SUDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF COMPUTER SCIENCE & INFORMATION TECHNOLOGY

DISTRIBUTED PROXY MOBILE IPV6

(D-PMIPv6)

A Project Submitted as One of the Requirements for Obtaining a B.Sc. Honors in Computer Systems and Networks

بسم الله الرحــــــمن الرحيــــــــم

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(D-PMIPV6)

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بسم الله الرحـــــمن الرحيــــم

} رَبِّ أَوْزِعْنِىَ أَنْ أشكُر نِعْمَتَكَ الَتِىّ
أنْعَمْتَ عَلَىَّ وَعَلَىَ وَلِدَيَّ وأنْ أَعْمَلَ
صَلِحًا تَرْضَهُ وَأدْخِلْنِى بِرَحْمتِكَ فِي
عِبادِكَ ٱلصّلِحِيـــنَ {

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At the beginning and in the end all thanks belongs to **ALLAH**, we thank ALLAH for giving us the will power and strength that keeps us standing and patience to complete this work.

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DEDICATION

I wish to express my gratitude to all people whom helped us throughout our journey.

To our families for their endless love, abundant support and their understanding through the duration of our studies.

I am truly grateful to the man who have always been a source of encouragement, hope, strength, inspiration and supported me in all stages of my life may Allah forever bless him **My father.**

And to whom give us an unconditional love to the light of the dark and the heaven on the earth may Allah forever bless her **My mother.**

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ABSTRACT

As mobile networks have an unstable nature and constantly changing, the problems that are faced are increasing. So the issue of routing packets between any pair of nodes has become a difficult task. One of the most important goals in the design of future wireless network generations is the ability to keep continuous connection for users while moving from one point to another. So in order to achieve a smooth and fast transition and fast, the PMIPv6 has been the adopted by the IETF as a mechanism to manage the movement of local networks and the fourth generation networks.

This research provides an innovative way to manage the mobility. It is based on the distribution of the anchors on the edges of the network to be closer to mobile points, and rely entirely on the standard protocol (PMIPv6). The proposed scheme has been built using the networks simulator OMNET ++ v4.6. Simulation results showed that the proposed scheme is superior to the standard protocol PMIPv6 when measuring three factors: the delay to move to another network (handover

latency), packets loss during the transition (packet loss) and reducing signal (signaling cost).

المستخلص

بما أن شبكة الإنترنت النقالـة ذات طبيعـة غيـر ثابتـة وتتغيـر بإسـتمرار فإن المشاكل التي تواجهها في إزدياد مستمر .لذلك فإن مسألة تـوجيه الحزم بين أي زوج من العقد (nodes) أصبحت مهمة صعبة .من أهــم الأهـداف فـي تصـميم الأجيـال القادمـة مـن الشـبكات اللاسـلكية هـي القدرة على إبقاء إستمرارية الإتصال للمسـتخدمين أثنـاء تجـوالهم مـن نقطة إتصال إلى أخرى ومـن أجـل تحقيـق إنتقـال سـلس وسـريع، تـم إعتماد برتوكول الإنترنت الإصدار السادس للنقاط المتنقلة (PMIPv6) مـن قبـل منظمـة (IETF) وتـم إختيـاره كآليـة لإدارة التنقـل للشـبكات المحلية وشبكات الجيل الرابع .

يسعى هذا البحث إلى تقديم طريقة مبتكـرة لإدارة التنقـل تقـوم علـى توزيع نقاط الإرساء (anchor point) على حواف الشبكة لتكون قريبة من النقاط المتنقلة(mobile nodes) ،وتعتمد كليـاَ علـى الـبروتوكول القياسـي (PMIPv6). تـم بنـاء النمـوذج المقـترح بإسـتخدام محاكـاة

الشـبكة (OMNET ++v4.6) . بينـت النتائـج أن النمـوذج المقـترح يتفوق على البروتوكول القياسي (PMIPv6) عند قيـاس ثلاثـة عوامـل هــي : زمــن التــأخير للأنتقــال مــن شــبكة لإخــرى (handover latency) ،فقدان حزم البيانات أثناء الإنتقال (packet loss) وتقليل الأشارات المتبادلة (signaling cost) .

TABLE CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

4G	Fourth generation.

AC	Address Configuration.
AP-ID	Access Point Identifier.
AR	Access Router.
AAA	Authentication, Authorization and Accounting server.
BU	Binding Update.
BCEs	Contains Binding Cache Entries.
BUL	Binding Upbeat List.
CoA	Care-of Address.
CM	Control Mobility.
CN	Correspondent Node.
D-PMIPv6	Distributed Proxy Mobil Internet Protocol version 6.
DMM	Distributed mobility Management.
ESP	Encapsulated Security Payload.
HA	Home Agent.
EH	Extension Header.
HL	Handover Latency.
IPsec	Internet Protocol Security.
HNP	Home Network prefixes.
HoA	Home Address.
IETF	Internet Engineering Task Force.
L2	layer 2
LMA	Local Mobility Anchor.
LMD	Local Mobility Domain.
MAG	Mobile Access Gateway.
MN-ID	Mobile Node Identifier.
MN	Mobile Node.

MIPv6	Mobil Internet Protocol version 6.
MT	Mobile Terminal.
NetLMM	Network based Localized Mobility Management.
NS	Network simulator.
ND	Neighbor Discovery.
PMIPv6	Proxy Mobil Internet Protocol version 6.
PBA	Proxy Binding Acknowledge.
PBU	Proxy Binding Update.
pCoA	proxy Care of Address.
PL-PMIPv6	Packet loss-less PMIPv6.
RO	Route Optimization.
RA	Router Advertisement.
SLAAC	Stateless Address Auto-Configuration.
SC	Signaling Cost.
VoIP	Voice Over Internet Protocol.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

The world is witnessing the era of portable computing, and the demand for mobile communication is increasing. Mobile communication requires a lot of resource from the network and mobile devices, especially while moving between two access point. The Mobile connectivity is an importance service, as mobile user's demands for data traffic while on the move are increasing dramatically. Operators statistics shows that the usage of mobile data traffic has doubled during the last year. it is expected that the data will grow by 24.3 Exabyte (1000 Petabytes) per month by 2019 .and is expected to continue to grow in this decade as shown in Figure 1.1. [1].

We have witnessed the explosion of a "mobile revolution", mainly driven by the massive market penetration of powerful mobile handsets. Along with this, the number of available mobile applications has also exploded. Many of these applications benefit from the use of Internet connectivity. Figure 1.2[1].

We are not concerned about the great source of information, entertainment, interactivity and productivity that the Internet has become in these years, but, instead, we regard at how these services are consumed by users from portable mobile devices, granting the anywhere, anytime connectivity. Therefore, the networks need to cope with this increasing volume of data saturating their access links, and triggering the need for additional access technologies to be made available to the users. Operators migrate their networks to full IP based architectures, such as the WiMAX [2] related standards or the 3rd Generation participation protocol (3GPP) [3]and Evolved Packet System (EPS).

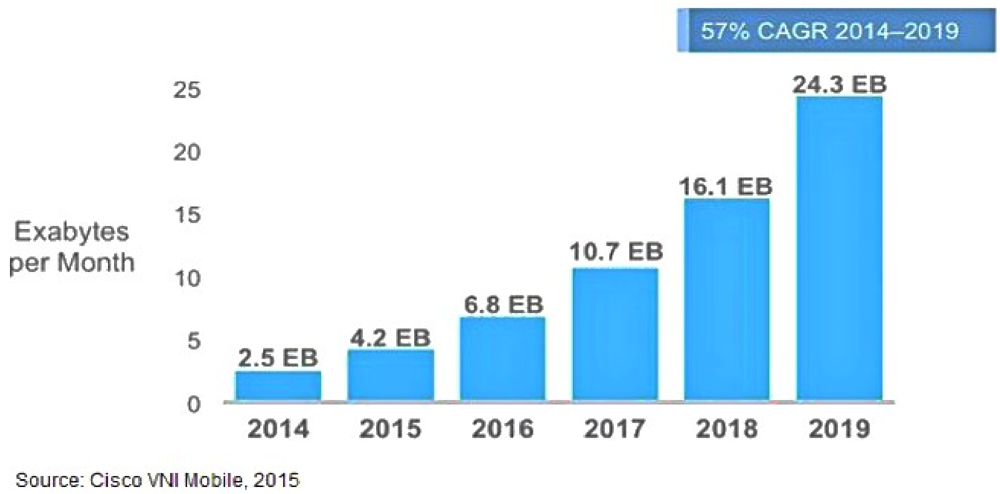

Figure-1 Cisco forecasts on mobile data traffic growth

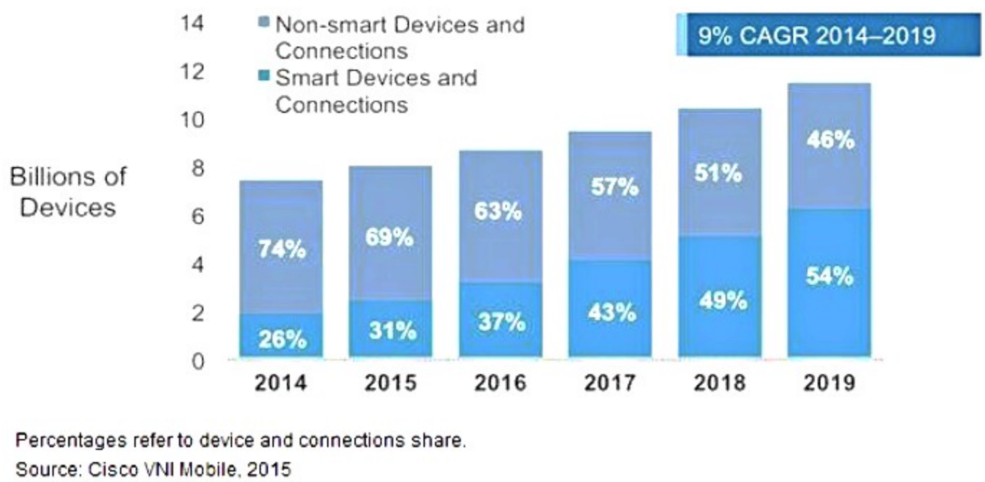

Figure 1 Cisco forecasts on global growth of smart mobile devices and connections

1.2 PROBLEM STATEMENT

Current network architectures and mobility management protocols, are generally deployed in a centralized manner. Due to that fact, all the data traffic passes through a single centralized entity, which makes the centralized mobility solutions prone to several problems and limitations. These problems include scalability issues (e.g. network bottleneck, and single point of failure), as it handles traffic for millions of users, security issues (e.g. attacks focused on the centralized anchor), as well as performance issues (e.g. centralized and non-optimal routing, large tunneling etc.). As a result, mobile network needs to handle such problems. Several new technologies and practices are showing up as hot topics. Despite the fact that centralized approaches have been fully investigated in the last decades, there are still several limitations due to its centralized nature.

The key question is: how do can we overcome some of these limitations by extending the current standard centralized approaches (e.g. MIPv6, PMIPv6) to work in a distributed manner? Which implies defining new mobility management components to tackle the mobility of mobile nodes in a seamless and smooth manner.

1.3 RESEARCH SIGNIFICANCE

This research aims to overcome some of the limitations experienced by the current centralized mobility management schemes through introducing the concept of distributed mobility management.

1.4 RESEARCH OBJECTIVES

In order to achieve the aim of the research, we are looking to achieve the following objectives:

- Develop a network-based distributed mobility management scheme.
- Reduce the handover latency, packet loss and signaling cost.
- Compare the performance of the proposed scheme with the standard centralized mobility management scheme PMIPv6 by using simulation methods.

1.5 RESEARCH SCOPE

This research focuses on enhancing the mobility management protocols (PMIPv6) to function in a distributed manner. Hence, we carry out a qualitative analysis in terms of reduction of handover latency, packet loss and signaling cost.

1.6 RESEARCH METHODOLOGY

In ordered to achieve the above objectives, we propose a novel scheme to develop a network-based Distributed Mobility scheme that addresses the shortcomings experienced by centralized scheme. The performance of the proposed scheme is evaluated by using simulation (OMNeT++ v4.6).

1.7 RESEARCH LAYOUT

This research contains five chapters and is organized as following: -

Chapter one: provides a brief introduction of the study. It covers topics on problem statement, research significance, objectives, scope of research and research methodology. Chapter two: introduces a general overview of mobility management, mobility definition, types, classifications, problem, limitation and related work.

Chapter three: describes the proposed scheme of our study here-after called. (D-PMIPv6) as an extension of PMIPv6 protocol and the motivations for choosing PMIPV6.

Chapter four: presents the evaluation of the proposed scheme using simulation model and discuss the results. Finally, Chapter five concludes the research by pointing-out the main contributions and raising up some of the issues that require more research in the near future.

CHAPTER TWO

MOBILITY MANAGEMENT AND RELATED WOR

2.1 OVERVIEW

This chapter provides the background knowledge regarding to IPv6, and the different mobile data networks architectures as well as the different mobility protocols (e.g. MIPv6, PMIPv6). In addition, it explains the processes which occur when such a handover is initiated. It’s also reviewed the recent works undertaken by IETF [4] and research community.

2.2 MOBILITY MANAGEMENT PROTOCOLS FOR IPV6 NETWORKS

In this section, we describe the solutions that have been introduced by Internet Engineering Task Force (IETF) for mobility management at IP layer. Mobility in IP-based is a critical step in order to provide connectivity for mobile user. In addition, mobile node changes its point of access while moving from one point to another, which cause the loss of IP address in such case the probability of non-reachability for the IP address is considered by the host. Because that the packets carrying that IP address as destination are lost, as they are still delivered through the old path towards the former access network [5].

This case solve what is known as (portability) the connectivity is maintained, but ongoing sessions need to be refreshed. Real timing application, cannot survive an IP address change without producing a lake of quality of service, this issue is known as (mobility) that refers to the possibility of keeping active ongoing sessions in a seamless manner for the user [6]. Figure 2.1 showing two approaches of mobility management: Host-based solutions with

Mobile IPv6 and Network-based solutions with Proxy Mobile IPv6.This protocol represents the starting point of our study.

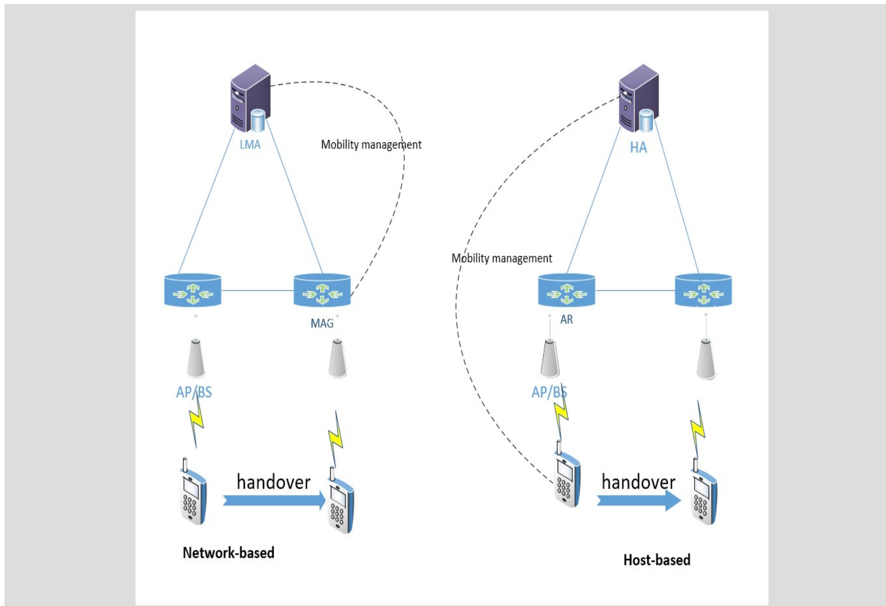

Figure 2- Catogry of mobility mangment

2.2.1 HOST-BASED MOBILITY MANAGEMENT PROTOCOLS

The IP host-based mobility management protocols provide global reachability for mobile nodes while roaming, and the mobile nodes are involved in managing their mobility. Therefore, they need to perform mobility management operations, in order to maintain their reachability, these protocols require a modification of the mobile nodes stack, which is difficult [7].

2.2.1.1 MOBILE IPV6 OVERVIEW (MIPV6)

The basic idea of MIPv6 is when the MN moving from one subnet to another it configures a permanent IPv6 address in its home network, and a temporary one when it is in foreign network. But the issues for MIPv6 its suffers from critical performance aspects such as handover latency, packet loss, update latency, and signaling overhead [7].

2.2.1.2 MIPV6 OPERATIONS

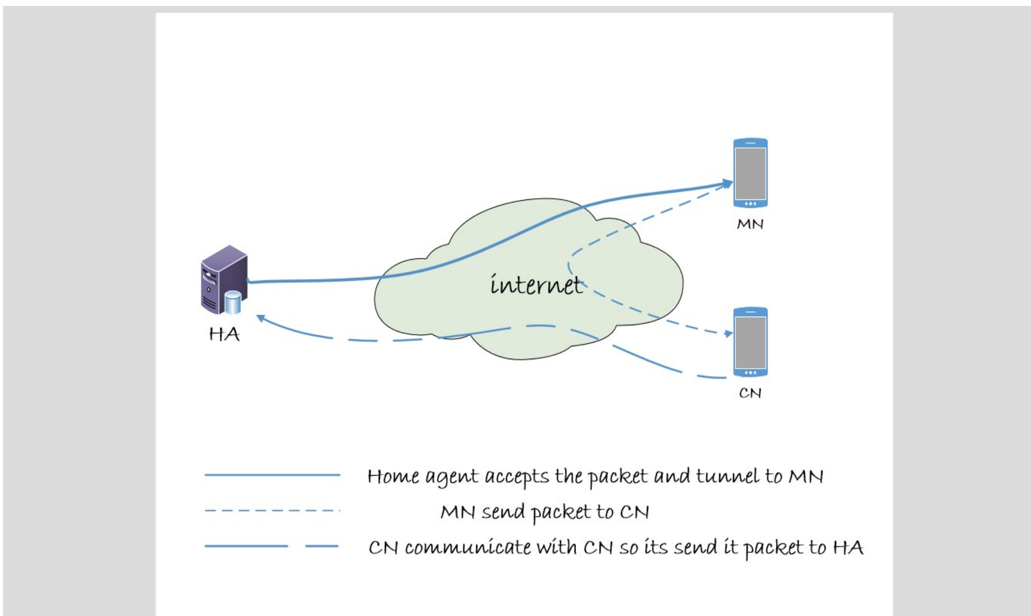

Figure2 Mobile IPv6 routing

As shows in figure 2.2 the operation that occurring when mobile entre the MIPv6 domain are [8]:

- MN tries to acquire an IPv6 address using either stateful or stateless IPv6 configuration
- Then network interface knows about the existence of the router through Router Advertisement messages (RA).
- Upon MN accursing the address in the new network, this address becomes the Care-of-Address then, the MN sends a Binding Update message(BU) to its Home Agent(HA) which

contains the newly Care-of-Address (CoA) and the Home Address of the MN. In addition, the BU sent to all of the (CNs) that are communicating with the MN (registration).

- Agent receives the Binding Update message, it updates its cache table with the of Care-of-Address and Home Address.
- CN sending the packets to MN Home Address and the Home Agent intercepts the packets and forwards them to the MN Care-of-Address. But when MN wishes to send to CN a data packet, then it is routed directly to CN.

2.2.2 NETWORK-BASED MOBILITY MANAGEMENT PROTOCOL

The network-based IP mobility management protocol deal with host-based issues which are [9]: the need for protocol stack modification to all the mobile nodes, in addition to reducing handover delay, packet loss and to provide the mobility management support to a mobile node, without requiring the participation of the mobile in any IP mobility related signaling.

2.2.2.1 PROXY MIPV6 OVERVIEW(PMIPV6)

Proxy Mobile IPv6 (PMIPv6) is a mobility management protocol that have been developed to enhance the mobility management in MIPv6 and it use for a common network operator’s such as 3rd Generation Partnership Project (3GPP), wireless LAN (WLAN) and Worldwide Interoperability for Microwave Access (WiMAX). PMIPv6 provides mobility support within a localized area.

2.2.2.2 PMIPV6 TERMINOLOGY

Here is some definition that have been used in PMIPv6 to manage the mobility [8]:

- Proxy Mobile IPv6 Domain (PMIPv6-Domain):is the network where the mobility management of a mobile node and it contains one LMA and multiple MAGs.
- Local Mobility Anchor (LMA): It is the entity that manages the mobile node's. and all the traffic from and to the MN is routed through the LMA.
- Mobile Access Gateway (MAG): is an access router that manages the mobility-related signaling for a mobile node and It is responsible for tracking the MN's movements and for signaling of the MN's local mobility anchor.
- Mobile Node (MN): is refer to any device that connects through a wireless network to the LMD.
- Corresponding Node (CN): Any node in the Internet or also in the LMD that communicates with an MN.
- Proxy Care-of Address (Proxy-CoA): is the global address configured on the interface of the MAG.
- Mobile Node's Home Network Prefix (MN-HNP): is a unique prefix assigned to the MN by the LMA.in the link between the mobile node and the mobile access gateway.
- Mobile Node's Home Address (MN-HoA): is an address from a mobile node's home network prefix.

- Mobile Node Identifier (MN-Identifier): The identity of a mobile node in the Proxy Mobile IPv6 domain and it is stable identifier of a mobile node.
- Proxy Binding Update (PBU): is a request message sent by a MAG to the LMA for establishing a binding between the MN's home network prefix(es) and its current care-of address (Proxy-CoA), and has the fields MN-ID, Proxy-CoA, handoff indicator (HI); to indicate if the MN-attachment is a new one or a handoff from another MAG.
- Proxy Binding Acknowledgement (PBA): is a reply message sent by a local mobility anchor in response to a PBU message that it received from a MAG.
- Binding Cache (BC): Cache maintained by the LMA that contains Binding Cache Entries.
- Binding Cache Entry (BCEs): Entry in the LMA 's binding cache. And has the fields MN-ID, MAG Proxy-CoA and MN-prefix.
- Binding Update List (BUL): Cache maintained by the MAG that contains information about the attached MNs.

2.2.2.3 PMIPV6 REGISTRATION

Figure 2.3 shows the registration process occurring during the mobile node enters the Proxy Mobile IPv6 domain [9].

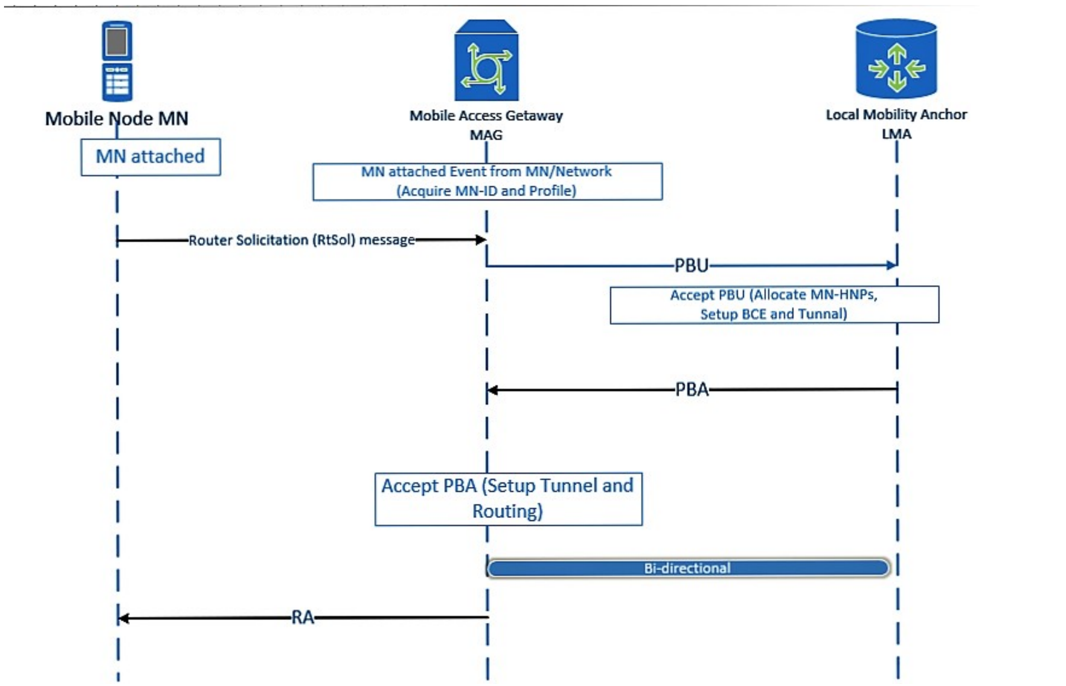

Figure 2- Registration in PMIPv6

- As shows in the figure when the mobile node's attachment new link, the MAG located the authenticates to new link through an Authentication, Authorization and Accounting (AAA) server. Then the MAG sends a Proxy Binding Update(BPU) message to the mobile node's local mobility anchor LMA.
- Upon receiving this PBU, the LMA sends a Proxy Binding Acknowledgement (PBA) message that including the MN-HNP and creates the Binding Cache entry (BCE) and sets up the bi directional tunnel to the mobile access gateway.
- The MAG after receiving the PBA that send from the LMA it’s sets up its endpoint bi-directional tunnel to LMA. At this point the MAG sends Router Advertisement (RA) messages to the MN on giving the MN's it’s HNP.
- The mobile node, upon receiving the RA message, it’s attempts to configure its interface address using either stateful or stateless address configuration mechanism.

- The LMA start to receives the packets that are sent to the MN by corresponding nodes (CN), then The LMA forwards these packets to the MAG through the bi-directional tunnel. Then it removes the outer header and forwards the packet to the mobile node. But in some cases, the packets sent from a CN that is connected. to the MAG may not be received by the LMA and may be routed locally by the MAG.

2.2.2.4 PMIPV6 HANDOVER

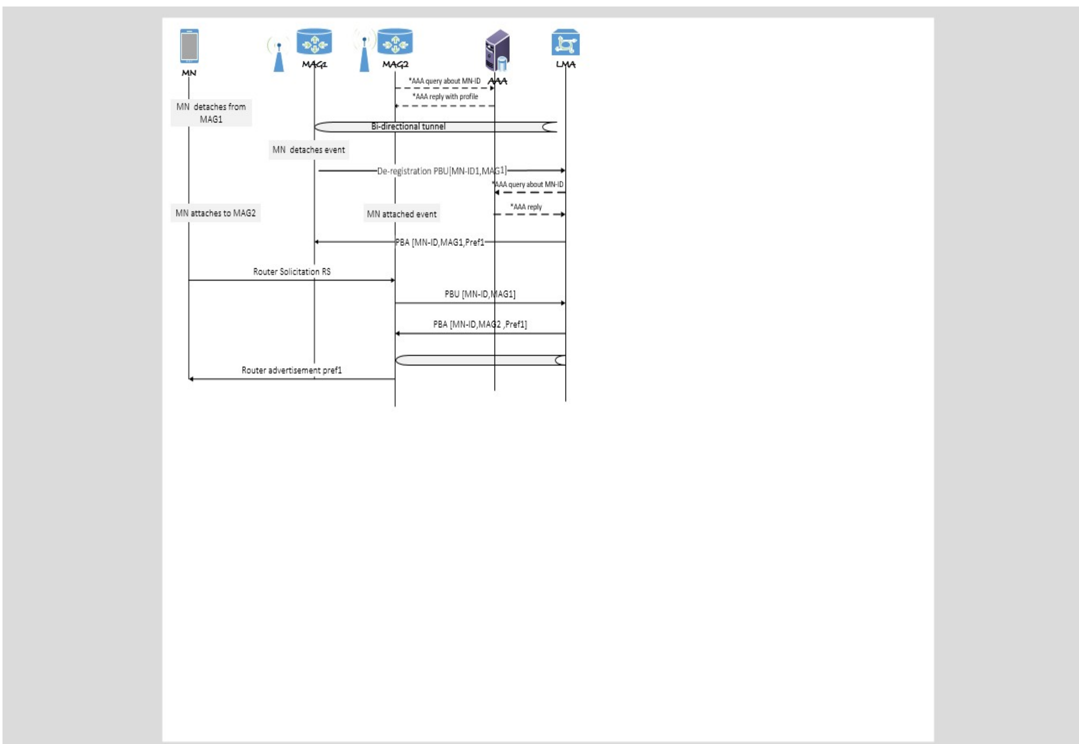

Figure 2 handover process in PMIPv6

Figure 2.4 illiterate the MN's handover from the previously attached mobile access gateway (MAG1) to the new mobile access gateway (MAG2) [9].

- The registration message from the n-MAG may arrive before the de-registration message from the p-MAG arrives.

- After obtaining the initial address configuration in the Proxy Mobile IPv6 domain. the mobile node changes its point of attachment, then mobile access gateway on the previous link will detect the mobile node's detachment from the link.
- It will inform the LMA and will remove the binding and routing state for that mobile node.
- The LMA, upon receiving this request, it identify the corresponding mobility session for which the request was received, and accepts the request after it waits for an amount of time to allow the MAG on the new link to update the BCE. but, if it does not receive any PBU Update message within the given time, it will delete the BCE.
- The MAG on the new access link, upon detecting the mobile node on its access link, will inform the LMA to update the binding list PBL.
- The serving MAG will send the RA containing the MN's home network prefix and this will ensure that the mobile node will not detect any change of its interface.

2.2.2.2 PMIPV6 LIMITATIONS

Proxy Mobile IPv6 (PMIPv6) takes advantage of the network-based mobility management that provides mobility support for moving nodes (MNs) without their involvement as we mentioned before [7]. However, the main drawback of PMIPv6 is that the inter-domain handover is not supported. That means when an MN moves to another PMIPv6 domain, the on-going sessions cannot be maintained (dropped) [9].

Table 2- Summary comparison between MIPv6 and PMIPv6.

category	MIPv6	PMIPv6

Mobility scope	Global	Local
Mobility management type	Host-based	Network-based
MN address	HoA or CoA	HoA (always)
Infrastructure entity	HA	LMA,MAG
Handover latency	Bad	Good
Link type	Any link	Point-to point
Route optimization	Supported	Not Supported
MN modification	Yes	No
Single point of failure	Yes	Yes
Handover latency	Bad	Good
RA Type	Broadcast	Unicast
Movement detection	Performed by RS/RA	Not required (performed by layer 2)

2.3 RELATED WORK

Here are related approaches and schemes proposed by IETF and research community that targeted to deploy the standard PMIPv6 to work in a distributed way.

[10] CJ. Bernardos, M. Calderon proposed scheme that are both Proxy-based Approach plus NEMO it reduce signaling overhead while NEMO move. The proposed solution still has some problem of different IP address prefix in each domain (M, NEMO)

In [11], the authors introduce a scenario for PMIPv6 is used an intra-domain mobility management whereas MIPv6 as a global mobility management (named H-PMIP). As a result, the complexity of the hosts is increased. Another scenario is also considered, where

PMIPv6 and MIPv6 are co-located at LMA/HA. There exist some problems due to the natural difference between the two protocols.

In [12], an extension to PMIPv6 (called I-PMIP) is proposed for the inter-domain mobility support by reusing the LMA as a global anchor point when the MN is away from home. Then the traffic is forwarded from/to the anchor. One critical problem of this solution is that the mobility service is provided on a per user basis

Our proposed D-PMIPv6 distinguishes from the above schemes by the following features:

- It employs a new handover mechanism that reduces major issues in PMIPv6 the handover latency, packet loss signaling cost.
- The architecture is fully distributed.
- Solves the scalability problem.

The details of our proposed scheme (D-PMIPv6) [5] is presented in the next chapter.

CHAPTER THREE

PROPOSED SCHEME (D-PMIPV6)

3.1 D-PMIPV6 OVERVIEW

The D-PMIPv6 scheme presented in this section is developed based on the DMM concepts [13]: it re-uses the existing mobility management protocol by enhancing PMIPv6 to support DMM, while overcome some of aforementioned limitations in centralized approach. Figure 3.1 illiterate general overview of D-PMIPv6.In which the Local Mobility Anchor (LMA) is moved from the core to the edge of network, and distributes the functionality of LMA to Mobile Access Gateway (MAG) to provide the mobility functions in closer manner to the mobile node, by induce a new component that called ‘control mobility’ (CM). The scheme hereafter called distributed PMIPv6 (D-PMIPv6).

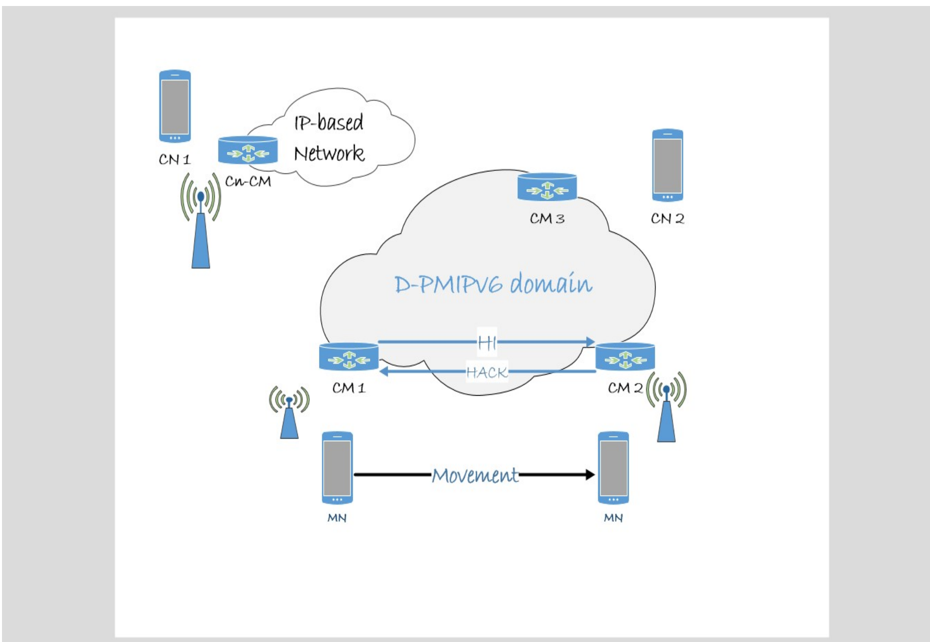

Figure 3 D-PMIPv6 Architecture

3.2 METHODS OF DISTRIBUTED MOBILITY FUNCTIONS

Distributed mobility management solutions can be classified according to the level of distribution of the control plane [14] to:

- Fully distributed solutions: which completely distribute both the data and control planes, there is no centralized control entity.
- Partially distributed solutions: which distribute the data path among several anchors deployed closer to the end user MN, but still keep the control plane centralized. Figures 3.2 and 3.3 illustrate the two methods

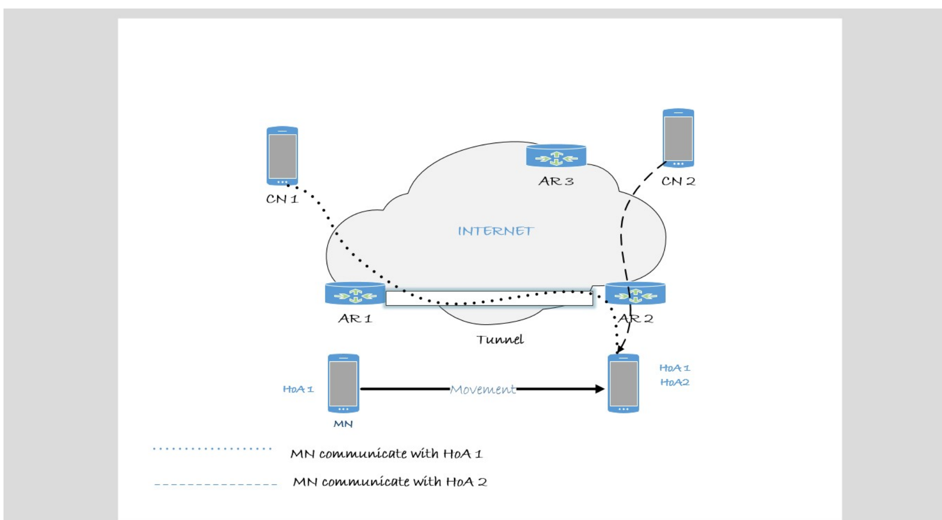

Figure 3 Fully Distrbiuted Architecture

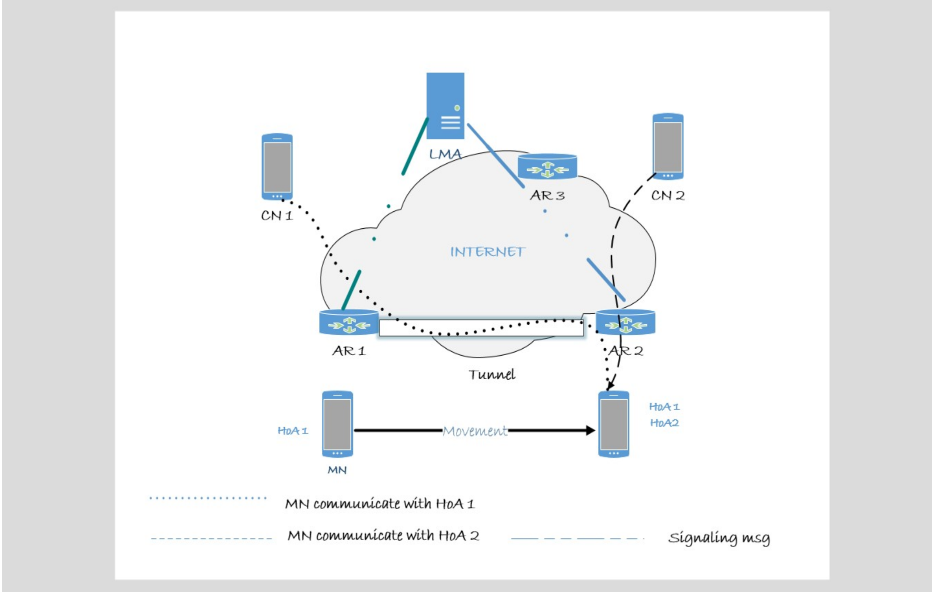

Figure 3 Partially Distributed architecture

3.3 D-PMIPv6 OPERATION

3.3.1 Registration Procedure in D-PMIPv6

Figure 3.4 shows the registration process occurring during the mobile node enters the D-PMIPv6 domain [5].

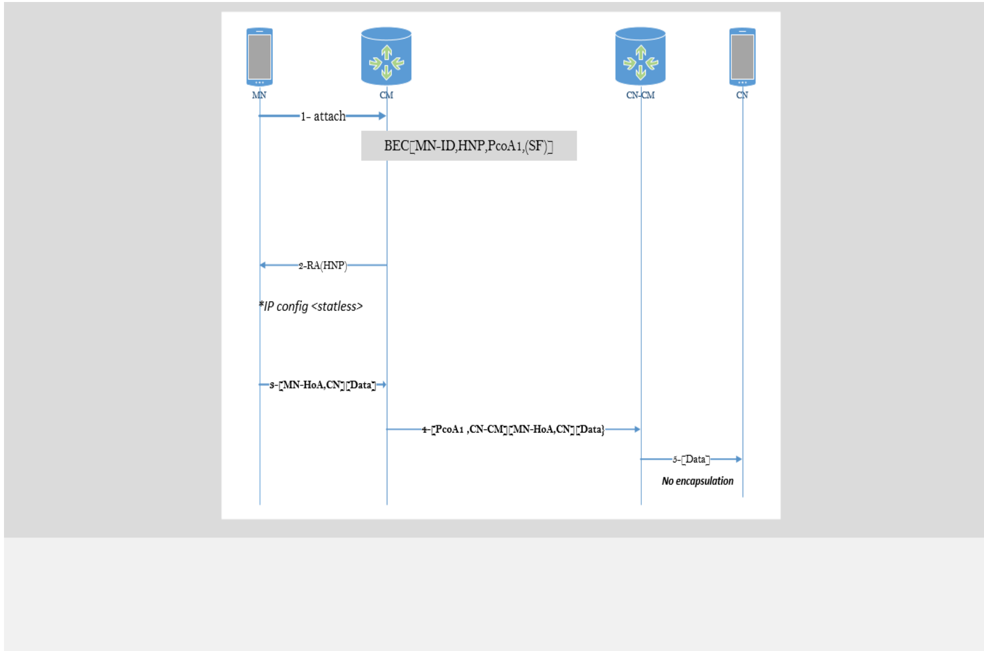

Figure 3-4 Registration process in D-PMIPv6

- Frist when CM1 detects the presence of MN on the link it creates a binding entry cache for it and sends a Router Advertisement (RA) which contains [Home Network Prefix (HNP) named (pref1)].
- MN then uses the prefix (pref1) to configure an IPv6 address (HoA) use stateless configuration mechanism [15].
- After obtaining the initial address configuration in the D-PMIPv6 domain.MN uses the address to communicate with the CN without the need for tunneling.
- CM1 then receives the data sent by MN. At this point it acts as standard IPv6 router and forwards the data to its address (CM-CN) without need to encapsulation.
- Upon receiving the data, CN-CM relays it to its destination CN.

3.2.2 Intra-Handover Procedure

The handover process consists of two phases. Figure 3.5 show how a handover is performed and how the data are delivered after handover takes place.

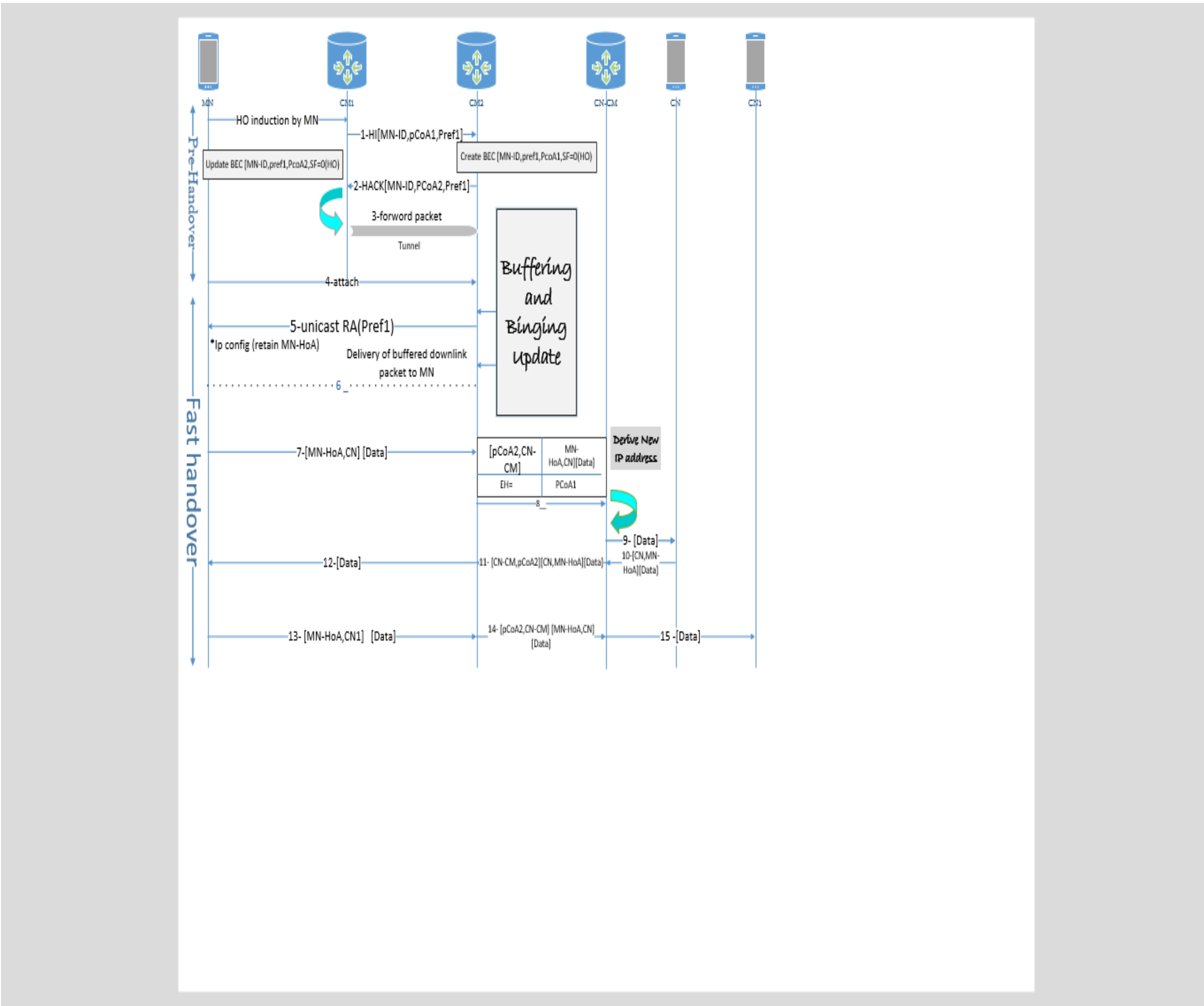

Figure 3.5 Handover Procedure and Data flow after Handover

- Before the MN leaves its current CM1 to another CM2, CM1 sends a Handover Initiation message (HI) to CM2. The message continues [MN-ID, the proxy Care of Address (pCoA1) of CM1 and the Home Network Prefix (pref1)]

- CM1 detects this event through some mechanisms such as receiving a report from the MN that contains [MN-ID and the new access point identifier (new AP-ID)].
- The CM1 derives the new CM -ID (i.e. CM2) from the new AP-ID.
- Upon receiving the HI, CM2 binds it and replies with a HACK message containing [MN-ID, pref1, pCoA2].
- It then builds a bi-directional IPv6-in-IPv6 tunnel.
- Upon receiving the HACK, CM1 forwards the MN's packets to CM2 which buffers them to prevent packet loss as shown in steps (3-6).
- When CM2 realizes the connection with the MN, it verifies registration of the MN in its binding upbeat it list (BUL).
- CM2 then sends RA to the MN to configure an IP address. Step (4).
- Upon receiving the RA with the same prefix assigned to MN in the previous CM (e.g. pref1), MN will not see an address change and therefore it retains the same home address (i.e. MN-HoA) by using stateless configuration mechanism; as a result, all open transport connections (TCP, UDP) remain open and handover latency will be reduced.
- CM2 delivers the buffered down link packets to MN according to their arrival times (Frist-In-First-Out (FIFO)) step (5).
- MN configures the home address while communicating with the CN (retains MN- HoA step (6).

- The MN then sends a new Packet to CM2 that is destined to the CN.

- Since CM2's address (i.e. pCoA2) is unknown to CN-CM, the latter will reject delivered packets from the former. In such a case, a new mechanism to solve this problem is proposed, by the author, saying that inserting the previous pCoA1 of the predecessor CM (i.e. CM1) into the Extension Header (EH) field of IPv6 Packet. Once the CN-CM receives a new packet, it checks the Extension Header (EH) field of IPv6 Packet and accepts the packet only if its corresponding pCoA1 is verified.

- The CN-CM recognizes the move by the MN to a new CM then it forwards the received packet to CN (step 8).

- The D-PMIPv6 allows direct packet routing from CM-CN and CM currently serving the MN (i.e., CM2) and it facilitates route optimization for ongoing communication, and reduces the handover latency and packet loss respectively.

- The CN then sends new packets destined to MN via CN-CM, which in turn forwards them directly to the corresponding CM (CM2) and to MN (steps 9, 10).

- As MN is staying at CM2, it can send packets to another CN connected to CN-CM (i.e. CN1), and CM2 will forward them directly without tunneling. (steps 13,14,15).

As we mentioned early the D-PMIPv6 scheme based on PMIPv6. So we are relied on the same security mechanism that is Authentication, Authorization and Account (AAA) server [16]. Which are an authorization center for all registered MN's in the domain. Hence the lake of security and additional delay consumed by AAA server is one of the drawback of the proposed scheme.

CHAPTER FOUR

D-PMIPv6 EVALUATION USING SIMULATIO

4.1 Overview

In communication and computer network research, network simulation is a technique where a program models the behavior of a network by calculating the interaction between the different network entities. Various attributes of the environment can be modified in a controlled manner. This technique is also referred to as network emulation. The performance and analysis of our study is simulated using OMNet++4.6. [17].

4.2.1 Motivations for Choosing OMNET

There is a number of famous network simulators. Such as the well-known NS-2[18] and OPNET [19] and many. However, what makes the NS-2 not a suitable chose is that is difficult to use. OPNET provides a global environment to model, simulate and evaluate performances of all kinds of networks, including graphical tools. But, OPNET is a very expensive commercial package.

OMNeT++ is an object-oriented modular discrete event network simulation framework. That can be used in various problem domains. OMNET feature include:

- Rich graphical user interface (GUI).
- Easy to use, more flexible in model development, and modification.
- Open source.
- Tools are highly portable.

Figure 4.1 shows the main GUI of OMNET++v4.6.

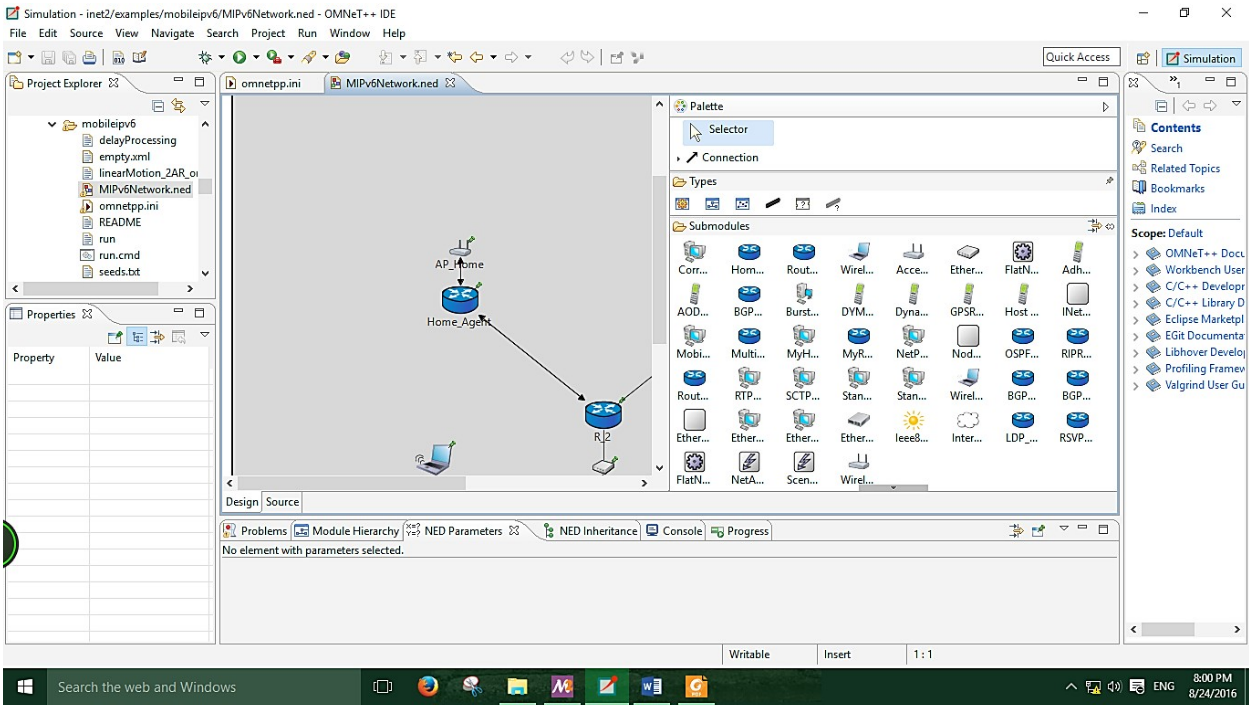

Figure 4- The main GUI for OMNeT++v4.6

4.2 SIMULATION ENVIRONMENT

4.2.1 Simulation Setup

This section presents a performance comparison between PMIPv6 and our scheme (D-PMIPv6).

To make it possible. D-PMIPv6 is done in a flat architecture, considering a rectangle of 850 meters' x 850 meters. There are two base stations, represented by (i) the Access Point of the Home Agent and (ii) the Access Point of the Foreign Access Router. The initial location of MN has been selected at point (180, 100), MN is moving at the speed of v=1 m/s, from West to East. The simulated UDP packet traffic starts at t_0=150 seconds, and the size of the packet is 1.5KB. 0.1seconds is the waiting interval. The transmission range of every node is 200 meters. Figure 4.2 shows the network topology for D-PMIPv6.

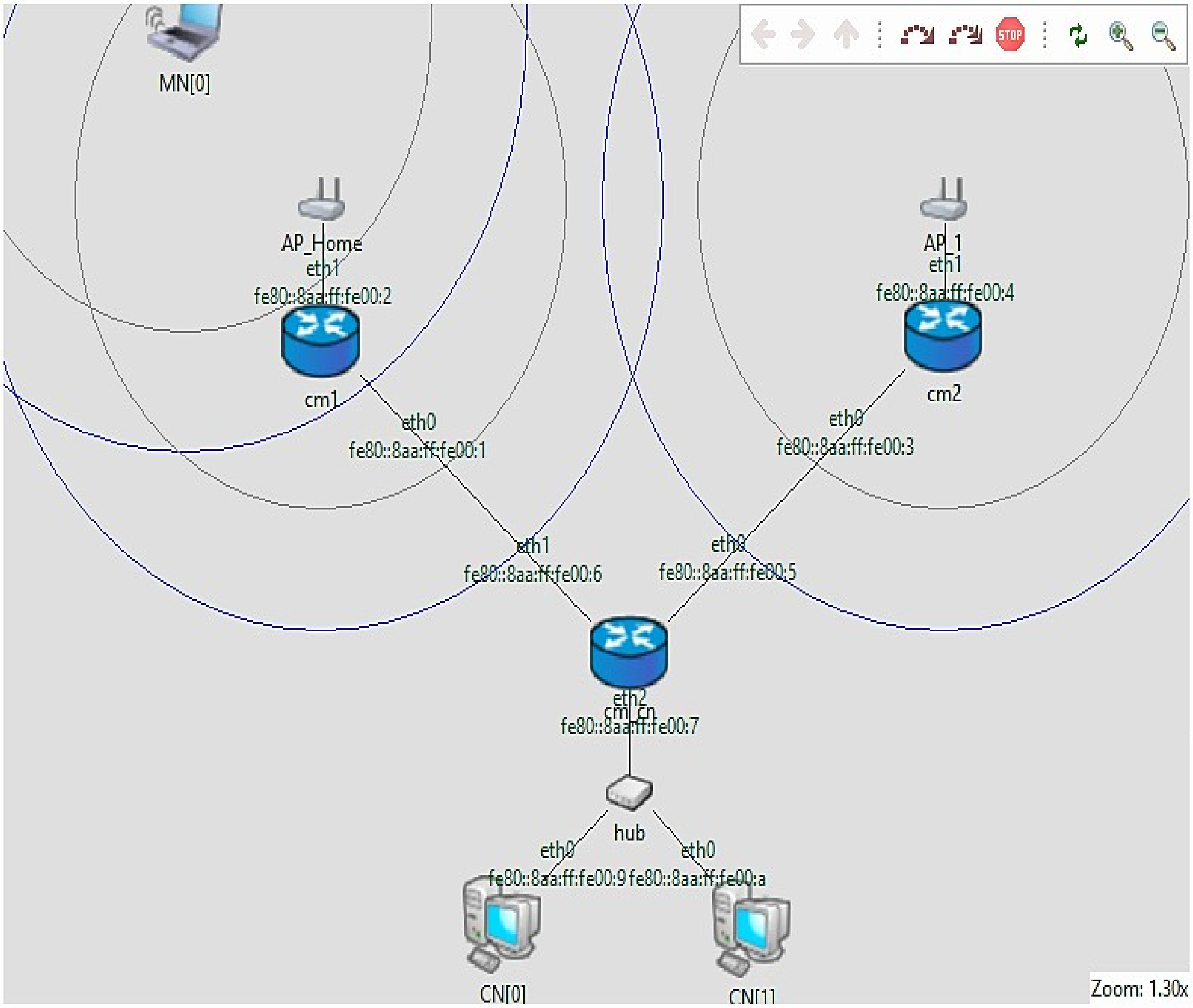

Figure 4-2 D-PMIPv6 Topology in OMNeT++v4.6

As can be seen in figure 4.2, we have simulated a MN [0] as a user that is watching a video while walking along a street. There are two Correspondent Nodes CN [0] and CN [1], but only CN [1] actually communicates with MN [0]. In addition to the Control Mobility CM [1] and CM [2].

4.2.2 Simulation Parameters

The parameters used in simulating D-PMIPv6 are presented in table 4.1.

Table 4-1 Simulation Parameters

Parameter	Value	Parameter	Value
Speed	1 m/s	Mobility Model	Rectangle
Number of CN	1	Transmit Rate	0.13 second
Number of MN	1	Packet Size	1500 byte
Grid Size(m^2)	850 x 850	Number of Beacon	2
Beacon Interval	0.1second	AP Power	2.0 mW
Interval between RA	0.3 – 0.7 second	Packet Flow	Bi-dir CBR

4.3 SIMULATION RESULTS

The performance analysis of D-PMIPv6 is provided in terms of three mobility issues: handover latency, packet loss and signaling cost. In the following section we present the obtained results and thoroughly discuss them.

4.3.1 Handover Latency

Handover latency is referred to as the time between receiving the last packet from the old subnet and receiving the first packet in the new subnet (delay). Figures 4.3 and 4.4 show the simulation results of D-PMIPv6 and the standard PMIPv6.

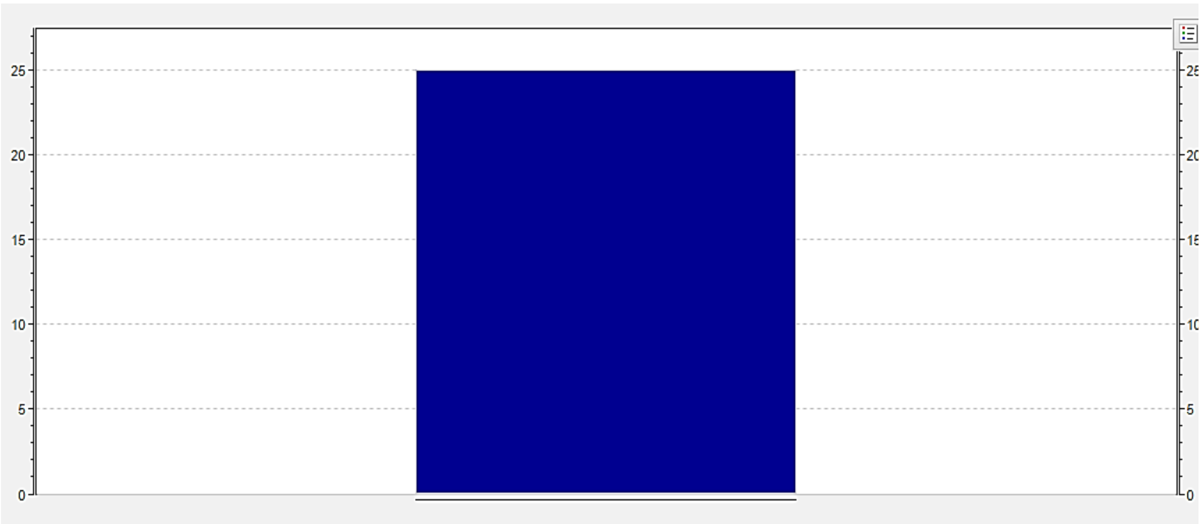

Figure 4-3 handover latency in D-PMIPv6 in ms

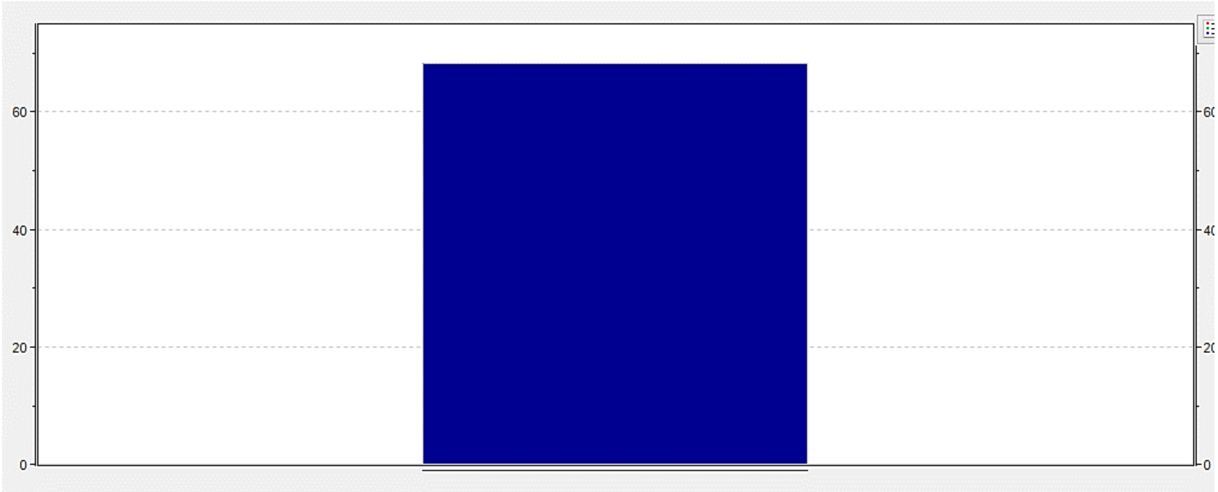

Figure 4-4 handover latency in PMIPv6 in ms

As shown in figure 4.3 and 4.4, the handover latency of the D-PMIPv6 is the lower compared to that of the standard PMIPv6, because D-PMIPv6 deploys a fast mechanism that reduces the exchanged binding and authenticating messages between MAGs, LMA and AAA server, which results in reducing the handover latency.

4.3.2 Packet loss

The packet loss means the number of lost packets during the handover process. As we apply the scheme on OMNet++ simulator and its work in ideal environment. Hence we didn’t notice any packet loss. However, since our scheme is introducing a new mechanism that embedded the predecessor CM-IP into the extension header of the sent packets and also we remove the authentication process and the new IP configuration, hence no packet is loss is considered

4.3.3 Signaling Cost

The signaling cost means the number of signaling during handover, in particular moving from one subnet to another. Figures 4.5 and 4.6 show the simulation results for signaling cost for D-PMIPv6 and PMIPv6.

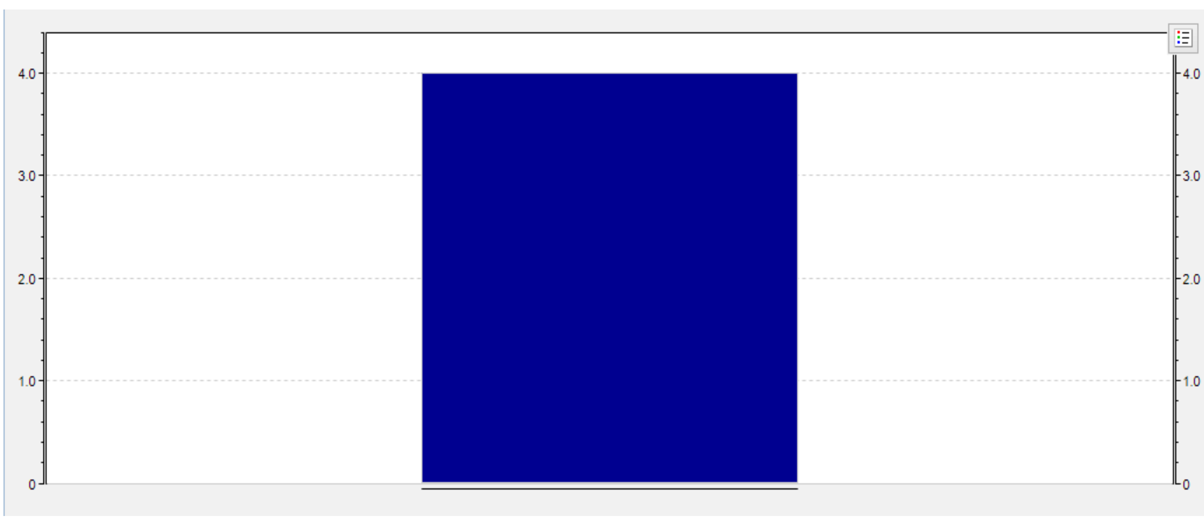

Figure 4-5 signaling cost for D-PMIPv6 in ms

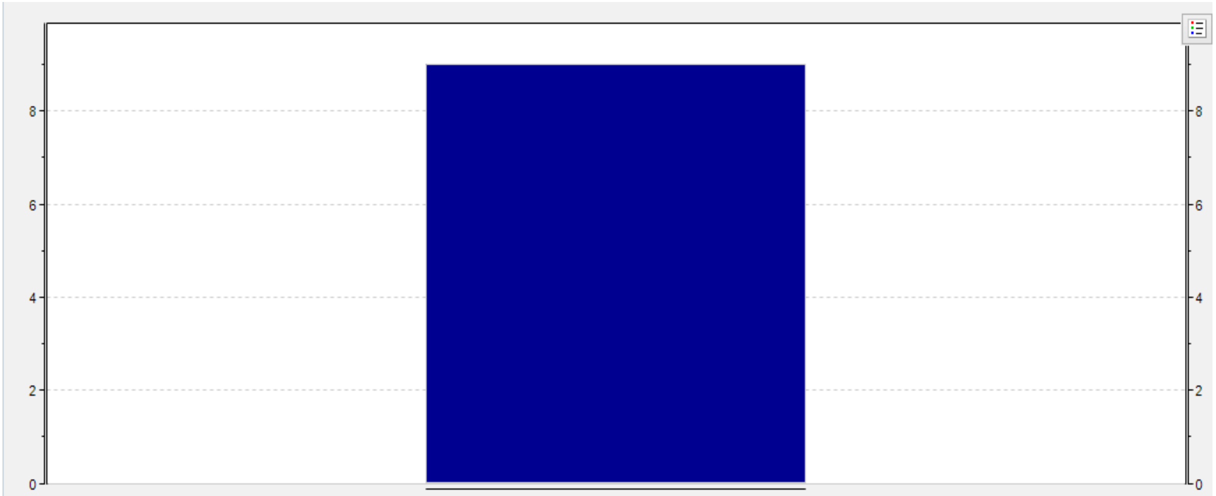

Figure 4-6 signaling cost for PMIPv6 in ms

As show in Figures 4.5 and 4.6 the lowest SC is belonging to our scheme D-PMIPv6 while the highest belongs to the standard PMIPv6. This because no extra signals are exchanged between the old Control Mobility (CM) and the serving CM, to provide location management function, and the previous CM address is sent with the delivered packets. Hence, by sending the security information of the MN in advance from the previous CM to the serving CM and this process reduces the handover latency since it avoids the authentication process.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATION

5.1 CONCLUSIONS

As we mentioned previously the future of mobile networks, are increasing loads imposed by mobile Internet traffic will force the network architecture to be changed from hierarchical to flat structure. Most of the existing mobility protocols are based on a centralized mobility anchor, which process all control and data traffic. However, the centralized mobility scheme has some limitations. This schemes support the distributed mobility management in flat network architecture. Based on the Proxy Mobile IPv6 (PMIP), In which the Local Mobility Anchor (LMA) is moved from the core to the edge of network and distribute it functionality to the Mobile Access Gateway (MAG) to provide the mobility functions. The proposed scheme reduced the packet transmission delay, handover latency and signaling cost.

5.2 RESULTS

After designing our model using OMNeT++v4.6 following are the results:

- The handover latency for D-PMIPv6 was 25 ms and for PMIPv6 was 70 ms.
- The signaling cost for D-PMIPv6 was 4ms and for PMIPv6 10ms.
- Our scheme optimizes the packet loss for the standard PMIPv6 by embedded the predecessor CM-IP into the extension header of the sent packets

- OMNeT++ is a flexible simulator for networks and easy to use.

5.3 RECOMMENDATIONS

From the observations during this research, the following recommendations are suggested for further work:

- Since the authentication and authenticity process defined by PMIPv6 protocol adds considerable delay which in not preferable for real time applications, further studies are required to improve the security of the proposed scheme.
- As we see we compared our scheme with one protocol, it is recommendable to compare with alternative protocols.
- We recommend to extend the scheme to work as an intra-domain.

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