Sudan University of Science and Technology

College of Graduate Studies

Improving Mobile IPv6 handover in Wireless Local Area Networks

تحسين آلية الإستلام لبرتوكول الأنترنت الاصدار السادس النقال في الشبكات المحلية اللاسلكية

A Thesis submitted in Partial Fulfilment of the Requirements for the Degree of M.Sc. in Electronics Engineering (Telecommunication Engineering)

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جامعة السودان للعلوم والتكنلوجيا

كلية الدراسات العليا

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بحث تكميلي مقدم لنيل درجة الماجستر في هندسة الإلكترونيات (هندسة الإتصالات)

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الآية

بسم الله الرحمن الرحيم

قال تعالي:

(يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ ۚ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِير)

صدق الله العظيم

سورة المجادلة- الآية رقْم 11

DEDICATION

First my ultimate thanks to the only God and His prophet, and my lovely parents.

And to all sisters and brothersI get together with them in this life and sharing goodness and assistance with them.

And thanks to my husband the big kind heart.

And to all teachers whose set up their life to serve us by introducing the acknowledgment and science we need for better living.

With my respect

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I submit my gratitude to the persons who assisted and helped me to accomplish this study.

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Last and not the least I introduce all the appreciation to my husband Eng. Mohammed Tag Elser, for getting along with me in this life experience, support and encouragement.

Abstract

In this study the issue of handover in WLAN networks will be considered with existence of Mobile IPv6 deployment, a simple User Datagram Protocol UDP video application is used to represent the traffic between the Mobile Node MN and the Correspondent Node CN while the MN is roaming out from its Home Agent HA Network to enter the Foreign Agent FA in other network, passing through a blind areas between the WLAN access points with no enough coverage, to evaluate the performance of the handover mechanism and then propose some network configuration enhancements to improve the handover process, these enhancements are configured in the wired routing networks by tuning the routing advertisement and neighbour parameter in order to reduce the packet transmission latency and to avoid dropping of packets in process, hosts binding messages and return routability test messages parameters are also adjusted. The network performance is evaluated in terms of WLAN physical layer statistics such as delay, load, media access delay, packet drop, and throughput, in addition to application statistics as UDP traffic received in MN, these enhancements are considered as routing optimization and WLAN regulations. Actually the aim of this study is to improve horizontal-hard .handover mechanism

OPNET network modeler simulation is used in order to apply these proposed enhancementswe get satisfied

expected results in terms of performance metrics like data dropped which reduced by approximately 50%, and the physical layer delay reduced by 84%.

المستخلص

في هذه الدراسة سيتم أعتبار مشكلة إستلام وتسليم البيانـات أثنـاء التجـوال فـي الشـبكات اللاسـلكية المحليـة مـع وجـود وتطـبيق الأصـدار السادس لـبروتوكول الأنـترنت للتنقـل، نـوع البيانـات المـارة بيـن الوحـدة المتنقلـة والوحـدة المتصـل معهـا هـو تطـبيق فيـديو بسـيط ينتقـل عـبر بروتوكول مخطط البيانات للمستخدم ، أثناء تجـوال الوحـدة المتنقلـة مـن شبكة الوكيل المنزلي أو المحلي الى وكيل أجنبي فـي شـبكة أخـرى مـاراً بمناطق عمياء بين نقـاط وصـول الشـبكات المحليـة اللاسـلكية ليـس بهـا تغطية كافية أو أماكن تغطية متقاطعة، لتقييم أداء آلية الإسـتلام والتسـليم ومـن ثـم إقـتراح بعـض التهيئـات والإعـدادات لتحسـين عمليـة الإسـتلام والتسليم، هذه التحسينات يجب أن يتم ضبطها في شبكة التوجيه السلكية بضبط إعلانات التوجيه و معاملات مكونات الشبكة المجاورة لمايؤدي إلـى تقليل التأخير في نقل البيانـات وتفـادي سـقوط وإهمـال الحـزم المتـأخرة أثناء المعالجة، رسائل تعلق المضيف ورسائل إختبار إعادة التوجيه أيضاً تم ضبطها، ومن ثم سيتم تقييم أداء الشبكة حسب معايير وإحصائيات قيـاس أداء الطبقـة الفيزيائيـة للشـبكات المحليـة اللاسـلكية مثـل التـأخير العـام، الحمل علـى الشـبكة، التـأخر فـي الوصـول للوسـائط، الحـزم السـاقطة، والخرج. بالإضافة لإحصائيات قياس تطبيق الفيديو مثل البيانات المسـتلمة في الوحدة المتنقلة، التأخير من النهاية المرسـلة الـى النهايـة المسـتقبلة، والتغيير في تأخيير وصول الحزم. تلك التحسينات يمكـن إعتبارهـا كـترتيب وتنظيم للتوجيه والشبكات اللاسلكية المحلية، حقيقةً الهدف الأساسي من هذه الدراسة هو تحسين عملية الإستلام والتسليم الصعب للبيانـات عنـدما

يمر المستخدم المتنقل بين الشبكات السلكية المحلية أفقياً ماراً بمنــاطق تغطية عمياء.

تــم عمــل المحاكــاة للشــبكة بإســتخدام برنامــج الأوبنــت لنمذجــة الشبكات وبتطـبيق التحسـينات المقترحـة تحصـلنا علـى النتائـج المرضـية المتوقعة من حيث مقــاييس الأداء مثلالحــزم الســاقطة الـتي قلّـت بنسـبة 50%، و التاخير في الطبقة الفيزيائية قلَّ بنسبة 84% تقريباً.

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List of Abbreviations

4G	Fourth Generation
ACK	Acknowledgement
ACM	Association of Computer Machinery
AODV	Ad Hoc on Demand Vector
AP	Access Point
AR	Access Router
BAck	Binding Acknowledgement
BDT	Bi-Directional Tunnelling
BSS	Basic Service Set
BU	Binding Update
CN	Corresponding Node
CoA	Care-of-Address
DAD	Duplication Address Detection
DHCP	Dynamic Host Configuration Protocol
FA	Foreign Agent
FBAck	Fast Binding Acknowledgement
FBU	Fast Binding Update
FHMIPv6	Fast handover for Hierarchical Mobile IPv6
FMIPv6	Fast Mobile IPv6
GPRS	General Packet Radio Service
HA	Home Agent
HAck	Handover Acknowledgement
HI	Handover Initiation
HI-HAck	Handover Initiation handover acknowledgment
HMIPv6	Hierarchical Mobile IPv6
ICANN	Internet Corporation for Assigned Names and Numbers
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
kbps	Kilobit Per Second

LTE	Long Term Evolution
MAC	Media Access Control
MaxRtrAdvInterval	Maximum Router Advertisement Interval
Mbps	megabit per second
MIPv4	Mobile Internet Protocol version 4
MIPv6	Mobile IPv6
MinRtrAdvInterval	Minimum Router Advertisement Interval
MN	Mobile Node
NAT	Network Address Translation
OPNET	Optimized Network Engineering Tool
OSI	Open Systems Interconnection
PPP	Point to Point Protocol
PRD	Pre-handover Route Discovery
RtAdv	Router Advertisement
QoS	Quality of Service
RFC	Request for Comments
RIPng	Router Information Protocol next generation
RO	Route Optimization
TCP	Transfer Control Protocol
UDP	User Datagram Protocol
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide interoperability Microwave Access
WLAN	Wireless Local Area Network
WMN	Wireless Mesh Network

Chapter1

1. Introduction

Wireless communications are generally introduce to provide connectivity to mobile or moving end users, WLAN is one of the famous applications of wireless communications that are widely deployed and developed to provide an internet connection in mobility environments.

Internet Protocol IP provides identification for network nodes including end users, mainly two versions of IP are used in wired and wireless networks which are the IPv4 and IPv6, mobile IP is introduced to provide connectivity for those users are moving around various routers inside the network, there are mobile IP for both versions MIPv4 and MIPv6. MIPv6 has introduce many advantage over MIPv4 as in large and growing wireless communication for e.g. internet broadband networks deployment, most of 3G network services are being carried over IPv4. However, as the number of users grows, the IP address shortage will become heavier [1].

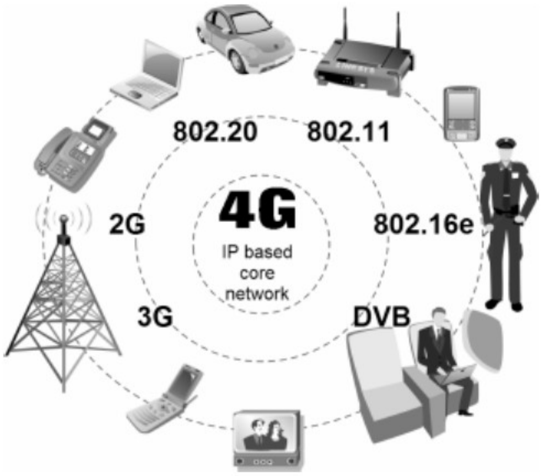

Figure 1: 4G network field

Mobile IPv6 (MIPv6) is the perfect candidate to provide mobility and sufficient addresses that may resolve the issues. Fourth generation (4G) networks will include all-IP (Internet Protocol) wired and wireless networks interworking together as heterogeneous networks (see Figure 1.1 above) and to provide data rates up to a hundred times faster than current networks [1]. Its high capacity will be beneficial as seen by these days, and overall global data traffic will grow up to 6.3 Exabyte's per month [2].

The main traffic stream has become more and more real-time sensible. Therefore, achieving a good quality of service (QoS) has become the main focus of many Internet Service Providers (ISPs). To adopt MIPv6 as the preferable protocol, it is essential that MIPv6 meets the QoS requirements. Currently, the MIPv6 standard fails to provide good QoS in some circumstances. It is especially the case when portable communication equipment is roaming from one MIPv6 network to another which is called the “handover” process. QoS requirement in Handover or handoff refers to provide a constant connectivity when mobile is going from one cell coverage to another while communicating with other network components.

1.1 Background

MIPv6 in WLAN network architecture refers to the existence of two communication nodes at least one of them is mobile node and the other the correspondent node, or both can be moving while communicating with each other, the home agent access point defines the default access point that provide connectivity to the mobile node, and this is one of the mobility management tasks.

1.1.1 Mobility management

Mobility management has become the most important element in ubiquitous networks since the All-IP next generation heterogeneous networks get better. It provides seamless support of real-time and non-real-time services for mobile subscribers and facilitates connection maintenance for subscribers on the move when they change points of attachment. Furthermore, mobility management involves location management and handover management (as Figure 1-2) [3].

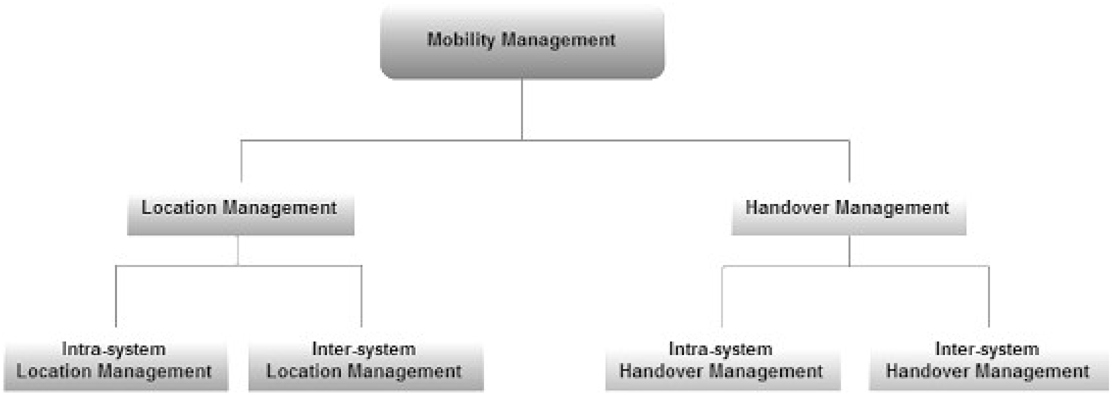

Figure 1: mobility management functions.

Keeping track of the mobile clients location's in the network is allowed by the Location management, and it involves two procedures: location registration and paging. In a location registration procedure, the network is informed periodically by the mobile node communicating its current location which the network updates in the location database. After location management takes place, paging procedure requests the network to get information about the specific location of a mobile client so that data is delivered successfully [4].

The mechanism of keeping the Mobile node connection active when the MN passes from one attachment point to another is known as the Handover Management. The handover procedure involves three stages:

1. Either the MN or the network triggers the initiation of handover.

2. Then the network finds new resources for the handover connection.

3. Finally, data flow control maintains the delivery of data from the old point of attachment to the new point of attachment with quality of service (QoS) [3].

Several protocols and mechanisms have been developed to support handover for internet services. To support handover for internet services, several protocols and mechanisms have been developed. Due to nodes motion classification the Handover can be classified as horizontal or vertical handover. Handover from one access point to another within the homogeneous technology refers to the Horizontal handover (as Figure 1.3), for e.g. from WLAN AP to another WLAN AP. [5].

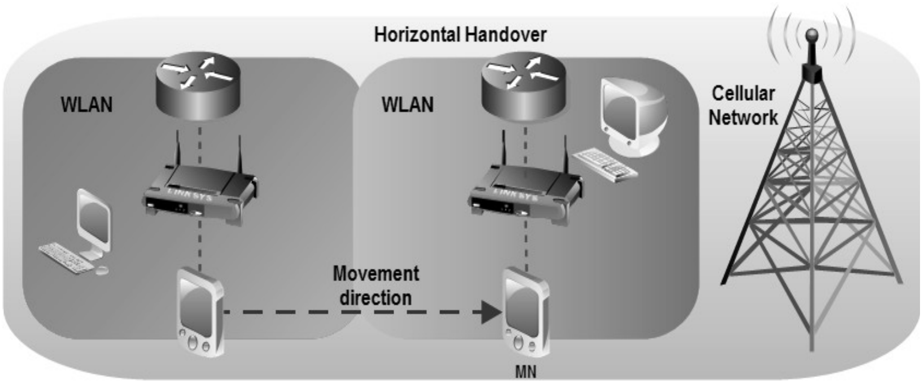

Figure 1: Horizontal handover.

While handover operation between heterogeneous networks, refers to vertical handover (as Figure 1.4). For e.g. from WLAN to WiMAX, or from GSM to WLAN, or from HSPA to LTE … etc. Vertical handover has been researched on different levels of the OSI reference stack because its complexity is increasing in heterogeneous networks. And this is not considered in this case of study.

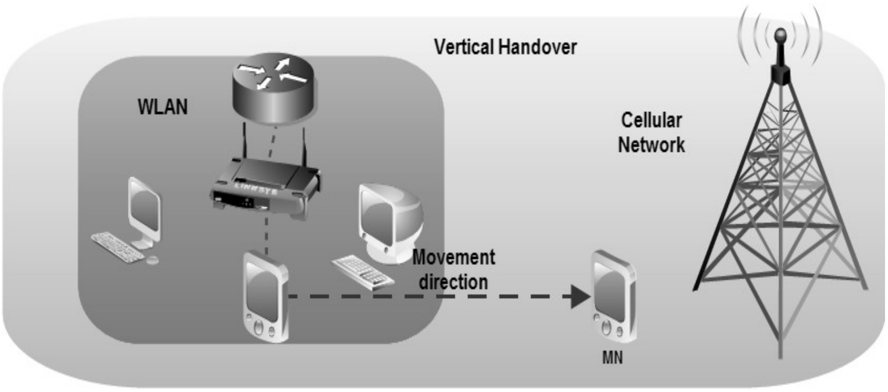

Figure 1: handover from WLAN to a GSM (Vertical handover).

1.1.2 Soft and Hard handover

When the handover process is categorized according to its connection status for which vertical or horizontal handover, a handover can be soft or hard (as in Figure 1-5).

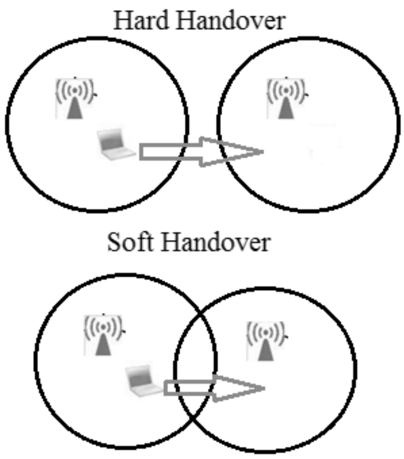

Figure 1: Hard and Soft handover

The difference between them is based on whether a mobile device maintains a connection with at least one access points during the handover process. In the handover period, if the mobile device keeps its connection with the old access point until it fully establishes its connection with a new access point, the handover is called a soft handover. In contrast, if the mobile device breaks its connection with the old access point before it is connected with a new access point, we deal with a hard handover [6].

1.2 Problem Statement

IPv4 shortage when the number of users grows specifically in mobile environment, because of number of available IP addresses is limited and insufficient for wireless network development.

Roaming mobile nodes suffers from signal attenuation while going far from the attached wireless access point which reduce traffic transmission and maximize latency, which affects negatively the handover process and some traffic can be delayed and/or dropped.

1.3 Proposed Solution

Using of IPv6 in wireless mobile communication has been proven as sufficient protocol for mobility environment with quality of service prerequisites.

Reducing the routing advertising interval can reduce the packet routing process time which lead to less packet latency, and also help new access point to early discover new roaming mobile nodes this help mobile node to quickly initiate association process and attach to the new access point.

Maximizing neighbour cache parameters introduce more packet buffer or queue size to holds more packets while discovering the destination in the network, this reduce the dropping traffic packets which lead to better throughput.

1.4 Objectives

- To determine WLAN network architecture with existence of MIPv6 while moving equipment are communicating.

- To construct a network model consist of mobile node communicating with a correspondent node by MIPv6 in WLAN environment using OPNET modeller.

- To demonstrate a horizontal-hard handover where a mobile moves from one WLAN access point to another WLAN access point with no overlapping area between them, using traffic tunnel.

- Improving the handover process while the mobile node is roaming through various network access points by introducing some enhancement and routing optimization configuration that can positively help handover mechanism.

1.5 Methodology

By using the OPNET modeler software we can model and simulate the network scenarios and by tuning the simulated node’s attributes we can simulate the communication behavior and so different performances can be easily observed.

The simulation model will include two scenarios, first one uses default and ordinary parameters that are considered by the standard global attributes, by using traffic tunnel mechanism. The second one is customized to perform an extended handover mechanism while a mobile node moves from one WLAN cell to another using routing optimization. Then the performance of the two scenarios will be compared in order to investigate the impact of the customizations in the resulted chosen statistics.

1.6 Research layout

Next chapter will introduce a literature review for WLAN networks in various aspects, and then chapter 3 will describe the simulation environment setup and parameters configuration, chapter 4 includes all the collected statistics that generated by OPNET discrete event simulation individual statistics that are chosen to evaluate the network performance, and finally chapter 5 represent a summarization of the gained acknowledge understood from this study.

Chapter 2

2. Literature review

2.1. Introduction

The development of the wireless radio communication growth up rabidly from traditional usages like ZigBee and Bluetooth to more sophisticated applications like Wi-Fi, WiMAX, and LTE networks, with this development more features introduced and better spectral efficiency usages become available for providers.

Wi-Fi acronym has different abbreviations it can refer to Wireless Internet for Frequent Interface and sometimes stands for Wireless Fidelity or Wireless Fidelity Alliance, but it’s all referring to a same meaning which is local area wireless network access or WLAN, and it’s standardized by IEEE-802.11, Wi-Fi is the most popular network access for indoor coverage and it’s applicable for all networking applications and protocols that been in use, the standard IEEE-802.11 of Wi-Fi has been developed through many stages until these days to introduce more features and better usage experience [10].

In general, Wi-Fi is used and deployed for internet service endpoint, Internet Service Providers (ISP) becomes more comfortable with introducing the Wi-Fi access point’s technology for their users, and the Access Point is the main component in the Wi-Fi network, which provides the network services for all the users in the range of it coverage [13].

2.2. Overview of WLAN

IEEE 802.11 WLAN or as called these days (Wi-Fi) is a very popular wireless technology that covers small geographical region. WLAN is popularly used because deployment of network is easier and cheaper, easier maintenance and low infrastructure cost. It supports two kinds of working mode namely Ad-hoc mode and infrastructure mode. As shown in Fig2-1. For infrastructure mode the wireless stations communicate with other wireless stations using Access Point (AP). Access Points are the ones that transmit and receive radio frequencies and are responsible for communication between wireless stations [11].

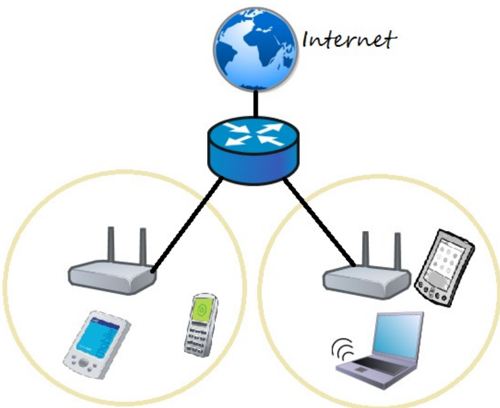

Figure 2: IEEE 802.11 WLAN Architecture.

The set of all wireless stations that communicate with each other forms the Basic Service Set (BSS). A set of all connected BSSs forms Extended Service Set (ESS). Access Points present in an Extended Service Set are connected by means of a Distribution System (DS) and it can be both wired or wireless [5].

It is possible to create high-speed wireless local area networks With Wi-Fi, distances between mobile equipment and access points should be considered as possible to avoid signal threshold.

IEEE 802.11 working group is the major developer and the official sponsor standard of Wi-Fi or WLAN which is originally defined and designed as low range indoor coverage wirelessnetwork. But now it passes through many developments and become more popular.

2.2.1 802.11 standard overview

The IEEE 802.11 is an international standard describing the characteristics of a wireless local area network (WLAN). The name Wi-Fi corresponds to the name of the certification given by the Wi-Fi Alliance, the group which ensures compatibility between hardware devices that use the 802.11 standard [4].

modifications have be made to the original standard in order to enhance bandwidth (these include the 802.11a, 802.11b and 802.11g standards, which are called 802.11 physical standards) or to better select components in order to ensure enhanced compatibilityor security[6]. Table (2-1) shows summarization of 802.11 standard releases and developments.

Table 2: 802.11 standard releases summaries

Standard Protocol	Release date	Frequency	Data Rate (Typical)	Data rate (Max)	Range (Indoor)	Range (Outdoor)
Legacy	1997	2.4 GHz	1 Mbps	2 Mbps	?	?
802.11a [7]	1999	5 GHz	25 Mbps	54 Mbps	30 m	120 m
802.11b [7,8]	1999	2.4 GHz	6.5 Mbps	11 Mbps	30 m	140 m
802.11g [9]	2003	2.4 GHz	25 Mbps	54 Mbps	30 m	140 m
802.11n [9]	2008	2.4&5GHz	200 Mbps	540 Mbps	50 m	250 m

2.2.2 802.11 reference model

The reference model represents the tectonic design view, confirming the demarcation of the WLAN 802.11 system into two main parts: the Media Access Control (MAC) of the Data Link Layer (DLL) and the Physical Layer (PHY). These layers are intended to correspond closely to the lowest layers of the ISO/IEC basic reference model of Open Systems Interconnection (OSI) (ISO/IEC 74981:1994). The layers and sub layers described in this standard are shown in (Figure 2-2) [12].

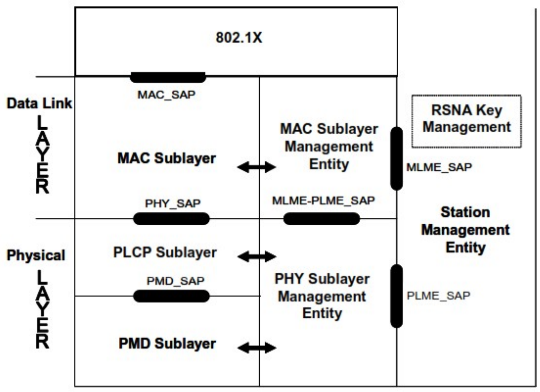

Figure 2: 802.11 reference model.

2.2.3 Wi-Fi physical standard

The 802.11a, 802.11b and 802.11g standards, called "physical standards" are modifications to the 802.11 standard and supports different modes of operation, which lets them, reach different data transfer speeds according to their range [10].

The 802.11g standard allows for a maximum data transfer speed of 54 Mbps at ranges comparable to those of the 802.11b standard. What's more, as the 802.11g standard uses the 2.4GHz frequency range with OFDM modulation, this standard is compatible with 802.11b devices, with the exception of some older devices [10]. WLAN OFDM physical layer block diagram can be illustrated as in (Figure 2-3) below.

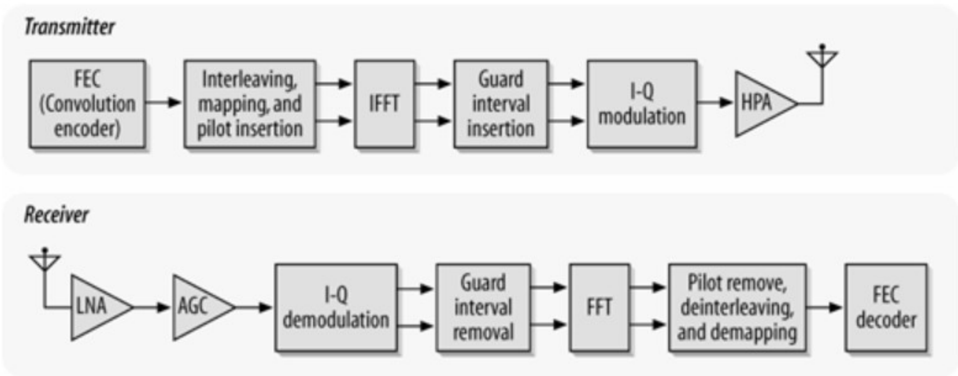

Figure 2: WLAN OFDM physical layer.

Where FEC is the Forward Error Correction mechanism, HPA refers to High Power Amplifier, LNA is the Low Noise Amplifier, and AGC is the Automatic Gain Control amplifier.

2.3. OFDM

The word orthogonal (mathematically) means independent items. Orthogonality is best seen in the frequency domain, looking at a spectral split-up of a signal. In OFDM, the frequencies of the sub-carriers are chosen so that at each sub-carrier frequency, all other sub-carriers don’t partake to the general waveform (see Fig2-4). The signal has been spliced into its three sub-carriers. The head of each sub-carrier, shown by the top of the sub-carrier signals, modulates data. The subcarrier set is properly designed to be perpendicular; the peaks of the sub-carriers, while the other sub-carriers have amplitude equals to zero.

OFDM takes the encoded signal for each sub-channel and uses the Inverse Fast Fourier Transform (IFFT) to create a complex waveform from the intensity of each sub-channel. Then the OFDM receiver applies the Fast Fourier Transform FFT to the received waveform to recover the amplitude of each component sub-carrier.

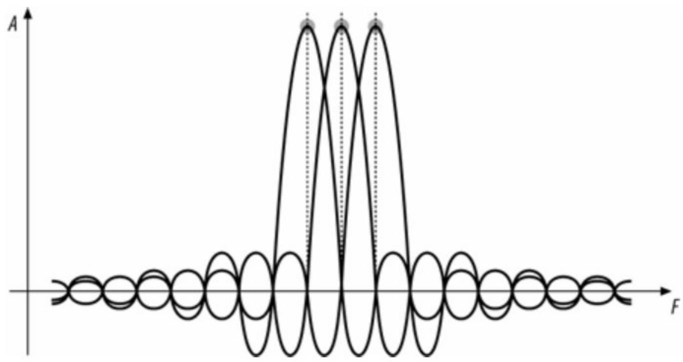

Figure 2: OFDM waveform.

An orthogonal frequency division multiplexing OFDM system introduces a WLAN with data payload communication support of 6, 9, 12, 18, 24, 36, 48, and 54 Mb/s. The capability of transmitting and receiving at data rates of 6, 12, and 24 Mb/s is compulsory. The system uses 52 sub-carriers that are modulated using binary or quadrature phase shift keying (BPSK or QPSK) or using 16- or 64-quadrature amplitude modulation (16-QAM or 64-QAM). Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, or 3/4.

The OFDM system also introduces a “half-clocked” operation using 10 MHz channel spacing with data communications capabilities of 3, 4.5, 6, 9, 12, 18, 24, and 27 Mb/s. The support of transmitting and receiving at data rates of 3, 6, and 12 Mb/s is mandatory when using 10 MHz channel spacing. The half-clocked operation doubles symbol times and clear channel assessment (CCA) times when using 10 MHz channel spacing.

The OFDM system also provides a “quarter-clocked” operation using 5 MHz channel spacing with data communication capabilities of 1.5, 2.25, 3, 4.5, 6, 9, 12, and 13.5 Mb/s. The support of transmitting and receiving at data rates of 1.5, 3, and 6 Mb/s is mandatory when using 5 MHz channel spacing. The quarter-clocked operation quadruples symbol times and CCA times when using 5 MHz channel spacing. Modulation and coding schemes affects the WLAN data rate according to OFDM parameters (as in Table 2-2).

Table 2: OFDM Modulation-dependent parameters

Modulation	Coding rate (R)	Coded bits per subcarrier (N_{BPSC})	Coded bits per OFDM symbol (N_{CBPS})	Data bits per OFDM symbol (N_{DBPS})	Data rate (Mb/s) (20 MHz channel spacing)	Data rate (Mb/s) (10 MHz channel spacing)	Data rate (Mb/s) (5 MHz channel spacing)
BPSK	1/2	1	48	24	6	3	1.5
BPSK	3/4	1	48	36	9	4.5	2.25
QPSK	1/2	2	96	48	12	6	3
QPSK	3/4	2	96	72	18	9	4.5
16-QAM	1/2	4	192	96	24	12	6
16-QAM	3/4	4	192	144	36	18	9
64-QAM	2/3	6	288	192	48	24	12
64-QAM	3/4	6	288	216	54	27	13.5

2.4. Internet Protocol version 6

Internet Protocol version 6 (IPv6) is the next generation of Internet Protocol (IP) which was released by Internet Engineering Task Force (IETF) in 1996. The motivation of the protocol is to resolve the problem of IPv4 address shortage in global Internet. However, the adoption of IPv6 has been slowed by the introduction of network address translation (NAT). The NAT alleviates the address exhaustion by separating the local IPv4 address and the global IPv4 address, and reusing the global addresses locally. However, NAT also makes it difficult and sometimes impossible to use peer-to-peer applications, such as Voice over Internet Protocol (VoIP) and multi-user games. Recently, due to the increasing demand and requirement for the wireless Internet, the deployment of IPv6 has become an urgent issue for the future Internet [13].

2.4.1 Mobile IPv6

Mobile IPv6 ("Mobility Support in IPv6") is the protocol with which the mobile IPv6 equipped devices (Laptop computers, PDAs and broadband internet mobile phones) keep a single point of presence while roaming on other IPv6 networks. This is done through the support of the Home Agent (HA) and Correspondent Nodes (CN).

MIPv6 introduces the use of the new IPv6 extension headers known as mobility headers. It utilizes several IPv6 existing mechanisms in order to perform mobility operations [39]:

- IPv6 neighbour discovery
- IPv6 extension headers (mobility, routing and destination extension headers)
- IPv6 address auto-configuration
- IPv6 tunnel encapsulation

There are two possible modes for communication between a mobile node and a correspondent node, which are the Bi-directional tunnelling and Route optimization. The MIPv6 models support both.

Internet Engineering Task Force (IEFT) transported into use of MIPv6 to make mobile nodes (MN) handy and maintained current connection while the mobile node is moving within network without changing the allocated IP address [14]. The operation of MIPv6 is as illustrated in (figures2-5,2-6).

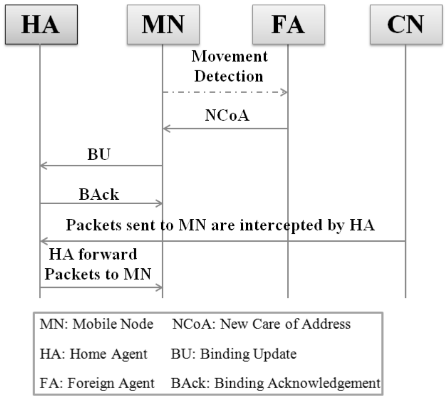

Figure 2: MIPv6 flow diagram

The operation starts as MN detects movement to a Foreign Agent (FA) and auto set up itself with a New Care of Address (NCoA) using either state-full or stateless method. MN sends Binding Update (BU) to its Home Agent (HA) to indicate the new address and HA returns back Binding Acknowledgment (BAck). Then, all packets is tunnelled to MN’s NCoA with the support of HA as HA encapsulate packets and sends to MN’s NCoA and MN de-capsulate the packets received from HA. An additional mode for MIPv6 is Route Optimization (RO). It enables that the packets to be received using the shortest path. This process requires MN to register its current Binding to Corresponding Node (CN). This allows CN to navigate packets to be delivered to MN without concerning HA. This measure reduces congestion at MN’s HA and Home Link **[31]**.

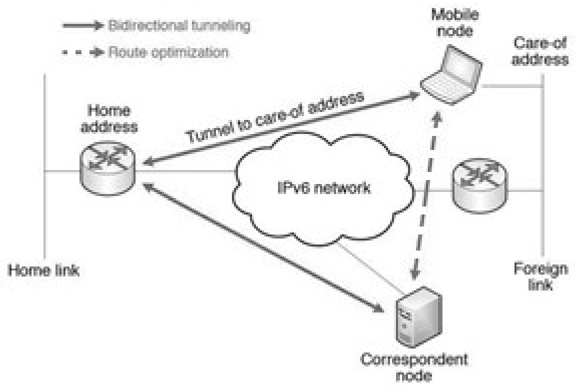

Figure 2: MIPv6 network diagram.

In a wireless IPv6 network, every MN and sub network has an interface identifier. The stateless address configuration forms the CoA by combining the prefix of the network and the prefix of the MN.

The state-full address configuration is usually performed by DHCPv6 which behaves in a similar way as DHCPv4. The method in general appears to be too time consuming for a handover. Therefore, the stateless address configuration is usually preferred [37].

The stateless address configuration forms the CoA by combining the prefix of the network and the prefix of the MN (as in Figure 2-7).

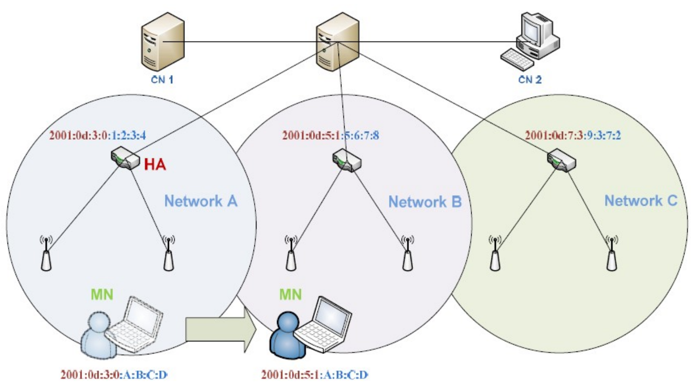

Figure 2: Example of an Address Configuration Process

2.5. Performance metrics

Multiple performance metrics and evaluation factors are used in this study in order to investigate the different case and enable the comparison study to be performed; these performance metrics will be discussed and described in details with their characteristics as in the following sections.

2.5.1 Throughput

In any communication networks, throughput is the average rate of successfully received packets through a communication medium. So this means more messages received over Channel will make network more dependable, trusty, reliable and fast. [15]

2.5.2 Network delay

Delay in networkingdeterminesthe time taken to deliver a packet from transmitter to receiver. It is typically measured in multiples or fractions of seconds. Delay may change somewhat, according to the communicating nodes location [16].

2.5.3 Packet Delay Variation "Jitter"

Jitter can most easily be described as a discrepancy/variation in the delay/interval in received/arrived packet. Packets are formed in order to have some sort of digital communication so that the sending side packets are continuously formed and sent in a form of simultaneous streams in a way where packets are set to send in evenly spaced order. There are many aspects which can cause jitter.

2.5.4 Packet End to End delay

E2E Delay is the time which is calculated as the time which video traffic takes to generate and travel from transmitter node to receiver and decoded. E2E Delay is an important factor which initializes the problem accruing in a transmission. Delay can be distinguished in two main categories as: fixed delay and variable delay. Fixed delay involves various components which are predictable resulting in inclined overall delay, component include coding, packetization and serialization. Variable delay also involves different components but most known is queuing delay. Delay can cause noticeable difference in performance of any real time multimedia transmission and communication. [36]

2.6. Related work

In [31], multiple topologies for all the mobile routing protocols are proposed, to be designed and developed. In this related research, it is believed that the design and develop FHMIPv6 over WMN performs better as compare to the others routing protocols over the Internet. In [32] a session mobility framework capable approach is proposed for vertical handover between GPRS and WiMAX, the proposed approach has advantages by illuminating the handover related packet loss. in [33] Handover in WMN environment for infrastructure internet is discussed as mobility management protocols related topics, in this study conclusion states that Fast HO for HMIPv6 outperforms the MIPv6 in terms of throughput and delay but MIPv6 has the advantages in term of packet drop rate.In [34] a mobility management issue is addressed and simulated in both WLAN and WMN environment, results shows that vertical handover between WMN and WLAN can be managed using MIPv6 .In [35] an Extended Handover Control Function (*E-HCF*) is proposed as a new control function to introduce better handover performance in case ofMIPv6 over WLAN networks, the results in this study showed that the proposed solution allows to enable less latency, less packet drop when compared to standard handover of MIPv6.

Mobile IP [25] (RFC 2002) has made it possible for MNs to have roaming capabilities. MNs can change their point-of-attachment without changing their IP addresses. This permits seamless mobility of MNs from one network to another while maintaining the existing connection. There are two versions of MIP; MIP version 4 (MIPv4) [25], which enables roaming capabilities of MNs in IPv4 networks and MIP version 6 (MIPv6) [26], which allows mobility in IPv6 networks. Although MIPv4 has been a standard for the past few years, MIPv6 is becoming more popular [27].

Table 2: Comparative study of previously introduced related work

Reference No.	Advantages	disadvantages

[31]	Enhancement procedure for FHMIPv6 over WMN analysis.	No result analysis introduced, just assumptions.
[32]	Proposed mobility framework between GPRS and WiMAX.	Used MIPv4, no MIPv6 approach introduced.
[33]	Comparative study concludes that FHMIPv6 has fewer packets data dropped than MIPv6 in WMN.	Considered overlapping area, this can easily implement soft handover in WMN.
[34]	Simulation of MIPv6 in WMN.	No MIPv6 enhancements introduced.
[35]	Proposed a new control function called Extended Handover Control Function.	Time taken in initialization is longer, and also takes more time for new MN detection and addressing.
This study	Proposes a procedure of network layer configuration that can enhance or improve the performance of hard hieratical handover in WLAN with MIPv6 existence, to reduce dropped traffic and handover latency issue.	New MIPv6 protocols as FMIPv6, HMIPv6, and FHMIPv6 are not included, because they are only supported in later versions of OPNET as 16.0 and higher which is not freely available for individuals and has some restrictions, in the other hand free open sourced simulators are very complex and needs more time to study and practices.

Chapter 3

3. Methodology

3.1. Overview

The documentation of MIPv6 mobility related parameters is described in the Request-For-Comments RFC 2461 documentation [28] and discussed in this section as used in our handover enhancement procedures. Generally, the RFC documentation mentioned above describes the Neighbour discovery protocol in MIPv6, Neighbour Discovery is used by IPv6 nodes to implement important functions, among which are the following:

- Locating neighbour routers
- Learning prefixes and configuration parameters related to address configuration
- Auto-configuring their addresses to establish relationships between link layer addresses and IPv6 addresses
- Determining that a neighbour is no longer reachable
- Discovering duplicated addresses

Multiple parameters are set to configure a suitable neighbour discovery protocol mechanism between the network various nodes, this parameter are the router advertisement and neighbour cache parameters in MIPv6 routing configuration.

3.2. Simulation Definitions

In order to understand the different characteristics and components used in this study some definitions should be declared first as considered, these definitions are:

- Mobile Node: represents the transceiver that communicates with the correspondent node.
- Corresponding Node: A host that mobile node communicates with which can be any severs (e.g., FTP, Web, VoIP, Video …) or just some devices either mobile or stationary.
- Home Agent: is the router that firstly attached to the mobile node which represent its home default network and it's also used to tunnel traffic when the mobile is moving into a foreign agent network when route optimization is not used.
- Foreign Agent: represent the new router that the mobile node visits while moving.
- Agent Advertisement: An advertisement message constructed by attaching a special extension to a router advertisement message.
- Agent Solicitation: An advertisement message sent by the mobile node when it wants to join a network.
- Care-of -Address: This address is assigned by foreign network subnet and when the mobile node is assigned this address, it will inform its home agent. The protocol can use two different types of care-of addresses: a "foreign agent care-of address" is an address of a foreign agent with which the mobile node is registered, and a "co-located care-of address" is an externally obtained local address that the mobile node has associated with one of its own network interfaces (e.g., DHCP).
- Home Address: The address is assigned by home network subnet, and this is a static address for mobile node, which means that the mobile node will never change its IP address once it gets that.
- Tunnel: The path followed by a packet while it is encapsulated. It is routed to a knowledgeable decapsulating agent which decapsulates the datagram and then correctly delivers it to its ultimate destination.

3.2.1 Router Advertisement

Router advertisement is a messages sent from both wired and wireless routers to all nearby neighbour routers and host to advertise its existence and availability.

There are two types of router advertisements messages, the Solicited advertise and unsolicited advertise. If this attribute is set to 'Disabled', no Router Advertisement messages will be sent out on this interface. This is true for both Unsolicited Router Advertisements and Solicited Router Advertisements. Solicited advertisement is used to know the link-layer address (MAC address) of neighbour, neighbour unreachability detection, and Duplicate Address Detection DAD.

Routers advertise interval is the Distribution that is used to compute the interval between successive unsolicited router advertisements in seconds.

MaxRtrAdvInterval: The maximum time allowed between sending unsolicited multicast Router Advertisements from the interface, in seconds. This value must be no less than 4 seconds, and no greater than 1800 seconds. Default: 600 second [28].

MinRtrAdvInterval: The minimum time allowed between sendingunsolicited multicast Router Advertisements fromthe interface, in seconds. This value must be no less than 3seconds and no greater than 0.75 *MaxRtrAdvInterval. Default: 0.33 * MaxRtrAdvInterval = 200 sec [28].

3.2.1.1 Router Advertised Lifetime

The value to be placed in the Router Lifetime time field of Router Advertisements sent from the interface [28].

A value of zero indicates that this router is not to be used as a default router. If the value is non-zero, it should be between MaxRtrAdvInterval (The upper limit of the distribution specified for Router Advertise Interval) and 9000s.

Default: 3*MaxRtrAdvInterval = 1800 sec [28].

If this attribute is set to 0, host nodes will not use this node as the default gateway. But the actual value if the attribute is not modelled.

3.2.1.2 Advertised Reachable Time

The time, in milliseconds, that a node assumes a neighbour is reachable after having received a reachability confirmation.

The Reachable Time field in the Router Advertisement messages sent out on the interface will be set to this value. A value of 0 indicates that the value is unspecified by this router [28].

Note that the reachable time used by the neighbour discovery process on the interface is specified separately under the Neighbour Cache Parameters attribute. The two values do not have to be the same [28].

3.2.2 NeighbourCache Parameters

Attributes used by Address Resolution and the Neighbour Unreachability Detection algorithm can be configured under this attribute.

3.2.2.1 Maximum Queue Size

Maximum queue size represents the maximum number of packets to be sent to a particular address that will be queued while address resolution is being performed for the packet destination address. If the number of packets exceeds the specified value, then the oldest packet will be dropped.

3.2.2.2 NeighbourSolicit Interval

Neighbour solicit interval is the time between retransmitted Neighbour Solicitation messages, in milliseconds, used by address resolution and Neighbour Unreachability Detection algorithms.

3.2.2.3 Maximum Solicitation Attempt

Maximum number of solicitation messages that will be sent for an address before concluding that address resolution has failed.

3.2.2.4 Base Reachable Time

A base value used for computing the random value for which a neighbour is considered reachable after receiving a reachability confirmation. The actual value will be a uniformly-distributed random value between 0.5 and 1.5 times this value.

On host interfaces, if a router advertisement received has the advertised reachable time value set, it will overwrite the value specified using this attribute.

3.3. Network Design and Model:

Generally, there are three network domains in the simulation scenario, the CN network which allow access to and from the CN node, the Home Agent HA network which allows the MN to communicate with the CN in the beginning of the simulation, and the FA network which consist of two WLAN access points that the MN node uses when roaming out from the HA network to continue the application with the CN node.

The IPv6 network is composed by four WLAN access points connected through an IP cloud. The core of the network, represented by the IP cloud, has a constant latency of 0.1 seconds. This makes easier to note the effects of the different MIPv6 mechanisms over the application delay.

MN and CN communicate to each other by running a video application as a source of constant UDP traffic. Initially the MN is placed into his corresponding home networks. Then MN is served by it home agent HA and CN is served by home agent access point CN_AP. This introduce more advanced feature with MIPv6 over MIPv4, which is that both MN and CN nodes can support roaming between access points, this means the CN also can move into the network while communication with the MN, so each one of the two nodes can be a client or server or both while moving around.

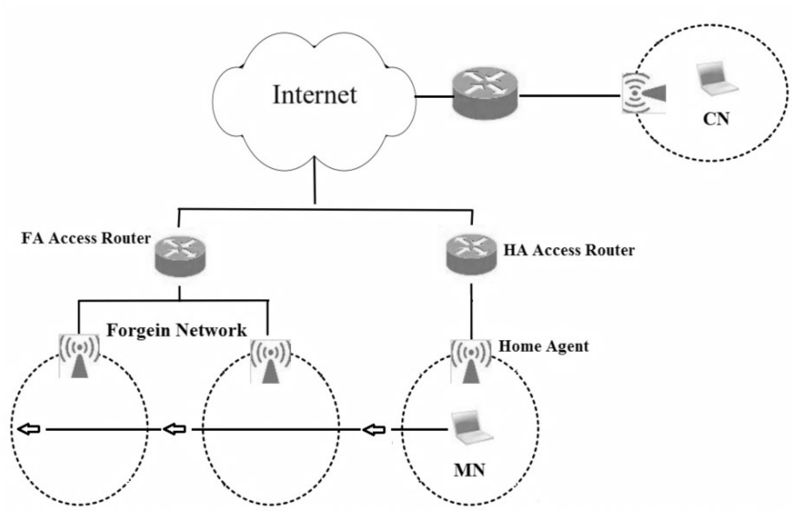

Figure 3: network illustration

The trajectory defines the movement of the MN from it serving HA to a different network which also supports MIPv6 to be served from other access points of the FA. (Figure 3-1) shows the network system model applied in OPNET scenarios, while (Figure 3-2) shows the experimental design used to gather the statistics represented in the results.

Initialization

Default parameters and Bi-Directional Tunneling

Configuration enhancement & Route Optimization

Compare Results

Output

Figure 3: Experimental design

Below in (Figure 3-3) the considered flow chart is illustrated as assumptions of this study, the flow chart starts with the mobile node sending it’s binding messages while detecting motion, when the retransmission attempts of binding message exceeded this means it’s too far from the associated AP, then it looks for advertisement messages in neighbour cache and return a solicitation message, then the MN tries to associate with the new AP using CoA, if the association is successful then the MIPv6 routing mechanism is figured, if routing optimizations is used then the traffic is routed with the best route and minimum delays is used which lead to better transmission. If routing optimizations is not used then the traffic will be encapsulated and tunnelled through the HA and then the MN decapsulates it again, which takes more time leads to higher latency, and may be some traffic dropped while processing older packets.

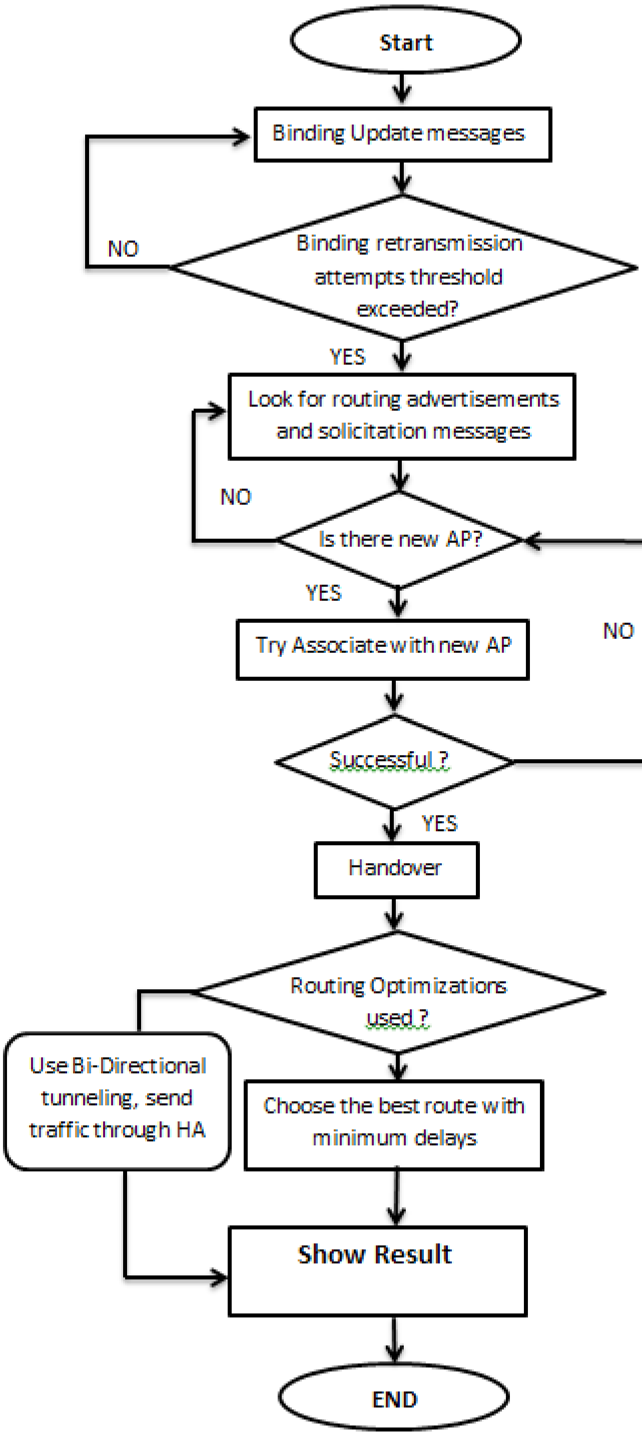

Figure 3: Handover mechanism flowchart

Chapter 4

4. Simulation Results and Discussion

Last chapter has described the details of the MIPv6 parameter definitions used in the proposed mechanism in this thesis. In the academic world, to verify the performance of such a mechanism, we can conduct simulations and/or experiments. In this case, we choose to use simulations. In this chapter, we will describe the main assumptions of our simulation study and the simulation models used to evaluate performance of the proposed mechanism. The numerical results obtained from simulations are presented and discussed in the later part of this chapter.

4.1. Overview

The system model used in this study is simulated using the OPNET modeller software, OPNET Modeller is a C/C++ language based discrete-event simulation with Graphical User Interface (GUI) [5]. Simulations with GUI can be easily interpreted, hence convenient to develop networks.

Network model performance analysis is accomplished by using the standalone discrete event simulation from the Optimized Network modeller software (OPNET) of version 14.5, which offers an exclusive set of tools for planning, configuring, and analysing wireless networks projects.

The simulation of system used in this study uses integration environment between the WLAN 802.11a and Mobile IPv6 (MIPv6) models, the version of the academic modeller software used has some limitations to implement the latest technology updates, but it’s enough to just simulate the idea of this study which meant to improving or enhancing the handover process in WLAN network whilst MIPv6 is used.

4.2. Simulation Parameters

Table 4-1 expresses the general parameters used in the simulation for network physical layer and traffic application and mobility settings.

Table 4: Simulation parameters

Parameter	**Value**
WLAN Standard release	802.11a
Physical Layer Profile	OFDM
Data rate	6 Mbps
Transmit power	0.005 W
Packet Reception power threshold	-95 dBm
Buffer size	256 kb
Network area	5x4 km
AP coverage area	200 m^2
Simulation time	35 min
MN speed	36 km/hr

Application	Video Conferencing
Transport protocol	UDP
WLAN routing protocol	PIPng

4.3. Simulation Attributes Configuration

First the simulation model which applied in both scenarios is illustrated in (Figure 4.1) below.

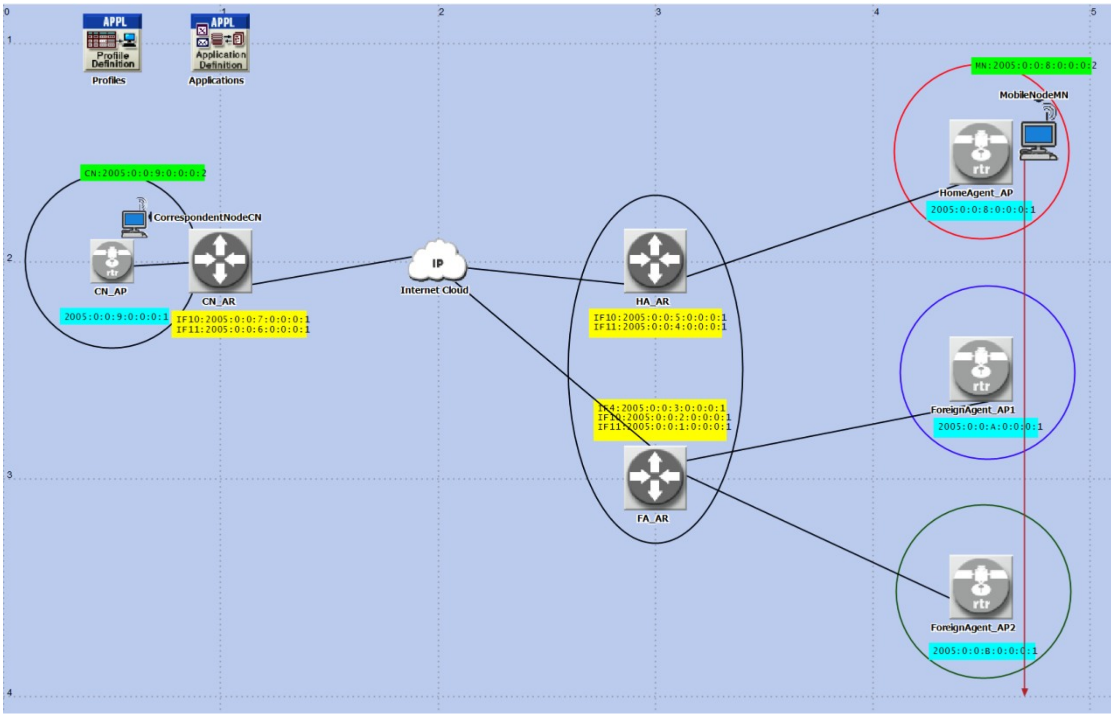

Figure 4: Network OPNET model

4.2.1 WLAN general configuration

The wireless LAN configuration is set in all wireless capable nodes, which are the access points and the workstation, to establish physical layer compatibility between them, this configuration as in (Figure 4-2) below.

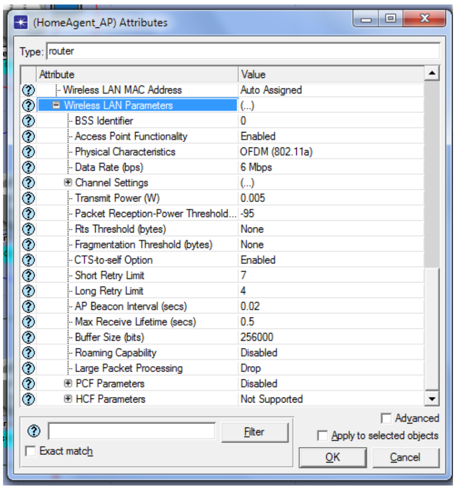

Figure 4: WLAN attributes configuration

4.2.2 Routers IPv6 interfaces parameters with enhancements

Reducing the router advertisement interval time and neighbor solicitation interval enables early motion detection and low latency. Increasing the neighbor cache queue size enables more buffers for packets in processing which reduce packet drop ratio.

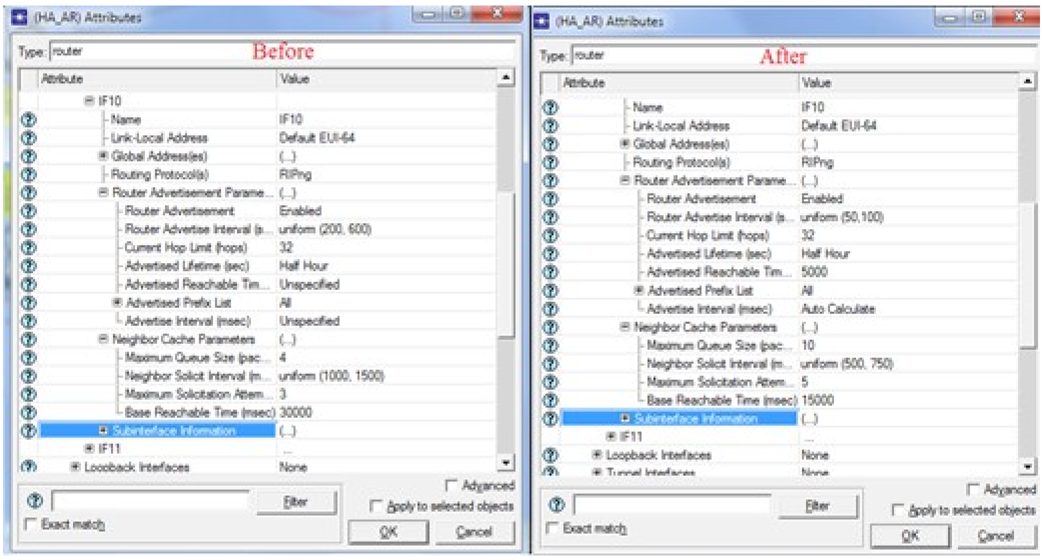

Figure 4: HA and FA Access Routers attributes

4.2.3 Mobile node MIPv6 attributes

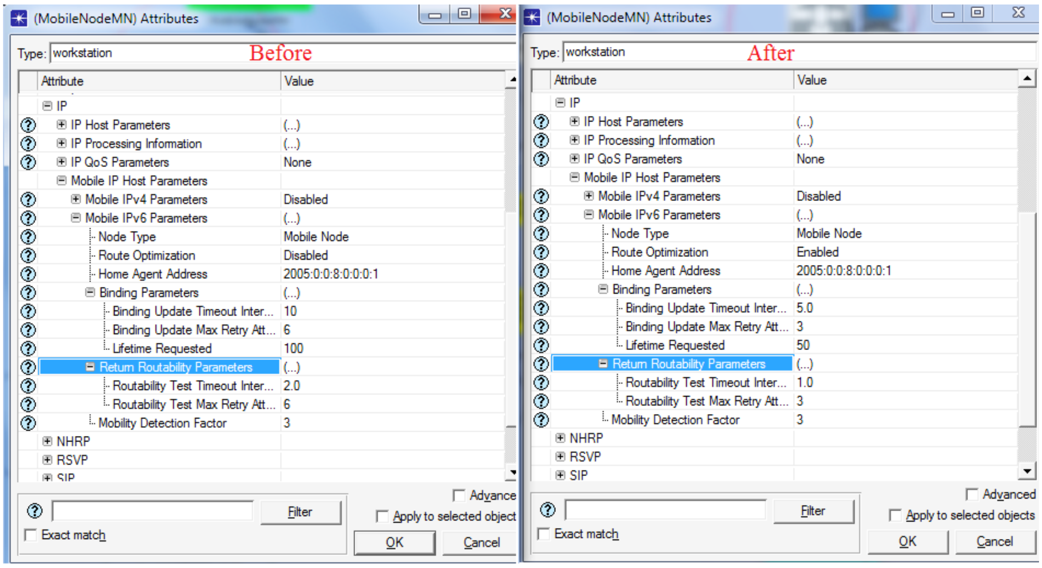

Figure 4: Mobile node attributes

Reducing binding update parameters also helps in early detection of movement in the network. ReturnRout abilityare used to define new route for a MN when it's not founded in previous location.

4.4. Wireless LAN general results

Data dropped because retry threshold exceeded shown in (Figure 4-5) whichdata dropped in retry threshold exceeded is cause by the wireless access point when the packet reception power is less than -95 dBm as in simulation parameters, here the amount of packets dropped is reduced from (8,000 to 4,000 bits/sec) by %50 approximately, which means better throughput performance is expected.

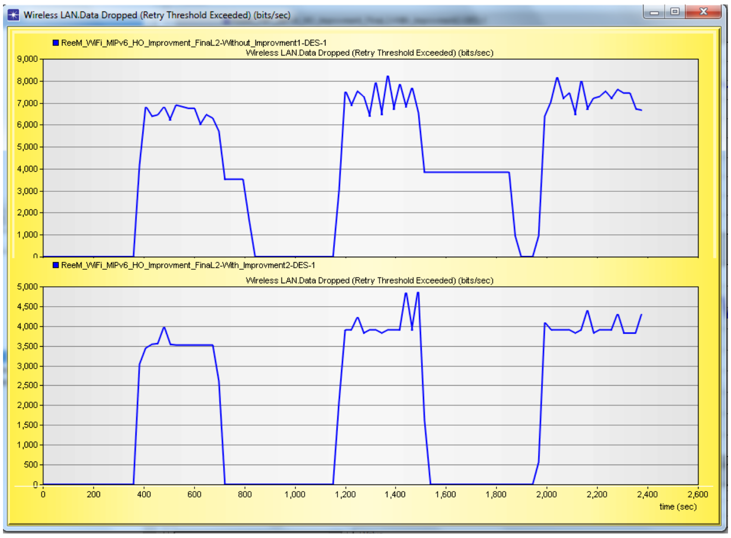

Figure 4: WLAN data dropped by retry threshold exceed

Delay in physical layer (Figure 4-6)is the actual delay in bits, which only happens when the mobile node is not in a coverage area, and as can be seen here the delay scale is reduce by %84 if we consider 1.1 max delay in without improvement scenario and 0.17 max delay in with improvement scenario results.

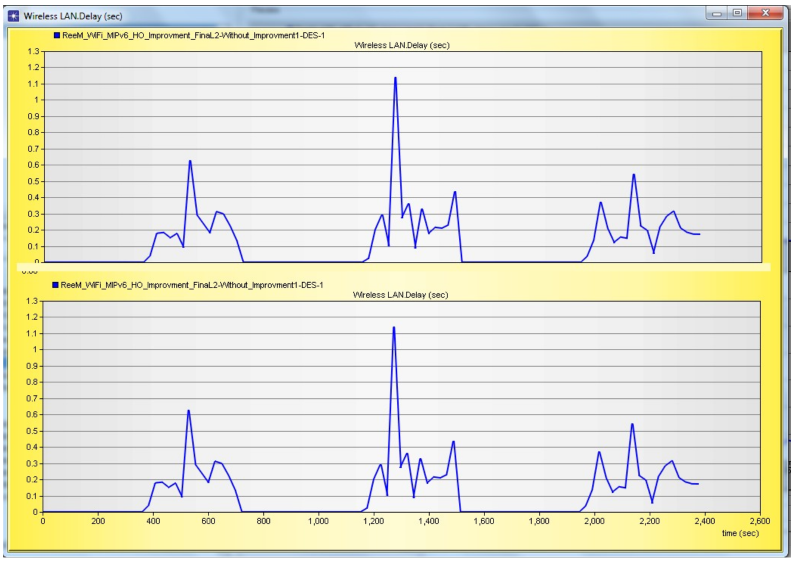

Figure 4: WLAN physical layer delay

Load on physical layer (Figure 4-7) is calculated to figure the performance of the network when compare with the throughput, here the load in the improvement applied scenario is higher because the routing processing and messages intervals is minimum means there is more additional activities is performed in the network, so the overload here is expected and it’s acceptable when looking in other performance metrics like the throughput.

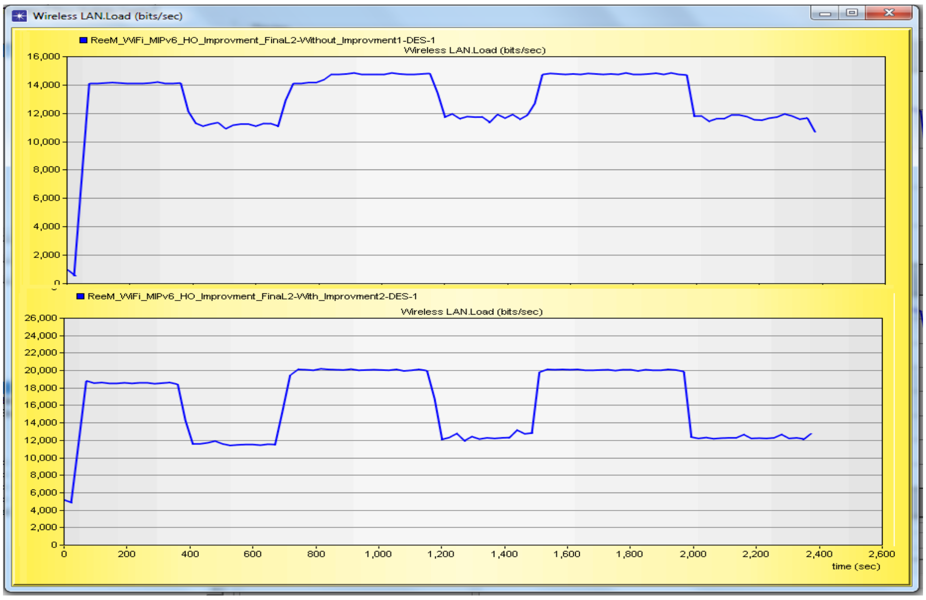

Figure 4: WLAN Load on physical layer

WLAN media access delay (Figure 4-8) represent delay in MAC layer, here also as in the physical layer the delay is reduced by %93 if we considered 2.3 max value in delay for without improvement scenario and 0.14 as max value for with improvement scenario delay.

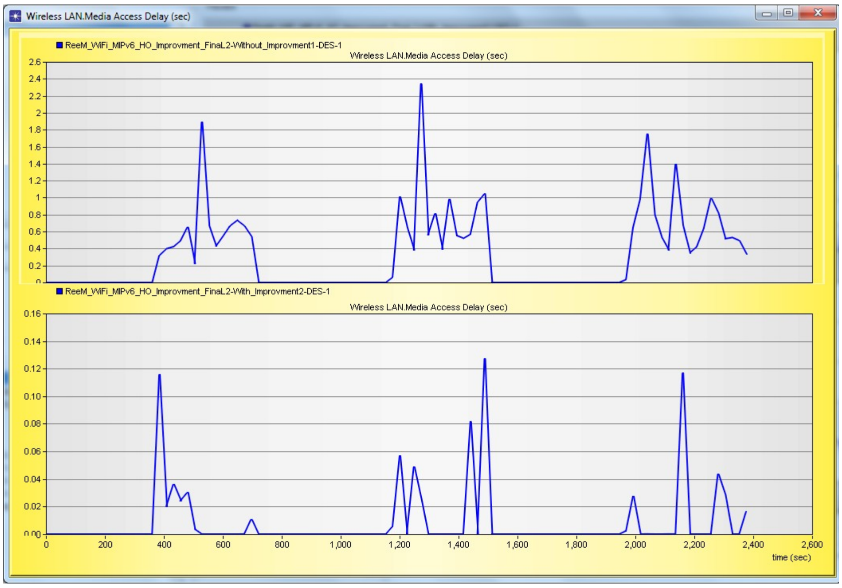

Figure 4: WLAN Media access delay

Retransmission attempts (in Figure 4-9) happen when the threshold is exceeded, as we can see the number of packets is reduce from 3.5 to 3 in general axis, it represent %14 approximately less than without improvement value.

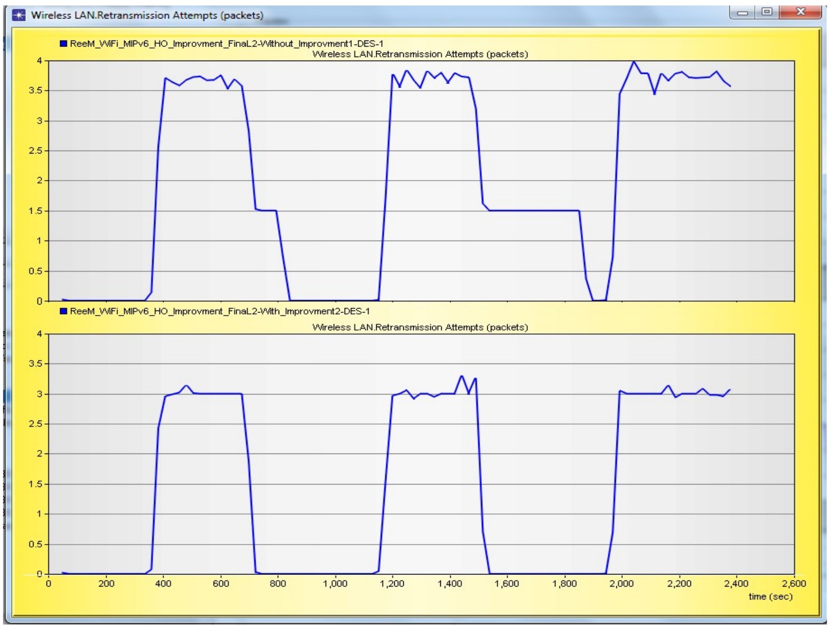

Figure 4: WLAN retransmission attempts

WLAN throughput from physical layer (in Figure 4-10) which corresponds to the general performance of the network and as the load increment before this proves the increment was corresponds to an increment in the throughput.

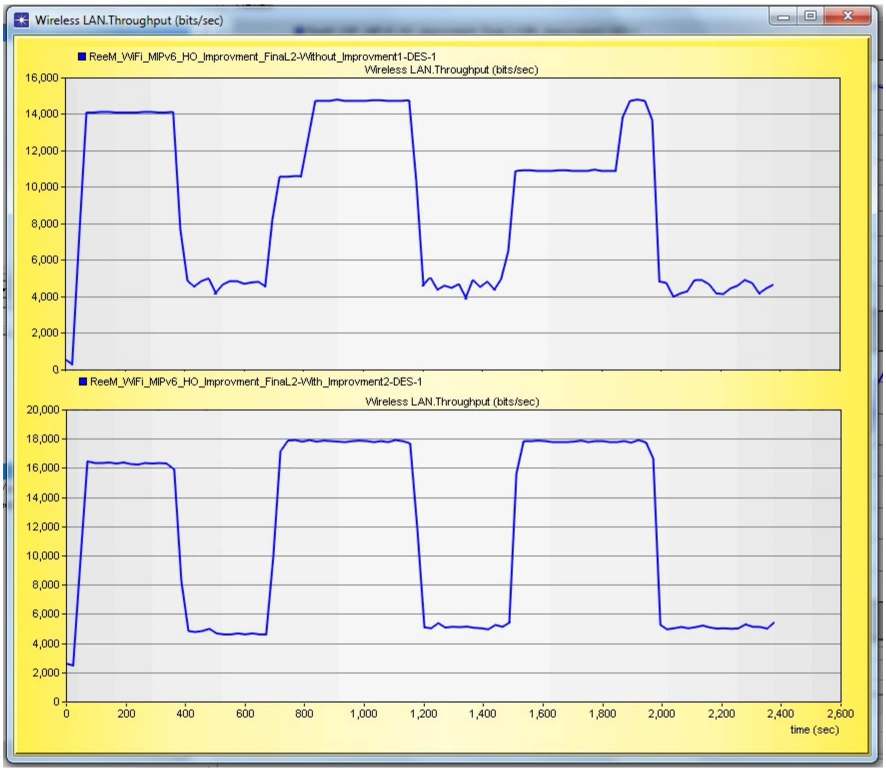

Figure 4: WLAN Physical layer throughput

4.5. Video application general results

The average video packet delay variation or jitter is show in (Figure 4-11) below shows the advantages in the improvement scenario as happens in video application packets, the decrement can represent %95 advantages over the result without improvement if we consider 0.035 max average values for improvement scenario and 0.8 max average values for other one.

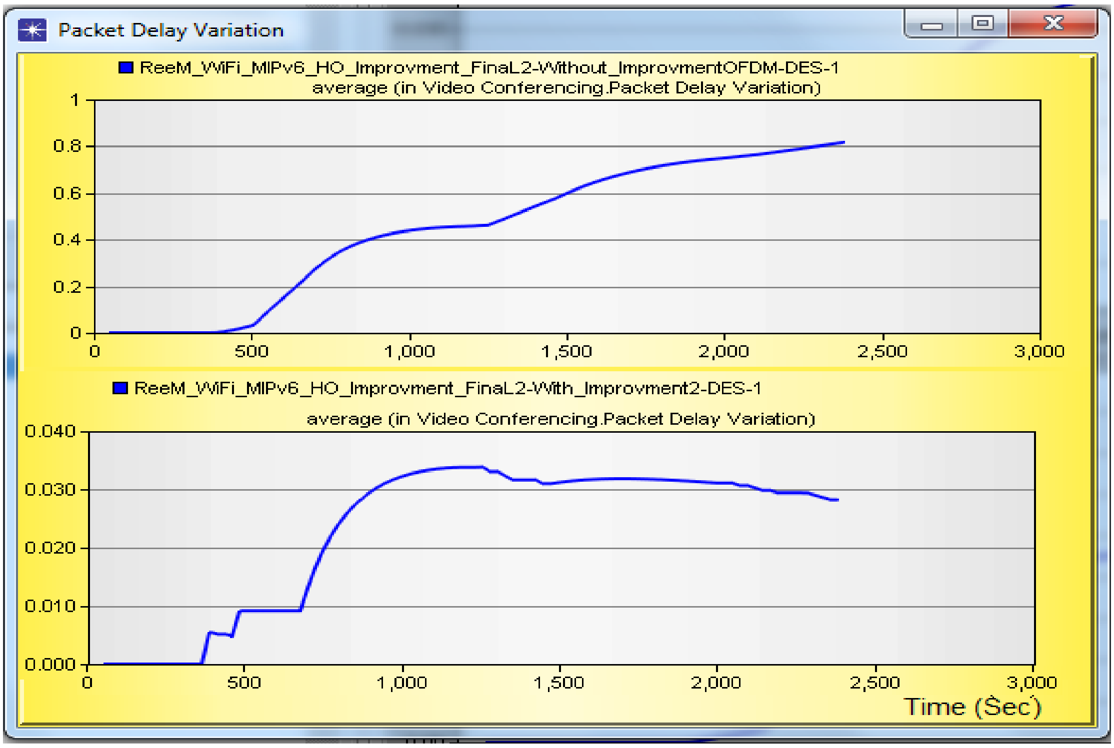

Figure 4: Video traffic average packet delay variation

Video packets End to End delay is shown in (figure 4-12) and here also proposed improvement result has the advantage by %71 if we consider the max value of improvement scenario result is 0.4 and 1.4 for other scenario result.

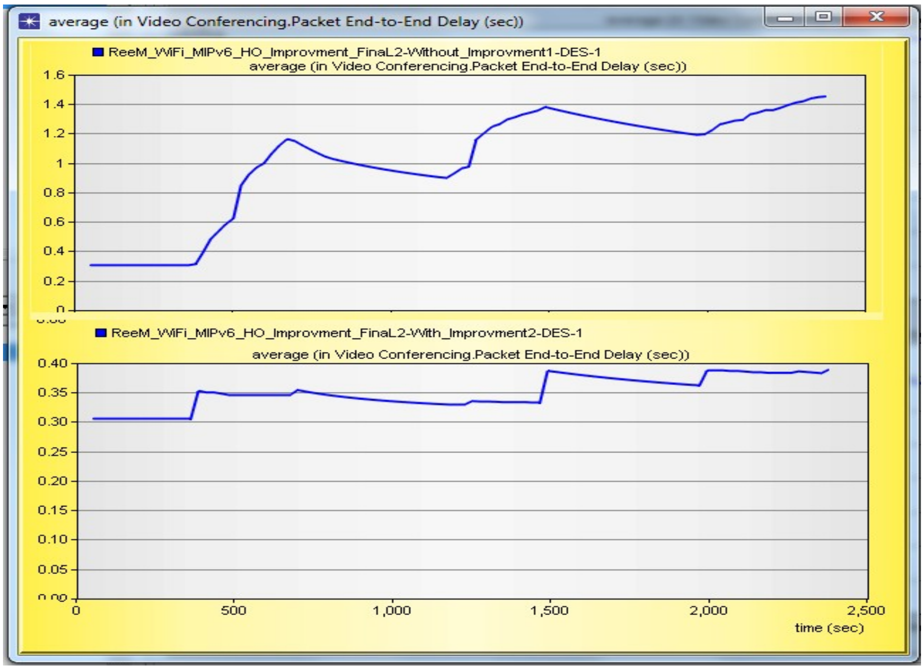

Figure 4: Video traffic average End-to-End delay

4.6. MN UDP application traffic received results

Mobile Node UDP application traffic received result by MN (in figure 4-13), which represent the main statistics used to evaluate the performance of the handover mechanism, and as can be seen the gaps represents the non-overlapping spaces between the access points, that also represent the traffic latency while the mobile moving, so shorter gaps represent lower latency and better performance, and as can be seen here the traffic received latency in the improvement scenario is less than before.

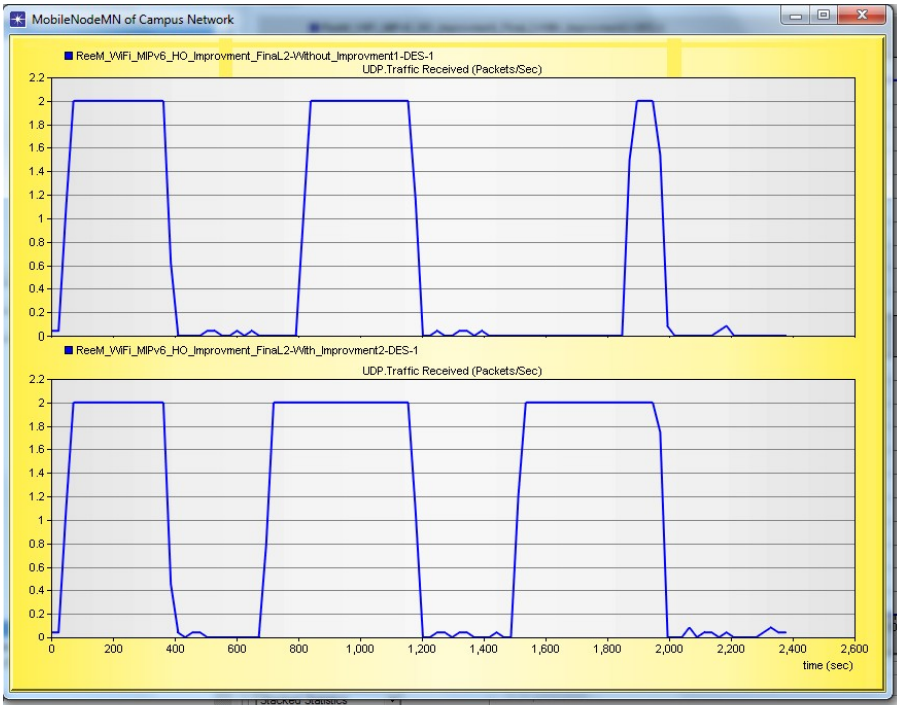

Figure 4: UDP application traffic received by MN

Chapter 5

5. Conclusion

5.1. Overview

The standard solution consists of five sub-processes which are: Movement Detection, Candidate Access Router Selection, Address Configuration, Authentication & Authorization and Binding Update. Each of these sub-processes contributes in extending the duration of the handover process. We have looked at the existing solutions and tried to make them more efficient.

In the process of deploying our improvement mechanism, finding reliable simulation model is a critical issue. We have found that most of the previous publications in this area report in NS2 and OMNET++, but they are pretty complex and needs some special programming environment background and extensive practical. So we decide to use the OPNET network modeller software which provides a comprehensive network modelling and simulation environment with easy use. However, these simulation models are out of date since they were designed in early 14.5 version of OPNET which is the only one available, and there is many updates comes after, for MIPv6 and its relatives standard comes with the new versions update.

5.2. Conclusion and Future Work

Acknowledge gained from this study is extensive and represent a good practical methodology to experience and testing, a major issue in wireless communication is discussed and carefully expressed, which the handover in WLAN with MIPv6 existence, network simulation model is created, configured, and adjusted using OPNET modeller, two scenarios are created, one using default standard parameter with bidirectional tunnelling, and the other using route optimization with our customized parameter configuration, individual statistics result are shown and represent better performance for our proposed procedure and configuration in all performance metrics.

As mentioned in the conclusion overview above in earlier section of this chapter, the MIPv6 handover process can be divided into five sub-processes. This thesis has not focused on the authentication & authorization process which is related with issues of network security. To have an optimal solution for shortening the handover process, this is certainly an issue that requires further study.

5.3. Recommendations

It’s recommended that to implement the proposed enhancements in newer protocols of MIPv6 but it needs an earlier free version of simulation software, OMNET++ and NS2 simulators can provide a suitable just-enough platform to do that but they needs Linux OS background, and some programming and scripting skills in C++ language.

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