PERFORMANCE INVESTIGATION OF MOBILE INTERNET PROTOCOLS IN WIRELESS MESH NETWORK

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bps	bit per second
-	De-queue
d	drop
+	En-queue
Kbps	Kilo bit per second
Mbps	Mega bit per second
m	meter
ms	mili second
r	receive
s	send

LIST OF ABBREVIATION

3G	Third Generation
4G	Fourth Generation
ACK	Acknowledgement
AHRA	Ad Hoc Routing Agent
AP	Access Point
AR	Access Router
ARP	Address Resolution Protocol
AWK	Aho Weinberger Kernighan
BAck	Binding Acknowledgement
BDT	Bi-Directional Tunnelling
BERNAMA	Berita Nasional Malaysia
BSS	Basic Service Set
BU	Binding Update
CBR	Constant Bit Rate
CN	Corresponding Node
CoA	Care of Address
DAD	Duplication Address Detection
DHCP	Dynamic Host Configuration Protocol
EHCF	Extended Handover Control Function
FA	Foreign Agent
FBAck	Fast Binding Acknowledgement
FBU	Fast Binding Update
FHMIPv6	Fast Handover and Hierarchical Mobile Internet Protocol version 6

FMIPv6	Fast Handover Mobile Internet Protocol version 6
FNA	Fast Neighbour Advertisement
GPRS	General Packet Radio Service
HA	Home Agent
HAck	Handover Acknowledgement
HI	Handover Initiation
HI-HAck	Handover Initiation Handover Acknowledgment
HMIPv6	Hierarchical Mobile Internet Protocol version 6
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
InterNIC	Internet Network Information Center
IP	Internet Protocol
IHL	Internet Protocol Header Length
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
IPng	Internet Protocol next generation
ISP	Internet Service Provider
Kbps	Kilobit per second
LAN	Local Area Network
LBAck	Local Binding Acknowledgment
LCoA	Local Care of Address
LTE	Long Term Evolution
LTS	Long Term Support
M-2-M	Machine-to-Machine

MAC	Media Access Control
MANET	Mobile Ad Hoc Network
MAP	Mobility Anchor Point
Mbps	Megabit per second
MIP	Mobile Internet Protocol
MIPv4	Mobile Internet Protocol version 4
MIPv6	Mobile Internet Protocol version 6
MN	Mobile Node
MLD	Multicast Listener Discovery
NAM	Network Animator
NAR	New Access Router
NAT	Network Address Translation
NLCoA	Next Link Care of Address
NOAH	NO Ad Hoc routing Agent
NS-2	Network Simulator 2
OLSR	Optimized Link State Routing
OS	Operating System
OPNET	Optimized Network Engineering Tool
OSI	Open Systems Interconnection
oTCL	Object-oriented Tool Command Language
PAR	Previous Access Router
PDR	Packet Delivery Ratio
PLCoA	Previous Link Care-of-Address
PPP	Point to Point Protocol
PRD	Pre-handover Route Discovery

PrRtAdv	Proxy Router Advertisement
QoS	Quality of Service
RCoA	Regional Care of Address
RIP	Routing Information Protocol
RIPng	Router Information Protocol next generation
RO	Route Optimization
RtSolPr	Router Solicitation for Proxy Advertisement
SIGMA	Generalized Mobility Architecture
SMIP	Seamless Mobile Internet Protocol
SSID	Service Set Identification
ToS	Type of Service
TCP	Transfer Control Protocol
UDP	User Datagram Protocol
VoIP	Voice over Internet Protocol
WiFi	Wireless Fidelity
WiMAX	Worldwide interoperability Microwave Access
WLAN	Wireless Local Area Network
WMN	Wireless Mesh Network

Penyiasatan Prestasi Protokol Internet Mudah Alih Di Rangkaian Jejaring Tanpa Wayar

ABSTRAK

Teknologi tanpa wayar pada masa kini telah meningkat dengan pesat, terdapat pelbagai jenis protokol Internet mudah alih (MIP) dalam rangkaian Internet mudah alih. Pelbagai MIP telah diperkenalkan untuk menangani peningkatan jumlah penggunaan dan pada masa yang sama menyelesaikan masalah kesesakan, penyerahan dan perkhidmatan. Tetapi, MIP tidak dapat menyelesaikan masalah liputan yang berlaku di kawasan-kawasan tertentu dalam kawasan liputan sel. Tambahan pula, pembekal perkhidmatan tidak memberikan perkhidmatan yang terbaik untuk pengguna di kawasan luar bandar dan di beberapa bahagian kawasan bandar di mana liputan komunikasi di beberapa kawasan ini adalah terhad kerana menara telekomunikasi untuk kawasan-kawasan ini terpaksa dikongsi dan ada yang terletak berjauhan dari lokasi perkhidmatan. Setelah meneliti isu-isu ini, dalam kajian ini, kami telah memperkenalkan satu pendekatan baru yang inovatif untuk mencadangkan cadangan untuk mengatasi masalah liputan dan perkhidmatan dengan membina satu senario bersepadu yang menggabungkan tiga jenis MIP iaitu protokol Internet mudah alih Versi 6 (MIPv6), protokol Internet mudah alih hierarki versi 6 (HMIPv6) dan protokol Internet mudah alih serahan cepat versi 6 (FMIPv6) dalam rangkaian jejaring tanpa wayar (WMN). Integrasi ini memerlukan rangkaian penghantaran data antara dan dalam yang membolehkan liputan ke kawasan tertentu yang tidak dapat dihubungi dapat dihubungi. Satu topologi untuk ketiga-tiga MIP berserta integrasi dengan WMN telah dirancang dengan menggunakan parameter simulasi yang sedia ada yang diperoleh daripada kajian sebelum ini. Walau bagaimanapun, data simulasi gabungan protokol Internet mudah pelbagai jenis dengan WMN ini tidak mencukupi dari segi kelewatan hujung ke hujung, nisbah paket penghantaran (PDR) dan jumlah pemprosesan yang dijalankan. Oleh itu satu siasatan prestasi telah dijalankan untuk menentukan kekuatan setiap MIP dengan gabungan suasana WMN. Simulasi kajian ini telah dijalankan dengan menggunakan perisian Network Simulator 2 (NS-2) dengan program tambahan yang dibekalkan oleh rakan-rakan penyelidik lain untuk membolehkan aturcara MIP dan WMN dapat dijalankan. Pada akhir kajian ini, ia terbukti bahawa HMIPv6 dengan WMN beroperasi dengan lebih baik berbanding dengan protokol Internet mudah alih yang lain dari segi PDR dan jumlah pemprosesan yang diproses.

Performance Investigation of Mobile Internet Protocols in Wireless Mesh Network

ABSTRACT

Current generation wireless technology has boosted rapidly, there are various Mobile Internet Protocol (MIP) available over the mobile Internet network. Various MIP has been introduced to cope with the increasing number of usage and at the same time to solve congestion, handover and services degrade issues. However, MIPs are unable to solve coverage issues occurred in certain areas in its cell coverage area. Furthermore, service providers are not giving out best services for users in rural area and in some part of urban areas where communication coverage in some of this areas are limited as telecommunication tower has to be shared and located faraway from service locations. Having known these issues, in this research, we have introduced an innovative approach to propose suggestion to overcome coverage and services degrade issues by setting up an integrated scenario that combines three types of MIP which are Mobile Internet Protocol version 6 (MIPv6), Hierarchical Mobile Internet Protocol version 6 (HMIPv6) and Fast Handover Mobile Internet Protocol version 6 (FMIPv6) in Wireless Mesh Network (WMN). This integration requires inter and intra networks data transmission which allows coverage to certain unreachable area reachable. A topology for all three MIP and integration with WMN had been planned by using existing standalone simulation parameter acquired from previous researches. However, data of the integrated different types of mobile Internet protocol in WMN are insufficient in terms of end-to-end delay, Packet Delivery Ratio (PDR) and throughput. Thus a performance investigation has been carried out to determine strength of each of MIPs performance in WMN. Simulations of this research have been conducted by using Network Simulator 2 (NS-2) software with patches provided by fellow researcher to accommodate MIP and WMN. At the end of this research, it is proven that the HMIPv6 with WMN performs the best compared to the others MIP over the proposed WMN environment in term of throughput and PDR.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Current generation mobile Internet users have increased drastically in recent years since introduction of smart phones and other devices that can be connected to Internet such as smart television, wireless printers, gaming console and many others. Figure 1.1 illustrates wireless network usage in a medium scale network environment.

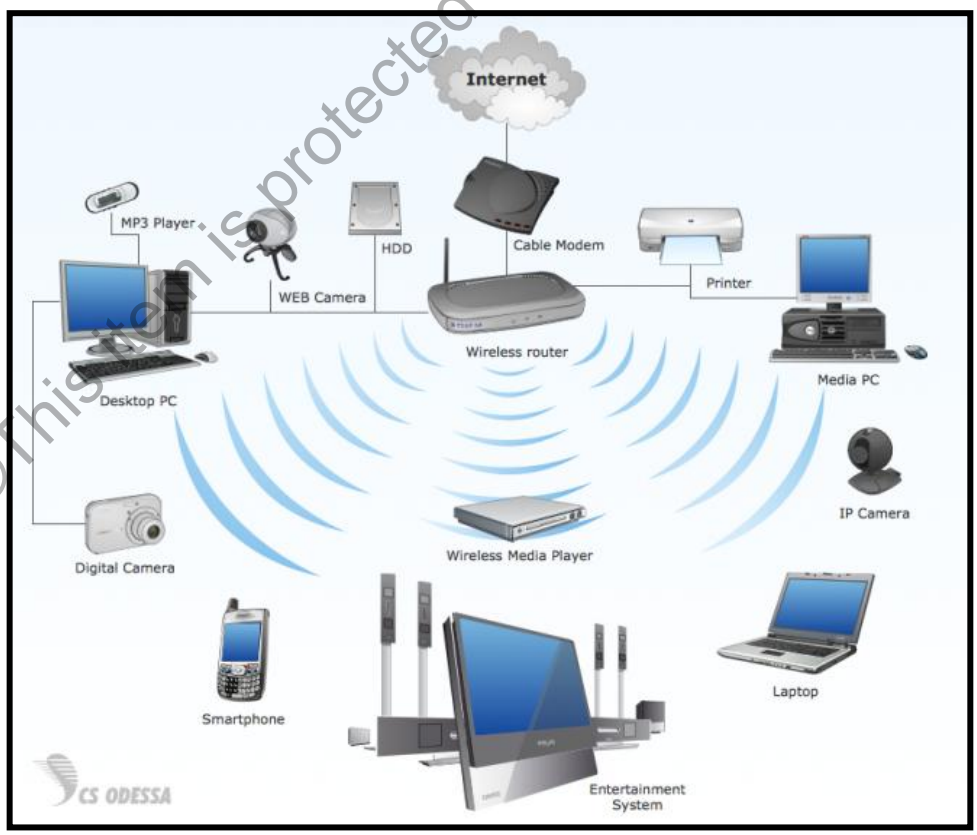

Figure 1.1: Wireless Network Usage Diagram (Odessa, 2015)

In Figure 1.1 it is shown the many devices that could be connected to Internet such as television, personal computer, hand phone, printer, entertainment system and many others. These devices come pre-equip with Internet accessing parts such as wireless card and Local Area Network (LAN) port. Reason behind this is many devices in market nowadays require a frequent software and firmware update that requires a constant Internet connectivity.

These excessive invention have raise the usage of Internet thus causes congestion and intermittent connection issues to rise rapidly (For, 2002). Present telecommunication infrastructures also have some coverage issues as it cannot cover some specific areas in its coverage area such as underground facilities, high rise buildings and many more places. Furthermore, people from rural areas have been receiving limited coverage from entire major telecommunication service providers (Liew, Yeo, Ab, & Othman, 2004).

Lack of connectivity in rural areas are caused by poor infrastructure as most rural areas have to depend on service tower that are miles away from their service province to receive signals. Since population in rural areas are not greater than those in urban areas, telecommunication companies are not showing a greater interest in expanding coverage radius in those areas (Abdul Kadir, Mat Yusoff, & Almah Saaid, 2014). Cost of upgrade at this phase could cause a fortune and it is less profitable base on business and market point of view.

En-route for solution to solve the congestion and intermittent connection problem, Internet Engineering Task Force (IETF) came out with an upgraded IPv4 version of mobility protocols which are low latency handover and regional handover to fast handover and hierarchical with several new updates which is made available to the protocol (Barbudhe & Barbudhe, 2013).

Having known the advantages of fast handover and hierarchical handover, IETF proposes the new Internet protocol which is IPv6, it is proposed to integrate the Hierarchical and Fast Handover with IPv6 which namely, Hierarchical Mobile Internet Protocol version 6 (HMIPv6) and Fast Handover Mobile Internet Protocol version 6 (FMIPv6) (Mathur, Malik, & Arora, 2012). HMIPv6 is designed to reduce the amount of signalling and FMIPv6 is designed to reduce the service degradation by minimizing the time during which a mobile node is unable to send or receive IP packets (Yunsheng, 2011).

Hence, in this research, we have introduced a new research field in Wireless Mesh Networks (WMN) which combines FMIPv6 and HMIPv6 interworking harmoniously as inter network and intra network respectively to provide better service coverage and service quality. Interworking of Mobile Internet Protocol (MIP) with WMN is expected to reduce cost of operation and cost of telecommunication infrastructure building by 80% and still provide a good coverage for people in rural and urban areas where coverage is moderate.

Researches are less performed thoroughly in these areas where the outcome can contribute big time on coverage area and performance improvement when a user tries to access network connection from rural areas, underground building, underground parking bay and many others.

WMN can be connected to wireless networks such as worldwide interoperability microwave access (WiMAX), generic wireless fidelity (Wi-Fi), cellular and sensor networks. Third and fourth generation (3G/4G) networks includes all Internet Protocol (IP) which is wired and wireless networks interworks together as heterogeneous networks (Hui & Yeung, 2003).

However, the challenge is to connect to MIP based mobility management. MIP and its extensions rely on the good performance of an infrastructure-based network but a typical WMN topology tends to be an unplanned graph and routes of it changes dynamically (Chitedze & Tucker, 2012) (Akyildiz & Wang, 2005).

Mobility management provides an undisrupted support of real-time and non-real-time services for mobile network users and facilitates the maintenance of connections for users on the move when they change their points of attachment from 1 access point (AP) to another. Mobility management involves handover management and location management. Handover management is a procedure that allows mobile node to keep its connection undisrupted when it moves from one point to another. Location management allows the system to keep track of the location of a mobile node (Chitedze & Tucker, 2012).

Handover can be categorized into two, which are vertical handover and horizontal handover (Chitedze & Tucker, 2010). Vertical handover refers to the ability to roam between heterogeneous wireless networks. Horizontal handover refers to the move from one access point to the other within the same network subnet (Dunmore, Pagtzis, & Edwards, 2005). Having discussed the location management and mobility management over the networks, in this research, MIP (MIPv6, FMIPv6 and HMIPv6 interworking with WMN) have been studied firmly in terms of performance metrics: end-to-end delay, throughput and Packet Delivery Ratio (PDR).

1.2 Problem Statement

The motivation for this research comes as we came to know regarding poor coverage issues existence in many areas of Malaysia. Currently many areas in a cell

coverage area provided by telecommunication companies are unreachable cause by Malaysian geography terrain and building patterns. Furthermore, telecommunication companies have failed to provide a decent coverage access to remote areas eluding the high cost involve in building proper infrastructure to cope with the technology.

Moreover, there is not much simulation data for performance investigation of MIPv6 integrate with WMN, FMIPv6 integrate with WMN and HMIPv6 integrate with WMN in terms of end-to-end delay, throughput and PDR. Last but not the lease, there are insufficient simulation, analysis, comparison and discussion being done to measure the performance of MIPv6, FMIPv6 and HMIPv6 interworking with WMN in terms of end-to-end delay, throughput and PDR.

1.3 Research Objective

The research objectives are as follow:

i. To integrate MIPv6, FMIPv6 and HMIPv6 in WMN as inter and intra networks
ii. To simulate, analyse, compare and discuss result obtained from simulation between MIPv6, FMIPv6 and HMIPv6 with WMN
iii. To investigate performance of MIPv6, FMIPv6 and HMIPv6 interworking with WMN in term end-to-end delay, throughput and PDR

1.4 Research Contribution

The research contributions are as follow:

i. Integrated MIPv6, FMIPv6 and HMIPv6 in WMN as inter and intra networks
ii. Performance investigation of MIPv6, FMIPv6 and HMIPv6 interworking with WMN are presented extensively in term of delay, throughput and PDR
iii. Presented , analysed, compared and discussed performance statistic for MIPv6, FMIPv6 and HMIPv6 interworking with WMN

1.5 Research Scope

Scope of this research include the performance analysis of various types of MIP, that are MIPv6, HMIPv6 and FMIPv6 interworking with WMN based on Malaysian geographical terrain and building formation.

The main focus will be on the types of MIP namely Hierarchical and Fast Handover with WMN and will not touched based on the version of the Internet Protocols (IP) which is IPv4 and IPv6. However a small portion of explanation will be included in chapter 2 explaining the difference between IPv4 MIP, IPv6 MIP and generations of WMN to fully understand the working mechanism in this research scope.

While the type of MIP with WMN been discussed, we will also be looking into the Inter and Intra network while implementing the Integration of Fast Handover and Hierarchical Mobile Internet Protocol with WMN where MIP will work as Inter network and WMN will be configured as Intra network. In section 1.6, the scope of this

research has been justified and have been reasoned based on the current technology improvement in Malaysia.

1.6 Research Scope Justification

The reason behind the selected research scope is explained in this section. We begin with the types of IP version which are IPv4 and IPv6. Since the research in aiming to attain outcome based on environment in Malaysia, we selected a scope that is considered new to this country as Malaysia is still a great user of IPv4 technology. IPv6 evolution is still at its very beginning stage where the Malaysian Communications and Multimedia Commission (MCMC) have released a statement stating that the governing body is in the final stage of its first step in migrating to IPv6. Thus this will be a great opportunity to conduct research on this area of IPv6 environment to contribute the migration and upgrade.

Through knowing regarding the working phase of IPv6 in Malaysia, we selected MIPv6, HMIPv6 and FMIPv6 with WMN taken in count the geographical surface of Malaysia and telecommunication infrastructure in Malaysia. Reason for selecting the mentioned MIP is because all those named MIP have received and upgrade from its predecessor that are Low latency MIPv4 for FMIPv6 and Regional Handover MIPv4 for HMIPv6 and perform extremely well even before the integration with WMN.

Thru the intended integration, the research outcome is not only able to provide a good delivery ratio but also could help increase the coverage area with the integration with WMN.