UNIVERSITI PUTRA MALAYSIA

SEAMLESS VERTICAL HANDOVER TECHNIQUE FOR VEHICULAR AD-HOC NETWORKS USING ARTIFICIAL BEE COLONY-PARTICLE SWARM OPTIMISATION

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By

MOHANAD MAZIN ABDULWAHHAB

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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DEDICATION

This thesis is dedicated to

All my loved ones

Especially

My dearest mother

And my sister

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

And to all my friends

And 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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Chairman : Associate Professor Mohd. Fadlee A. Rasid, PhD
Faculty : Engineering

The vehicular ad-hoc networks are becoming a significant service in recent years. However, they are facing many challenges that require solutions so that wireless communication systems are able to coexist with each other effectively. One of these challenges is the mobility solution that facilitates mobile nodes with seamless heterogeneous roaming abilities that requires a seamless handover technique. Naturally, the vertical handover that occurs during inter-system roaming requires both link layer and network layer handovers to take place once the change occurs in the network point of attachment and device interface. Many institutions and individuals are investigating and standardising efforts trying to design a final implementation of these communication layers. Nevertheless, for the particular purpose of vertical handover in a heterogeneous vehicular network, these two layers require an information preparation before any operations of handover as it affects the performance parameters directly and thus required to achieve a seamless handover. This thesis aimed to probe in detail the vertical handover in a heterogeneous vehicular ad-hoc network that comprises two significant aspects. These aspects are the information gathering of the network and the information usage during the vertical handover.

Firstly, we proposed a multi-criteria artificial bee colony hybrid with particle swarm optimisation algorithm (MC ABC-PSO) for evaluating the information gathered from the mobile nodes in the handover. The algorithm will process and calculate the required handover timing for each node in advance, based on the mobile nodes' velocity and received signal strength to reduce the handover process latency. Secondly, the information is used to support all vertical handover operations, which includes network discovery, handover decision, and handover implementation.

In the initial stage of the operation, the previous access point provides information about the neighbouring networks for the mobile node (MN) to quickly discover available networks. The second stage of the operation is selecting the best available network for the MN by considering its velocity and distance. The final operation involves the mobile node sharing the current information with its neighbours' nodes based on its current location. The results show the benefits of the proposed MC ABC-PSO method by reducing the handover decision delays by 25%. It gives the optimum performance in terms of network selections and reducing the handover latency by 14.5% and the number of unnecessary handovers by 48% as compared to the previous technique for three different mobility scenarios based on traffic environments (highway, urban and traffic jam).

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

TEKNIK SERAHAN MENEGAK SELANJAR UNTUK RANGKAIAN AD HOC KENDERAAN MENGGUNAKAN BUATAN BEE COLONY-PARTIKEL SWARM OPTIMASI

Oleh

MOHANAD MAZIN ABDULWAHHAB

Julai 2019

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

Rangkaian ad hoc kenderaan telah menjadi perkhidmatan yang penting dalam beberapa tahun kebelakangan ini. Bagaimanapun, rangkaian ini kini menghadapi banyak cabaran yang memerlukan penyelesaian supaya rangkaian-rangkaian ini boleh wujud bersama-sama secara berkesan. Salah satu daripada cabaran ini adalah penyelesaian mobiliti yang memudahkan nod bergerak dengan kebolehan perayaan heterogen selanjar yang memerlukan suatu teknik penyerahan selanjar. Sewajarnya, serahan menegak yang berlaku semasa perayauan antara sistem memerlukan serahan kedua-dua lapisan pautan dan lapisan rangkaian berlaku apabila perubahan terjadi pada titik sambungan rangkaian serta antara muka peranti. Terdapat banyak institusi dan individu yang sedang menyiasat dan menyeragamkan usaha untuk mereka bentuk pelaksanaan terakhir lapisan komunikasi tersebut. Walau bagaimanapun, untuk tujuan khusus serahan menegak dalam rangkaian kenderaan heterogen, kedua-dua lapisan ini memerlukan penyediaan maklumat sebelum sebarang operasi serahan kerana ia mempengaruhi parameter prestasi secara langsung dan dengan itu perlu untuk mencapai serahan lancar. Tesis ini bertujuan memperincikan kajian serahan menegak dalam rangkaian ad hoc kenderaan heterogen yang merangkumi dua aspek utama. Aspek ini adalah pengumpulan maklumat rangkaian dan penggunaan maklumat ini semasa serahan menegak.

Yang pertama, kami mencadangkan hibrid koloni lebah buatan multi-kriteria dengan algoritma pengoptimuman kawanan zarah (MC ABC-PSO) untuk menilai maklumat yang dikumpul dari nod bergerak dalam serahan. Algoritma akan memproses dan mengira pemasaan serahan yang diperlukan untuk setiap nod terlebih dahulu, berdasarkan halaju dan kekuatan isyarat nod bergerak yang diterima untuk mengurangkan kependaman proses serahan. Yang kedua, maklumat ini digunakan untuk menyokong semua operasi serahan menegak, termasuk penemuan rangkaian, keputusan serahan dan pelaksanaan serahan.

Pada peringkat awal operasi, titik capaian yang sebelumnya memberikan maklumat mengenai rangkaian berjiran untuk nod bergerak (MN) mencari rangkaian sedia ada dengan cepat. Tahap kedua operasi ialah memilih rangkaian terbaik untuk MN dengan mempertimbangkan halaju dan jaraknya. Dalam operasi terakhir, nod bergerak berkongsi maklumat semasa dengan nod jirannya berdasarkan lokasi semasa. Keputusan yang didapati menunjukkan manfaat kaedah MC ABC-PSO yang dicadangkan dengan memperbaiki lengah keputusan serahan sebanyak 25%. Ia memberikan prestasi optimum daripada segi pilihan rangkaian dan mengurangkan latensi penyerahan sebanyak 14.5% dan bilangan penyumbat yang tidak perlu sebanyak 48% berbanding teknik biasa dalam tiga senario mobiliti persekitaran trafik yang berbeza (lebuh raya, bandar dan kesesakan lalu lintas).

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Most importantly, I want to say thanks to my dearest mother and sister. They helped me out of many difficulties in life and provided me with earnest encouragement.

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
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Name of Member of Supervisory Committee: Dr. Fazirulhisyam b. Hashim

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

3G	Third-Generation Cell-Phone Technology
4G	Fourth-Generation Cell-Phone Technology
ABC	Artificial Bee Colony
ACO	Ant Colony Optimisation
AIFS	Arbitration Inter-Frame Space
AP	Access Point
AU	Application Units
BBO	Biogeography-Based Optimisation (BBO)
BSS	Basic Service Set
CCH	Central Control Channel
CF	Curve Fitting
CoA	Care of Address
CSMA/CA	Carrier Sense Multiple Access with Collision Avoidance
DSRC	Dedicated Short–Range Communications
EA-DAD	Enhanced Advanced Duplicate Address Detection
EDCA	Enhanced Distributed Channel Access
FIPSO	Fully Informed PSO
FMIPv6	Fast Mobile Internet Protocol version 6
FNN	Fuzzy Neural Network
GA	Genetic Algorithm
gbest	Global best solution
GPRS	General Packet Radio Service
GSL	GNU Scientific Library

GSM	Global System for Mobile
GW	Gateway
HCF	Hybrid Coordination Function
HO	Handover
HoA	Home Address
HS	Hot-Spot
ICA	Imperialist Competition Algorithm
IEEE	Institute of Electrical and Electronics Engineers
IETF	The Internet Engineering Task Force
IoT	Internet of Things
ITS	Intelligent Transport System
LLC	Logical Link Control
LTE	Long Term Evolution
MAC	Media Access Control
MADM	Multiple Attribute Decision Making
MANET	Mobile Ad-Hoc Network
MDP	Markov decision process
MIPv6	Mobile Internet Protocol version 6
MN	Mobile Node
MPSO-OM	Multi-PSO algorithm with Optimum Mutation
NPAH	Neighbour Predictive Adaptive Handoff
NS2	Network Simulator version 2
OBU	On-Board Unit
OFDM	Orthogonal Frequency Division Multiplex

OMNeT++	Objective Modular Network Testbed in C++
OSI	Open Systems Interconnection
pbest	Best position
PDU	Packet Data Unit
PHY	Physical Layer
PLCP	Physical Layer Convergence
PMD	Physical Medium Access
PSO	Particle Swarm Optimisation
QoS	Quality of Service
RSS	Received Signal Strength
RSU	Road Side Unit
SA	Simulated Annealing
SAW	Simple Additive Weighting
SCH	Service Channels
STDMA	Selective Time Division Multiple Access
SUMO	Simulation of Urban Mobility
TCP	Transmission Control Protocol
TDMA	Time Division Multiple Access
TMC	Traffic Management Centres
TOPSIS	Techniques for Order Preference by Similarity to Ideal Solutions
UDP	User Datagram Protocol
UMTS	Universal Mobile Telecommunications System
V2B	Vehicle-to-broadband cloud
V2I	Vehicle to Interface

V2V	Vehicle to Vehicle
VANET	Vehicular Ad-Hoc Network
VHO	Vertical Handover
WAVE	Wireless Access for Vehicular Environments
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network
WSMP	Wave Short Message Protocol

CHAPTER 1

INTRODUCTION

1.1 Background

As a part of the wireless communication technology, vehicular ad-hoc networks are facing many challenges that need to be resolved to coexist with each other. The mobility solution is the main obstacle towards the seamless inter-technological roaming capability, which involves a seamless transfer between systems. Of course, any roaming between systems will lead to a vertical handover (VHO) that need the link layer and network layer handovers to be performed while the network connection point and device interface have been transformed.

Several institutions and individuals are conducting various standardisation surveys and efforts for designing and implementing these communication layers. For the exact reason of the VHO in a heterogeneous wireless environment, the prepared information for the link and the network layers before any handover operation can directly affect the handover performance and, as a result, will lead to an uninterrupted handover.

For mobility, another problem in addition to handover latency and network throughput is the requirement of stream media transmission support through a wireless mobile network because of the high possibility of packet loss during user movements. Other reasons that may lead to this problem are, for example, the necessary extended time for the mobile node (MN) to discover the available networks by scanning many radio channels on each interface, the disparity in the amount of bandwidth available in each network and the increase in the number of messages during handover operations.

Therefore, the concept of mobility in a heterogeneous wireless network implies the continuation of data transmission or the maintenance of a session in progress, even when the connection point changes during the VHO. Unlike a horizontal handover, which occurs due to the roaming between two stations on a network, VHO is known as the change in the direction of the data session without interruption, which implies a change of interface of the device on the user's side and a technological switch from a network point of view. Accordingly, VHO requires modification of the connection point in the network layer and lower layers. Therefore, unlike horizontal handover, the preparation of network-layer mobility must be considered for this type of movement.

1.2 Problem Statement

The management techniques of Vehicular Ad-Hoc Network (VANET) services between different wireless technologies are particularly relevant to complete the handover

operations with the least delay possible. In the VANET technique, when an MN moves to another network, it is necessary to perform VHO operations. These operations (discovery of the network, selection of handover and implementation of handover) have a substantial impact on the latency of the handover. During this investigation, three problems were identified as follows:

1- One of the most challenging tasks in coordinating the VHO is the discovery of available access networks. Although the MN can easily access the LTE network, it continually scans all channels through its interface card to discover available WLANs (RSUs), which provide high data rates but have a limited coverage area. Therefore, the time is taken by the process of exploring all channels to discover available networks will contribute to the increase in latency for the handover process.
2. The selection of the MN handover between the different available networks discovered is particularly essential to guarantee the availability of the AP. The selection of random networks available for mobile nodes can lead to the loss and delay of packets for MNs.
3. The cost of time in the process of implementing vertical handover is remarkably high because the MN must remain connected to the previous link for a long time to complete and process all messages.

Since this study aims to implement a seamless vertical handover, its' requirements will lead to the proposed solutions to reduce the delay that occurs during the stages of the handover process. Thus, an improved algorithm that relies on cooperating with the mobile nodes in that approach is significant to be proposed.

1.3 Research Aim and Objectives

This thesis proposes a seamless VHO solution in an integrated heterogeneous wireless LTE WLAN network. In implementing this method, a solution for vehicular ad-hoc network mobility systems with the support of the network and link layers is proposed.This support is presented through the collection and gathering of information from a heterogeneous environment involving LTE with WLAN technologies. With this information, this study tends to solve the challenges of high VANET's mobility by processing the gathered information from mobile nodes and access points and evaluate the best available network and predefine it before the handover process is established. Hence, the handover latency and the number of handovers and packet loss are reduced.

The objectives of this thesis are summarised below:

1- To investigate the suitability of ABC-PSO in a vehicular ad-hoc network.
2- To design a vertical handover decision technique depending on the number of MNs and velocity together with the prioritization approach.

3- To propose a seamless VHO technique that is suitable for multiple mobility scenarios based on traffic environments (highway, urban and traffic jam).

1.4 Thesis Scope

This work focuses on the effect of ABC-PSO algorithm on vehicular ad-hoc network performance in general and vertical handover performance in specific. Besides, the scope is also on how to exchange and use information between networks to support MNs to discover and select the best available network. This information includes the MNs' velocity, current AP, RSS and packet loss.

Moreover, the infrastructure that has been used to achieve the objectives of this thesis is the wireless communication that depends on the WLAN as a roadside unit (RSU), LTE as a wide coverage wireless communication and focuses on the IEEE 802.11p, which is a standard supporting vehicular ad-hoc networks. The Artificial Bee Colony, Particle Swarm Optimisation algorithm (ABC-PSO) is also widely used for other applications.

Each car can be a mobile node (MN), and each uses the algorithm to process the received signals. The main challenge in the ABC-PSO is when the MN is moving from one network to another and need the handover process to occur. Thus, this work attempts to optimise handover latency by using the ABC-PSO algorithm.

Figure (1.1) shows the followed directions in the study module.

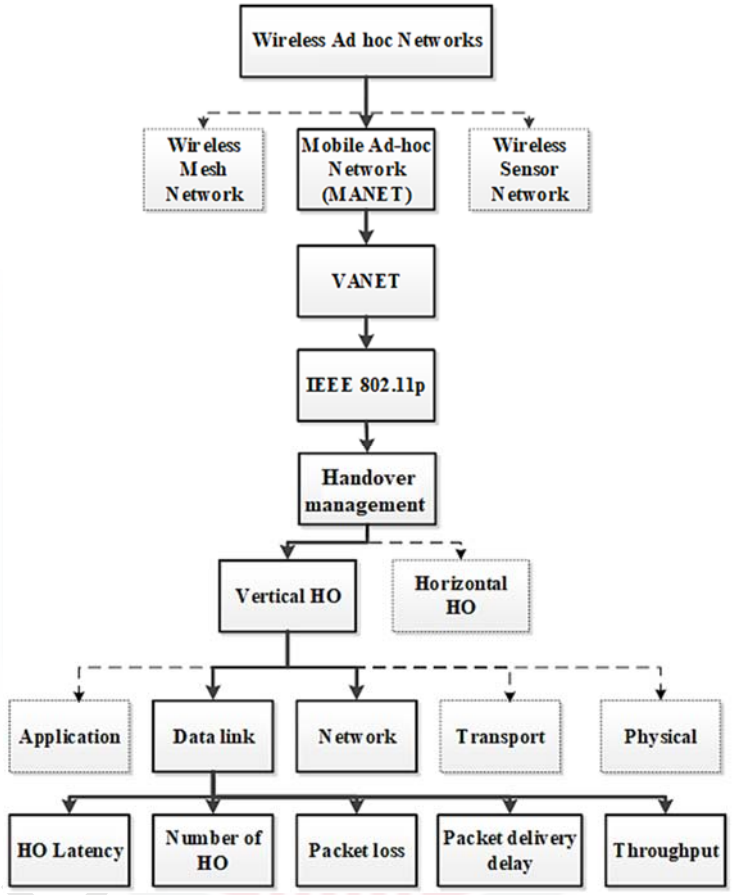

Figure 1.1 : Study module

1.5 Thesis Organisation

Chapter 1 provides an overall introduction to the investigation concerning the context, as well as the objectives and scope of the research topic.

Chapter 2 describes the essential concepts related to the ABC-PSO algorithm and previous works and protocols that also contain the architecture of 802.11p and the kinds of APs this study used. This chapter also explains the IEEE 802.11p, in addition to the types of mobility in VANET. Moreover, this chapter reviews the optimisation algorithms and methods used for VANET previously.

Chapter 3 explains the methodology of this study. To evaluate the performance of the ABC-PSO algorithm, the simulation method was used.

Chapter 4 The proposed method and the obtained simulation results are described in detail in this chapter.

Chapter 5 provides the conclusions, contributions and future observations in this field.

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