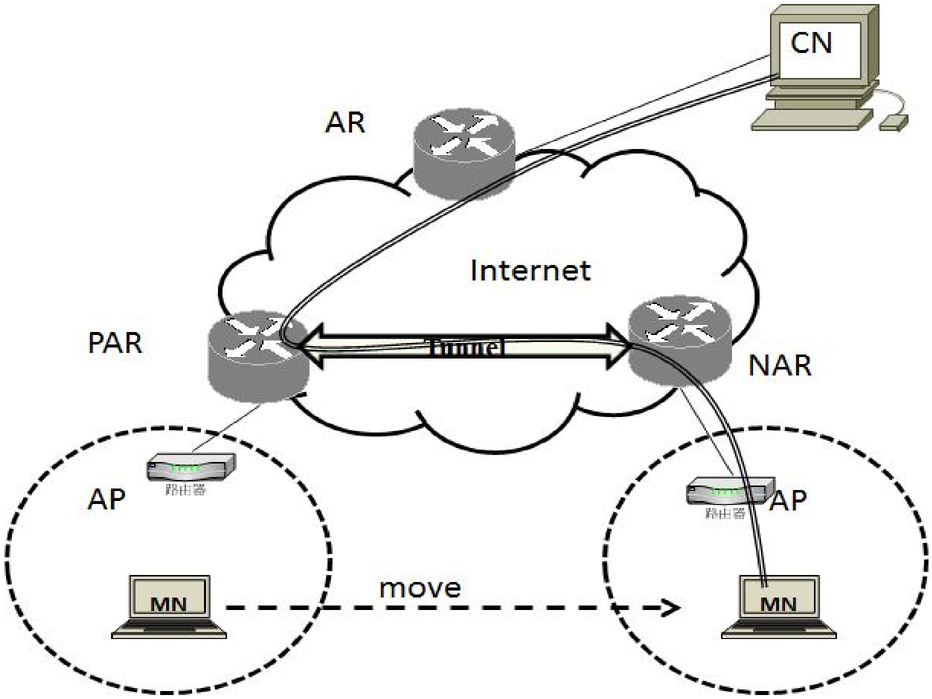


Figure 2.9: Fast handover operation

The host mobility management suffers from many issues to support seamless mobility for mobile node. However all MNs participate in mobility function when changes its point of attachment and do BU to update their routing status in home agent. In addition to authorization in signaling and routing updates.

2.6.1.2 Proxy Mobile ProtocolIPv6 (PMIPv6):

To solve host mobility problems Network Localized Mobility Management (NetLMM) is proposed. NetLMM protocol is used to reduce cost of equipment supporting technology and network management, In addition to easier integration and extenuation to other networks. However, PMIPv6 protocol is standardized by IETF design to perform mobility managements on behalf of the mobile node, without requiring its participation in any related IP-mobility function, In addition to related security functions.

PMIPv6 extends the signaling of MIPv6 and introduces new elements known as Local Mobility Anchor (LMA) and Mobile Access Gateway (MAG). The LMA behaves like the HA inMIPv6 domain and it introduces other capabilities required for Network-based mobility management (Gundavelli, 2008).PMIPv6 supports MN within a topological localized domain by utilizing the MAG entity. MAG exchange a few messages with the access routersand handles mobility signaling on behalf of the MN.

The functional elements in thenetwork architecture of PMIPv6 is shown in Fig.2.10include the following:

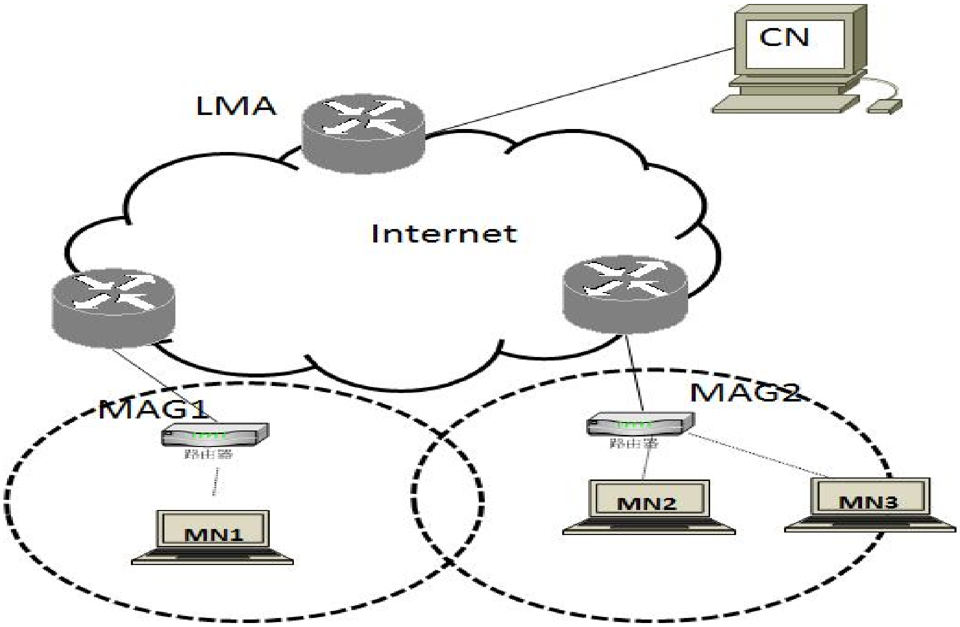


Figure 2.10: Network Entities in Proxy Mobile

- Mobile Access Gateway (MAG): when MNs are attached to another access link, the MAG that is generally the first AR performs the mobility-related signaling on behalf MNs. In addition it is in charge for track the movements of the MN in the LMD, which it has a multiple MAGs.

- Local Mobility Anchor (LMA): it maintains a collection of paths for each MN associated to the LMD. Messages delivered to or from the MN are forward through tunnels between the LMA and the related MAG. In LMD the LMA is a topological anchor point for the addresses assign to MNs.

2.5.6..4 *Operation of PMIPv6*

When the MNmoves to a PMIPv6 domain as shown in Fig.2.11, MN sends RS to MAG1. MAG1 check itsauthorized to use network-based mobility management service and then process mobility signaling on behalf of the Mobile Node. LMA allocates a prefix to MN after MAG sending proxy binding update (PBU) to LMA and receive a proxy binding Acknowledgement. In addition to this MAG send a deregistration BU to LMA to delete binding cache entry (BCE) in pervious MAG.Upon receiving BA the MN detects it had moved to MAG. MAG send proxy BU message to LMA. When MAG receive proxy binding acknowledgement (PBA) from LMA, it creates a bi-directional tunnel between the LMA and MAG. However, MAG made mobility of MN transparent by updating the location of the mobile node to LMA using RA with it is MN-IP(Gundavelli, 2008).

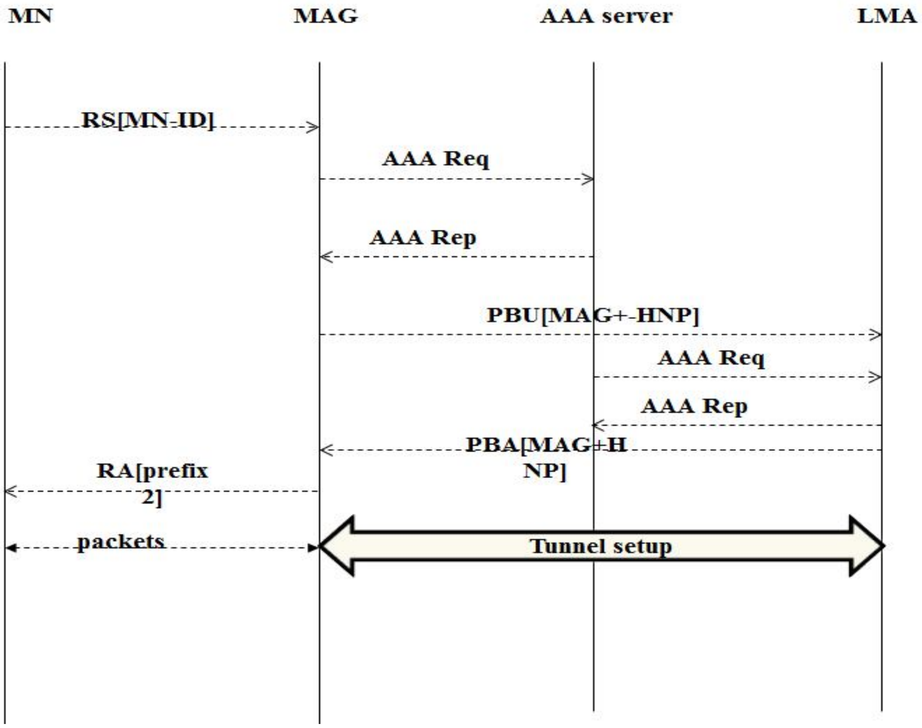


Figure 2.11: Signal Diagram Handover for old MAG

However, the limitation of PMIPv6 is that the Mobile access gateways use a fixed link-local address. In addition, the LMA generate a fixed link-layer address to be used by MAGs with specific MN through PMIPv6 signaling messages in (Gundavelli, 2012).

To address these limitations Kheyaproposed an efficient handover scheme within a PMIPv6 domain in the WiMAX network (Kheya Banerjee1, 2011). The analysis was done by NS-2. Then examined proposed handover scheme delay to general PMIPV6. The evaluated resultsof the schema Reduces handover latency by eliminating the need of a Policy Server (PS) and Pre-registration of the mobile node for a new access point. Fig.2.12 illustrates the handover schema scenario.

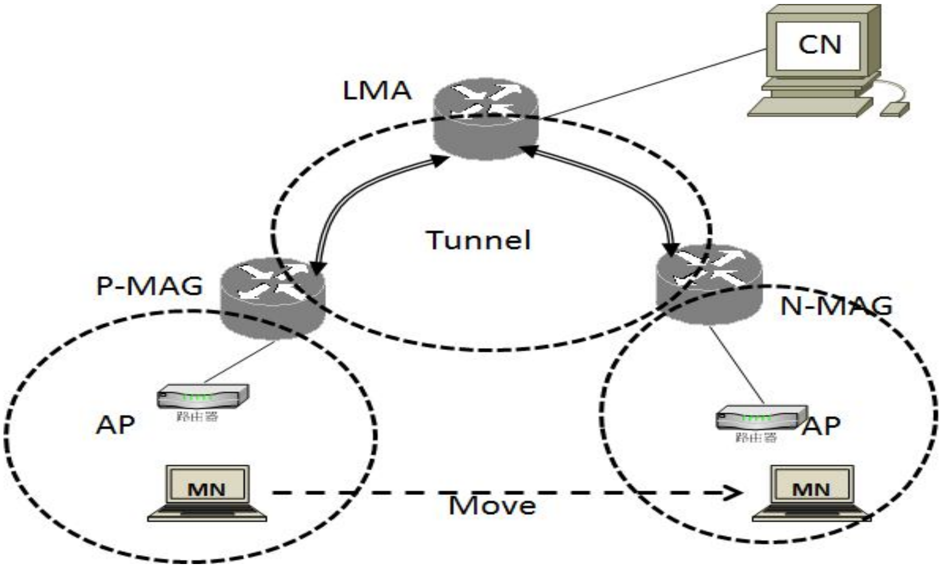


Figure 2.12: PMIPv6 Handover Procedure

2.6.1.3 Hierarchical Mobile (HMIPv6)

HMIPv6 improve MIPv6 protocol by introducing MAP in inter-domain movement, when the MN moves to new inter-domain it receivesa router advertisement from local maps. The MN binds its current CoA with a Regional-CoA address (RCoA) of the MAP. The MAP function same as MIPv4 home agent.The MAP receives all packets send to the mobile node and then encapsulates and forward them directly to the mobile node's existing address. If the mobile node changes its existing address Local-CoA (LCoA) inthe inter-domain it only needs to register the new address with the MAP (Dart, 2012) (Kempf, 2004). For this the registrationof the Regional CoA (RCoA) with correspondent nodes and the HA is needed(Dart, 2012). However, registering Regional CoA (RCoA) with correspondent nodes add additional message for BU and BA when MN move.To enhance this theypredicta handover before the MN move from inter-domain to another inter-domain. While pre-requesting router solicitation from neighbor access router in inter-domain, the AR replies with a router advertisement (RA) that provides for the MN information about the neighboring AR so that the MN can generate a tentative new CoA. When a mobile node Enter a new domain, it is need to agree with the previous registration of CoA by sending BU.Then tunnel configured to send packets destined to the MN from the old CoA. However, the RCoA does not change since the MN moves within a MAP domain. This makes the mobile node's mobility transparent to correspondent nodes that communicate with it. In addition, the inter-domain's boundaries are defined by the Access Routers (ARs) advertising the MAP information to the attached mobile nodes (Dart, 2012). However, for mobility management the MAP gain longer signaling delay and single point of failure due to network operation load.

Aisha Hassan, and Nazreen they proposed a method for setting the MAP in the center of the inter-domain (Zohra Slimane, 2012). The advantage of this method is to reduce the distance to be shorter for minimizing the delay. When other researchers increase the distance of the MAP this lead to longer delay. However, the limitation of this schema the queues delay gain from access routers with MAP (Kheya Banerjee1, 2011).To solve these problem a MAP Distributions traffic between all MAPs in current inter-Domain is proposed.

While Patil proposed method of integrating Fast Mobile IPv6 and HMIPv6 with their limitation as described above to effective in Hierarchical Mobil IPv6 (Islam, et al., 2012) . The advantage of this integration is to minimize the hand-over time to signal the MAP and reducing packet loss. However still long delay in MAP and seamless handover for correspondent node to home agents. We supposed to solve this using buffer form old access tracking (Kheya Banerjee1, 2011)..

Daeseon Park ,used an efficient buffering scheme to afford continuous services with buffered data backup mechanism for deliver the data .the advantage is to reduce the inter-domain HO delay connecting different PMIPv6 domains (Kheya Banerjee1, 2011). The main advantages of these methods are Reduce inter-domain handover delay and the enhancement of seamless services.

Table 2.2: Comparison of host mobility managements Schemes

Category	Approach	Strengths	Limitations
C. Perkins	MIPv6	Used route optimization, To Reduce packets loss	High latency due to a handover in real-time applications 1.5 RT(BU&BA)
J. Kempf and R. Koodli	FMIPv6	low latency for handover, by utilizing information from layer 2	High registration time
H. Soliman & C.Castelluccia	HMIPv6	reduces the signaling traffic of BA by using MAP	High delay in intra-domain & Bottleneck for MAP
HeeYoung Jung, ETRI Hesham Soliman, Flarion-draft	FHMIPV6	improves the handover latency and packet loss	Still packets lost in DAD
Aisha Hassan Abdalla Hashim, Fauzana Ridzuan, and Nazreen Rusli	Evaluation of Handover Latency in Intra- Domain Mobility	Reduce the delay for short distance	queues delay from AR with MAP
Dipali P. Patil and G. A. Patil	Integration of FMIPv6 in HMIPv6 to Improve Handover Performance	Improve packet loss and hand-over delay.	long delay in MAP & seamless handover for CN to home agents
Daeseon	PMIPv6-based Inter-Domain Handover using Efficient Buffering Scheme	Reduce inter-domain handover delay and the enhancement of seamless services	Still delay in MAP no location privacy.

2.6.1.4 Summary of Host Mobility Management's Schemes

Referring to table.2.2, In MIPv6 the MN must send a Binding Update message to its HA and CN while attachingtodifferent networks(Dart, 2012) (Yan, 2010). If HA or CN isset at far distance from form each other. MN can face update latency while changing network attachment frequently. To reduce the latency of binding update, MNintroduces localized movement to mobility management to solve this problem.Hierarchical Mobile IPv6 (HMIPv6) is one of the solution for this approach.

The HMIPv6 protocol involves the following phases (Yan, 2010): MAP discovery, MAP registration, and packet forwarding. However, When MN moves from one MAP's domain to another MAP's domain i.e. for Inter-domain mobility it is again inefficient. It faces higher handover latency and packet loss which decreases its overall performance. However HMIPv6 reduces the Binding Update message cost to network but if the size of MAP increased bottle neck can be created at MAP (Tsai, n.d.).

End-to-end path establishment is necessary for transmission and due to which BU and BA are waited for. Signals and packets get lost during waiting if the mobile node and its home agent are in different Inter-domain (Dart, 2012).

There is no location privacy in HMIPv6 since the change in temporary local address as the MN moves exposes the MN's location to CN its home agent by using its Regional MAP address in the source field of the packets that it sends. As a result, location tracking of a mobile node by its correspondent nodes or its home agent is more difficult because they only know its Regional MAP address and not its location (Dart, 2012).

Due to wireless spread, frequency change location of the mobile node is increasing. For this, it is very important to choose mobility management scheme such that the latency should be minimum and reduce registration time. MIPv6 uses Return Routability Procedure to update the Care-of-Address, every time it changes, whereas, HMIPv6 used MAP domain in inter domain movement. This makes the mobile node's mobility transparent to correspondent nodes it communicates with.

However, none of these completely address the complex interaction of parameters and protocols needed for Seamless Handovers. This research propose a new scheme that aim to reduce Packet drops and registration time when MN moving from Access router with MAP to another, so as not to impact the applications running on a mobile node or mobile network.

2.6.2 Network Mobility Management (NMM)

The Internet Protocol (IP) is currently accelerating the integration of voice and data communications. The Mobile IP protocol enables host mobility support, but several scenarios exist today, such as the provision of Internet access from mobile platforms (for example, planes, trains, cars, etc.), making it necessary to also support the mobility of complete networks. In response to this demand, the Internet Engineering Task Force (IETF) has developed the Network Mobility (NEMO) Basic Support Protocol (Parin Sornlertlamvanich, 2012), enabling IPv6 network mobility.

This research explains the Network Mobility Basic Support Protocol, by first providing a general overview and then examining the details.

Why Network Mobility?

Accelerated by the success of cellular technologies, mobility has changed the way people communicate. As Internet access becomes more and more ubiquitous, demands for mobility are not restricted to single terminals anymore. It is also needed to support the movement of a complete network that changes its point of attachment to the fixed infrastructure, maintaining the sessions of every device of the network: what is known as network mobility in IP networks. In this scenario, the mobile network has at least a mobile router that connects to the fixed infrastructure, and the devices of the mobile network connect to the outside through this mobile router.

Support of the roaming of networks that move as a whole is required in order to enable the transparent provision of Internet access in mobile platforms, such as the following:

Public transportation systems: These systems would let passengers in trains, planes, ships, etc. access the Internet from terminals onboard (for example, laptops, cellular phones, Personal Digital Assistants [PDAs], and so on) through a mobile router located at the transport vehicle that connects to the fixed infrastructure.

Personal networks: Electronic devices carried by people, such as PDAs, photo cameras, etc. would connect through a cellular phone acting as the mobile router of the personal network.

Vehicular scenarios: Future cars will benefit from having Internet connectivity, not only to enhance safety (for example, by using sensors that could control multiple aspects of the vehicle operation, interacting with the environment and communicating with the Internet), but also to provide personal communication, entertainment, and Internet-based services to passengers.

However, IP networks were not designed for mobile environments. In both IPv4 (Lei, 2008), (Devarapalli, 2005) and IPv6 (Kim, 2012), IP addresses play two different roles. On one hand, they are locators that specify, based on a routing system, how to reach the node that is using that address. The routing system keeps information about how to reach different sets of addresses that have a common network prefix. This address aggregation in the routing system satisfies scalability requirements. On the other hand, IP addresses are also part of the endpoint identifiers of a communication, and upper layers use the identifiers of the peers of a communication to identify them. For example, the Transmission Control Protocol (TCP), which is used to support most of the Internet applications, uses the IP address as part of the TCP connection identifier.

This dual role played by IP addresses imposes some restrictions on mobility, because when a terminal moves from one network (IP subnet) to another, maintaining the IP address of the node that moves (associated to one of its network interfaces) in order not to change the identifier that upper layers are using in their ongoing sessions is needed. However, change to the IP address to make it topologically correct in the new location of the terminal is needed, and to allow the routing system to reach the terminal.

Protocols such as the Dynamic Host Configuration Protocol (DHCP) (Koodli, 2005) (Gundavelli, 2008)facilitated the portability of terminals by enabling the dynamic acquisition of IP configuration information without involving manual intervention. However, this automation is not enough to achieve real and transparent mobility because it requires the restarting of ongoing transport sessions after the point of attachment changes. The IETF has studied the problem of terminal mobility in IP networks for a long time, and IP-layer solutions exist for both IPv4 (Mobile IPv4 (Abdalla Hashim, 2012)(Islam, et al., 2012)) and IPv6 (Mobile IPv6 (Dart, 2012)) that enable the movement of terminals without stopping their ongoing sessions.

focusing on IPv6 (Devarapalli, 2005) networks, Mobile IPv6 does not support, as it is now defined, the movement of complete networks. One way of achieving the transparent mobility of all the nodes of a network moving together (for example, in a plane) could be enabling host mobility support in all of them, so they independently manage their mobility. However, this approach has the following drawbacks:

Host mobility support is required in all the nodes of the network(Gundavelli, 2008) (Koodli, 2005). This support might not be possible, for example, because of the limited capacities of the nodes (such as in sensors or embedded devices) or because it is not possible to update the software in some older devices. By having a single entity (the mobile router) that manages the mobility of the complete network, nodes of the network do not require any special mobility software to benefit from the transparent mobility support provided by the mobile router.

The signaling exchanged because of the roaming of the network is limited to a single node sending only one message (avoiding "storms" of signaling messages every time the network moves).

Nodes of the network must be able to attach to the access technology available to connect to the Internet. This requirement might mean that all the nodes of the network should have Universal Mobile Telecommunications Service (UMTS) or WiMAX interfaces, for example. On the other hand, by putting this requirement on a single node (the mobile router), nodes of the network can gain access to the Internet through the mobile router, using cheaper and widely available access technologies (for example, wireless LAN [WLAN] or Bluetooth).

Because of these problems, the IETF NEMO Working Group was created to standardize a solution enabling network mobility at the IPv6 layer. The current solution, called the Network Mobility Basic Support Protocol, is defined in (Devarapalli, 2005).

2.6.2.1 Network Mobility Operations

Network mobility NEMO is a network that changes its point of attachment while they move through different network routing infrastructure as one unit. A NEMO has at least one Mobile Router (MR) maintain and manage the mobility of Mobile Network Nodes (MNNs). The MR is register with it is Home Agent HA located in it is Home Network. Its assigned a permanent unique mobile home of addresses HoA and mobile network prefix (MNP). When MR is residing at its home network, all the packets delivered to MNNs and Correspondent Nodes (CNs) are sent through a path between the MR and HA. If MR changes its point of attachment to another network (Visited network), it obtain a new address called care-of-address (CoA). Then MR sends binding update (BU) message with a flag R to the HA, then HA creates a binding cache to bind the HoA and CoA. While, the HA bonding the CoA and HoA Successfully, it sends binding Acknowledgment (BA) to the MR. After this, the bi-directional tunnel created between HA and MR to deliver the traffic between NEMO and Internet through established tunnel. Then, all the packets sent from CNs, were intercepted By HA and forwarded to MR using Bi-directional tunnel. Finally, the packets were forwards to be received by MNNs (Kim, 2012)and (Gundavelli, 2008). However, the binding cache of mobile router HA contains only the HoA of it. For this, the Packets tunneled to MR have limitation of binding MNNs addresses to mobile router CoA. To fix this limitation Prefix scope binding update (PSBU) schema was proposed (Ernst T, 2002). The mobile router sends BU with MNP rather than HoA (MNNs) to it is current CoA. As a result, all packets sent to MNNs can be route using the MR care-of Address. In addition, the mobile network supports Local Mobile Node LMN. The LMN home agent is located in the mobile network and their HoA taken from the MNP. While, fixed mobile nodes (FMN) that are not support mobility to change its point of attachment, their address taken form MNP delegated from NEMO. Hence, the visiting mobile nodes (VMN) which their home agent are outside the mobile network, its attached temporally to NEMO as foreign network and get CoA from MNP. Fig.2.13 shows the operation of NEMO. However, the mobile network it called nested if its mobile router connected to another mobile router of visited mobile network while in move.

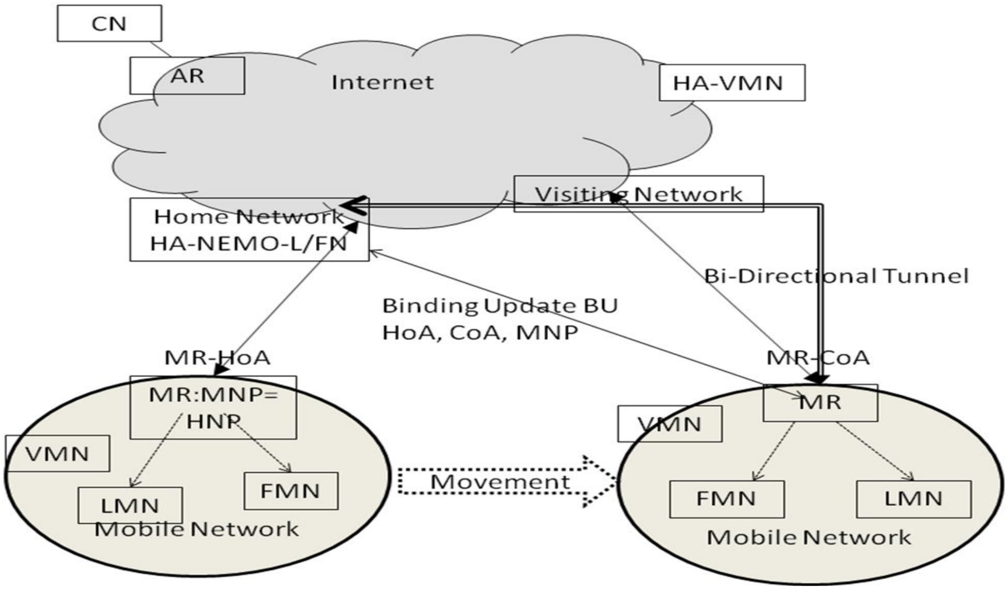
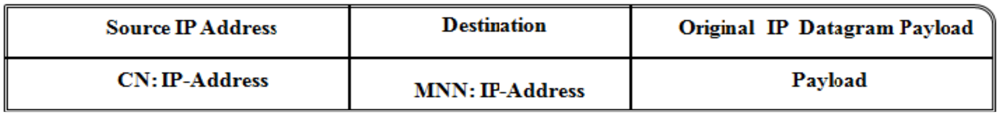
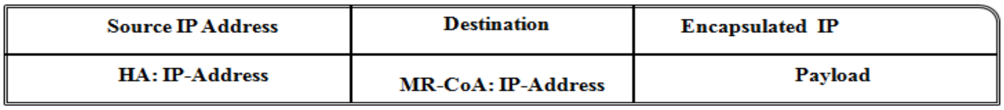


Figure 2.13: Operation of NEMO Network



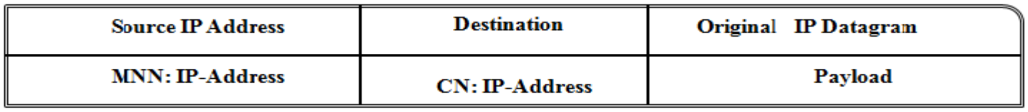
Source IP Address	Destination	Original IP Datagram Payload
CN: IP-Address	MNN: IP-Address	Payload

Figure 2.14: Packet Encapsulation from CN to MNN



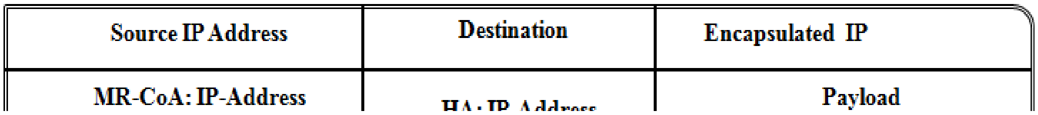
Source IP Address	Destination	Encapsulated IP
HA: IP-Address	MR-CoA: IP-Address	Payload

Figure 2.15: Packet Encapsulation form MNN to CN.



Source IP Address	Destination	Original IP Datagram
MNN: IP-Address	CN: IP-Address	Payload

Figure 2.16: Packet Encapsulation form MNN to CN.



Source IP Address	Destination	Encapsulated IP
MR-CoA: IP-Address	HA : IP Address	Payload

Figure 2.17: Packet Encapsulation form MNN to CN.

When any node located at the Internet, known as a Correspondent Node (CN), exchanges IP datagrams with a Mobile Network Node (MNN) as shown in Fig.2.14, the following operations are involved in the communication:

1. The correspondent node transmits an IP datagram destined for MNN A. This datagram carries as its destination addresses the IPv6 address of MNN A, which belongs to the MNP of the NEMO fig.2.15.
2. This IP datagram is routed to the home network of the NEMO, where it is encapsulated inside a new IP datagram by a special node located on the home network of the NEMO, called the Home Agent (HA). The new datagram is sent to the CoA of the mobile router, with the IP address of the home agent as source address. This encapsulation (as shown in Figure 2.16) preserves mobility transparency (that is, neither MNN A nor the correspondent node are aware of the mobility of the NEMO) while maintaining the established Internet connections of the MNN.
3. The mobile router receives the encapsulated IP datagram, removes the outer IPv6 header, and delivers the original datagram to MNN A.
4. In the opposite direction, the operation is analogous. The mobile router encapsulates the IP datagrams sent by MNN A toward its home agent, which then forwards the original datagram toward its destination (that is, the correspondent node). This encapsulation is required to avoid problems with ingress filtering, because many routers implement security policies that do not allow the forwarding of packets that have a source address that appears topologically incorrectFig.2.16 and Fig.2.17.

The following are different types of MNNs:

a) Local Fixed Node (LFN): This node has no mobility-specific software and therefore cannot change its point of attachment while maintaining ongoing sessions. Its IPv6 address is taken from a MNP of the NEMO to which it is attached.

b) Local Mobile Node (LMN): This node implements the Mobile IPv6 protocol; its home network is located in the mobile network. Its home address (HoA) is taken from an MNP.

c) Visiting Mobile Node (VMN): This node implements the Mobile IP protocol (and therefore, it can change its point of attachment while maintaining ongoing sessions), has its home network outside the mobile network, and it is visiting the mobile network. A VMN that is temporarily attached to a mobile subnet (used as a foreign link) obtains an address on that subnet (that is, its CoA is taken from an MNP).

Additionally, mobile networks can be nested. A mobile network is said to be nested when it attaches to another mobile network and obtains connectivity through it (refer to Fig.2.18). An example is a user who enters a vehicle with his personal area network (mobile network 2) and connects, through a mobile router—like a Wi-Fi enabled PDA—to the network of the car (mobile network 1), which is connected to the fixed infrastructure.

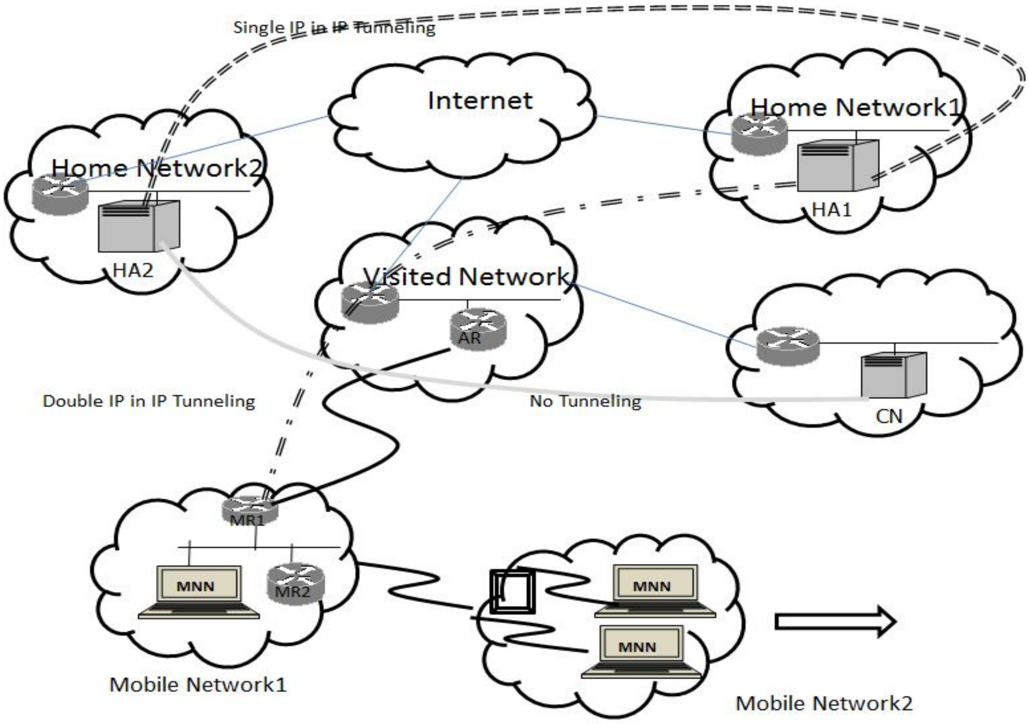


Figure 2.18: Nested Mobile Network: Operation of the NEMO Basic Support Protocol (multi-angular routing)

2.6.3 Protocol Details: NEMO Vs Mobile IPv6

The NEMO Basic Support Protocol is an extension of the solution proposed for host mobility support,MIPv6(Devarapalli, 2005).

In MIPv6, three mechanisms support the mobility of a host: movement detection, location registration, and traffic tunneling. The NEMO Basic Support Protocol (NEMO BSP) extends some of these mechanisms to support the movement of complete networks. These mechanisms are described next, with those parts that are different from the MIPv6 protocol highlighted.

2.6.3.1 Movement Detection (MD)

In MIPv6, the host needs to discover its own movement, so it can proceed with the required signaling and operations that allow its transportRouter Advertisements (RAs). Routers send these router advertisement messages, both periodically and in response to a Router Solicitation message issued by a host. By looking at the information contained in the router advertisements, a host can determine whether or not it has moved to a new link.

The NEMO BSP does not introduce any change on the movement-detection mechanisms that a mobile router can use.

2.6.3.2 Location Registration (LR)

When a host moves to a new network, it has to configure a new IPv6 address on the visited link (belonging to the IPv6 address space of that visited network): the CoA, and inform the home agent of the movement. In Mobile IPv6, the mobile node (that is, a mobile host) informs its home agent of its current CoA using a mobility message called the Binding Update (BU). This message is carried in an IPv6 datagram using a special extension header defined by Mobile IPv6 to encapsulate all messaging related to the creation and management of mobility bindings, called the mobility header. The binding-update message contains information required by the home agent to create a mobility binding, such as the home address of the Mobile Node (MN) and its CoA, where the home agent should encapsulate all the traffic destined to the mobile node.

The home agent replies to the mobile node by returning a Binding Acknowledgement (BA) message.

The NEMO Basic Support Protocol extends the binding-update message to convey the following additional information:

a) Mobile Router Flag (R): The mobile router flag is set to indicate to the home agent that the binding update is from a mobile router. A mobile router can behave as a mobile host: by setting this flag to 0, the home agent does not forward packets destined for the mobile network to the mobile router, but forwards only those packets destined to the home address of the mobile router.
b) Mobile Network Prefix Option: This option is in the binding update to indicate the prefix information for the mobile network to the home agent. There could be multiple mobile network prefix options if the mobile router has more than one IPv6 prefix in the mobile network and wants the home agent to forward packets for each of these prefixes to the current location of the mobile router.

When the NEMO Basic Support Protocol is used to provide mobility to a complete network, only one binding-update or binding-acknowledgement signaling messages exchange is performed, whereas if the Mobile IP protocol were used by all the nodes of an N-node network, N + (Binding-update or Binding-acknowledgement) signaling messages synchronized exchanges would be required—usually referred to as a "binding-update signaling storm."

MIPv6 defines a route-optimization mechanism that enables direct path communication between the mobile node and a correspondent node (avoiding traversal of the home agent). This route optimization is achieved by allowing the mobile node to send BU messages to the correspondent nodes. In this way the correspondent node is aware of the CoA, where the home address of the mobile node is currently reachable. A special mechanism—called the Return Routability (RR) procedure—is defined to prove that the mobile node has been assigned (that is, "owns") both the home address and the CoA at a particular moment in time (Kempf, 2004), and therefore provides the correspondent node with some security guarantees.

Because of the nature of the network-mobility scenario, the task of providing mobile networks with route-optimization support becomes more complex. The IETF is currently working on this topic (Pack, 2008) (Calderon, 2012) (Yan, 2010).

2.6.3.3 *Traffic Tunneling*

In Mobile IPv6, after the mobile node has successfully registered its current location, the home agent starts encapsulating the data traffic destined to the mobile node toward its CoA.

In a NEMO scenario, the home agent forwards not only those IP datagrams arriving at the home network that are destined to the home address of the mobile router, but all the traffic addressed to any of the mobile-network prefixes managed by the mobile router. The home agent can determine which prefixes belong to the mobile router in three different ways fig 2.19:

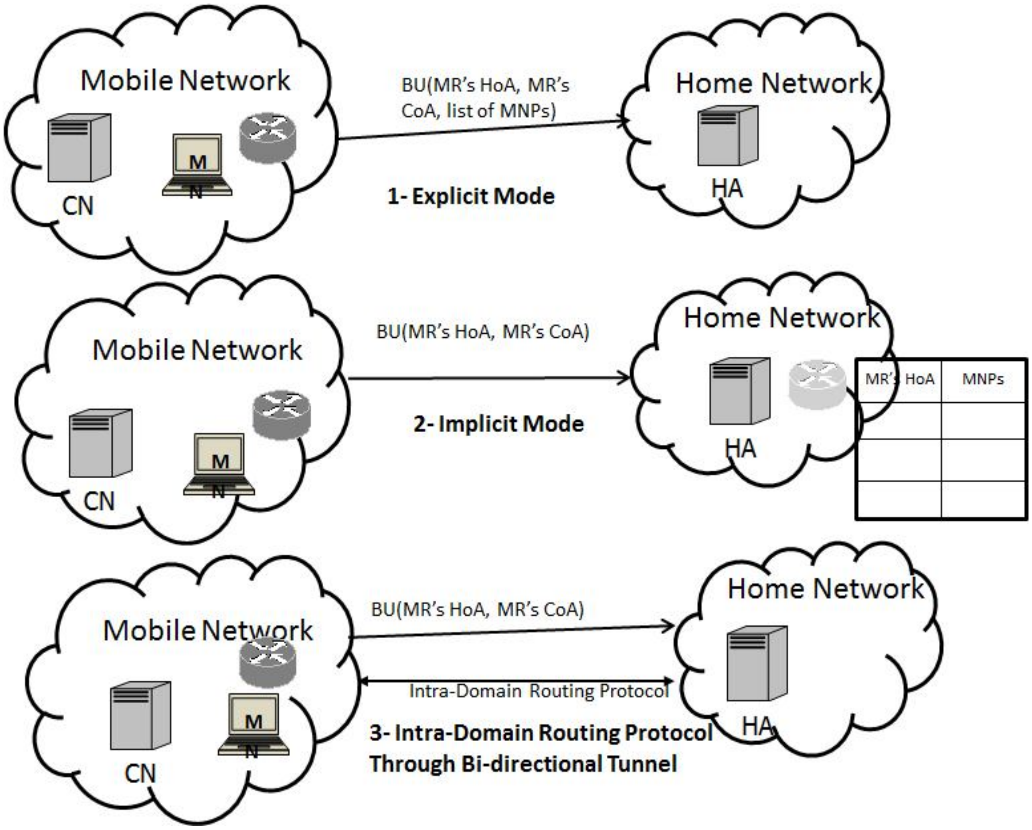


Figure 2.19: NEMO Basic Support Modes of Operation

a) Explicit mode: The mobile router includes one or more mobile network prefix options in the binding-update message that it sends to the home agent. These options contain information about the mobile-network prefix(es) configured on the mobile network.

b) Implicit mode: The mobile router does not include prefix information in the binding-update message it sends to the home agent. The home agent determines the mobile-network prefix(es) owned by the mobile router by using any other mechanism (the NEMO Basic Support Protocol does not define any, leaving this prefix determination open to be implementation-specific).

   One example would be manual configuration at the home agent mapping the home address of the mobile router to the information required for setting up forwarding for the mobile network.

c) Intra-domain Dynamic Routing Protocol through the bidirectional tunnel: Alternatively to the previous two modes of operation, the home agent and the mobile router can run an intra-domain routing protocol (for example, Routing Information Protocol next generation [RIPng] or Open Shortest Path First [OSPF]) through the bidirectional tunnel. The mobile router can continue running the same routing protocol that it ran when attached to the home link.

Fragmentation may be needed to forward packets through the tunnel between the mobile router and the home agent. In this case, the other end of the tunnel (the home agent of the mobile router) must reassemble the packet before forwarding it to the final destination. This requirement does not contradict the fact that intermediate IPv6 routers do not fragment (as opposed to IPv4), because the mobile router and home agent are the actual ends of the tunnel.

2.6.4 Classification of NEMO

There are two types of NEMO.First, NEMO Basic Support (NEMO BS) which is persevering session continuity using bidirectional tunneling between the Home Agent (HA) and a mobile network. Second, NEMO Extended Support (NEMO ES) which provides the essential route optimization between uninformed Mobile Networks Nodes (MNN) and correspondent Nodes (CN). However, routing overheads in NEMO

BSP makes the use of limited wireless network resources inefficiently due to sensitive application packet loss. To solve this problem, integration of the FMIPv6 with NEMO schema proposed (Abdalla Hashim, 2012). In addition to, handoff latency and signaling overhead, that leads to decrease overall application performance. To overcome these limitations, analysis mobility management's schema in NEMO proposed (Islam, et al., 2012). While this method faces limitationfor using multiple interfaces on mobile devices.However, this method fails in power consumption, packet size and delay cost.

2.6.5 HandoffWithNEMO

Handoff process is classified into:

- Link layer handoff (Layer two delays): which is the process time form MR to find and associate with a new Access Point.
- Network layer handoff (layer three delays):Which is theprocess of Router Discovery and the assignment of CoA. This include of process of sending a Router Solicitation (RS) and receiving a Router Advertisement (RA) from a new Access Router.
- Stateless address autoconfiguration: This is the process of concatenating of access router prefix with the EUI-64.Alternatively, statefull mechanisms, such as DHCP are used.
- Assignment of CoA required Duplicate Address Detection (DAD) process.
- NEMO home agent registration latency (layer three delays). The process of sending a BU from MR to its HA and receive a binding acknowledgement BA from HA. However, this layer adds additional handoff latency and packet loss. Besides, Router discovery it can be reduced by using the Fast Router Advertisement mechanism(Kempf, 2004). On the other hand, we can use Optimistic duplicate address detection for (Dart, 2012) then DAD.

The mobility management in NEMO is different from host mobility. In host mobility, every MN performs mobility function each time it changes its point of attachment. However, in network mobility the mobile node does not introduce any changes when performs movement. In addition to this, every mobile node performs BU and BA, however, in NEMO only a BU and a BA signaling exchange by the mobile router. For those in host mobility after location update and registration the tunnel setup between home agent and mobile node's care of address (CoA). In NEMO, all traffic forward through tunnel between the home agent and mobile router CoA.

In addition to this, it can reducethe delay and packet loss.Besides, enhances the performance of the whole system in NEMO by integration of different host mobility management’s schemes.

2.7 RELATED WORK

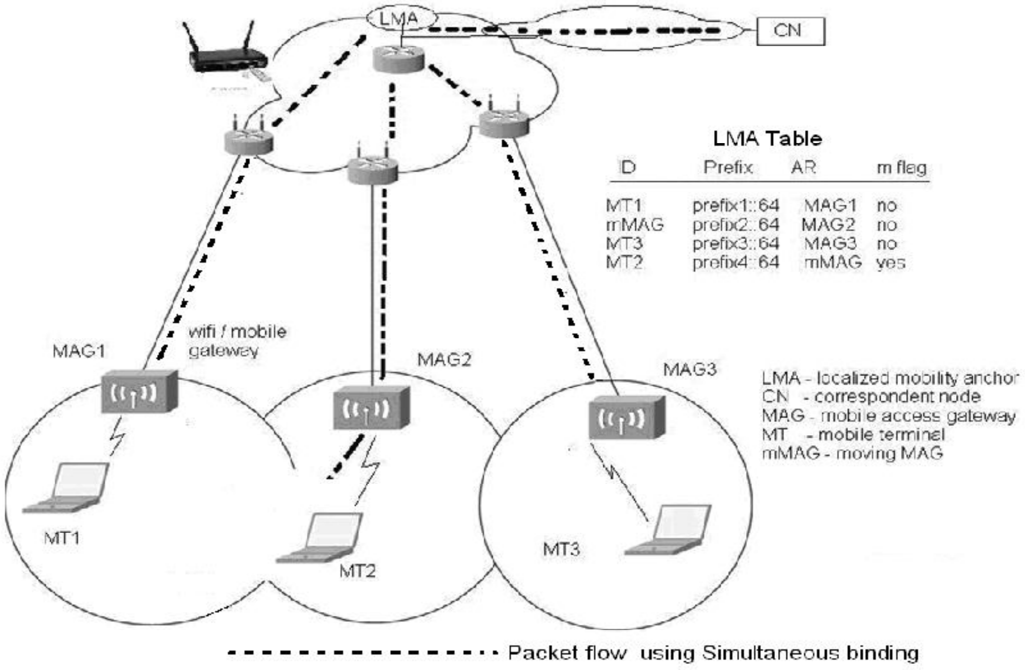
The combination of network mobility with host mobility management is the future turn for researchers. This part focused in these directions.

2.7.1 Proxy-Based Approach withNEMO

NEMO BS extenuation to MIPv6, it inherits all MIPv6 problems such as packet loss, handover latency, movement detection and registration updates. To solve these problems relay-based NEMO proposed (Pack, 2008). This introduces a method of relay station to forward all messages from MAG to MNs after receiving RA from the MAG. This method tries to reduce deployment cost, processing latency. However, the MAG performs forward all messages to CN when the packet tunnel from LMA to MAG. Hence, in draft (Calderon, 2012) proposed the integration of NEMO BS to PMIPv6 reduce signaling overhead while NEMO move. Nevertheless, it has problem of different IP address prefix in each domain of MIPv6 and NEMO.

To fix the scalability problem N-NEMO schema was proposed by (Yan, 2010). This schema is proposed to improve efficiency and scalability of NEMO in PMIPv6, in addition to reduce signaling overhead and less packet loss. This method enables MNs to continue their access to internet without changing point of attachment. In addition to this N-NEMO used tunnel splitting to distinguish micro-Mobility Access Gateway between LMA and MAG (MAG) mobility and macro-MAG mobility between MR and MAG. To achieve this goal, they evaluate the protocol cost performance of N-PMIPv6 and proposed N-NEMO(Reaz, 2006) (Hossain, 2011).

However, the packet loss decreases the performance of NEMO in term of real-time application like video streaming and multimedia data transmission, integrating N-PMIPv6 (Dinakaran, 2011)protocol with simultaneous binding was proposed in(Dinakaran, 2012). This scheme uses a simultaneous binding update SBU algorithm. In this algorithm the packet sent to nearest and future location of MAGs with short lifetime. While the current location of MAG accepts the packet with minimum lifetime, the other MAGs location discards them. This approach lead to avoid packet loss. However, the N-PMIPv6 has improved the handover by using MAG and LMA. In addition to thus, it enhances the performance of NEMO by less bandwidth consumption and very low time for reverse tunnel. However, this schema neglects the delay time used to authenticate MAG, LMA and flood of message in the network. This delay it consume wireless bandwidth. In addition to these, the packets are mange by MN and nested mobilityproblem CN-MAG-LMA. See fig.2.20.



LMA Table

ID	Prefix	AR	m flag
MT1	prefix1::64	MAG1	no
mMAG	prefix2::64	MAG2	no
MT3	prefix3::64	MAG3	no
MT2	prefix4::64	mMAG	yes

Figure 2.20: Integration of Simultaneous Binding Topology (Dinakaran, 2012).

In (Jebaseeli, 2013), extended the BU’s and BA’s message format to include information of a group of mobile nodes, fig.2.21 shows the messages flow diagram. For this, the MAG needs to send only one BU and receive one BA forms LMA. This scheme is working on resource efficient handoff and minimal packet loss during handover. However, this schema does not prove any algorithm to group of messages and if this made the collection adds additional processing time to decrease the performance.

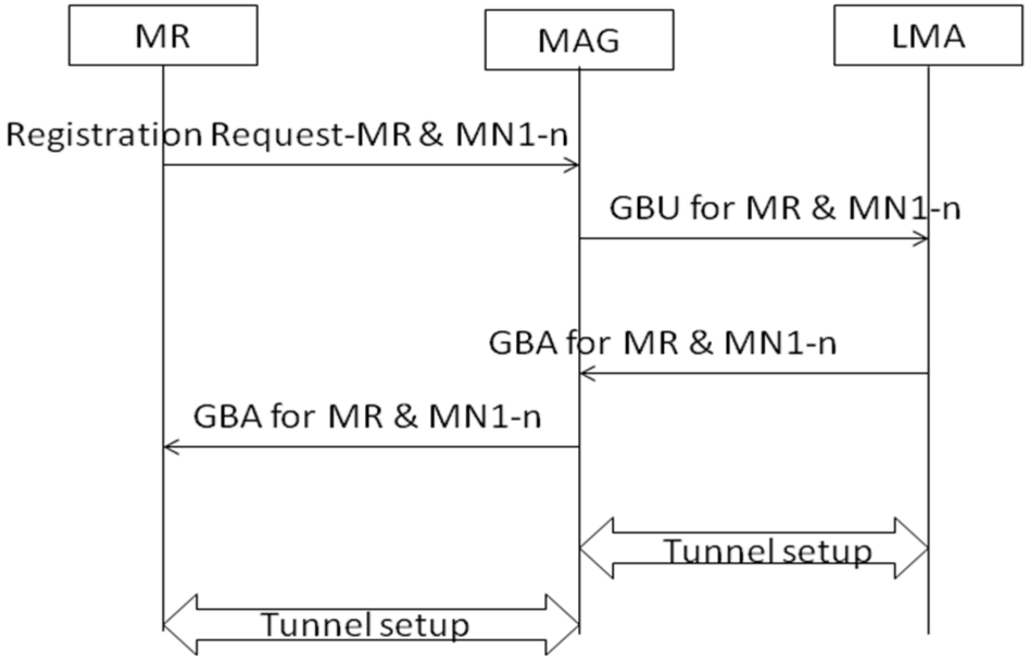


Figure 2.21: Message flow with the extended format of GBU and GBA (Jebaseeli, 2013).

2.7.2 Hierarchical ApproachwithNEMO

To address the seamless mobility limitation of NEMO an extension to MIPv6 proposed VehiclebasedHMIPv6 (V-HMIPv6)(Tsai, n.d.). This method is used to reduce the signaling overhead of messages in binding update and triangle routing. They used binding update cache to support V-HMIPv6 process in home agent and mobile router. In addition to this they reconfigurethe design of HMIPv6 message format. To achieve this goal they used network simulators NS2.

In addition to this, some limitation of the binding update (BU) traffic and tunneling overhead fixed by Proposed an adaptive NEMO support protocol based on HierarchicalMIPv6(Li, et al., 2010). The proposed to reduce bindingupdate (BU) traffic and tunneling overhead by employed the adaptive BU approach, based on the session-to-mobility ratio(SMR). The MR and the VMNs configure two care-of-addresses (LCoA and RCoA). When the SMR is lower than a predefined threshold, the MR and VMNsperform RCoA and LCoA binding update BU procedures to their home agents (HAs). Otherwise, the MR and VMNs conduct LCoA and RCoA BU procedures. However, implementationoverhead problem due to SMR measurement and security issues in the adaptive. Besides these, this approach works in layer two handoff signaling phase.

2.7.3 Fast Handover Approachwith NEMO

Host mobility managements for fast handover schema was proposed in(Petander, 2006). Thisscheme is used to reduce the delay and packet loss in NEMO. It is used Make-Before-Break MBB handover mechanism with two network interfaces. This schema improves the near optimal performance and extended route optimization, OptiNets to hand off overhead compared to MIPv6.It is measure the performance of an implementation of a set of the protocols. This measurementtoolis analyzingand their the results are important to understanding the performance and limitations of the protocols in a real network environment, by developing a network mobility tested and carried out the NEMO Basic Support protocol. However, they used to enhance the handoff performance by Fast Router Advertisements and Optimistic Duplicate Address Detection to minimize handoff latency for mobile networks. In addition to this a Comparison study of handoffs with NEMO, Used Make-Before-Break handoff with two network interfaces for NEMO and Used extended route optimization scheme, OptiNets.

However, still handoff performance not solved completely, for this Islam, proposed (Islam, et al., 2012). This schema improves the integration of FMN with NEMO BS to achieve seamless handoff. The method used, shared MAP information table among MRs. The information on this table update after receiving router advertisement RA messages for mobile router movements. The MAP information is composed of LCoA and RCoA as CMAP. In fast handover in host mobility the handover can be triggered after singling handover and sending the FBU to PAR (MMR). For this NEMO can start handoff after receiving proxy router solicitation RtSolPo. This way is leads to improve seamless mobility. However, proposed schema FPMIPV6 integration methods of extended RtStPr message option used in MAP information table for every RS and RA. The 1 bit option is set on behalf of the SMR to formulate NLCoA and NRCoA to support fast handover. Then tunnel between CMAP and NMR initiated for packet transmission. This schema compared to NEMO BS in layer three signaling delay for location update performance. In reverse, this schema face problem in MAP that implements the single point of failure, not support FMN and SMR can frequently disconnect when performing fast handover.

Enema proposed in (Ryu, 2014) to enhanced handover delay in the advance registration process and packet loss by using buffer. It used tentative binding update (BU) and binding acknowledgement (BA) before layer 2 handover to register NCoA of MR with HA. This schema registers the tunnel end point in advanced (MRCoA with HA-HoA). However, the tunnel is initiated once handover to layer-2 triggered form mobile router. EFNEMO do this by sending tentative binding update to register MR-CoA with HA. However, as mentioned in section 3 this method lets MNNs to do mobility functioning it have problem of host mobility. In addition, it's not supported full NEMO characteristic (reg without tunnel CN RO MN) and double registration.

Lin Tain proposed (Tain, et al., 2011). This scheme is used 2 wireless MR one of them in the tail of a train MRt and the other in head of train MRh to improve seamless handover. The two mobile routers work as the default gateway to mobile network nodes by sharing the load balance. While MRh functioning in mobility management, the MRt uploading the packets send to MNN. In assumption to train length is 200-400m the MRh is connecting faster than MRt. From this it can benefit to get fast registration of mobile network nodes. The system topology detail is shown in fig.2.22. However, the delay between 2MR (length 200-400m/high speed train 250kh) it has minimum effect to seamless handover in response to (Petander, 2006). In addition to complex traffic load division and not fit the NEMO BS characteristics.

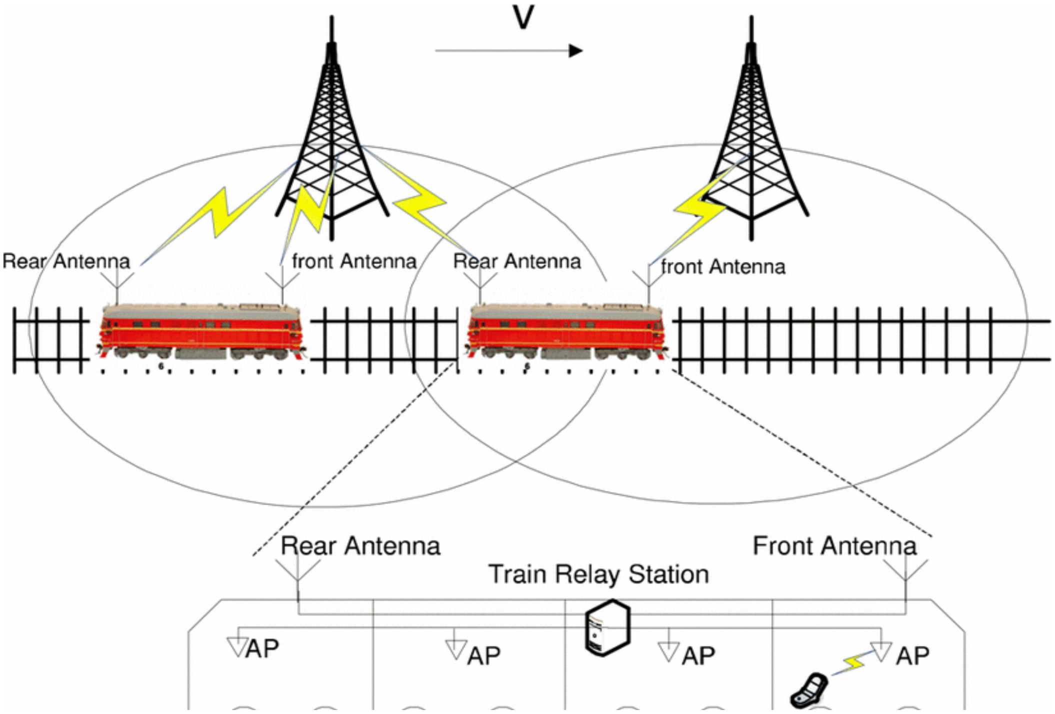


Figure 2.22: 2MR High speed railway system topology (Tain, et al., 2011).

Table 2.3:Limitations and Advantages of mobility management Schemas

Category	**Approach**	**Strengths**	**Limitations**
C. Perkins	M	Used route optimization, To Reduce packets loss	High latency due to a handover in real-time applications 1.5 RT(BU&BA)
J. Kempf and R. Koodli	FM	low latency for handover, by utilizing information from layer 2	High registration time
H. Soliman & C.Castelluccia	HM	reduces the signaling traffic of BA by using MAP	High delay in intra-domain & Bottleneck for MAP
HeeYoung Jung, ETRI Hesham Soliman	FHM	improves the handover latency and packet loss	Still packets lost in DAD
Aisha Hassan Abdalla Hashim, Fauzana Ridzuan, and Nazreen Rusli	Evaluation of Handover Latency in Intra-Domain	Reduce the delay for short distance	queues delay from AR with MAP

	Mobility		
Dipali P. Patil and G. A. Patil	Integration of FM in M to improve Handover Performance	Improve packet loss and hand-over delay.	long delay in MAP & seamless handover for CN to home agents
Daeseon	PMIPV6-based Inter-Domain Handover using Efficient Buffering Scheme	Reduce inter-domain handover delay and the enhancement of seamless services	Still delay in MAP No location privacy.
V. Devara R. Wakikawa palli, A. Petrescu Motorola P. Thubert Cisco Systems	NEMO BS	Provide mobility support to MNNs without their involvement, Mobility transparency, reduce MNs delay and packet loss Scalability: mobility manages by MR, reduce complexity: no change in IP address while MNN move.	routing overheads ,limited wireless network resources inefficiently due to sensitive applications, face bottleneck between HAs and MR for packets processing
A.Hashim, Wan H	FM with NEMO	enhance seamless mobility (packet loss and handoff delay),	face problem in MAP which implement the single point of failure
Islam, S.; Abdalla, A.-H.; Khalifa, M.K.H.O.O.; Mahmoud, O.; Saeed	analysis mobility managements schema in NEMO	high-speed of mobile router	has short range radio technologies, multiple interfaces in mobile devices, like an increase in power consumption, and increasing packet size and delay cost
CJ. Bernardos, M. Calderon	Proxy-based Approach + NEMO	reduce signaling overhead while NEMO move	problem of different IP address prefix in each domain (M, NEMO)

Zhiwei Yan, Huachun Zhou and Ilsun	N-NEMO schema	improve efficiency and scalability of NEMO in PMIPV6, reduce signaling overhead, and encapsulation cost	Seamless handoff
Chun-Shian Tsai	Vehicle based HM (V-HM)	reduce signaling overhead of messages in binding update and triangle routing	binding update (BU) traffic and tunneling overhead
Sangheon Pack, Taekyoung Kwon, Yanghee Choi, and Eun Kyoung Paik	adaptive NEMO support protocol based on Hierarchical Mobile	reduce binding update (BU) traffic and tunneling overhead	implementation overhead problem due to SMR measurement and security issues in the adaptive NEMO
Petander, Henrik; Perera, E.; Kun-chan Lan; Seneviratne,	Measuring and Improving the Performance of Network Mobility Management in Networks	reduce delay and packet loss in NEMO, improves the near optimal performance and extended route optimization	increase in power consumption, Interference caused by the usage of multiple interfaces and increased size and cost. A small increase in the size and cost of a Mobile Router

2.8 OPEN ISSUES

1- Multi-angular Routing (Pinball problem): The use of a bidirectional tunneling between MRs and HAs is to continue a communication to the CN and MNN within the NEMO. Tracing the path between Correspondent Node to a MNN, in nested networks the number of nested levels increases this lead to increase packet loss and latency.

2- Route optimization :Transparency and Seamless Mobility: MR, MNN.

3- Overlay routing: non optimal routing path by using a protocol header overhead for every packet.

4- Performance issues: when the NEMO need to change its point of attachment, it performs the handover procedure. Upon movement detection the MR obtains CoA form visited network and bonded with HoA form HA. This increase latency and packet loss in addition to signaling overhead for MR between HA for every time NEMO perform handoff.

5- Delay overhead for intercepting message between MNNs and CNs when MR in visited networks besides, the tunneling overhead.
6- For LFN delay cause by BU, BA. But for VMN it adds mobility management overhead , this can be reduced by using route optimization (RO)
7- The delay is less when HA is closed topological to visit network, otherwise it is high delay.
8- Security: the location of the MNNs not cleared to CNs, checking the tunnel packets between the MR and HA, HAs check authorization of to bind MNP.

2.9 SUMMARY

Internet Engineering Task Force (IETF) has developed Network Mobility (NEMO) Basic Support Protocol (BS) (Devarapalli, 2005). This scheme solves some problems of MNs. In reference to table2.3 its conserve the power of MNNs by few signaling handoff because, MR does this functions on behalf of MNNs. In addition to this, transparency, and it has Low Complexity (Devarapalli, 2005). However, the important issue of Network mobility management's scheme is the hands-off management. Handoff is how to keep services continue to internet without interruption. When MR changes it's point of attachment to another network (Visited network) it need to update its home agent HA with new location. The MR acquires Care-of-Address CoA from visited network and send binding update message to its HA. These messages decreases the performance of NEMO. NEMO which supported by one MR to MNNs have some limitations such as protocol overhead, inefficient routing, security, lack of multihoming support, handover delay and low power consummation compared to network mobility management schemes.

However, comprehensive study have been made to solve these problems (Abdalla Hashim, 2012), (Islam, et al., 2012), (Pack, 2008), (Calderon, 2012), (Yan, 2010), (Dinakaran, 2012), (Jebaseeli, 2013), (Ryu, 2014) and (Li, et al., 2010). Besides these, the MAP problem in is leads to non-optimal routing path by using a protocol header overhead for every packet. While enhanced the seamless mobility and deployment cost. Still performance issues fails when the NEMO need to change its point of attachment to performs the handover procedure. Upon movement detection the MR obtains CoA form visited network and bonded with HoA form HA. This increase latency and packet loss in addition to signaling overhead for MR between HA for every time NEMO perform handoff. In response to this, proposed techniques in (Yan, 2010), (Dinakaran, 2012), (Islam, et al., 2012), (Calderon, 2012) and (Ryu, 2014)to solve these issues by functions of mobility signals on behalf of mobile node. Nonetheless, these techniques fail in complete solutions to NEMO BS. Besides, Delay overhead for intercepting message between MNNs and CNs when MR in visited networks in addition to, tunneling overhead. On the other hand For LFN delay cause by BU, BA. But for VMN it adds mobility management overhead due to tunnel. In hierarchical approaches proposed in (Li, et al., 2010) and (Tsai, n.d.)the delay is less when HA is closed topological to visit network, otherwise it has high delay. In addition to, the location of the MNNs not cleared to CNs, checking the tunnel packets between the MR and HA, HAs check authorization to bind MNP.

CHAPTER THREE DESIGN OF THE PROPOSED BUNSD-LMA SCHEME

3.1 INTRODUCTION

With the increase of wireless network technology, IP face many short comes to support network addresses. For this the network engineer extends the existing protocol with a new feature that has been gained from previous one. New protocols have been improved called IPv6 to solve networks addressing shortcomings. Besides this the previous one faces some issues for mobility management. Due to this the researcher extends the existing protocol to mobile internet protocol version six (MIPv6). This protocol used to support the mobile node movement in IPv6 networks. It allows mobile nodes (MNs) user to continual their network connection to previous network whiles they move between different IP networks. MIPv6 is a mobility management protocol, for future all-IP mobile systems are expected to have wide deployment. With the rapid increase in wireless network technology, MIPv6 become very important to researchers to develop powerful mobile devices running mobile applications to get access to multimedia and data services over broadband wireless connections based on IPv6, to reducenetwork costs in IPv6 networks (Gundavelli, 2008) and(Devarapalli, 2005). The key benefit of Mobile IPv6 is that even though the mobile node changes domains and addresses during handover, the existing connections through which the mobile node is communicating can be maintained. To do this, connections to mobile nodes has configured with a specific address that is always assigned to the mobile node interface generated from it is a link layer address, and through which the mobile node is always reachable (Pack, 2008).

Mobile IPv6 faces some limitations in packet loss and latency during handoff operations and binding it is a new address. For this, mobility management protocol proposed to achieve mobile network nodes MNNs as one unit is called network mobility NEMO which supported by the IETF group as NEMO Basic Support. Mobility management is to continueservices to mobile network nodes MNNswhile mobile router MR change its point of attachments in different networks. One of the important issues of mobility management scheme is the hands-off management.

Handoff is how to keep services continue without interruption. When MR changes it is a point of attachment to another network (Visited network) need to update it is home agent HA with a new location. The MR acquires Care-of-Address CoA from visited network and sends binding update message to its HA. These messages decrease the performance of NEMO. NEMO which supported by one MR to MNNshave some limitations such as handover delay and low power consummation compared to network mobility management schemes (Pack, 2008), (Calderon, 2012), (Yan, 2010), and (Tsai, n.d.).

However, there is a requirement for seamless handover problem in NEMO environment.

3.2 CHALLENGES

NEMO BS is extenuation to MIPv6, it inherits all MIPv6 problems such as packet loss, handover latency, movement detection and registration updates. The mobility management in NEMO is different from host mobility; in host mobility every mobile node performs mobility function each time changes its point of attachment. However, in network mobility the mobile node does not introduce any changes when performs movement. When the NEMO need to change its point of attachment, it performs the handover procedure. Upon movement detection the MR obtains CoA form visited network and bonded with HoA form HA. This increase latency and packet loss in addition to signaling overhead for MR between HA for every time NEMO perform handoff. In addition to this every mobile node performs BU and BA, however, in NEMO only one BU and BA signaling exchange by the mobile router. For those in host mobility after location update and registration the tunnel setup between home agent and mobile node's care of address (CoA). In NEMO all traffic forward through bi-directional tunnel between the home agent and mobile router CoA. The mobile router can attached to another mobile router of moving NEMO in another visited network. This is cause Multi-angular Routing.It is called Pinball: theuse of bidirectional tunneling between the MR and HA to achieve communication to CN and MNN within the NEMO. This tunnel addsprotocol overhead to overlay routing to decrease the performance. In addition to these, tracing the path between Correspondent Node to a MNN it is adding additional problem.However in nested networks the number of nested levels increases this lead to increase packet loss and latency. Beside these there are no transparency and Seamless Mobility between the MR and MNNs by mean of route optimization (RO). While Delay overhead for intercepting message between MNNs and CNs when MR in visited networks. This delay is less when HA is closed topological to visit network, otherwise it is high delay. For Security issuesthe location of the MNNs not cleared to CNs, checking the tunnel packets between the MR and HA, HAs check authorization of to bind MNP.

3.3 THE PROPOSED BUNSD-LMA ARCHITECTURE

This section, describe the network topology of the proposed BUNSD-LMA scheme and its elements. Then explain the scenario of how to solve the problem of packet loss and handover delay by integration of PMIPv6 with NEMO BS using pre-registration of MNP (HNP) in advance with short time update in binding update extensions massage format Fig.3.1 show more details.

Network mobility NEMO is an extension of MIPv6 protocol support from IETF standard. The NEMO change its point of attachment to network infrastructure as a vehicle or train using a mobile router MR as one unit. The proposed architectureof Binding Update No Send Drop LMA (BUNSD-LMA)consists of local and fixed mobile nodes L/FMN such as cameras, sensors and visiting mobile nodes VMN such as customers with PDAs, smart phone and laptop to use their local services to connect to the internet. The mobile router takes the advantage of handover to mobile network nodes MNNs as one unit, in addition to negotiates the mobile network prefix MNP with the home agent HA which reside in the home mobile network by using binding update BA. The last mobile network prefix generated from its home network it sent back by binding acknowledgement BA to the MR. in this time the MR configures its permanent HoA and MNNs get their IPv6 address from the advertised MNP. However, the VMNs configure it as CoAs because, their home agents outside the mobile home network.

The Mobile Access Gateway MAG in BUNSD-LMA used to implements the mobility function on behalf of MNNs. However, it uses extended Binding Update message format to register the shared Mobile network prefix of MNNs with flag G set to “1” on behalf of MR. This prefix acquired from previous (PMAG). While registering MNP of MNNs it set with short time valid for one session. When the MR finishes the configuration of CoA, it maintains a bi-directional tunnel between HA and MR to forward all packets sent form/to MNN and the correspondent node CNs.correspondent nodes are any device that communicates with mobile network nodes. If LMA Sense any messages sent to MNN then register it and send fast Binding Acknowledgement FBA message to PMAG to drop the bonded Cache Entry. However if LMA not Sense any package sent from any other MNNs it Drop BCE of LMA which have short time.

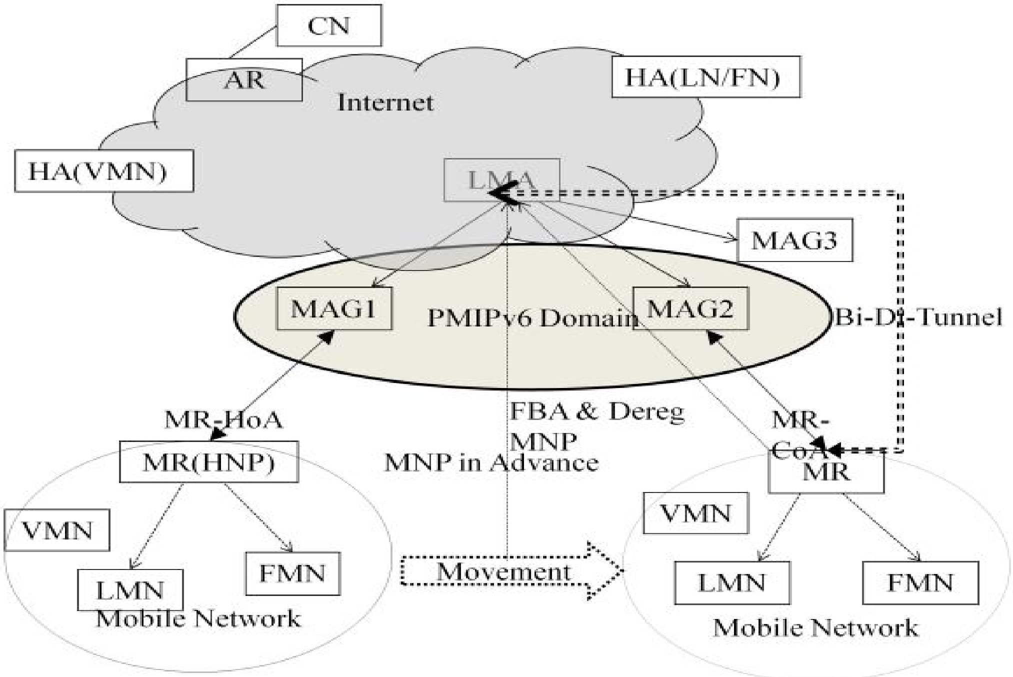
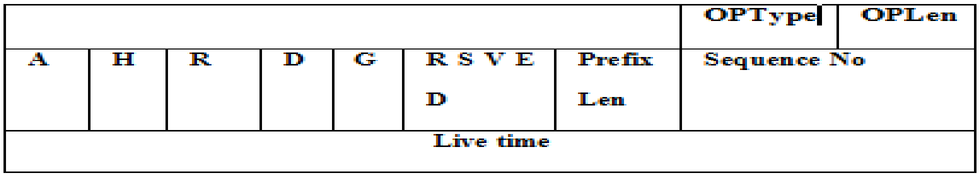


Figure 3.1: BUNSD-LMA Proposed architecture

3.4 EXTENDED BINDING UPDATE MESSAGE FORMAT



							OPType	OPLen
A	H	R	D	G	R S V E D	Prefix Len	Sequence No	
Live time								

Figure 3.2:BUNSD–LMA Binding Update Message Format

Extended binding update used to register MNNs location in one message. Because, all MNNs have the same mobile network prefix MNP under MR of NEMO. However, we include new extended binding update messages format option in fig3.2, to indicate mobile network prefix. The HA (LMA) binds the MNP with MNNs care of addresses and the CoA of MR and in its binding cache entry BCE. Then if HA intercept packet form any CNs its search binding cache entry for IP address that match bonded MNP prefix.

The correspondent Nodes can receive the same binding update from HA by using multicast group of IPv6 protocol.

1- **Flag G:** When set to “1” it indicates that the MR needs to register its CoA and MNP in sub-option with HA. In this case the life time must be short.
2- **HA Operation:** While HA intercepts any packets distend to or from MNNs, the HA must verify the HA-BCE, if flag G=”1” it must update the binding path lifetime and delete the flag G.

3.5 HOME AGENT OF BUNSD-LMA OPERATION

The home agent of BUNSD-LMA is LMA. The LMA is Local Mobility Anchor point in the proposed scheme uses the function capabilities of LMA in PMIPv6 (Gundavelli, 2008). It maintains a collection of network path for MNNs moved within integrated network mobility domain INMD and location managements. INMD is consisting of PMIPv6 domain and NEMO BS. The MNNs addresses are bonded in the LMA Binding Cache Entry BCE. Hence, all MNNs have the same mobile network prefix of MNP. The MNNs are registers with one BU in BCE of LMA. When LMA receive BU for MAG, it register this prefix with short time and set flag G=1. While LMA intercept any message sent to MNN from any CNs or sent to CN form any MNNs. At this time LMA check its cache and search for flag G. If flag G=1 it update the prefix lifetime to valid time which defined by domain network and delete flag G. Otherwise, it’s sent the message to the last destination as normal operation as forwarding.

3.6 MOBILE ACCESS GATEWAY OPERATION MAG

TheMAG performs the mobility-related signaling on behalf of the Mobile Router attached to its access links. The MAG is usually the first-hop access router for the Mobile Router in the BUNSD-LMA Management infrastructure. It is taking the responsibility of tracking the movements of the Mobile Router in the PMIPv6 domain. Hence, A PMIPv6 Domain has multiple MAGs. In BUND-LMA scheme, the MAG performs the handover of MR and the registrations of MNNs in the first time for MNNs NEMO BS standard operation. In this time the MNNs prefixes registers with D=1 flag in its Binding Cache list BCL for proxy domain registration. However, in the second movement the MAG uses BUNSD-LMA scheme to register the MNNs. In addition to this, the MAG is responsible to delegate the mobile network prefix to every attachment of mobile router.

3.7 MOBILE ROUTER OPERATION

In BUNSD-LMA scheme the Mobile Router operation is operate as a host, a router (Deering, 1998), and a Mobile Node (Johnson, 2004). However, Mobile router in BUNSD-LMA acts as a Mobile Node into two scenarios:-

First as a Mobile Host: In this case, the Home Agent of BUNSD-LMA does not maintain any prefix information relatedto the Mobile Host's Home Address but, does maintaining a binding cache entry associated to the Mobile Host's Home Address.

Second as a Mobile Router: in thiscase, in addition to maintain the binding cache entry related to the Mobile Router Home Address of BUNSD-LMA, the Home Agent maintaining forwards information related to prefixes assign to theMobile Network. Besides every mobile router must delegates MNP prefix to MNNs in the equivalent way if MAG detect attachments of MN in proxy domain. The difference between the two modes is representingby the Flag (R) value of the Mobile Router.

3.7.1 Sending Binding Updates

A Binding Updates sent by Mobile Router to its Home Agent (LMA) for first registration, is describedin (Johnson, 2004).However, in BUNSD-LMA we extended the binding update message for fast registration of group of mobile network Nodes as mentioned in (3.5). Extended binding Update is send by MAG to LMA on behalf of MR. In this time LMA must to create binding cache entry for all MNNs included in the MNP in BU message option. Then it must enable forwarding for correspondent mobile network prefix.

3.7.2 Binding Acknowledgements

In response to the Binding Updates which sent bythe Mobile Router,it can receives Binding Acknowledgements same as in (Devarapalli, 2005). While in BUNSD-LMA the BindingAcknowledgement can be received after any successfully interception of any messages, send to or form MNNs.

3.7.3 Establishment Of Bi-Directional Tunnel

For the implementation of the bi-directional of BUNSD-LMA MUST be met the following operations:

1. The Home Agent of the BUNSD-LMA scheme can tunnel packets sent for the Mobile Network prefix to the MR’s current location, by meanof Care-of-Address.
2. The Home Agent of the BUNSD-LMA scheme can receive packets tunneled by the MR with the source of address of the outer IPv6 header that set to the MRCoA.

3.8 OPERATION OF PROPOSED BUNSD-LMA

Binding Update No Sense Drop BCE in LMA (BUNSD-LMA). This scheme extend BU and BA message format in the MNP option to register a mobile network prefix of MNNs to the home agent of mobile network (HA=LMA) in NEMO integrated with PMIPv6 domain.This method is used to improve seamless mobility. Firstly,when the MAG1 in PMIPv6 domain senses movement of MR to MAG2, this event is initiated by sending router solicitation (RS) containing the MNP of MNNs, and the MNP that delegated to supports all MNNs (FMN, LMN, and VMN). The MAG1 check its authorization to use BUNSD-LMA mobility management services. Then MAG1 exchange signaling to HA on behalf of MR. the HA authorizes the MR and responses by a router advertisement containing the new MAG2 prefix. This prefix is forwarded to MR by MAG1. Then MR configures the CoA address from MNP and tunnel set up between MAG2 and LMA. During NEMO change of its point of attachments, every MNN sends BU and receive BA through the established tunnel between the LMA and MAG2. The PMIPv6 domain registers the MNNs of NEMO based in HNP obtained from LMA. However, all mobile nodes in the movement of NEMO are assigned HNP as MNP delegated by the mobile router (MR). When MR initiate the handover to MAG3, the MAG2 sends PBU to LMA with HNP flag to pre-register all nodes bonded with MAG2 and MNP=HNP to be bonded with MAG3 in LMA in advance. In this case the HNPrifx life time must be short. Then if LMA (as HA) intercepts any packet delivered to MNNs. The LMA must update the BCE of LMA with valid lifetime and send fast deregistration message FPA to MAG2 to delete all MNP bonded cache. Otherwise the bonded MNP prefix in LMA cache must be dropped see fig3.3. However, in the second movement to MAG3, all MNNs registered with one PBU and PBA to LMA. This binding update has extended message format option flag set to 1. However this leads to consume less bandwidth. In addition to this, the handover of the MR take two signals to join MAG3.

3.8.1 Signaling Diagram First Move MAG1

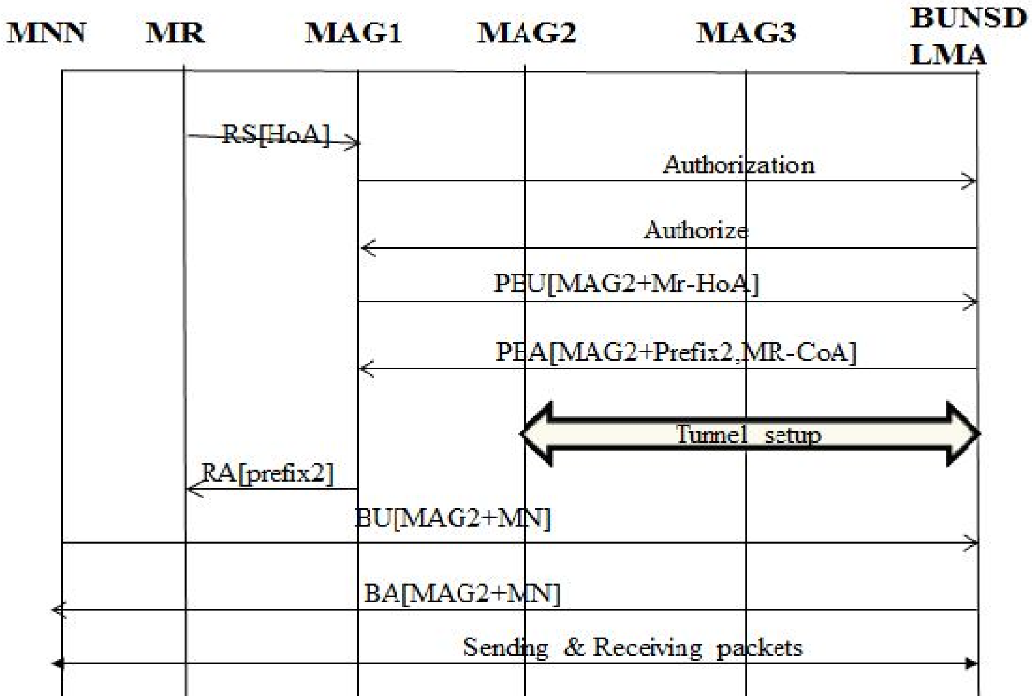


Figure 3.3: Proposed BUNSD-LMA signaling Diagram

1- The MR decides to attach to MAG2.This phase detected by receiving router solicitation (pre-movements) or MR solicit the MAG2 for movement’s uses router solicitation (RS).MR receives high signal strength form MAG2. In this timeMAG1 detects the movement of MR to MAG2 and performs deregistration process at LMA for the MR. Then MAG1 waits for the registration of MR through MAG2.
2- L2 handover process is performed for MR and the MR will be attached to MAG2.
3- The authentication will be performed using MAG2 for the MR.
4- Upon detecting the attachment to the access link, the MAG1 assigns the MR to a group Proxy domain and the group identifier (G=1) is assigned by including it in the mobile node group identifier optionin the PBU message. The MAG1 send PBU message to LMA for registering MNN.
5- After accepting the PBU message from MAG, the LMA creates a binding cache Entry and assigns to a group G. Then LMA send proxy-binding acknowledgement PBA back to the MAG1. Forward to the MR.
6- Upon receiving the PBA, the MAG1 also updates the binding cache entry for the mobility session by using G. Now both MAG and LMA are aware of the group identifiers for the INMD.
7- The MR configures its care of address and forwards the MNP to MNN.
8- Bi-directional tunnel is create between the LMA and MAG and between MAG and MR
9- After this, MNNs can send and receive from any CNs.

3.8.2 Signaling Diagram Second Moveto MAG3

MR will be uses the extended binding update process to exchange the group identifier for the MNP such as G=1. Here, the MR is also assigned to the same MAG's group binding update flag G and LMA's extended binding update message format. Now MAG and LMA are also aware of MR message group identifier.

1- The MR decides to attach to MAG3.This phase detected by receiving router solicitation (pre-movements) or MR solicit the MAG3 for movement’s uses router solicitation (RS).MR receives high signal strength form MAG3. In this time MAG2 detects the movement of MR to MAG3 and performs deregistration process at LMA for the MR. Then MAG2 waits for the registration of MR through MAG3.

2- L2 handover process is performed for MR and the MR will be attached to MAG3.

3- The authentication will be performed using MAG2 for the MR.

4- Now MRwill be participated in theextended binding update process to exchange the group identifiers such as G=1. Here, the MR is assigned to a MAG's extended binding update group identifier with flag G=1 and LMA's extended binding update group identifier D=1(Proxy domain). Now at this point MAG treats MR as group G for MNP registration. Whereas LMA treats the MRas domain registration D=1. Now both the entities can perform the extended binding operations on a group of mobility sessions identified by the respective extended binding update group identifier.

5- The MAG3 sends a EPBU message for short lifetime of all the mobile Network Nodes identified by the group identifier G. Upon accepting the PBU, the LMA will update the lifetimes of MNP prefix, and MR in the binding cache entries.

6- Upon LMA interceptsany message from any part of the group G. the LMA verify BCE for flag G=1. Then update MNN lifetime,and sends a binding acknowledge message to MAG2 with fast BA. Upon accepting FBA message, the MAG2deletesMNN for its cache.

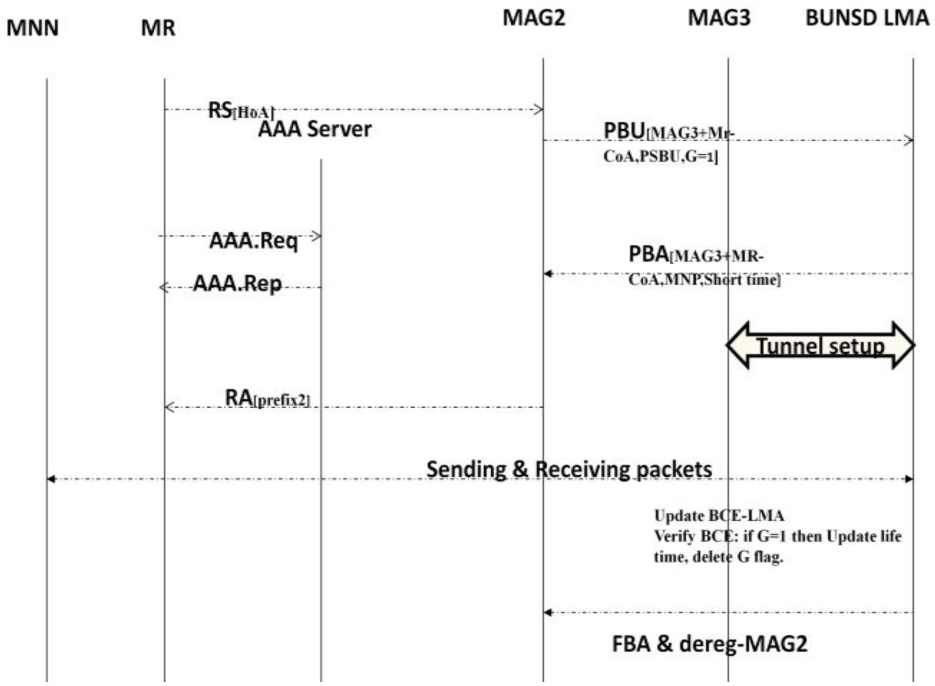


Figure 3.4: Proposed BUNSD-LMA signaling Diagram

3.9 IMPLEMTATION OF BUNSD-LMA ROUTE DECISION

The BUNSD-LMA, shown in fig.3.5 flowchart is implementing route decision operations for the proposed scheme described into these steps:

1- The route decision operation of proposed BUNSD-LMA scheme start by the mobile router movements to foreign network.
2- The MR perform authentication with BUNSD-LMA Domain or INMD. If the authentication fails its stop movement in proxy domain, otherwise, then check proxy domain applicability.
3- If MR is registered in BUNSD-LMA proxy domain then, MAG perform the registrations for MNNs using extended binding update message with flag G=1. In this time it call fast registration.
4- If MR is not registered in BUNSD-LMA proxy domain then, MAG perform the registrations for MNNs using first timeproxy domain registration with flag D=1.
5- After successfully registration for MNP prefix with flag G=1. The LMA update MNNs lifetime to short.

6- Upon intercepting, any message for the network LMA updates the lifetime and sends FBA to MNN through NMAG.

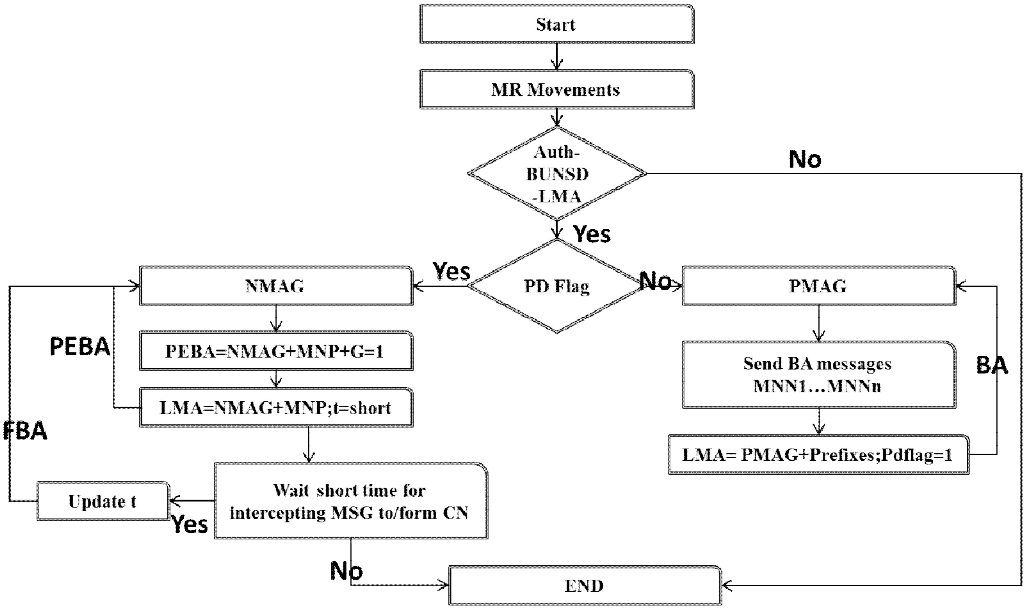


Figure 3.5: BUNSD-LMA Flowchart

3.10 SUMMARY

Mobility has changed the way people communicate due to Accelerated by the success of cellular technologies. As Internet access becomes ubiquitous, demands for mobility are not restricted to single terminals anymore. It is also needed to support the movement of a complete network that changes its point of attachment to the fixed infrastructure, maintaining the sessions of every device of the network: what is known as network mobility in IP networks. In this scenario, the mobile network has at least a (mobile) router that connects to the fixed infrastructure, and the devices of the mobile network connect to the exterior through this mobile router.

With the Large scale deployment of wireless technology Public Area, Buses, Trains, and Airplanes. Users need to access the Internet and other services anytime and anywhere while they move. In addition, Vehicles, Trains and airplanes are equipped with Cameras and sensors for Monitoring.

NEMO BSP proposes to achieve mobility to whole MNNs as a one unit. However, NEMO BSP suffers from some problems and challenges, the most important challenges are route optimization, seamless mobility (handover latency and registration time) and security.

In this chapter, we describe the network topology of BUNSD-LMA scheme and its elements. Then we explain the scenario of how to solve the problem of packet loss and handover delay by integration of PMIPv6 with NEMO BS using pre-registration of MNP (HNP) in advance with short time update in binding update extensions massage format

CHAPTER FOUR PERFORMANCE ANALYSIS OF PROPOSED BUNSD-LMA

4.1 INTRODUCTION

This chapter,analyze the total cost of packet delivery in Binding update No sense Drop LMA, including the handover latency and packet loss of various mobility parameters of the proposed BUNSD-LMA schema, see table.4.1 .

The analytical cost model in this chapter cover all possible cost required for mobility management, and assist in estimating the actual resources (transmission cost, bandwidth cost, propagation cost, process cost) used by network parameters to maintain session continuity with other network nodes in the internet. The performance of proposed schema BUNSD-LMA is evaluated and bench marked with PMIPv6 and NEMO BS standards.

Table 4.1: Parameters Definition

Symbols	**Parameters**
N_{FMN}	Number of FMN
N_{LMN}	Number of LMN
N_{VMN}	Number of VMN
N_{MNN}	Number of MNN = $N_{FMN} + N_{LMN} + N_{VMN}$
N_{CN}	Number of CNs that communicate with MNNs
N_{CN-MNN}	Number of hops between any MNN and CN
N_{MR-HA}	Number of between the MR and the HA in hops
N_w	Number of hops in wired link
N_{wl}	Number of hops in wireless link
B_l	Bandwidth of wired links
B_{wl}	Bandwidth of wireless links
T_{BU}	Time of binding update message
L_{BA}	Time of binding acknowledgement message
L_w	Latency of wired link ...propagation delay + link layer delay
L_{wl}	Latency of wireless link
T_s	Time to process signalling message
T_p	Processing time for a packet in every hop
P_{len}	Packet length of message

P_{size}	Packet size of message
T_{Proc}	Processing time for packet.(MAG, LMA, MR, MNN)
T_{tunnel}	Processing time for tunnel packet
T_{trans}	Transmission time for packet
T_{prop}	Propagation delay over wired or wireless
T_{scan}	Time to scan wireless channel
T_{aaa}	Time for authentication
T_{re-ass}	Time for re-association
T_{CONF}	Time of CoA Configuration
T_{DAD}	Time of Duplicate address detection
T_{REG}	Time of registration
T_{MD}	Time of movement detection, discovering new link
T_{RS}	Time of router solicitation
T_{RA}	Time of router advertisement
T_{EBU}	Time of extended binding update
L_2	Layer Two-link layer
L_3	Network Layer, Layer 3
P_f	Probability failure in wireless link
N_f	Number of Packet failure over the wireless link
D_P	Packet services Delay

Assumptions:

1- LMA, HA, BUNSD-LMA is the home agent of MR, LFN, and LMN for the mobile network.

2- HA-MH is the home agent of VMN.

3- Session arrival rate for MNNs is equal.

4- Each CN has ongoing session with MNNs.

4.2 HANDOVER MANAGEMENT

In mobility management, during the handover process the MNs cannot send or receive any packet from the CNs. For this, IPv6 handover processes can be classified into Link layer handoff (Layer two delays) which is the process time from MR to find and associate with a new Access Point. Second the IPv6 network layer handoff (layer three delays) In which are Router Discovery and assignment of CoA. This can be done by sending a Router Solicitation (RS) and receives a Router Advertisement (RA) from a new Access Router. Then the assignment of CoA required Duplicate Address Detection (DAD) process(Fatima, 2013). Third is home agent registration latency (layer three delays). The process of sending a BU from MR or MN to its HA and receives a binding acknowledgement BA from HA.

Handover delay = link layer + network layer = L2 + L3

$$L_2=T_{scan}+T_{aaa}+T_{re-ass} \quad (4.1)$$

$$L_3=T_{CONF}+T_{DAD}+T_{REG}+T_{MD} \quad (4.2)$$

$$T_{MD}=T_{RS}+T_{RA} \quad (4.3)$$

$$T_{RS}=T_{RA}=\frac{1}{2}\frac{(\text{MinRTRInterval}+\text{MAXRTRInterval})}{2}$$

$$T_{REG}=T_{BU}+T_{BA} \quad (4.4)$$

4.2.1 Handover latency of PMIPv6

Firstly, PMIPv6 handover latency in our study is analyzed. assumed that MNNs and Mobile Router first attached to PMIPv6 domain to do mobility function on behalf of Mobile Router. After finishing handover process, the BUNSD-LMA can perform the full registration of MNNs. The signaling diagram of PMIPv6 registration scenarioshown in fig.4.1.

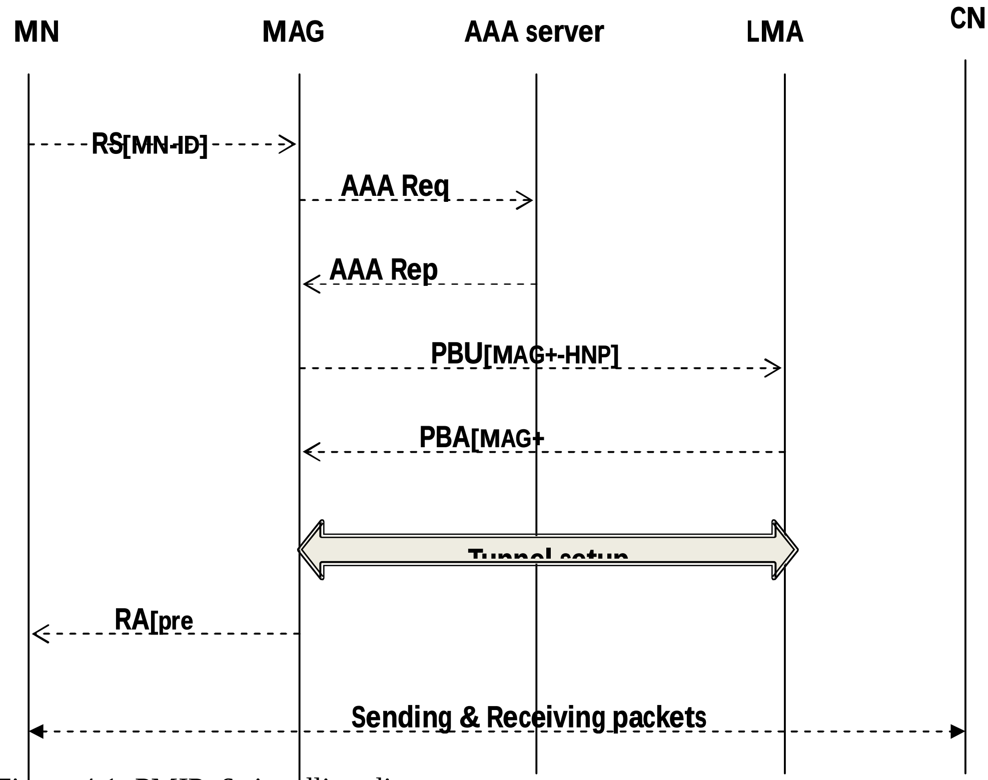


Figure 4.1: PMIPv6 signalling diagram

The PMIPv6 latency is composed of link layer and network layer, $T_{PMIPv6} = L2 + L3$

Thus, the latency of PMIPv6 when performing a handover from MAG to another MAG is calculated through the following formula.

$$T_{PMIPv6} = N_{MNN} \text{ x } (T_{scan} + T_{aaa} + T_{re-ass} + T_{CONF} + T_{DAD} + T_{RS} + T_{RA} + T_{PBU} + T_{PBA})$$

The N_{MNN} is the Total number of mobile network nodes that updating their locations compared to our proposed schema.

In PMIPv6, the MN uses the same address in all movements. However, no need for DAD and CoA Configuration due to PMIPv6 specification because the MN is already in proxy domain (Kong, 2008).

Reference to figure 4.1 RS=RA

By applying (1), (2), (3), and (4)

$$T_{PMIPv6} = N_{MNN} \times (T_{scan} + T_{aaa} + T_{re-ass} + 2T_{RS} + T_{PBU} + T_{PBA}) \quad (4.5)$$

4.2.2 Handover latency of NEMO BS

The handover latency of NEMO BS is composed of Layer three, layer two and registrations of all mobile network nodes. As mentioned in figure 4.2 signalling diagram.

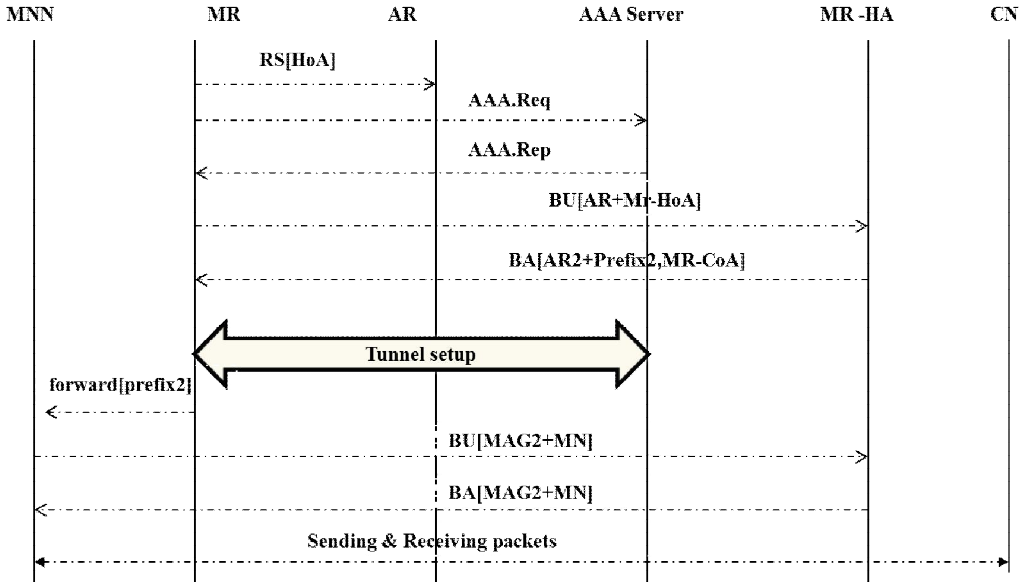


Figure 4.2: NEMO BS signalling diagram

$$T_{NEMO} = L2 + L3 + N_{MNN} \times (T_{BU} + T_{BA})$$

Where N_{MNN} are the number of mobile network nodes that updating their locations.

By applying (1), (2), (3), and (4) and RS=RA in fig 4.2

$$T_{NEMO} = T_{scan} + T_{aaa} + T_{re-ass} + T_{CONF} + T_{DAD} + 2T_{RS} + N_{MNN} \times (T_{BU} + T_{BA}) \quad (4.6)$$

4.2.3 Handover latency of EfNEMO

EFNEMO (Ryu, 2014) extend fNEMO to perform HA registration in advance to register the NCoA. This technique is used to send all packets between MNN and CN through path connect between NAR and PAR. However, using TBU embedded with FBU message to mitigate the burden on tunnel and reduce Handover Latency.

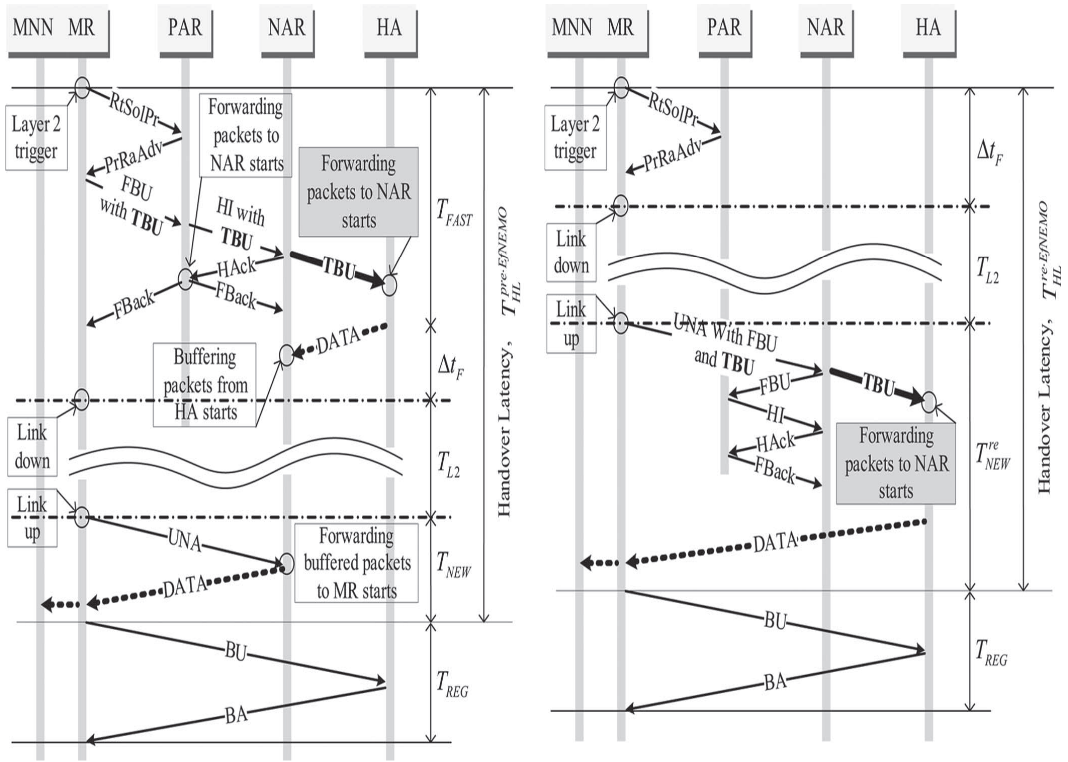


Figure 4.3: The Handover operations and timing diagrams in EfNEMO (Ryu, 2014).

$$\text{TEfNEMO} = T_{\text{scan}} + T_{\text{aaa}} + T_{\text{re-ass}} + T_{\text{CONF}} + \text{Tnew} + \text{TFast} + T_{\text{DAD}} + 2T_{\text{RS}} + N_{\text{MNN}} \text{ x } (T_{\text{BU}} + T_{\text{BA}}) \tag{4.7}$$

Where TFast is required time for additional signal before L2 handover. Tnew is delay time of informing attachments to NAR.

In P-NEMO (Lee, 2012)the handover performance of NEMO is supported by PMIPv6 domain by using MAG and LMA. However, the registration is done using PBU and PBA to register MNNs. To calculate the latency of whole scenario same as above formula, we use T_{NEMO}Integrated with PMIPv6 = L2 + L3

The PMIPv6 do the mobility functions on behalf of MR. However, any MNN send binding update and binding acknowledgement to complete their registration. And RS=RA

By applying (4.1), (4.2), (4.3), and (4.4)

$$T_{\text{NEMO+PMIPv6}} = T_{\text{scan}} + T_{\text{aaa}} + T_{\text{re-ass}} + 2T_{\text{RS}} + N_{\text{MNN}} \text{ x } (T_{\text{PBU}} + T_{\text{PBA}}) \tag{4.8}$$

4.2.4 Handover latency of BUNSD-LMA

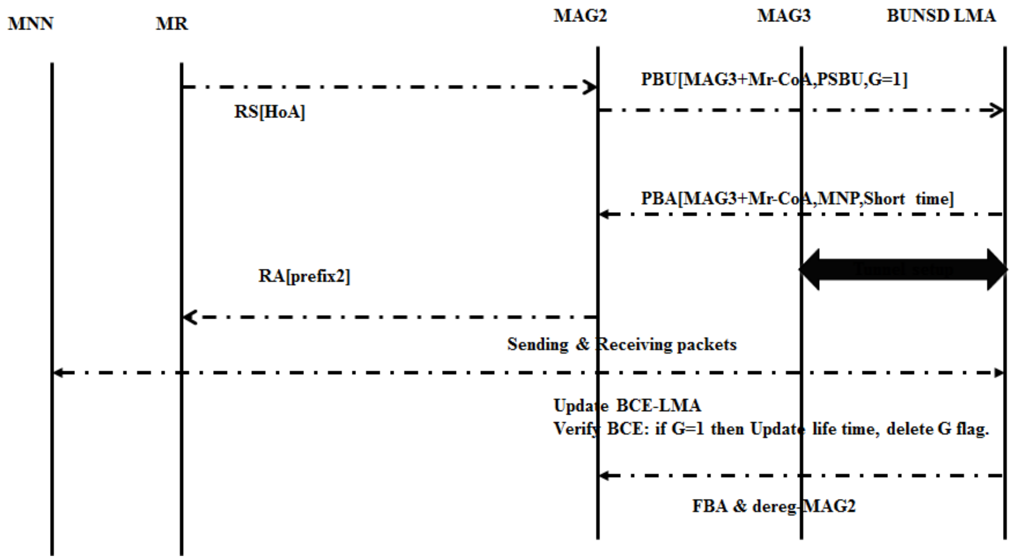


Figure 4.4: BUNSD-LMA signalling diagram

The handover latency of BUNSD-LMA is time between the movement of MR triggering layer-2 to move to another network and the time that MNNs receive first message from CN. Hence, the latency consist of link layer and network layer the formula is calculated as $T_{BUNSD-LMA} = L2 + L3$

Here also in PMIPv6, the MNN uses the same address in all movements. However, it is not needed DAD and CoA Configuration due to PMIPv6 specification because the MNN is already in proxy domain (Kong, 2008). And reference to fig 4.5 RS=RA

By applying (4.1), (4.2), (4.3), and (4.4)

$$T_{BUNSD-LMA} = T_{scan} + T_{aaa} + T_{re-ass} + 2T_{RS} + T_{EPBU} \tag{4.9}$$

BUNSD-LMA bind the N_{MNN} as Group using Extended Proxy binding update message format option (EPBA). However this message did not affect the equation because, it is included in BA message format design.

The TBA is received as TFBA after first packet intercepted through HA (LMA). This time can be omitted because, it does not affect handover.

4.3 PACKET DELAY

The delay of packet is composed of processing delay, transmission delay and propagation delay. This can be expressed in equation (4.9).

Packet delay$=T_{trans}+T_{prop}+T_{Proc}$ (4.10)

Where $\mathrm{T_{trans}}$the delay time for packet transmission, $\mathrm{T_{Prop}}$is the time for signal propagate from the source to destination device and $\mathrm{T_{Proc}}$ is time for processing packet.

$\mathrm{T_{trans}}$ = packet size / link bandwidth

$$\text{Wireless delay} = \mathrm{T_{Proc}} + \mathrm{P_{size}} / \mathrm{B_{wl}} + \mathrm{L_{wl}} \tag{4.11}$$

$$\text{Wired link delay} = (\mathrm{T_{Proc}} + \mathrm{P_{size}} / \mathrm{B_{w}} + \mathrm{L_{w}}) \times \mathrm{N_{w}} \tag{4.12}$$

The wired link is stable and we assume that wired link without transmission failure. However, the packets transmissions failure are expected in wireless. The Probability failure $\mathrm{P_f}$ for packet loss in every movement of MNN in the wireless link is calculated as follows (Ryu, 2014).

$$\mathrm{P_f} = \mathrm{f(P)} = \sum_{\mathrm{N_f}}^{\infty} \mathrm{N_f}\ \text{Prop}(\mathrm{N_f}\ \text{fialure and 1 success}) = \frac{\mathrm{P_f}}{1-\mathrm{P_f}} = \left(\frac{\mathrm{P_f}}{1-\mathrm{P_f}}\right)$$

$$\mathrm{T_{BA}} = \left(\mathrm{T_{Proc}} + \frac{\mathrm{P_{size}}}{\mathrm{B_{wl}}} + \mathrm{L_{wl}}\right) \times \left(\frac{\mathrm{P_f}}{1-\mathrm{P_f}}\right) + \left(\mathrm{T_{Proc}} + \frac{\mathrm{P_{size}}}{\mathrm{B_{w}}} + \mathrm{L_{w}}\right) \times \mathrm{N_{hop}} \tag{4.13}$$

$$\mathrm{T_{BA}} = \mathrm{N_{hop}}\left(\mathrm{L_w} + \mathrm{T_{Proc}} + \frac{\mathrm{P_{size}}}{\mathrm{B_w}}\right) + \frac{\mathrm{P_f}\left(\mathrm{L_{wl}} + \mathrm{T_{Proc}} + \frac{\mathrm{P_{size}}}{\mathrm{B_{wl}}}\right)}{1-\mathrm{P_f}} \quad \text{Where } \mathrm{P_f} \neq 1 \text{ and } \mathrm{B_{wl}} \neq 0 \text{ and } \mathrm{B_w} \neq 0$$

Where $\mathrm{H_{MR-AR}} = \mathrm{N_{wl}}$ and $\mathrm{H_{AR-HA-MR}} = \mathrm{N_w}$, $\mathrm{T_{BA}} = \mathrm{T_{BU}}$ in different packet size.

RS=RA= TRS (MN/MR,AR/MAG)

$$\mathrm{T_{RS}} = \mathrm{T_{RA}} = \left(\mathrm{T_{Proc}} + \frac{\mathrm{P_{size}}}{\mathrm{B_{wl}}} + \mathrm{L_{wl}}\right) \times \left(\frac{\mathrm{P_f}}{1-\mathrm{P_f}}\right)$$

$T_{RS} = \frac{P_f\left(L_{wl}+T_{Proc}+\frac{P_{size}}{B_{wl}}\right)}{1-P_f}$ Where $P_f \neq 1$ and B_{wl} ¯0

4.3.1 Packet Delivery cost PMIPv6

P_c(PMIPv6) = (P_c(MAG) + P_c(LMA) +T_{tunnel}) x N_{MNN}

By applying 4.11and 4.12

P_c(PMIPv6) = ((T_{Proc}+ $\frac{P_{size}}{B_{wl}}$ +L_{wl}) x
($\frac{P_f}{1-P_f}$) + (T_{Proc} + $\frac{P_{size}}{B_w}$ +L_w) x N_{hop} +T_{tunnel}) x N_{MNN}

$P_c(\text{PMIPv6})=N_{MNN}\left(N_{hop}\left(L_w+T_{Proc}+\frac{P_{size}}{B_w}\right)+\frac{P_f\left(L_{wl}+T_{Proc}+\frac{P_{size}}{B_{wl}}\right)}{1-P_f}+T_{tunnel}\right)$ Where
$P_f \neq 1$ and $B_{wl} \neq 0$ and $B_w \neq 0$

(4.14)

$T_{PBA} = (T_{Proc}+ \frac{P_{size}}{B_{wl}} +L_{wl}) \text{ x } (\frac{P_f}{1-P_f}) \text{x } N_{wl}$

$T_{PBA} = \frac{P_f N_{wl}\left(L_{wl}+T_{Proc}+\frac{P_{size}}{B_{wl}}\right)}{1-P_f}$ Where $P_f \neq 1$ and $B_{wl} \neq 0$

4.3.2 Packet delivery cost of FMIPv6

The packet is to be forward and buffered in FMIPv6 (Gohar, 2010).

P_c(FMIPv6) = T_{Proc} x (handover delay L2/L3) + MIP (BU, BA)

P_c(FMIPv6) = N_{MNN}x ($C_{forwarding}$+ $C_{buffering}$)

P_c(FMIPv6) = T_{Proc} x (2 T_{RA-HA}+ P_{HA}) + (T_{AR-AR}+ T_{NAR}) (4.15)

4.3.3 Packet Delivery cost NEMO BS

P_c(NEMO) = (P_c(MR) + P_c(HA_{MR}) +T_{tunnel}) x N_{MNN}

By applying 4.11 and 4.12

P_c(NEMO) = ((T_{Proc}+ $\frac{P_{size}}{B_{wl}}$ +L_{wl}) x ($\frac{P_f}{1-P_f}$) + (T_{Proc} + $\frac{P_{size}}{B_w}$ +L_w) x N_{hop} +T_{tunnel}) x N_{MNN}

$P_{c(NEMO)} = N_{MNN}\left(N_{hop}\left(L_w + T_{Proc} + \frac{P_{size}}{B_w}\right) + \frac{P_f\left(L_{wl} + T_{Proc} + \frac{P_{size}}{B_{wl}}\right)}{1-P_f} + T_{tunnel}\right)$ Where $P_f \neq 1$ and $B_{wl} \neq 0$ and $B_w \neq 0$ (4.16)

$T_{BA} = (T_{Proc} + \frac{P_{size}}{B_{wl}} + L_{wl}) \times (\frac{P_f}{1-P_f}) \times N_{wl} + (T_{Proc} + \frac{P_{size}}{B_w} + L_w) \times N_{hop}$

$T_{BA} = \frac{P_f N_{wl}\left(L_{wl} + T_{Proc} + \frac{P_{size}}{B_{wl}}\right)}{1-P_f} + N_{hop}\left(L_w + T_{Proc} + \frac{P_{size}}{B_w}\right)$ Where $P_f \neq 1$ and $B_{wl} \neq 0$ and $B_w \neq 0$

4.3.4 Packet delay cost of EfNEMO

$P_c(EfNEMO) = (P_c(MR) + P_c(FMIPv6) + T_{tunnel}) \times N_{MNN}$

By applying 4.11 and 4.12, and 4.16

$P_c(EfNEMO) = ((T_{Proc} + \frac{P_{size}}{B_{wl}} + L_{wl}) \times (\frac{P_f}{1-P_f}) + 2 \times ((T_{Proc} + \frac{P_{size}}{B_{wl}} + L_{wl}) \times (\frac{P_f}{1-P_f}) + (T_{Proc} + \frac{P_{size}}{B_w} + L_w) \times N_{hop}) + T_{tunnel}) \times N_{MNN}$

$P_c(EfNEMO) = N_{MNN}\left(N_{hop}\left(L_w + T_{Proc} + \frac{P_{size}}{B_w}\right) + \frac{4P_f\left(L_{wl} + T_{Proc} + \frac{P_{size}}{B_{wl}}\right)}{1-P_f} + T_{tunnel}\right)$ (4.17)

4.3.5 Packet Delivery cost NEMO BS + PMIPv6

$P_c(NEMO + PMIPv6) = (P_c(MR) + P_c(PMIPv6) + T_{tunnel}) \times N_{MNN}$

By applying 4.11 and 4.12, and 4.14

$P_c(NEMO + PMIPv6) = ((T_{Proc} + \frac{P_{size}}{B_{wl}} + L_{wl}) \times (\frac{P_f}{1-P_f}) + ((T_{Proc} + \frac{P_{size}}{B_{wl}} + L_{wl}) \times (\frac{P_f}{1-P_f}) + (T_{Proc} + \frac{P_{size}}{B_w} + L_w) \times N_{hop} + T_{tunnel}) + T_{tunnel}) \times N_{MNN}$

$P_c(NEMO + PMIPv6) = N_{MNN}\left(N_{hop}\left(L_w + T_{Proc} + \frac{P_{size}}{B_w}\right) + \frac{2P_f\left(L_{wl} + T_{Proc} + \frac{P_{size}}{B_{wl}}\right)}{1-P_f} + 2T_{tunnel}\right)$ (4.18)

Here the binding update is performing by PMIPv6 for this we use equation [6].

$T_{PBA} = (T_{Proc} + \frac{P_{size}}{B_{wl}} + L_{wl}) \times (\frac{P_f}{1-P_f}) \times N_{wl}$

$$T_{PBA} = \frac{P_f N_{wl}\left(L_{wl}+T_{Proc}+\frac{P_{size}}{B_{wl}}\right)}{1-P_f} \quad \text{Where} \quad P_f \neq 1 \text{ and } \quad B_{wl} \neq 0$$

4.3.6 Packet Delivery cost BUNSD-LMA

$$P_c(\text{BUNSD-LMA}) = (P_c(MR) + P_c(PMIPv6)) \text{ x } N_{MNN}$$

By applying 4.11 and 4.12, and 4.14

$$P_c(BUNSD - LMA) = ((T_{Proc} + \frac{P_{size}}{B_{wl}} + L_{wl}) \text{ x } (\frac{P_f}{1-P_f}) + ((T_{Proc} + \frac{P_{size}}{B_{wl}} + L_{wl}) \text{ x } (\frac{P_f}{1-P_f}) + (T_{Proc} + \frac{P_{size}}{B_{wl}} + L_w) \text{ x } N_{hop} + T_{tunnel})) \text{ x } N_{MNN}$$

$$P_c(BUNSD - LMA) = N_{MNN}\left(N_{hop}\left(L_w + T_{Proc} + \frac{P_{size}}{B_{wl}}\right) + \frac{2P_f\left(L_{wl}+T_{Proc}+\frac{P_{size}}{B_{wl}}\right)}{1-P_f} + T_{tunnel}\right)$$

$$\text{Where} \quad P_f \neq 1 \text{ and } \quad B_{wl} \neq 0 \qquad (4.19)$$

The binding update of BUNSD-LMA is performing by PMIPv6 for this equation [4.6] is used.

$$T_{PBA} = (T_{Proc} + \frac{P_{size}}{B_{wl}} + L_{wl}) \text{ x } (\frac{P_f}{1-P_f}) \text{x } N_{wl}$$

$$T_{PBA} = \frac{P_f N_{wl}\left(L_{wl}+T_{Proc}+\frac{P_{size}}{B_{wl}}\right)}{1-P_f} \quad \text{Where} \quad P_f \neq 1 \text{ and } \quad B_{wl} \neq 0$$

4.4 TOTAL COST

In this section we analysis of BUNSD-LMA related to PMIPv6 and NEMO BS schemes. The total cost (TC) is composed of handover latency cost and packet delay cost. We calculate the cost of mobile network nodes in the three schemes for comparative purpose.

4.4.1 Total Cost of PMIPv6

Following is the total cost of PMIPv6 by applying equation (4.5) and (4.14).

$$TC_{PMIPv6} = N_{MNN} \text{ x } (T_{scan} + T_{aaa} + T_{re-ass} + T_{CONF} + T_{DAD} + T_{RS} + T_{RA} + T_{BU} + T_{BA}) + ((T_{Proc} + \frac{P_{size}}{B_{wl}} + L_{wl}) \text{ x } (\frac{P_f}{1-P_f}) + (T_{Proc} + \frac{P_{size}}{B_w} + L_w) \text{ x } N_{hop} + T_{tunnel}) \text{ x } N_{MNN} \qquad (4.20)$$

4.4.2 Total Cost of NEMO BS

Following is the total cost of NEMO BS by applying equation (4.6) and (4.16)

$$.TC_{NEMO} = T_{NEMO} + P_c(NEMO)$$

$$TC_{NEMO} = T_{scan} + T_{aaa} + T_{re-ass} + T_{CONF} + T_{DAD} + T_{RS} + T_{RA} + N_{MNN} \times (T_{BU} + T_{BA}) + ((T_{Proc} + \frac{P_{size}}{B_{wl}} + L_{wl}) \times (\frac{P_f}{1-P_f}) + (T_{Proc} + \frac{P_{size}}{B_w} + L_w) \times N_{hop} + T_{tunnel}) \times N_{MNN} \qquad (4.21)$$

4.4.3 Total Cost of PMIPv6 with NEMOBS

Following is the total cost of NEMO + PMIPv6 by applying equation (4.8) and (4.18)

$$TC_{NEMO+PMIPv6} = T_{NEMO+PMIPv6} + P_c(NEMO + PMIPv6)$$

$$TC_{NEMO+PMIPv6} = T_{scan} + T_{aaa} + T_{re-ass} + T_{RS} + T_{RA} + T_{CONF} + N_{MNN} \times (T_{BU} + T_{BA}) + (T_{Proc} + P_{size} / B_{wl} + L_{wl} + ((T_{Proc} + \frac{P_{size}}{B_{wl}} + L_{wl}) \times (\frac{P_f}{1-P_f}) + ((T_{Proc} + \frac{P_{size}}{B_{wl}} + L_{wl}) \times (\frac{P_f}{1-P_f}) + (T_{Proc} + \frac{P_{size}}{B_w} + L_w) \times N_{hop} + T_{tunnel}) + T_{tunnel}) \times N_{MNN} \qquad (4.22)$$

4.4.4 Total Cost of Proposed BUNSD-LMA

Following is the total cost of BUNSD-LMA by applying equation (4.9) and (4.20)

$$TC_{BUNSD-LMA} = T_{BUNSD-LMA} + P_c(BUNSD\text{-}LMA)$$

$$T_{BUNSD-LMA} = T_{scan} + T_{aaa} + T_{re-ass} + T_{RS} + T_{RA} + T_{CONF} + T_{EBU} + ((T_{Proc} + \frac{P_{size}}{B_{wl}} + L_{wl}) \times (\frac{P_f}{1-P_f}) + ((T_{Proc} + \frac{P_{size}}{B_{wl}} + L_{wl}) \times (\frac{P_f}{1-P_f}) + (T_{Proc} + \frac{P_{size}}{B_{wl}} + L_w) \times N_{hop} + T_{tunnel})) \times N_{MNN} \qquad (4.23)$$

4.4.5 Packet loss

Packet loss mainly depends on the handover latency, which represents the packet dropped and is calculated as follows(Fatima, 2013):

$$PL = HL \times N_{MNN} \times \lambda_p \qquad (4.24)$$

4.5 NUMERICAL ANALYSIS RESULT

Thus, we analyze the numerical result for PMIPv6, NEMO BS, PMIPv6 with NEMO BS and BUNSD-LMA in term of total packet cost and handover latency. Parameters values used in this study are described in table 4.2.

Table 4.2: Parameters and Values

Symbols	**Value**
N_{MNN}	50-200
N_{w}	1
N_{wl}	3
B_{l}	100Mbps
B_{wl}	11Mbps
L_{w}	2 ms
L_{wl}	20ms
P_{size}	512 byte
T_{Proc}	10ms
T_{tunnel}	1ms
T_{scan}	30 ms
T_{aaa}	30ms
T_{re-ass}	30 ms
T_{CONF}	300ms
T_{DAD}	1000ms
T_{REG}	550ms
T_{RS}	1000ms
T_{RA}	1000ms
L_{2}	50 ms
P_{BU}	72 byte
P_{BA}	52 byte
P_{PBU}	76 byte
P_{PBA}	76 byte
P_{f}	0.1, 0.9

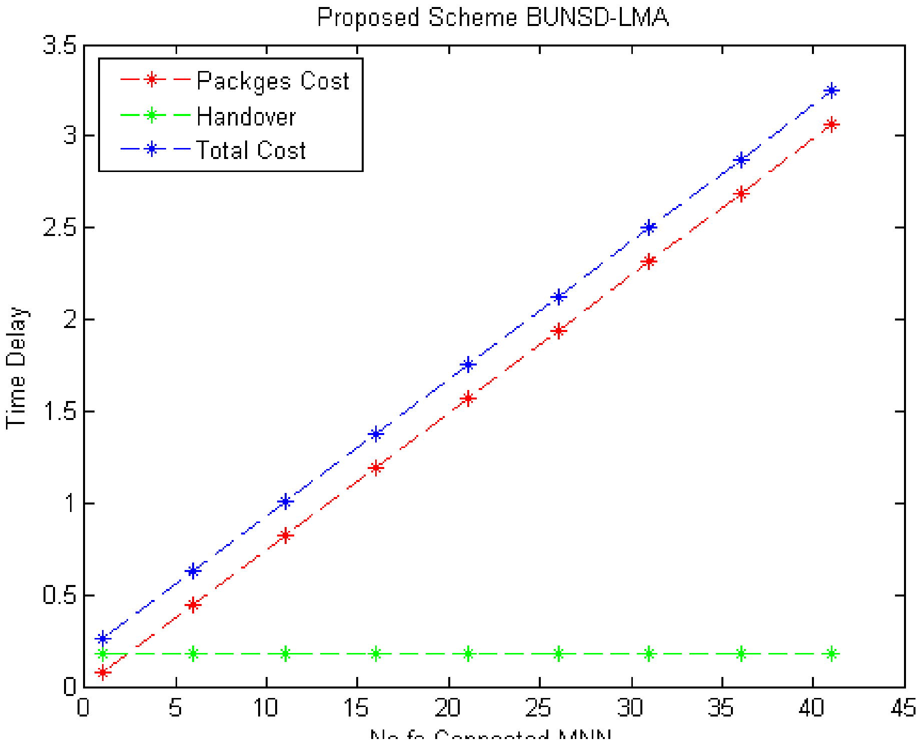


Figure 4.5: Cost analysis of BUNSD-LMA

Fig.4.5 shows the variation of the relative increasing number of MNNs against handover latency in BUNSD-LMA. Here, numbers of MNNs are between 0 and 45. However, the handover latency of MNNs is remaining fixed for any increasing of number of MNNs. The values of latency time did not change because, the MR take only one signal for handover for all MNNs as one unit. Beside these, the total packet cost is increase if the number of MNNs increases. In response to these, the total cost of BUNSD-LMA is increase regarding the relative effect of packet cost in total cost of the scheme.

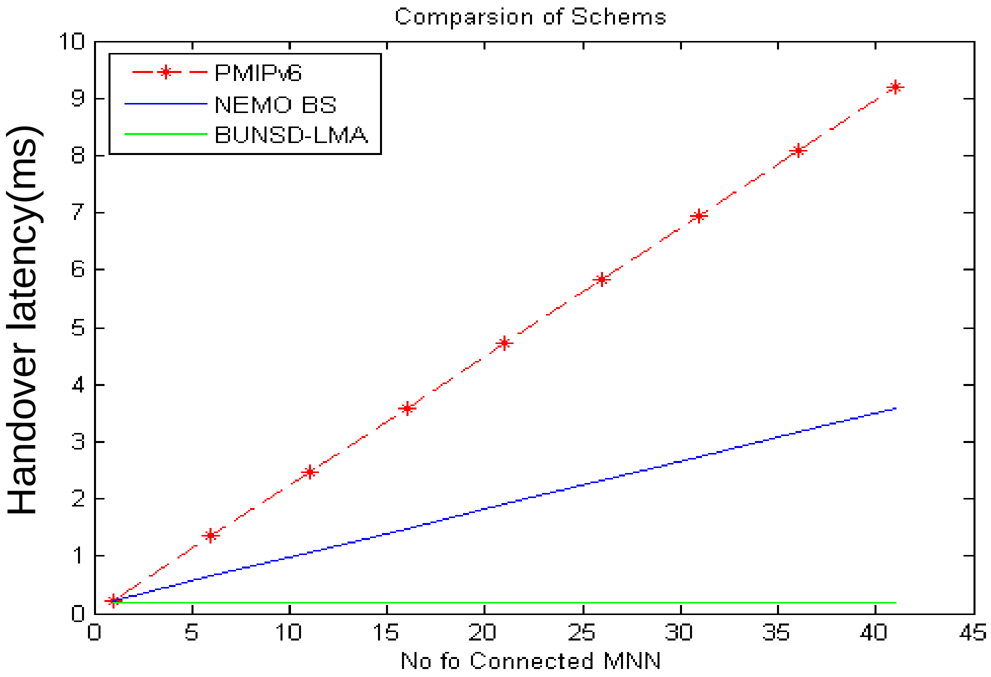


Figure 4.6: Handover analysis of schemes

Fig.4.6shows the variation of handover latency of PMIPv6, NEMO BS and BUNSD-LMA to the number of MNN. In PMIPv6 the time increases in regards to the number of MNNs increase, but in BUN-LMA the handover latency not change because, the handover perform by the mobile router in behalf of MNNs. For this, the increasing of MNN has no effect in the handover latency.

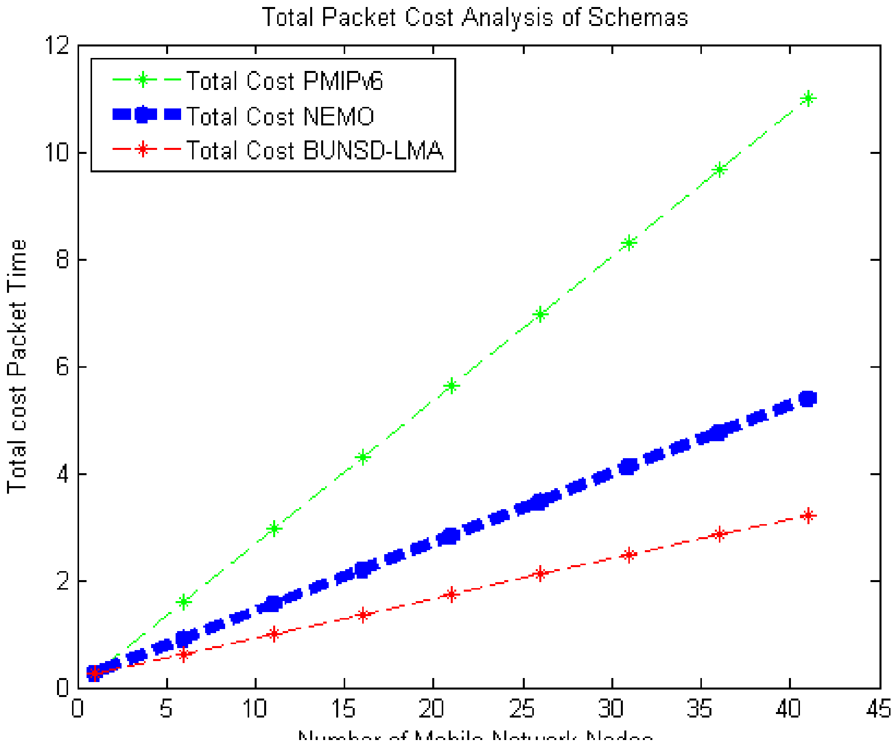


Figure 4.7: Total Packets Cost analysis of schemes

Fig.4.7 shows the variation of total packet cost of PMIPv6, NEMO BS and BUNSD-LMA to the total number of MNNs. However, BUNSD-LMA outperforms PMIPv6 and NEMO BS. The total cost of packet is composed of handover latency and packet transmission delay after handover completed. Besides these, the handover is near to equal for one MNN. But, if the number of mobile network nodes increase, the total packet cost of BUNSD-LMA decrease related to the other schemes in cost ratio.We conclude that the BUNSD-LMA performs better if the numbers of MNNs increase.

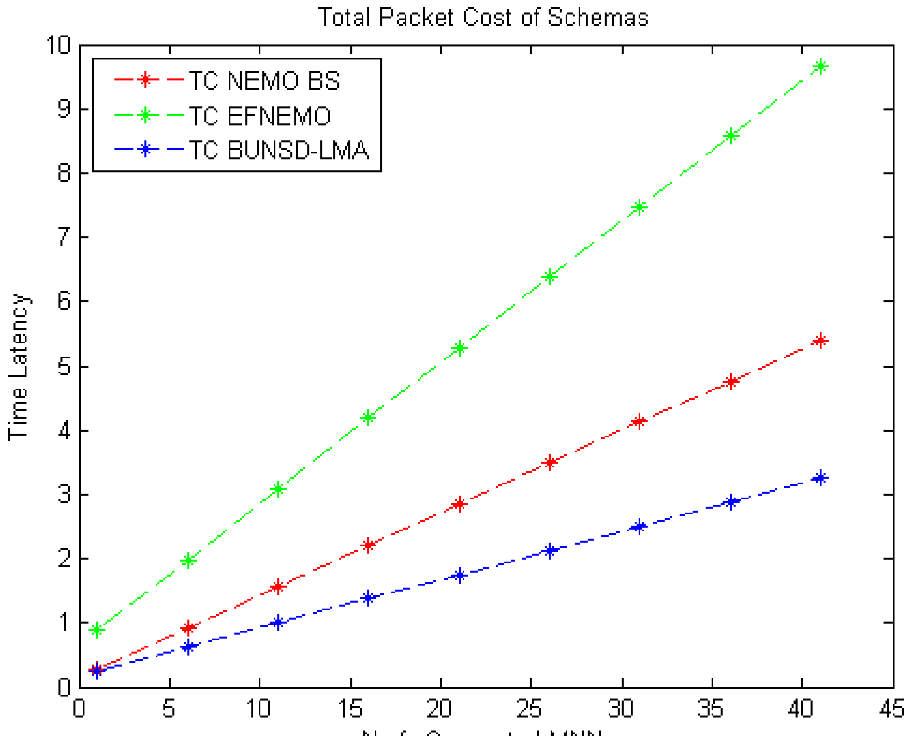


Figure 4.8: Total Packets Cost analysis of Schemes

Fig.4.8 shows the variation of total packet cost of EFNEMO, NEMO BS and BUNSD-LMA related to the total number of MNNs and handover latency. However, BUNSD-LMA outperforms EFNEMO and NEMO BS. The total cost of packet is composed of handover latency and packet transmission delay after handover completed. Besides these, if the movement in the same domain it is perform better than movements in different proxy domain. On the other hand, the first movement of MR has slightly high signalling cost than the second movement. However, it can be notice that, when the mobile network moves away from its home network it enhance the seamless mobility of mobile network nodes.

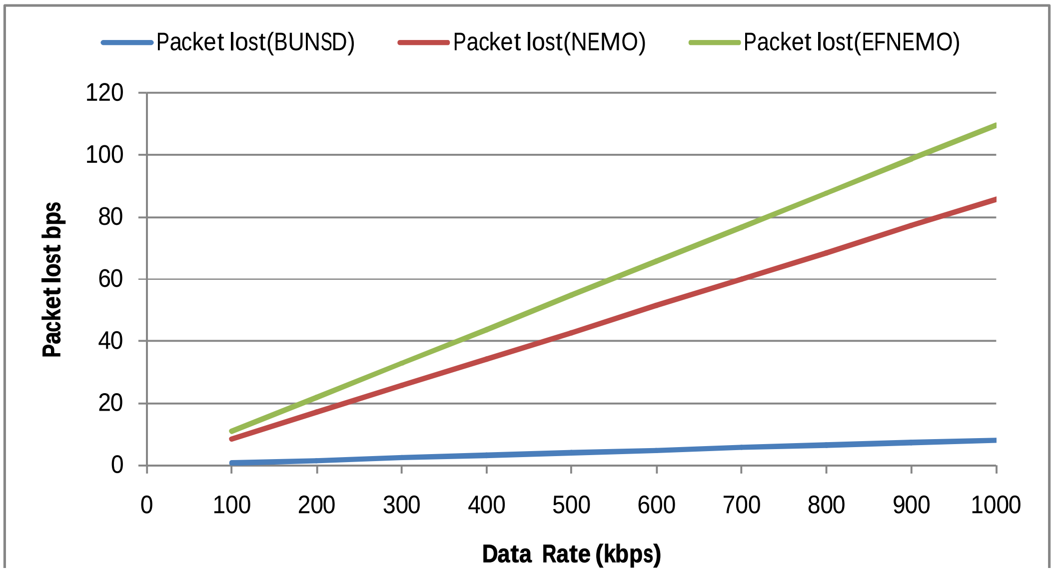


Figure 4.9:Total Packets loss analysis of schemes

Fig.4.9 shows the variation of total packet loss of EFNEMO, NEMO BS and BUNSD-LMA related to packet arrival rate.The total packet loss is composed of connected MNNs and packet arrival rate after handover completed. It notices that, BUNSD-LMA outperforms EFNEMO and NEMO BS.

4.6 CONCLUSION

In this Thesis, we have evaluated different mobility management's schemas in NEMO environments. We consider most of the current and previous solutions in NEMO. Then we proposed a BUNSD-LMA schema, to solve the problem of packet loss and handover delay, by integration of PMIPv6 with NEMO BS, using pre-registration of MNP (HNP) in advance with short time update in binding update extensions massage format.

According to NEMO BS, the packets sent by MNNs must be sent to the MR and then resent by HA through a tunnel. Besides, the registration to MNNs must be done using BU and BA for any MNNs. In this way, the efficiency decreases and the cost and delay of packet transmission increase. However, in BUNSD-LMA, we integrate PMIPv6 with NEMO. However, we used pre-registration of MNP (HNP) in advance with short time update in binding update extensions massage format. In order to support the connectivity of the MMN, the HNP assigned to an MMN is always in consistent with the advised prefix by the MR and MAG. In this way, all kinds of mobility can be supported in the PMIPv6 domain. Then we set up a network model and analyses the cost performance of NEMO, EFNEMO and BUNSD-LMA. The numerical results show that the packet in BUNSD-LMA can be transmitted through more optimized route, with fast registration and the handover latency can be decreased. And the total signalling cost can be reduced less compared with NEMO BS and EFNEMO.

CHAPTER FIVE SIMULATION OF BUNSD-LMA SCHEME USING OPNET

5.1 INTRODUCTION

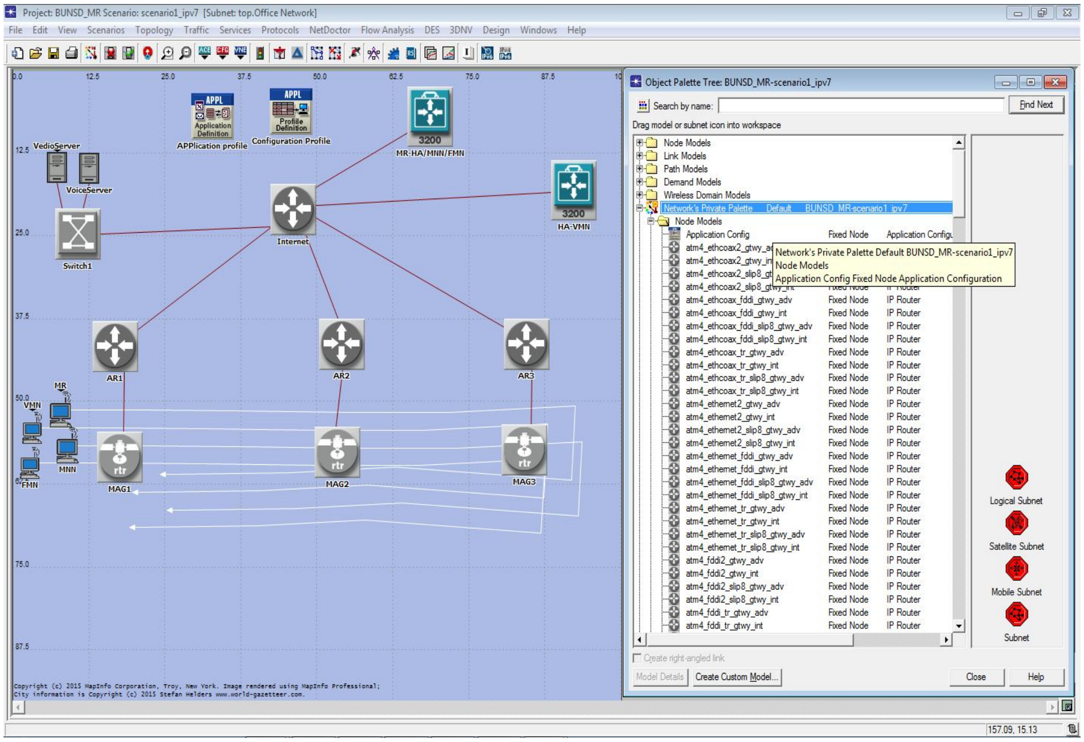
To build and model the wireless network, Mobile IPv6 Network, LAN nodes, and NEMO BSP in simulation software, we mostly considering Opnet modeller or NS2. NS2 was ruled out because, did not offer any graphical user interface and its command line only.

OPNET is a company that provides network managements software solutions (Salah, 2008). The OPNET simulation environment includes of many WLAN standards, common network devices, realistic traffic generation, realistic network packet propagation modeling, and tools for data collection and analysis. All of topologies features could be used to execute WLAN simulations with standard networks behavior. However, adding extended binding update functionality requires modifications to the standard Opnet module models. As described previously in our proposed scheme, the MNN needs to registers their CoAs with the HA to continue their session to Internet. To solve this issue, there is the need for an ability to add prefix flag G for group registration. OPNET WLAN models does not includes these mechanisms to its standard. Furthermore, the standard WLAN models do not include any scenario for NEMO. For this we need to build a network topology model to support NEMO and its features. Besides these issues, we need to update the message format for the registration between MAG and home agent. This chapter describes OPNET Modeller and the simulation of proposed BUNSD-LMA Scheme.

5.2 OPNET MODELLER OVERVIEW

There are many reasons and benefits offered by Opnet to be used in our research.OPNET Modeller is a discrete event simulator that assists researchers to develop and test network configurations and its technologies. It used by a lot of corporations and research bodies (Salah, 2008). The simulator is built to support many protocols and statistical gathering techniques. In addition, it provides great models of simulated network links and devices, such as switches and routers.

OPNET Modeller uses a GUI function to drag and drop nodes model into a network topology. The user can customize and define attributes for each node model by using menu options. Each node model is built from set of connected processes which represented by Transmission State Diagrams (TSD). The TSD can be converted to programming code C/C++. This mechanism allows the user to have control over the node at all stages and being able to define customized nodes. The design detail of a node within the Opnet Modeller interface is shown in Fig.5.1. This Figure shows nodes configuration in the main menu interface. Fig.5.2 shows the next level of abstraction which is the process diagram of MAG node. The state diagram for MAG node process is shown in fig.5.3. Each level can be modified by the user resulting in a custom model by adding or changing processes, states, and code. Link models are customizable if a user needs a different set of parameters for a link.



Network's Private Palette Default BUNSD_MR-scenario1_ipv7
Node Models
Application Config Fixed Node Application Configuration

Application Config	Fixed Node	Application Configu
atm4_ethcoax2_gtwy_ad		
atm4_ethcoax2_gtwy_in		
atm4_ethcoax2_slip8_gt		
atm4_ethcoax2_slip8_gtwy_int		
atm4_ethcoax_fddi_gtwy_adv	Fixed Node	IP Router
atm4_ethcoax_fddi_gtwy_int	Fixed Node	IP Router
atm4_ethcoax_fddi_slip8_gtwy_adv	Fixed Node	IP Router
atm4_ethcoax_fddi_slip8_gtwy_int	Fixed Node	IP Router
atm4_ethcoax_tr_gtwy_adv	Fixed Node	IP Router
atm4_ethcoax_tr_gtwy_int	Fixed Node	IP Router
atm4_ethcoax_tr_slip8_gtwy_adv	Fixed Node	IP Router
atm4_ethcoax_tr_slip8_gtwy_int	Fixed Node	IP Router
atm4_ethernet2_gtwy_adv	Fixed Node	IP Router
atm4_ethernet2_gtwy_int	Fixed Node	IP Router
atm4_ethernet2_slip8_gtwy_adv	Fixed Node	IP Router
atm4_ethernet2_slip8_gtwy_int	Fixed Node	IP Router
atm4_ethernet_fddi_gtwy_adv	Fixed Node	IP Router
atm4_ethernet_fddi_gtwy_int	Fixed Node	IP Router
atm4_ethernet_fddi_slip8_gtwy_adv	Fixed Node	IP Router
atm4_ethernet_fddi_slip8_gtwy_int	Fixed Node	IP Router
atm4_ethernet_tr_gtwy_adv	Fixed Node	IP Router
atm4_ethernet_tr_gtwy_int	Fixed Node	IP Router
atm4_ethernet_tr_slip8_gtwy_adv	Fixed Node	IP Router
atm4_ethernet_tr_slip8_gtwy_int	Fixed Node	IP Router
atm4_fddi2_gtwy_adv	Fixed Node	IP Router
atm4_fddi2_gtwy_int	Fixed Node	IP Router
atm4_fddi2_slip8_gtwy_adv	Fixed Node	IP Router
atm4_fddi2_slip8_gtwy_int	Fixed Node	IP Router
atm4_fddi_tr_gtwy_adv	Fixed Node	IP Router
atm4_fddi_tr_gtwy_int	Fixed Node	IP Router

Figure 5.1:Main Opnet GUI

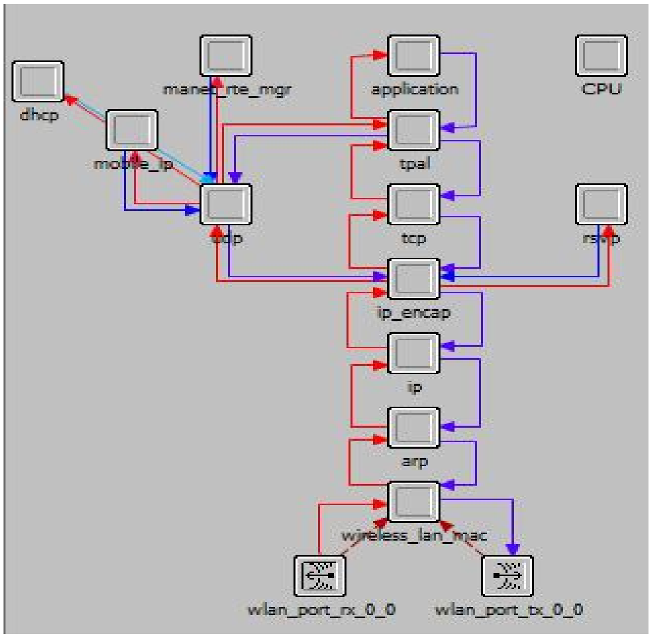


Figure 5.2: MNN-Node-Model

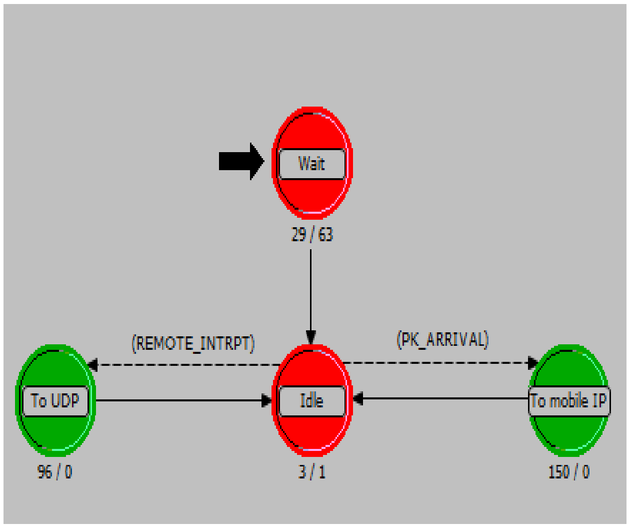


Figure 5.3: FSD-Node-Model

Opnet Modeller has many statisticalmethods available to analyze capturing amount of packets of a specific application or protocol received and sent by an interface, latency, link load. Statistics can be showed by resulting tools which defined by individual Discrete Event Simulation (DES) statistic. The user can identify the capturing statistics parameters on a specific node or on the global network.

Opnet Modeller structures are extended through add-on modules, example IPv6 and wireless support, available from OPNET (Jurčík, 2007). The System-in-the-Loop module (SITL) offers the ability to convert real network data into simulation (Bottura, 2013). This lets premade hardware models and software to cooperate with a simulated network without requiring creating a simulation model of these models. SITL is presented to support the basic protocol which includes IPv6.

5.3 THE ADVANTAGES AND DISADVANTAGES OF OPNET MODELLER

The disadvantage of OPNET is a copyrighted simulator and costs. A license must be obtained torun the Modeller software and any add-on modules (IPv6, SITL) require an additional license.

However, the OPNET has an educational version that gives free licenses for many of its products to universities for educational purposes(Garcia, 2008).

The advantage of Opnet is built in network models simulating companyproducts. Example, Cisco is available for developing network topologies. Other network simulators do not have these network models. Developers of other simulators software have to build their own network models. The availability of these built in prototypes helps users to build network topologies that carefully equal current networks. Second advantage is that the OPNET modular software is commonly reliable. Third advantage of Opnet Modeller is madeto support an unlimited amount of protocols. Fourth advantage of OPNET is to provide training for their products for fresh users. This decrease the time to study the parts of the software and reduction the time to build effective simulations. Finally, OPNET conducts its own platformwith new topologies and updates to products, development, and educational researches.

5.4 BACKGROUND ON SIMULATION

The concept of using network simulator environment is not a new. Some researchers have considered to simulation as a batter methods to test and measured new network configurations models and new devices.There are some cases of simulation frameworks settled for live networks, design newprotocols and test wireless configurations. The next frameworks assisted develop this research by validating parts that have been already tested and by studding topics that have not beenexamined.

Three studies were found that created network frameworks using OPNET Modeller. First study was done by (Senan, 2014). The purpose of this study is to design a new hierarchical route optimization in nested NEMO by using Advance Binding Update List (BUL+). They uses Opnet modeller simulator 14 to compare HRO-B+ scheme with NEMO BSP. Through the Opnet simulation scenario they compares different NEMO characteristic such as packet end-to-end delay, wireless LAN throughput, response time, and network traffic.

The second Opnet framework is developing Intrusion Detection (IDS) Systems created by Corral and others (Corral, 2005). They implements IDS in Opnet to show Opnet usage in company networks side. In this study, they create customized node model and node TSD. Besides, they analyzed IDS correctness and network traffic.

Third is “On the Performance of Wi-Fi, Ad Hoc and WiMAX Handovers with MIPv4 versus MIPv6” Opnet frameworks created by (Al Emam, 2014). This scheme is evaluated using NS2 and Opnet. In this scheme edited MIPv6, HMIPv6, MIPv4 and MANT features is studded.

However, many parameters such as BA, route optimization, and delay were taken into consideration.These studies assisted to create our proposed model using Opnet modeller. Fig.5.4 shows the details of our BUNSD-LMA architecture.

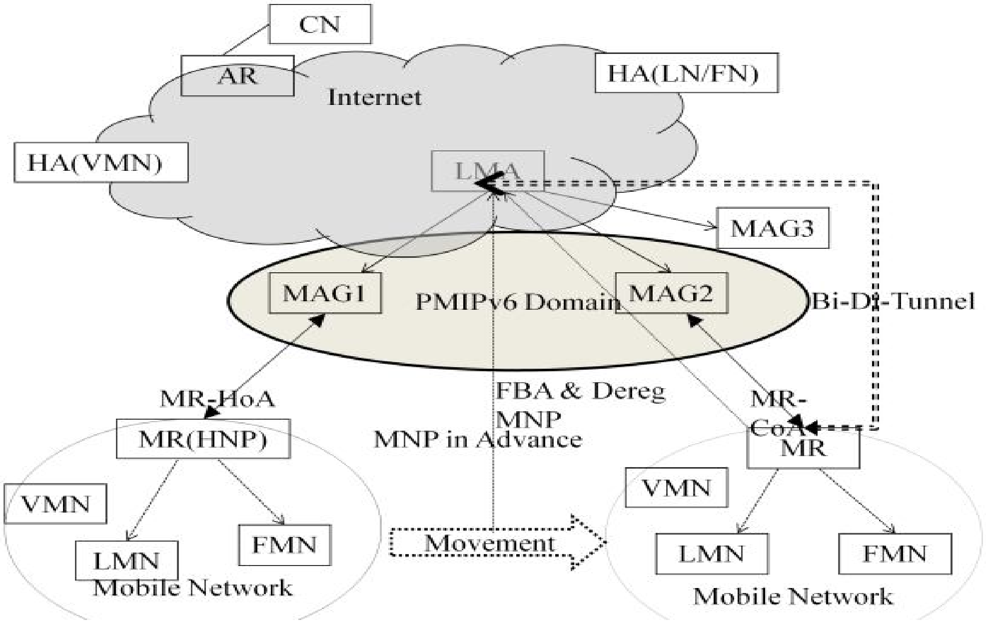


Figure 5.4: BUNSD-LMA Proposed architecture

5.5 SIMULATION SETUP

Fig. 5.6 shows the BUNSD-LMA network topology that we have developed in our simulation to investigate the basic characteristics of PMIPv6 integrated with NEMO BSP. In the figure, the AR1, R2, and R3 are denoting access routers in each subnetworkthat connect the subdomain to the Internet. MNN, FMN, and VMN represent the mobile network nodes that connected to mobile_router (MR) of BUNSD structures.MNNs can be freely attached to the NEMO while it changes its point of attachments to MAGs. While MNNs attached, they sends registration messages to their HAs.MR-HA/MNN/FMN represents the home agent of MR, MNN, and FMN.

Similarly, for VMNs the home agent is represented by HA-VMN. The MAG1, MAG2, and MAG2 are used to register the moving mobile networks nodes when attached to the BUNND-LMA domain. Hence, the MAG1 did normal registration, other MAGs register the MNP prefix rather than CoA addresses of MNNs. MR is used to handle handover on behalf of MNN. In the same way, MNN configures their CoA Addresses form MNP prefix which passed to MR form MAGs.

We have introduced voice and video server to simulate traffic send/receive form MNNs and CNs. Video-sever and voice-server connected to the topology through LAN switch as shown in the figure 5.6. Then the switch is connected to the Internet cloud. To offer voice and video services in the simulation environments we configured it using application-Config fig.5.7 and profile-config models as shown in fig.5.8.

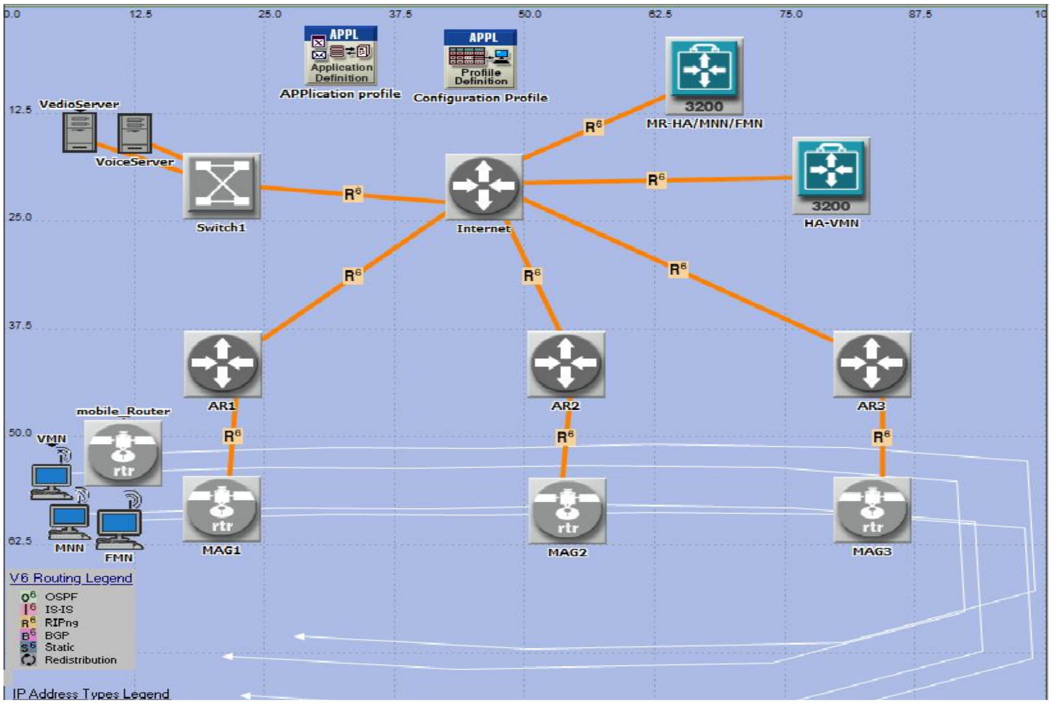
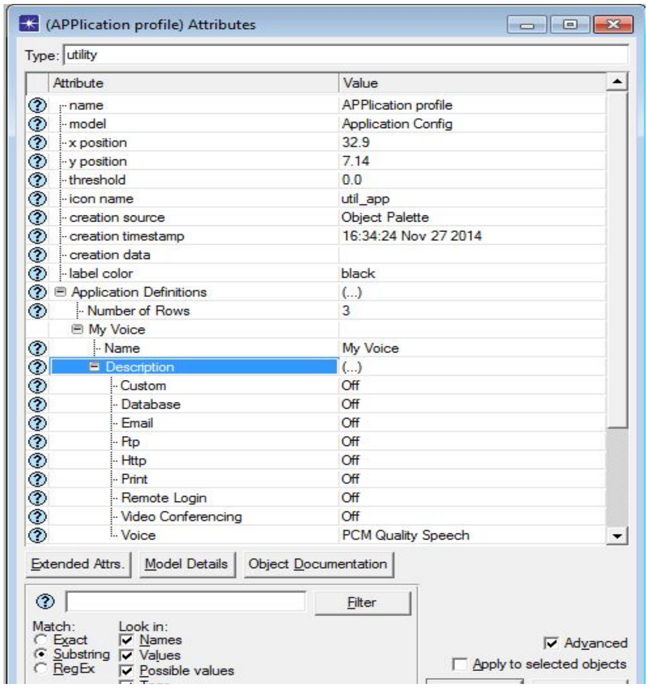


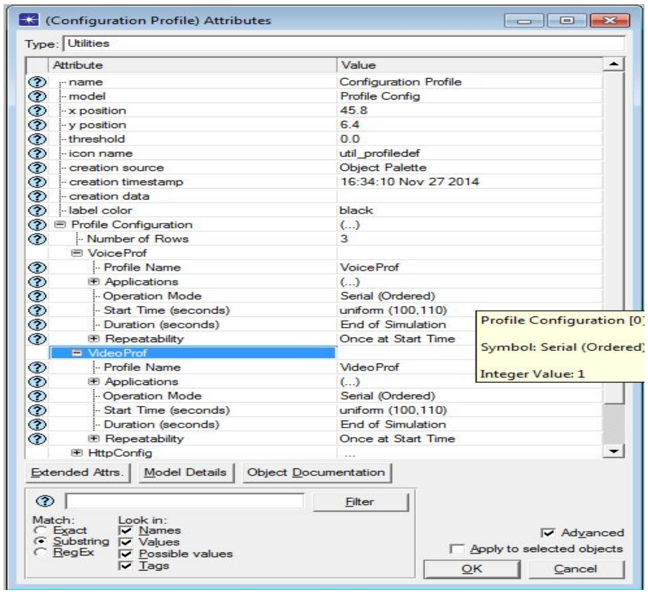
Figure 5.5: BUNSD-LMA Proposed architecture



Type: utility

Attribute	Value
name	APPlication profile
model	Application Config
x position	32.9
y position	7.14
threshold	0.0
icon name	util_app
creation source	Object Palette
creation timestamp	16:34:24 Nov 27 2014
creation data	
label color	black
Application Definitions	(...)
Number of Rows	3
My Voice	
Name	My Voice
Description	(...)
Custom	Off
Database	Off
Email	Off
Ftp	Off
Http	Off
Print	Off
Remote Login	Off
Video Conferencing	Off
Voice	PCM Quality Speech

Figure 5.6: Application Config



Type: Utilities

Attribute	Value
name	Configuration Profile
model	Profile Config
x position	45.8
y position	6.4
threshold	0.0
icon name	util_profiledef
creation source	Object Palette
creation timestamp	16:34:10 Nov 27 2014
creation data	
label color	black
Profile Configuration	(...)
Number of Rows	3
VoiceProf	
Profile Name	VoiceProf
Applications	(...)
Operation Mode	Serial (Ordered)
Start Time (seconds)	uniform (100,110)
Duration (seconds)	End of Simulation
Repeatability	Once at Start Time
VideoProf	
Profile Name	VideoProf
Applications	(...)
Operation Mode	Serial (Ordered)
Start Time (seconds)	uniform (100,110)
Duration (seconds)	End of Simulation
Repeatability	Once at Start Time
HttpConfig	...

Profile Configuration [0]
Symbol: Serial (Ordered)
Integer Value: 1

Figure 5.7: Profile Config.

5.5.1 Wireless LAN

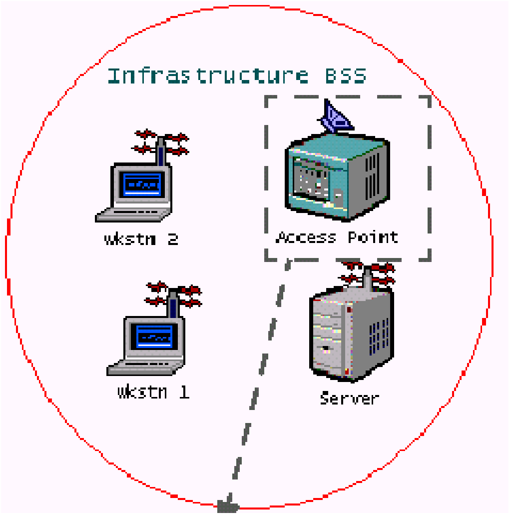
The Wireless LAN (WLAN) protocol is based on the IEEE standard, 802.11. This standard defines a medium access control (MAC) sublayer and three physical layers.

The architecture of the WLAN is designed to support a system where most routing and connectivity decisions are distributed across the mobile stations. The basic building blocks of the 802.11 based WLAN are:

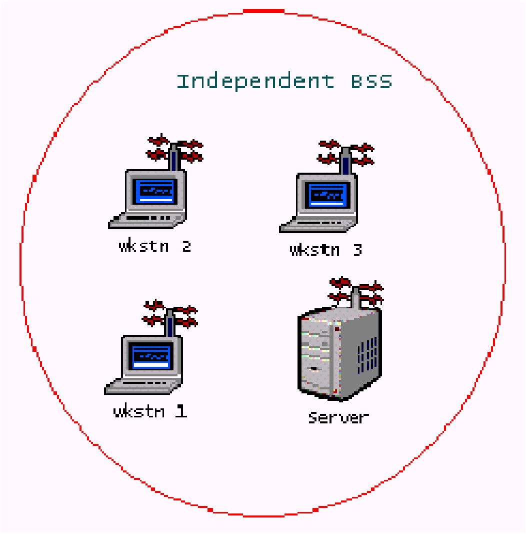
- A station that connects to the wireless medium. The station may be mobile, portable, or stationary.
- A Basic Service Set (BSS), a set of stations that communicate to one another. Adhoc networks exist when all stations in a set can communicate directly with no connection to a wired network.
- An Extended Service Set, a set of infrastructure BSSs. Access points within the BSSs communicates among each other to forward traffic to one another.

The MAC of the WLAN supplies the functionality to provide the efficient transmission of user data over wireless media. A MAC Frame Exchange provides a reliable data delivery service to the user. This frame exchange consists of a data frame sent from the source to the destination and an acknowledgement sent from the destination to the source. If no acknowledgement is received by the source, then the data is transmitted. A second mechanism of the MAC is the Basic Access Mechanism. This attempts to provide fair control access of shared wireless media. The Basic Access Mechanism is Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). In this access, a station will listen to the medium before transmission, if it detects an existing transmission, it will defer for a random amount of time and repeat. Collision Avoidance is achieved by using a network allocation vector that determines when the medium will become available. The third function of the MAC sublayer is to provide protection for the data it delivers. A private service, Wired Equivalent Privacy, performs this by encrypting the data it transmits.

In the Network Model of the WLAN implementation, BSS can be formed as both infrastructure BSS, with access points to other BSSs, or as independent BSSs, communicating to only those in their region, see Fig.5.8



(a)



(b)

Figure 5.8: (a) Basic Service Set with Access Points; (b) Independent Basic Service Set

The Node Model defines the behavior of the individual nodes. The WLAN modeling of the MAC and the physical layer is comprised of the wireless_lan_mac process, transmitter, receiver, and the channel streams. In the Node Model appropriate thresholds, data rates, physical characteristics, retry limits, and other WLAN statistics are also defined.

Table 5.1: Wireless LAN Statistics

Statistic	Description
Data Dropped	Rate at which data is dropped either due to the transmit buffer being full or because there were too many retransmissions.
Delay	Time it takes to successfully deliver data (including buffer delay)
Load	Rate at which data is sent by the wireless LAN source
Media Access Delay	Time it takes to successfully deliver a frame
Throughput	Rate at which data is received by the wireless LAN destination

Wireless LAN is configured as IEEE 802.11, with 11 Mbpsdata rate and no RTS/CTS or fragmentation used. EachWLAN radio is set to coverage 70-100 meters. Coverage is used to ensurenon-overlapping radio coverage of separate ARs.

Mobility pattern of the MNN is characterized by a horizontallinear path with constant ground speed of 10 km/h (the speedhas been varied from 1 to 10 km/h when needed to observethe impact of the moving speed on various performance measures). The moving speed (10 km/h) implies that MNN movesfaster than typical pedestrians but also slower than typicalpassenger vehicles in a metropolitan area. Consequently,mobility pattern results in moderate handover rates.

The traffic exchanged between the CN (Voice and Video server) and theMNN is configured to represent IPv6 Telephony using Voice-over-IPv6 techniques where CN and MNN act as clients to each other.The voice traffic exchanged between the MNN and CN can startand stop in each direction in a fixed manner. To reach our simulation result we need to design all address blogging to each device. Our next part describes this plan.

5.6 SIMULATION SCHEME IP ADDRESS PLAN.

The address must be carefully configured in simulation to be compared to real testbed. The address architecture begins from internet cloud interface to the leave of nodes. Table 5.2 shows the details of all devices IPv6 address.

Table 5.2: devices IPv6 address

Home Agent	**HA(**BUNSD-LMA**)-MR/FMN/MNN**	**HA-VMN**		**2014::/50**
BSS ID	1	2		
IP address	2014::1/50	2014::2/50		
IPv6 default route				
LMA	**LMA**			**2014:0:0:4000::/50**
BSS ID	11			
IP address	2014:0:0:4000::1/50			
IPv6 default route				
MAG	**MAG1**	**MAG2**	**MAG3**	**2014:0:0:8000::/50**
BSS ID	21	22	23	
IP address	2014:0:0:8000::1/50	2014:0:0:8000::2/50	2014:0:0:8000::3/50	
IPv6 default route				
MR	**NEMO-MR**			**2014:0:0:c000::/50**
BSS ID	31			
IP address	2014:0:0:C000::9/50			
IPv6 default route				
Mobile Nodes	**MNN**	**FMN**	**VMN**	**2014:0:0:c000::/50**
BSS ID	1	1	2	
IP address	2014:0:0:C000::1/50	2014:0:0:C000::2/50	2014:0:0:C000::3/50	
IPv6 default route	2014::1/50	2014::1/50	2014::2/50	

5.7 AREA OF WIRELESS NETWORK COVERAGE

First of all,the coverage of the wireless network must be considered, because it is a key point in the wireless network. The reason is that we need to knowhow much areawill be covered by the signal, and how many base stations areneeded.

Typical distances covered by802.11b and 802.11gare70m and the range of the 802.11n is increased to100m.

Due to the need for high speed data rates, manystandards IEEE 802.11a and the European Telecommunications Standards Institute (ETSI)‟s High Performance Local Area Network type , (HIPERLAN/2) are in place(others, 1997). A summary of the key WLAN standards is given in Table5.3 below(others, 1997)..

Table 5.3: Key WLAN Standards

Standard	**RF Band**	**Max .Data Rate**	**Physical Layer**	**Range**
IEEE 802.11	2.4GHz	2Mbps	FHSS,DSSS, IR	50 –100m
IEEE 802.11b	2.4GHz	11Mbps	DSSS	50 –100m
IEEE 802.11a	5GHz	54Mbps	OFDM	50 –100m
IEEE 802.11g	2.4GHz	54Mbps	OFDM	50 –100m
HIPERLAN/2	5GHz	54Mbps	OFDM	50m indoor 300m outdoor

5.8 PARAMETERS

The WLAN parameters used in the model are presented in tables 5.2. Parameters used for mobile and wireless stations are shown in Table 5.4. We applied the extended rate physical (PHY) layer (802.11g) standard for WiFi scenario with 24 Mbps date rate for both WiFi workstations and the AP(others, 1997).

Table 5.4: WiMAX parameters

BSS identifier	**Auto assigned**
Access point functionality	Enabled
Physical characteristics	Extended rate PHY (802.11g)
Data rate (bps)	24 Mbps
Transmit power (W)	2.0

5.9 SIMULATION RESULTS AND A NALYSIS

Using the simulation setup designated in the previous section,we have simulated a basic set of seamless mobility scenarios andobtained initial results. In the simulation, performancemeasures selected for the purpose of experiments. The performance parameters under consideration are registration time delayand packet loss. The measures are done during handover of MR through different MAGs. Basic MR Handover operates accordingto the standard specification of MIPv6 defined in (C. Perkins, 2011). In addition, the parameters and values is similarly to that used in analytical performance in chapter 4 which shown in table 4.1.

5.9.1 Traffic of Wireless LAN and throughput

Figure 5.9 and 5.10 shows the wireless throughput result for BUNSD-LMA and NEMO BSP with time delay for each. Simulation is done for both cases in 10 and 30 mints and total distance area of 500 Meters. The delay occurs when MNNs needs to register their CoAs. The registration latency in NEMO BSP is around 120 mints. While in BUNSD-LMA registration latency is a round 95m. In NEMO BSP as shown the throughput of wireless LAN is less than BUNSD-LMA. As a result BUNSD-LMA is out performed NEMO BSP in term of throughput.

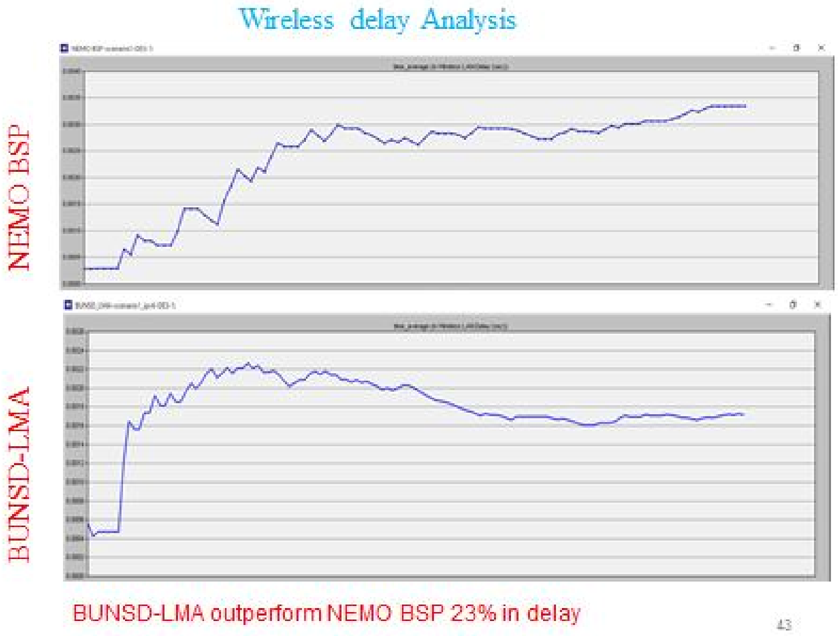


Figure 5.9:Delay Analysis

Figure 5.10: Throughput Analysis

5.9.2 Mobile Access Gateway traffic analysis

Traffic analysis of MAGs is compared to show different traffic load while MNNs moving through different networks infrastructures. As shown in figure 5.11 represents the first movement of MMNs. In this case BUNSD-LMA do normal registration for MNNs. In response to this the traffic load for wireless is very low.

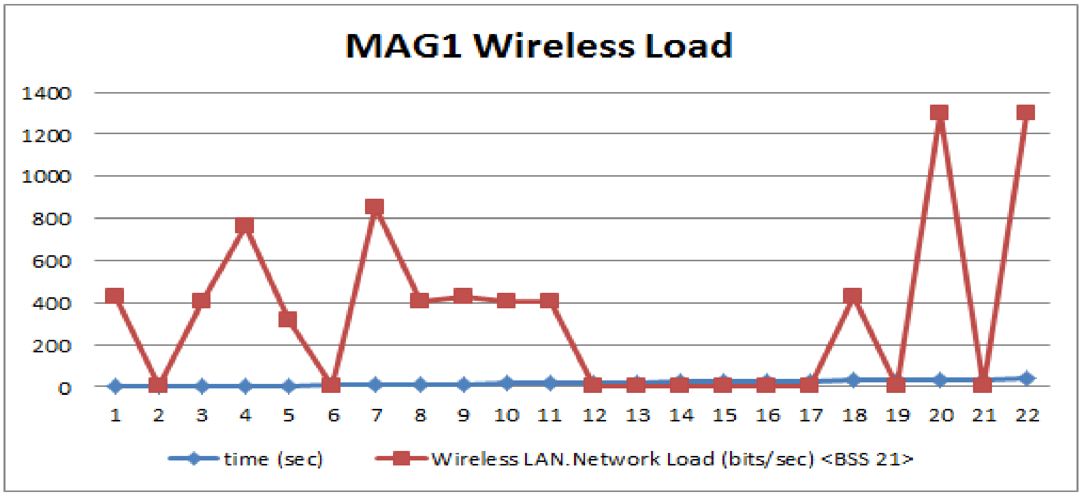


Figure 5.11: MAG1 wireless Load

In the second movements MAG1 do the registration on behalf of MNNs. For this, wireless traffic is decreases for second registration. The registration time is decrease because, it only registers the MNP prefix of MR. in this time performance is increase for BUNSD-LMA and traffic load due to high packets sent form MNNs as shown in fig 5.12.

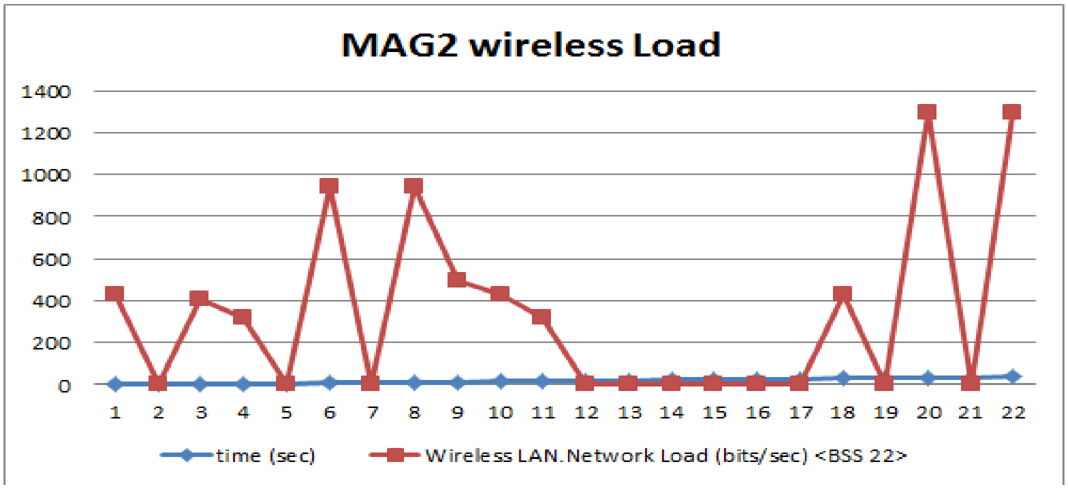


Figure 5.12: MAG2 wireless Load

In third movements MAG2 do the registration on behalf of MNNs same as pervious registration. For this, wireless traffic is decreases for second registration. The registration time is decrease because, it only registers the MNP of MR. in this time performance is increase for BUNSD-LMA and traffic load due to high packets sent form MNNs as shown in fig 5.13. However in this stage, the LAN throughput is High than the second one.

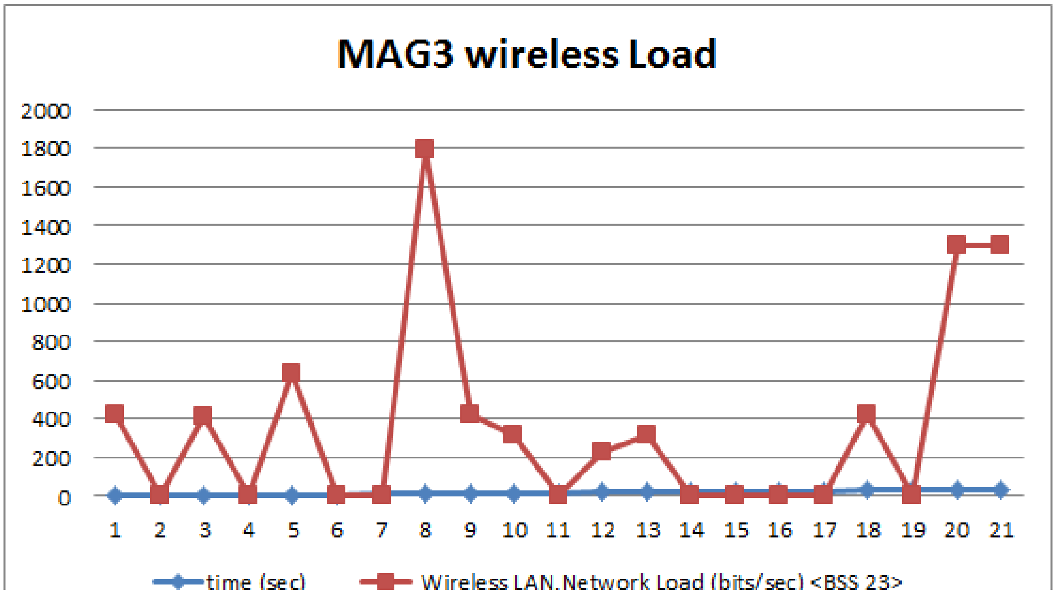


Figure 5.13: MAG3 wireless Load

5.10 SUMMARY

We have developed and verified a set of NEMO scenarios simulation models using OPNET network simulation environment. Preliminary simulation study was undertaken to verify the correctness of the developed simulation models, and to investigate some basic performance characteristics of NEMO BSP featuring a few additional seamless enhancement mechanisms.

Simulation results provide us with some insight as to the characteristics of the considered NEMO BSP mechanisms. As a result, MAGs can be used to guarantee less packet loss during handover, while advance registration used to minimize the registration time for MNNs. In addition BUNSD-LMA outperforms the NEMO BSP in total of packet loss 23%.

CHAPTER SIX CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

Network mobility NEMO standardized as extension to MIPV6 to support session continuity to the Internet services on behalf of mobile network nodes. But, still there are some issues such as packet loss and handover delay during the registration of MNNs and handoff of NEMO. This research proposes Binding Update No Sense Drop (BUNSD) Binding Cache Entry (BCE) in Local Mobility Anchor (LMA) schema. The BUNSD-LMA aims to find possible solution to allow MNNs that are roaming in a PMIPv6 domain to perform seamless mobility whiles maintaining their session continuity through mobile router. In this scheme, PMIPv6 is integrated with NEMO BS. Moreover, the binding update message format is extended to register the prefix of MNNs in advance with short time. The IETF has developed Network Mobility Basic Support (NEMO BSP) to support session continuity and reachability to the Mobile Network Nodes (MNNs) as one unit while they move. However, it suffers from many challenges such as route optimization, seamless mobility, handover latency and registration time. In this thesis, BUNSD-LMA is evaluated analytically and by simulation and benchmarkedwith NEMO BS. The performance metrics considered are based on handover latency, total packet delivery delay cost, and throughput. The analytical result shows that the BUNSD-LMA had better performance in term of handover, and registrations of MNNs. The mathematical result shows that BUNSD-LMA outperforms NEMO BSP in term of packet loss less than 38%.Simulation results provide us with some insight as to the characteristics of the considered NEMO BSP mechanisms. The MAGs it used to guarantee less packet loss during handover, while advance registration used to minimize the registration time for MNNs. As a result the total packet loss is decreased and seamless mobility of MNNs enhanced compared to NEMO BS benchmark.

6.2 RESEARCH CONTRIBUTIONS

The contributions of this study are summarized as follows:

- A Novell scheme for mobility management in NEMO with the following specifications.
    - It deals with the network layer to achieve seamless mobility because it provides transparency to the upper layers. No changes required to the upper layer existing protocol.
    - It uses PMIPv6 to register the MNNs on behalf of the MMNs, to decrease the handover latency.
    - It uses a pre-registration technique to register the MNP in advance using modified binding update extensions massage to reduce MNNs registration time as a group.
    - It uses the G Flag of values zero or one, which indicates that the MR needs to register its CoA and MNP in LMA or not.
    - It uses NEMOBSP to reduce the handover latency.
- Simulation evaluation using OPNET
    - We compared the performance of BUNSD-LMA with single PMIPv6 and NEMO BSP. The results had shown that the BUNSD-LMA has a lower handover latencyless than the NEMO BSP.
- Publications as shown in appendix

6.3 FUTURE WORK

NEMO BSP is a network-based mobility management protocol standardized by IETF. The proposed BUNSD-LMA integrates NEMO BSP with PMIPv6 to improve packet loss and registration time. In the future, this schema can help network engineers to estimate the actual resources in the network entities, future design and to compare other mobility protocols. As a future work, a fixed Local Mobility Anchor can be implemented in the wireless gateways to support MNN to move freely while it’s in the move. This feature will help in decreasing more handover latencies, packets loss and improves seamless mobility. Finally, this scheme expected to be developed to enhance node reliability and security.

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APPENDIX A

Conference papers:

1- Geaiger, Mohamed and Hassan Abdalla Hashim, Aisha and Khalifa, Othman Omran and elsheikh, Elsheikh Mohamed Ahmed (2014) *Development of an enhanced scheme for NEMO environment.* In: 5th International Conference on Computer & Communication Engineering 2014 , 23th -25th September 2014, Sunway Putra Hotel, Kuala Lumpur .

2- Geaiger, Mohamed and Hassan Abdalla Hashim, Aisha and Khalifa, Othman Omran and elsheikh, Elsheikh Mohamed Ahmed (2014) *Evaluation Study of Mobility Management Protocol in NEMO* . In: ICMAE 2014 ENGINEERING MATHEMATICS 2014 , 23th -25th September 2014, Sunway Putra Hotel, Kuala Lumpur .

3- Mohammed Geaiger ,Aisha H. Abdalla , Ismail El-azhary , Shayla Islam "*Evaluation of Mobility Management Protocol in NEMO: Survey*" , International Conference on Computer and Communication Engineering 2013

Journalspapers:

4- Geaiger, Mohamed and Hassan Abdalla Hashim, Aisha and Khalifa, Othman Omran and elsheikh, Elsheikh ; "*A Novel Scheme of Binding Update No Sense Drop BCE in LMA*" Paper ID: 141238 , IJCSNS International Journal of Computer Science and Network Security. 2014 ; 30-12-2014

5- Geaiger, Mohamed and Hassan Abdalla Hashim, Aisha and Khalifa, Othman Omran and elsheikh, Elsheikh "Performance Analysis of BUNSD-LMA" :International Journal of Computer and Information Science (IJCIS) ; published by International Association for Computer and Information Science (ACIS); IJCIS Journal Volume 16, Number 3- Sept-2015 -Indexed By INSPEC

Poster papers:

6- Mohamed Geaiger, Aisha Hassan, Elsheikh E lsheikh, and Wan Haslin Hassan “Binding Update No Sense Drop BCE in LMA (BUNSD- LMA)” poster ID: P225 , IEEE International Conference Bioinformatics and Biomedicine (BIBM 2014) ,Belfast ,UK. 2nd 5th November 2014

6.4 PSEUDO

6.4.1 LMA mobility message process –Pseudo Code

```
LMA mobility message process ()
{
    CASE Received Message OF
        PBU    : Perform default processing for PMIPv6.
        REG-G :  Check Flag G.
         IF the Flag G=1 THEN
            Update LMA BCE
             Update life time
             Send PBA to MAG
          ENDIF
         Configure Tunnel End Point.
         Packets intercepted:
```

```
                IF Packet intercepted to MNN THEN
                    Update MNN valid time.
                    Send FBA with G dereg to MAG.
                    Delete Flag G.
                ENDIF
            ENDCASE
        }
```

6.4.2 MAG mobility message process–Pseudo Code

```
MAG mobility message process()
{
    CASE Received Message OF
          PBA    : Perform default processing for PMIPv6.
          REG-G :  Check the function of BUNSD services .
           IF the registration Accepted THEN
               set MNP with Flag G=1 to RA message .
               ADD Entry to Binding Update List
            ENDIF
            Configure Tunnel End Point    MR-CoA.
             NEW MR attachments:
```

```
            IF the MR is Preregistered     THEN
                Send PBU Message with extended Flag G=1 to LMA
            ENDIF
            IF FBA + DeReg flag G +MNN-ID THEN
                Update BUL
            ENDIF
        ENDCASE
}
```

6.4.3 MR mobility message process –Pseudo Code

```
MR mobility message process()
{
    CASE Received Message OF
           Link-Attached  :
            IF Link attached THEN
                send RS message to MAG with Flag G=1 .
                ADD Entry to Binding Update List
             ENDIF
             //*Configure Tunnel End Point    MR-CoA.*//
              RA:
              IF the MR receive RA THEN
```

```
                    Configure MR CoA.
                    forward MNP Prefix to MMN.
                    Update BCL
               ENDIF
          ENDCASE
}
```