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HANDOVER ENHANCEMENT IN IP MOBILITY FOR 6LoWPAN SCENARIO

AHMED FARIS ABDULRAHMAN

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By

AHMED FARIS ABDULRAHMAN

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia in fulfillment of the requirements for the degree of Master of Science

December 2016

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DEDICATION

This thesis is dedicated to

All those I love

Especially

My dearest parents

My brother and sister

My best friends
Ali Nazar AL-Jourany & Ali Adnan Al-Khazraji

For their endless encouragement, patience, and support and for being a great source of motivation and inspiration

All my friends

And to my homeland, Iraq

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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AHMED FARIS ABDULRAHMAN

December 2016

Chairman : Mohd. Fadlee A. Rasid, PhD
Faculty : Engineering

There are an enormous number of applications that could benefit from Wireless Sensor Networks (WSN). One of the main issues is that these applications apply a broad range of exclusive **technologies** that are difficult to combine with the Internet such as the ability to provide internet services for mobility devices. Therefore, 6LoWPAN was formed to tackle these limitation. The 6LoWPAN nodes were made more flexible and, as such, researchers have enhanced its efficiency by enabling it to move and be mobility node. However, in enabling its mobility feature researchers encountered multiple challenges such as its effect on network lifetime, delays, signaling costs, packet loss, power consumption, and security. Hence, related works sought to reduce the handover delay in order to increase the network lifetime while other works attempted to reduce handover costs and packet loss to achieve optimum handover results. Some of the related works tend to minimize the high percentage of delays in Layer 3 (L3) while others attempt that in Layer 2 (L2). There are also other works reporting on the use of location prediction to obtain the best handover performance. This research focuses on handover delay, packet loss, and handover costs in intra-mobility (micro-mobility) and inter-mobility (macro-mobility) elements of mobile sensor networks. It offers a new framework for 6LoWPAN handover enhancement to reduce the issues noted above. In order to improve handover performance, the research will focus on both L2 and L3. The originality of this research is in the number of thresholds targeted by the coverage area. Two threshold values have been adopted to detect the mobility of the node from Received Signal Strength Indication (RSSI) and Link Quality Indicator (LQI) in handover decision; this concept has not been considered in previous works which depend on only one threshold. The first threshold acts as a mobility detecting factor while the second as a disconnect-reconnect. This research also introduce a timer based method as a signal distribution technique in the handover process. The effects of traffic load for inter-PAN mobility scenario were also investigated. With these approaches, the method can efficiently improve handover performance by minimizing handover delay, packet loss, and handover costs, which is the aim of this project. The analysis

of the simulation results with the proposed threshold based approach noted that handover delay is less than the benchmark work by 43.84%. In addition, handover cost is also reduced by 24.93% while the packet loss is minimized by 43.76%.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PENINGKATAN PENYERAHAN DALAM MOBILITI IP BAGI SCENARIO 6LoWPAN

Oleh

AHMED FARIS ABDULRAHMAN

Disember 2016

Pengerusi : Mohd. Fadlee A. Rasid, PhD
Fakulti : Kejuruteraan

Terdapat sejumlah besar aplikasi yang boleh dicapai dari Sistem Pautan rangkaian sensor tanpa wayar (WSN). Buat masakini, aplikasi tersebut menggunakan pelbagai teknik teknologi lain yang menjadikannya sukar untuk digunakan dengan internet yang sekaligus menjadi isu utama dalam hal ini. Sebelum ini, 6LoWPAN telah direka untuk mengatasi masalah ini dan lain-lain yang berkaitan dengannya. Pada hakikatnya, nod 6LoWPAN adalah lebih fleksibel dan penyelidik telah menghasilkan nod tersebut yang lebih cekap dengan menjadikanya mudahalih serta mudah untuk dipindahkan. Bagaimanapun, teknik ini telah menimbulkan pelbagai masalah yang lain kepada penyelidik. Ciri-ciri mudahalih tersebut member kesan yang kurang baik kerana menimbulkan isu-isu berkaitan dengan jangkahayat rangkaian, kelewatan, kos operasi, kehilangan data paket, jumlah penggunaan tenaga, dan keselamatan. Oleh itu, kajian yang dijalankan adalah untuk mengurangkan kesan kelewatan masa penyerahan untuk meningkatkan jangkahayat rangkaian. Manakala, penyelidikan yang berasingan bertujuan mengurangkan kos operasi semasa proses penyerahan dan kehilangan data paket untuk mencapai keputusan penyerahan yang terbaik. Padamasa yang sama, focus penyelidikan lain adalah untuk mengurangkan masa kelewatan di lapisan ketiga (L3) kesan masa kelewatan di lapisan tersebut manakala hasil kerja lain bertujuan mengurangkan masa kelewatan pada lapisan kedua (L2). Terdapat kajian terdahulu yang menunjukkan bahawa teknik ramalan lokasi mampu menghasilkan keputusan proses penyerahan yang terbaik. Focus kajian ini ialah pada kelewatan masa penyerahan, kehilangan data paket, serta kos operasi untuk proses penyerahan mudahalih setempat dan mudahalih besar pada rangkaian sensor mudah alih. Tesis ini menyarankan system rangkakerja yang baru untuk 6LoWPAN bagi penambahbaik proses penyerahan untuk mengurangkan masa kelewatan peneyerahan, kehilangan data paket, dan kos operasi proses penyerahan. Bagi meningkatkan prestasi proses penyerahan, kami akan bergantung kepada L2 dan L3. Matlamat kami adalah kawasan liputan berpandukan jumlah had yang ditetapkan. Oleh itu, keunikkan kajian ini adalah untuk menentukan jumlah had yang ditetapkan. Dua jenis

pembolehubah ditekankan untuk mengesan kesan nod mudahalih dari RSSI dan LQI dalam keputusan penyerahan, dan konsep ini berbeza dari kajian terdahulu dimana hanya satu jumlah had ditetapkan. Pertama, had yang ditetapkan bertindak sebagai pengesan mudahalih manakala jumlah had yang kedua bertindak sebagai suis penyambung-pemutus. Penyelidikan ini memperkenalkan kaedah berdasarkan masa sebagai teknik baru untuk penyampaian isyarat. Kesan kepada beban trafik bagi scenario antara mobility turut disiasat. Dengan penglibatan dua jenis had ketetapan, kami mampu mengurangkan kesan masa kelewatan penyerahan, kehilangan data paket, dan kos operasi proses penyerahan yang merupakan matlamat kajian ini. Hasil analisis dari keputusan simulasi menunjukkan bahawa masa kelewatan penyerahan adalah kurang dari kedudukan sediaada sebanyak 43.84%, kos operasi untuk proses penyerahan berkurangan sebanyak 24.93%, dan kehilangan data paket berkurangan sebanyak 43.76%. Akhir sekali, hasil keputusan simulasi membuktikan bahawa penggunaan dua jenis had ketetapan mampu meningkatkan prestasi proses penyerahan.

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I certify that a Thesis Examination Committee has met on 30 December 2016 to conduct the final examination of Ahmed Faris Abdulrahman on his thesis entitled "Handover Enhancement in IP Mobility for 6LoWPAN Scenario" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Aduwati binti Sali, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Fazirulhisyam bin Hashim, PhD
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Khaizuran Abdullah, PhD
Associate Professor
International Islamic University Malaysia
Malaysia
(External Examiner)

NOR AINI AB. SHUKOR, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 28 April 2017

This thesis was submitted to the senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the supervisory committee were as follows:

Mohd. Fadlee b. A. Rasid, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Borhanuddin b. Mohd. Ali, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Nurul Adilah bt. Abdul Latiff, PhD
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Member)

ROBIAH BINTI YUNUS, PhD
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This is to confirm that:

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Signature: _____
Name of Chairman of Supervisory Committee: Associate Professor Dr.Mohd. Fadlee b. A. Rasid

Signature: _____
Name of Member of Supervisory Committee: Professor Dr.Borhanuddin b. Mohd. Ali

Signature: _____
Name of Member of Supervisory Committee: Dr. Nurul Adilah bt. Abdul Latiff

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LIST OF ABBREVIATIONS

6LoWPAN	Low Power Wireless Personal Area Network based on IPv6
Ana.	Analytical
AoA	Angle of Arrival
BPSK	Binary phase-shift keying
CoA	Core-of-Address
DAD	Duplicate Address Detection
dBm	decibel-milliwatt
DSL	Digital Subscriber Line
ER	Edge Router
Exi.	Existing
FCD	Frame-Check-Sequence
FFD	Full-Function Device
FIB	Forwarding Information Base
GFSK	Gaussian frequency-shift keying
GHz	Gigahertz
GW	Gateway
HG	High Gateway
HGW	High Gateway
HO	Handover
HTTP	Hypertext Transfer Protocol
ICMPv6	Internet Control Message Protocol version 6
IDA	Infrared Data Association
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
Kbps	Kilobits per second
L2	Layer two
L3	Layer three
LAN	Local Area Network

LQI	Link Quality Indicator
m	meter
MAC	Media Access Control
MAG	Media Access Gateway
MAG	Media Access Gateway
MAN	Metropolitan Area Network
Mbps	Megabits per second
MFR	MAC Footer
MHR	MAC header
MIPv6	Mobility IPv6
MN	Mobility Node
MSDU	MAC Service Data Unit
MSN	Mobile Sensor Network
MTU	Maximum Transmission Unit
ND	Neighbor Discovery
NFFD	New Full-Function Device
NMAG	New Media Access Gateway
Ns-2	Network Simulator version 2
OPSK	Optimum Phase-Shift Keying
OSI	Open System Interconnection
PAN	Personal Area Network
PFFD	Previous Full-Function Device
PHY	Physical layer
PMAG	Previous Media Access Gateway
PMIPv6	Proxy Mobility IPv6
Pro.	Proposed
PSK	Phase-shift keying
RA	Router-Advertisement
RFD	Reduces-Function Device
RIB	Routing Information Base
RLS	Radio Location System

RS	Router-Solicitation
RSSI	Received Signal Strength Indicator
RTI	Routing Table Information
Sim.	simulation
SMH	Seamless Mobility Handover
SN	Sensor Network
TCP	Transmission Control Protocol
TG	Task Group
thre1	threshold 1
thre2	threshold 2
UDP	User Datagram Protocol
ULA	Unique Local unicast Address
UWB	Ultra-Wide-Band
v	Velocity
WAN	Wide Area Network
WEI	Wireless Embedded Internet
WPAN	Wireless Personal Area Network
WSN	Wireless Sensor Network

CHAPTER 1

INTRODUCTION

1.1 Background

Low Power Wireless Personal Area Networks are based on IPv6 (6LoWPAN) comprising nodes that have low power, limited memory capacity, and restricted resources. The most common and significant example is Wireless Sensor Network (WSN) in which sensor nodes have the ability to sense certain physical parameters. To optimize a 6LoWPAN protocol, they should support its mobility to enable it to accept an additional application. Over the past decades, wireless sensor networks have been used in various applications, such as for environment monitoring, health, home, industrial automation, military and others [1-3]. The massive spread of communication devices such as smartphones, laptops, and others have increased the need for the internet to accommodate these devices. All previous researchers have created new methodologies for each device to reach the internet for WSN optimization [4].

The Internet Engineering Task Force (IETF) utilises the 6LoWPAN for communication with the internet [5, 6]. Of more importance in the 6LoWPAN protocol is that it allows the nodes to self-organize, detect, configurate, and heal without any human interaction [6-8].

Previously, researchers aimed to use the IPv6 connection in WSN in order to support and provide a significant advantage to the WSN [9]. Moreover, devices having the IPv6 can communicate with other devices without any interpretation [10]. However, a main disadvantages is the frame size on WSN, which is the IEEE 802.15.4, which is limited to 127 bytes [9]. To address this, the IETF defined the IPv6 on the Power Wireless Personal Area Network. Also, now and in the future, all the focus is on the IPv6 as many devices will require internet connections. Since the IPv6 has 128 bit. Therefore the maximum number of nodes allowed is $3.4*10^{38}$ based on 2^{128} [11, 12]. The IPv4 in turn can include $2^{32}=4*10^{9}$ but this number cannot offer an address for all the devices in existence. The IPv6 is faster in routing, host configuration, and the handover process as well as being more secure. Also, IPv6 produces less packet traffic as compared with IPv4 when executing the same function [13]. The 6LoWPAN WSN should support the mobility node and that because most of the devices have the ability to move and change their position. The main issue in the mobility scheme is latency handover delay, handover cost, packet loss, and energy consumption [14-16]. This has led researchers to design new methodology or to optimize the existing one to achieve the best results for these parameter. Recently, some of the solutions used to optimize the mobility handover for 6LoWPAN have resulted in a method to reduce those parameters depending on location predict, certain protocols such as PMIPv6 and MIPv6, and Layer 2, Layer 3 or both. Layer 2 is responsible for channel scanning and network authentication while Layer 3 is responsible for movement node detection and registration. For this purpose, L2 and

L3 work together but the latter begins and is completed after the L2 handover [17]. To obtain good performance in handover latency, costs, and packet loss, this research proposes a new algorithm which supports the mobility scheme. The results have aproved that this malgorithm can reduce handover latency, packet loss, and handover costs.

1.2 Problem Statement

6LoWPAN is a protocol that supports the internet protocol over low power wireless personal area networks. For each network the signaling cost is considered as an important factor and should be taken into account by designers. An increase in the number of users in one network leads to a rise in the number of signals transferred between the users leading to increased power consumption. Hence, the handover latency process is considered as the most important for using the signals.

In the 6LoWPAN WSN, any design must take into account certain parameters that should take care of them, such as the signaling cost, packet loss, security, and power consumption. Recently all the nodes have the ability to become mobile nodes and, because of this, handover delays are considered the most important in this field. The nodes in 6LoWPAN face many challenges because they have restricted characteristics such as limited capacity, memory, and power. The signaling cost depends on the delay [18] and any increase in handover delays leads to higher signaling costs. At the same time, power consumption will increase because the signal transmission needs more power while the packets loss will also increase. As such, it is clear that packet loss and signaling costs depend on handover latency [19]. Consequently, any new method should optimize and reduce handover delays, signaling costs, and packet loss. This research proposes a new method that depends on the number of the threshold value and new signals distribution to process the following:

1- Handover delay
2- Handover cost (signaling cost)
3- Handover packet loss
4- Networking lifetime

1.3 Research Aim and Objectives

The objectives of this research work are as follows:

1- To study the 6LoWPAN entity for improving the system's ability to accommodate many mobile users at the lowest delay, signaling costs, and packet loss.
2- To provide a new approach for 6LoWPAN mobility by introducing two threshold values from RSSI and LQI in handover decision.
3- To introduce a timer based method as a new signaling distribution technique in the handover process.

1.4 Thesis Scope

The scope of work in this research focuses on the 6loWPAN Mobility Sensor Network (MSN) when the mobility node or user moves from one position to another. The work will concentrate on layer 2 (L2) and layer 3 (L3) since delays occur in them. Thus, this research will present a new method to optimize and reduce such delays, packet loss, and signaling costs.

Furthermore, a significant concept in this research includes a basic method and basic theory on 6LoWPAN MSN, that is, how the mobile node moves and what is the related protocol that organizes this movement. Finally, the study examines the main parameters involved.

Moreover, two means have been employed to obtain the objective of this thesis. The first is wireless communication and this research depends on WPAN as a wireless communication and focuses only on the IEEE 802.15.4. The second is the internet protocol which uses IPv6 because of its good characteristics. For IPv6 over Personal Area Network we depend on 6LoWPAN as the main protocol in this thesis. Each sensor node can be a mobile node and each uses 6LoWPAN as a protocol to transmit and receive signals. The main challenges in the 6LoWPAN protocol are when the sensors or users are moving. Thus, this study will seek to optimize the handover latency in the 6LoWPAN protocol. Figure 1.1 illustrates the study module and the main directions followed.

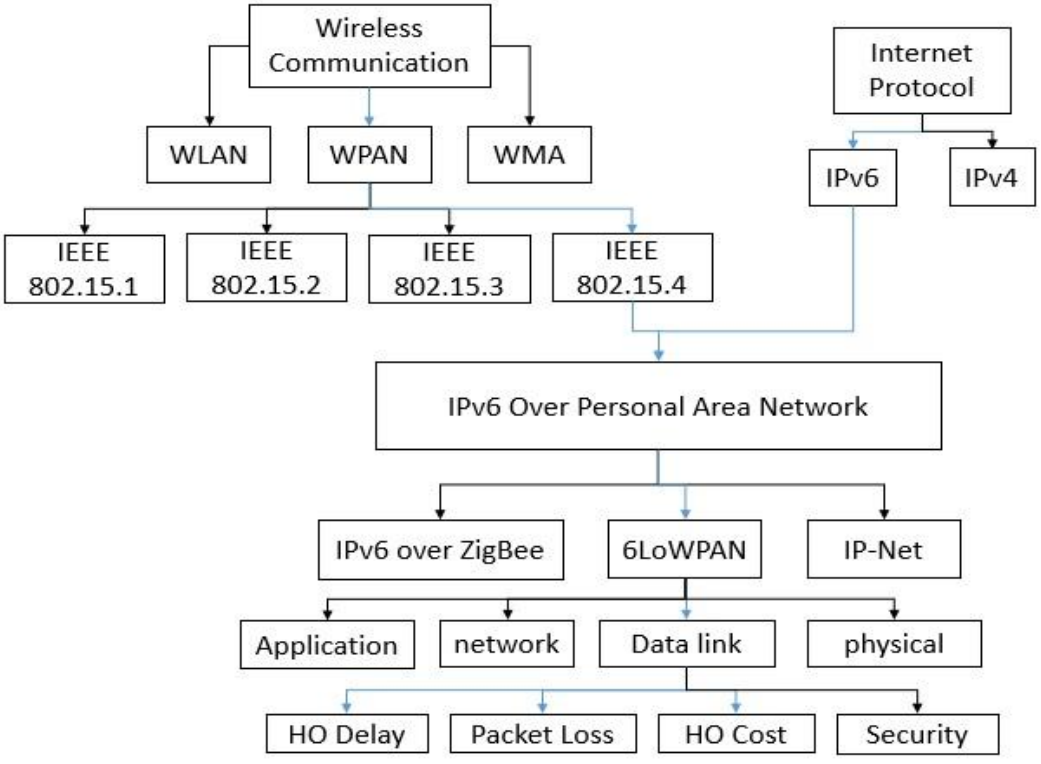

Figure 1.1: Study Module

1.5 Brief Methodology

The research data in this study depends on two main sources, namely the mathematical equation and the NS-2 simulator for estimating network performance. The handover latency threshold value is proposed to contain parameters to present the data for handover delay, packet loss, and handover cost.

Network lifetimes are important criteria in this field because of their limited capacity. Their lifetime is affected by the transmission signals number which is influenced by the time delay. That means that if the signal number increases the network lifetime will decrease. Thus, this research proposes a new method to reduce the handover latency parameters in order to enhance network performance.

The proposed method of this research depends on the number of the threshold values and takes the decision of disconnect and reconnect. It also has the benefit of using hops to communicate with the Media Access Gateway (MAG). The method aims to reduce handover delay, packet loss, and handover costs.

1.6 Thesis Organization

Chapter 1 provides a broad overview of this thesis and includes the introduction such as the background of 6LoWPAN, problem statement, and objective of this research.

Important concepts on the 6LoWPAN protocol and previous works and protocols on it are described in chapter 2 which also contains the 6LoWPAN architecture and the kinds of nodes used in this study. The chapter also presents the layers of the 6LoWPAN protocol stack as well as the mobility and types of mobility in 6LoWPAN. Then, the chapter reviews previous methods used to enhance or optimize the 6LoWPAN MSN work. The methodology of this thesis is explained in chapter 3. To evaluate the performance of 6LoWPAN, the main methods employed in this research are the simulation and analytical methods. All the results obtained from the simulation and analytical methods are described in chapter 4 as well as the proposed method used in this thesis. Finally, chapter 5 provides the conclusions as well as proposes future work to be done in this field.

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BIODATA OF STUDENT

The student, Ahmed Faris Abdulrahman, was born on 5th of November 1989 in Baghdad, Iraq. The author started his school at AL-Tameem in 1995 and continued his study at Al-Nidamia. After successfully finish the secondary school, he chose to pursue his Bachelor of Science degree in Al-Mansour university college, communication engineering department. Obtained his Master of Science communication and network from Universiti Putra Malaysia in 2017.

The student can be contacted via his supervisor, Assoc. Prof. Dr. Mohd. Fadlee b. A. Rasid, by address:

Department of Communication and Network Engineering
Faculty of Engineering
Universiti Putra Malaysia
Selangor
Malaysia

E-mail: fadlee@upm.edu.my

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