Performance Analysis of Vertical Handover in Vehicular Ad-hoc Network Using Media Independent Handover Services

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***Abstract*—Next-generation of the mobile communication, network services allow users to move in freedom while accessing the Internet and network applications with seamless communication through the different wireless networks technologies. Integrating different system networks is called vertical handover which is critically a challenging task using the traditional decision algorithm for the next-generation networks. In this study, we proposed a simulation result of performance quality of service (QoS) of the vertical handover in vehicle-to-Infrastructure (V2I) on Road-Side Unit (RSU) between Wifi, WiMAX, and LTE networks using IEEE 802.21 Media Independent Handover (MIH) standard. The simulation is carried out using the NS-2 simulator and the VanetMobiSim traffic generator for the IEEE 802.21 MIH standard. The results show the performance analysis of IEEE 802.21 MIH in terms of handover latency, throughput, end-to-end delay and packet loss. Hence, this study will help and guide the Intelligent Transport System (ITS) and Telecommunication System (Telcos) provider in Malaysia to cater the problems of internet services by increasing the QoS of networks for the user's convenience.**

***Index Terms*—Vertical Handover; Media Independent Handover; NS-2 Simulator; VanetMobiSim; Received Signal Strength; Quality of Service; Vehicular Ad-Hoc Network.**

I. INTRODUCTION

The growth wireless communication in the open market because of required by users to access the Internet and network applications anytime and anyplace in communication technologies that had been changed the people's daily life activities. In addition, the issues of selecting a wireless network connection to access available candidate networks when there are several different wireless communication technologies in the same area. According to the International Telecommunication Union (ITU) in [1] based on the statistical information and communication technology from 2007 to 2016, stated the estimation for key telecommunication or ICT indicators will be included with the mobile-cellular subscriptions, Internet use, fixed and mobile broadband services and home ICT access are slightly increased in mobile networks technology coverage (2G, 3G, and LTE) to the population.

The main challenge wireless communication management link must be ensured the delivery of available network resources such as the accessibility of wireless link resources that always differ due to the high-speed mobility of mobile nodes which are carried by vehicles. Moreover, another instability of link quality wireless access network because of the natural interference, multi-path fading and signal-to-noise ratio whereas more demanded by users which are concerned with wireless Internet access for entertainment purposes high-speed of Voice-over-IP (VoIP), Internet Protocol TV (IPTV) services during their travelling [2]. For that, the authors in [3, 4, 5, 6] stated the handover management approach must select the appropriate time of handover trigger and the most appropriate access from among available network to maintain service continuity.

II. VERTICAL HANDOVER (VHO)

In the part of handover management (HM) allows mobile user connected to their service network, which continued using the mobile terminal while moving from a single point of attachment (PoA) to another coverage network of PoA. HM can be divided into two categories: horizontal handover and vertical handover. Horizontal handover (as known as intra-system handoff or homogeneous) processes in different cells but still the same networks whereas, vertical handover (VHO) (as known as inter-system handoff or heterogeneous) is about the different network technologies. In a homogeneous network, it typically requires horizontal transmission when the router into an access service not available due to the movement of the mobile node (MN). For instance, the signalling changes in the signal transmission MN through standard IEEE 802.11 access point (AP) to neighbouring geographic AP IEEE 802.11 standard are two horizontal transformation processes. Otherwise, in heterogeneous networks, the changeover radio signal transmission between WLAN AP and base station (BS) that overlaid of the cellular network is vertical handover process.

Seamlessness and network switching are two important processes in the vertical handover management that researchers need to be investigated more. Vertical handover is a key of the future wireless communication in the advanced technologies when compared with the horizontal handover. Due to be integrated network grouping of multiple technologies that offered the broadband to mobile users [6]. However, horizontal handover happened only when the received signal strength (RSS) become weak in its coverage whereas, vertical handover case will handover depending on user assessment.

There are three categorized stages in the vertical handover process which are: handover information gathering, handover decision, and handover execution [7, 8]. The foremost anxiety of vertical handover is to sustain running services even with the adjustment of Internet Protocol (IP) addresses, but also the change of network interfaces and QoS characteristics of different networks. Any discussion on handover topics must be involved in that three main phases [9, 10]. The first stage is known as handover information gathering, where the mobile node identifies all the detail particulars of information required to determine the necessity in the handover process [11]. The information initiation normally prepared as shown in Table 1.

The next stage is handover decision process, where identify and determine the most suitable access network due to MN movement. This phase will be associated communicate instructions to the execution stage as known as system selection. In literature, there are various of study discuss in the categorization of vertical handover decision schemes [12, 13, 14, 15, 16] are presented.

Table 1
Data Collection in Handover Information Gathering

Data Information Collection	Description
Network detection in neighbours network	Throughput, handover rate, cost, packet loss ratio, Received Signal Strength (RSS), Noise Signal Ratio (NSR), Signal to Interference Ratio (SIR), Carrier to Interference Ratio (CIR), Bit Error Ratio (BER), distance, location, and QoS parameters.
Mobile node status	Battery status, speed, resources, and service category.
User preferences	Budget, monetary cost, and services

The last stage is the handover execution process, where the mobile node moved over from its current network to the new network coverage. Moreover, seamless connection of networks will be achieved if the handover decision algorithm must be intelligent to decide the best candidate network by considering on many parameters with the complexity of network architecture.

III. IEEE 802.21 Media Independent Handover (MIH)

The MIH protocol represented IEEE 802.21 standard deploys exchange information between peer of MIH elements for handover trigger, whereas it also allows common information payload through the variety of media technologies (802.3, 802.11, 802.16, Cellular/UMTS/LTE) [17]. Figure 1 shows IEEE 802.21 MIH architecture.

According to Figure 1, Media Independent Handover Function (MIHF) consists of three important services that allow communication and function in both directions of layers which are: Media Independent Event Services (MIES), Media Independent Command Services (MICS), and Media Independent Information Services (MIIS) [17, 18]. The following is the functionality of the three services inside the MIHF.

1) Media Independent Event Services (MIES)

It offers to detect any interchange in lower layers to identify if it a necessity to execute handover. For example, "MIH Event" will be transmitted by the MIHF to the upper layers (L3 and above), and "Link Event" that diffusion from the lower layers to the MIHF.

2) Media Independent Command Services (MICS)

It utilizes command services such as "MIH Commands" is sent by the mobile user through the MIHF, and "Link Commands" transmitted by MIHF to lower layers.

3) Media Independent Information Services (MIIS)

It allows the mobile node to find out and fetch particulars about features and services network that be offered by neighbouring networks such as network type, operator ID, network ID, cost, network QoS, and etc. This information will help to implement the optimal point and efficient handover decision through heterogeneous wireless networks.

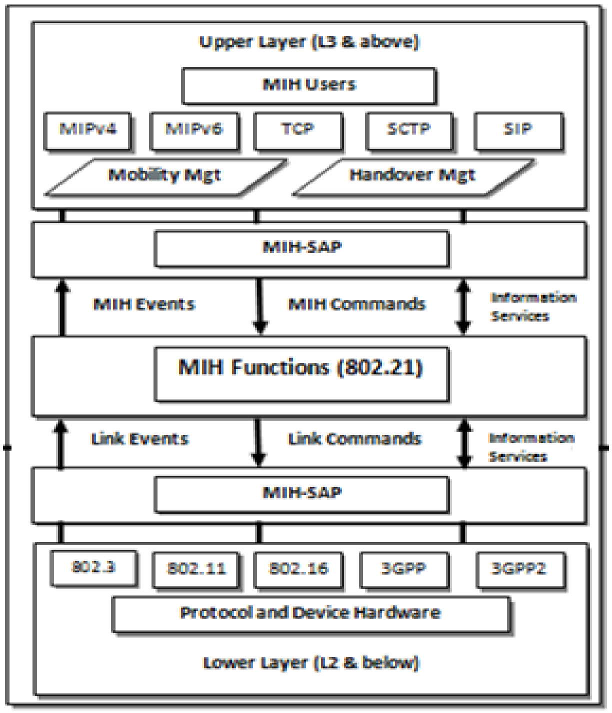

Figure 1: IEEE 802.21 MIH architecture [11]

In order to measure handover in a heterogeneous environment, the National Institute of Standards and Technology (NIST) integrated multiple packages providing a software package that includes the IEEE802.21 standard (MIH) library.

IV. Vertical Handover Decision Algorithm

In literature, there are various of the study discussed in the categorization of vertical handover decision schemes [3], [8]–[11], [19]–[21] are presented. Based on the existing works, VHO decision schemes can be categorized into five classes referred in the handover decision-making criteria and the methodology implemented to process the handover metrics are shown in Figure 2.

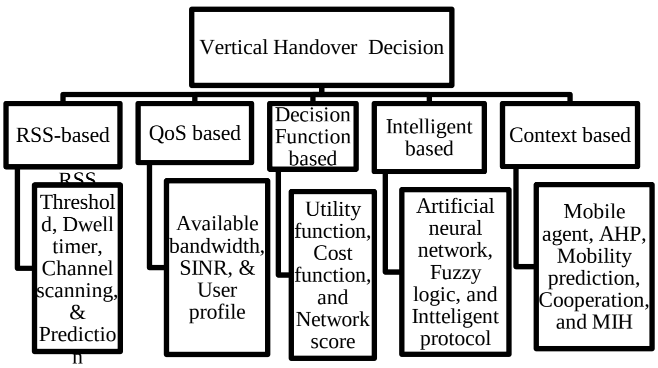

Figure 2: Categorization of Vertical Handover Decision Schemes [9]

V. EXPERIMENT

This section discusses the experiment in simulation scenario of the proposed RSS-Threshold algorithm by using IEEE 802.21 MIH mechanism. The simulation handover scenario is shown as in Figure 3, where it used the three different radio technologies: Wi-Fi, WiMAX, and LTE in the vehicular ad-hoc network (VANET) of traffic light scenario. VANET has three of important entities for an autonomous of self-organizing wireless networks such as vehicles, infrastructure, and communication channels [22].

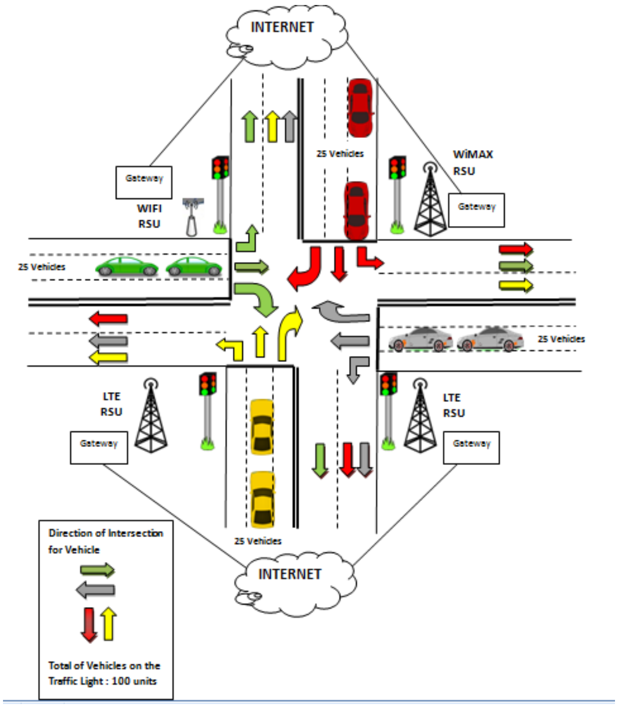

Figure 3: Simulation scenario

The simulation is carried out using ns2.29 which is integrated with the VanetMobiSim simulator. To get a real movement vehicles in the traffic light scenario of the Vanet environment, it should be used vehicular mobility models such as VanetMobiSim, SUMO, CityMob, and FreeSim, [23, 24, 25, 26, 27]. This study used the data traffic CanuMobisim Spatial Model provided by the University of Stuttgart Informatik which generated in VanetMobiSim simulator. It has the features of macroscopic and microscopic models such as road topology, road characteristics (multiples lane or directional traffic flow, speed constraint, and intersection crossing rules), and movement patterns selection. After that data traffic transformed in XML format, and then it will be integrated into the ns-2 simulation to evaluate the performance of QoS [28].

Table 2 shows the list of the simulation parameters. The mobility protocol was used the Mobility Protocol IPv6 (MIPv6) in the simulation. The effectiveness of MIH mechanism using RSS threshold algorithm handover predictive was evaluated based on simulation scenario. The RSS threshold algorithm was developed in C++ and was an interface with MIH library in the ns-2. In simulation scenario, the vehicles were configured to utilize the multiple interfaces such as Wi-Fi, WiMAX, and LTE networks. The hundreds of vehicles are available to access the different network coverage in this simulation. The simulation time, vehicles were travelling across the traffic light scenario heterogeneous network at 300s in the interactive application of traffic class. At the start of the simulation, traffic transmission begins both LTE and Wi-Fi interfaces and then continues to connect WiMAX interface. The traffic light was set up to make its function as in the real traffic light. The movement of the vehicle is begun from the first lane nearest the AP or BS coverages, cross it and leaves which are connected near in the LTE, Wi-Fi, and WiMAX. After that, it follows the second lane of the each side and continues to the third lane. The maximum interval time was set up in 5s. The method of RSS-based algorithm just fetched data process from the physical layer in NS-2 simulation to get the performance analysis of QoS.

Table 2
Simulation Parameters

Simulation Parameters	Values
Simulation range	2000m x 2000m
Simulation duration	300 s
Wi-Fi (IEEE 802.11)	
Frequency bandwidth of 802.11	2.4 GHz
Transmission radiuses of 802.11	20 m
Data rate of 802.11	11 Mbps
Propagation Model	TwoRayGround
Antenna	Omni antenna
Routing Protocol 802.11	DSDV
Max packet in if queue length 802.11	50
WiMAX (IEEE 802.16)	
Frequency bandwidth of 802.16	3.5 GHz
Transmission radiuses of IEEE 802.16	500m
802.16 channel bandwidth	10 MHz
Propagation Model	TwoRayGround
802.16 modulation and coding	OFDM 16QAM 3/4
MAC/802.16 UCD (uplink channel) interval	5 s
MAC/802.16 DCD (downlink channel) interval	5 s
UMTS/LTE	
UMTS/LTE uplink bandwidth	384 kbps
UMTS/LTE downlink bandwidth	384 kbps
Link data rate	100 Mb/s
UDP Max packet size (byte)	1,024
UDP header size (bytes)	8
Mobility protocol	MIPv6
Vehicle speed	1~100 / kmph

Using RSS threshold algorithm proposed by Bhosale and Daruwala in [29] as shown in Figure 4. The vehicle links with the new network before terminating with its current network. The vehicle will employ both interfaces at the same time in turn to execute a seamless handoff. IEEE 802.21 add-on modules utilize the only signal strength and the interface type for the interface selection. It measures up to compare RSS of the new connection (RSSnew) and RSS of the current network. If RSScurr is greater than a predefined RSS threshold value, then it remains connected to current network else the MN initiates handover to target network.

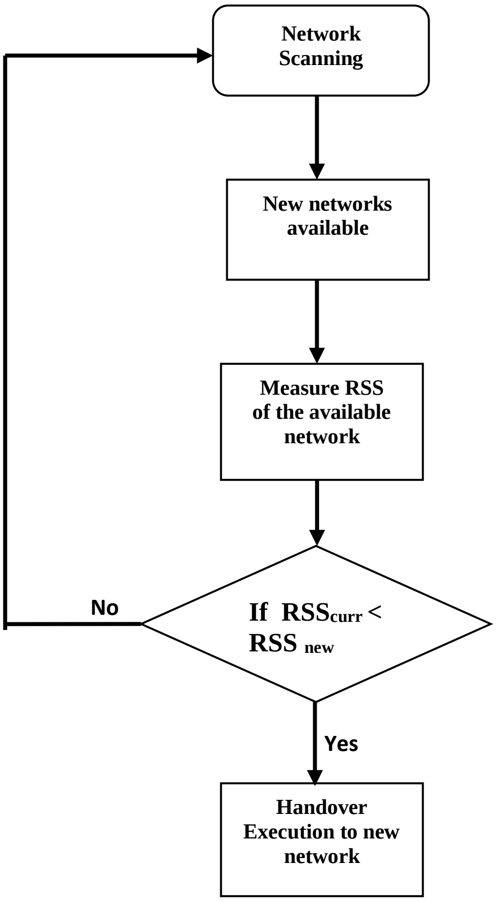

Figure 4: Flowchart of RSS-based scheme procedure

Accordingly, it generates Link_Going_Down (LGD) event. The pseudo code of RSS-Threshold algorithm for handover decision is given as follow:

RSS-Threshold Algorithm

1: Call MIH_Get_Status //Gets the status of links
2: execute MIH_Capability_Discovery
3: Register events //Link Detected, UP, Down, Going Down, and rollback
4: Type of Handoff // MIH1
5: case_of_scenario (figure 3)
6: process_link_parameter_config (scan request)
7: process_scan_response (mih_scan_response_)
8: **If** no network detected {
9: process_no_ link_detected
10: process_get_status_response (mih_get_status)
11: process_link_detected
12: connected to LTE
13: **If** (RSSNew > RSSTh && RSScurr < RSSTh) **then**
14: process_new_prefix
new_address
redirectMac
LGD Generation
Wait for Handover Complete Trigger
WiFi link_up
Shut Down LTE
15: **end If**

16: **Else**
17: Continue Current Connection
18: **end If**

VI. Results and Discussion

This section discusses the performance analysis of vertical handover in a vehicular ad-hoc network using IEEE 802.21 MIH standard based on handover latency, throughput, end-to-end delay, and packet loss against the speed of the vehicle (e.g. 20, 40, 60, 80, and 100 km/h).

A. Handover Latency

It is based on the period time obtained to transmit a data packet from sender node to receiver node. The end-to-end latency shows the totals of the network latency and the handover latency. In the graph shown in Figure 5, the handover latency for RSS-based is much less than compared to the RSS threshold based algorithm. The average latencies for RSS-based and RSS-Threshold are 11.9 and 13.2 seconds respectively. It improved approximately 10 percent reduction when increased the speed of the vehicle from 20 km/h to 100 km/h.

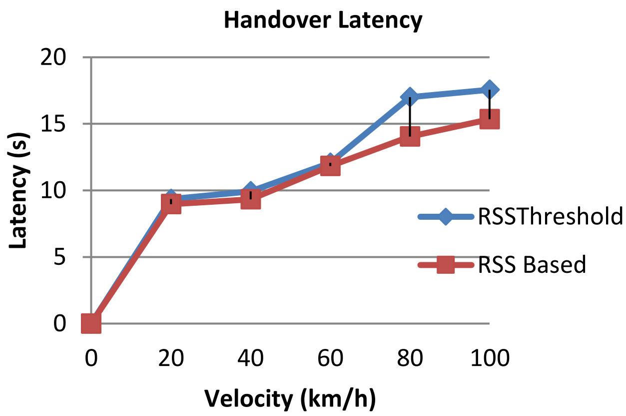

Figure 5: Graph of handover latency vs. velocity

B. Throughput

Throughput is defined as the data rate provided for the subscribers which can be obtained in the available networks. In other words, it is a total data moved from one sender node to receiver node during a set out time. Megabits per second (Mbps), and kilobits per second (Kbps) are usually the unit used in the measurement. In Figure 6, the average of throughput against velocity gradually raised 1 percent of RSS threshold rather than a RSS-based algorithm.

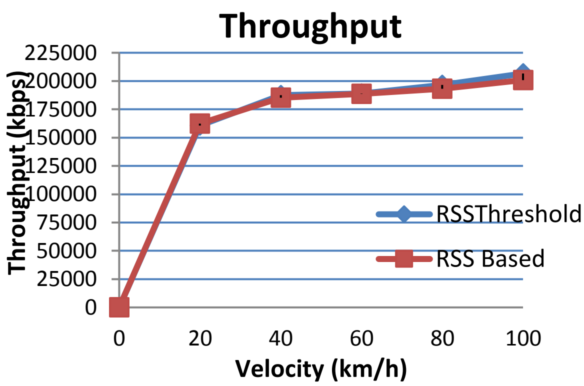

Figure 6: Graph of throughput vs velocity

C. End-to-end Delay

The delay is the time required to send a packet data. In another word, it is the amount of time when data is posted from the sender to receiver. It is measured in milliseconds to several hundred milliseconds in units. The graph of end-to-delay is shown in Figure 7. As the result, the RSS-based algorithm performed much better than RSS threshold based algorithm which has a lower average of end-to-end delay by about 6 percent. It is marginal values decreased of end-to-end up to 8 seconds when the speed of vehicles is increased from 20km/h to 100km/h.

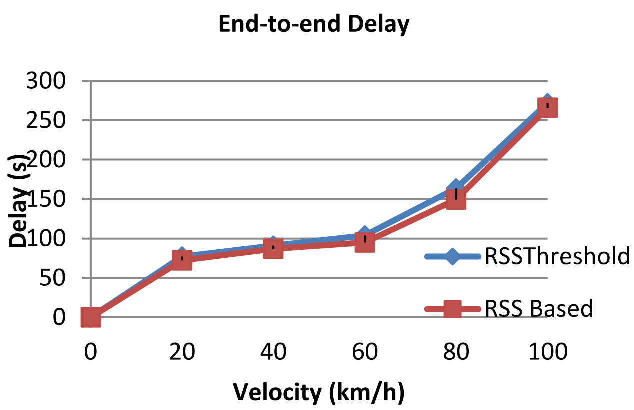

Figure 7: Graph of end-to-end delay vs velocity

D. Packet Loss

The total time of packet fails transmits the message from the source to the destination during the handover process. The packet loss must be measured only in the operation of handover triggering of the mobile node among different of networks. The graph of packet loss is shown in Figure 8. Generally, the average of packet loss also gets reduced when is decreased in the handover latency. The RSS-based will be reduced by 6 percent of the average packet loss when compared to the RSS threshold based algorithm.

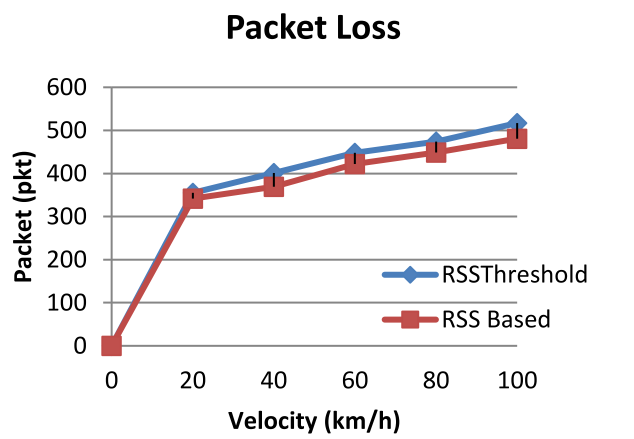

Figure 8: Graph of packet loss vs velocity

VII. CONCLUSION

In future vehicular heterogeneous wireless networks, network detection and handover decision procedures will play an important role in attaining efficient mobility solutions. However, accomplishing seamless service continuity vertical handover between vehicular ad-hoc heterogeneous networks is complicated work. This paper gives the detailed indication of IEEE 802.21 standard and its reference model as well as its simulation using ns2. The simulation results of the vertical handover between Wi-Fi, WiMAX, and LTE are presented. The simulation is performed using VanetMobiSim and NIST add-on module for ns2.29. From the simulation, it is clear that a better performance in terms of the throughput whereas the reducing of the latency, end-to-end delay and packet drop is obtained by using the MIH standard when adopting algorithms in the same category such as the RSS-based and the RSS threshold algorithm. However, it still produces marginal different results because of dissimilar method and measurement albeit in the same category of decision scheme algorithm.

ACKNOWLEDGMENT

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