PERFORMANCE EVALUATION OF ENHANCED VELOCITY-BASED HANDOFF ALGORITHM FOR VANET

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ABSTRACT

Vehicular Ad Hoc Networks (VANETs) is based on 802.11p standard where a vehicle is connected to a base station in a dynamic manner. The vehicle is traversed from one base station to another and may affect the transmission of packets. To minimize the disruption, handoff latency must be kept at minimum duration. This paper presents an improvement of existing handoff mechanism based on vehicle's velocity. The proposed algorithm is called Enhanced Velocity Handoff (EVHO) where it is defined based on two rules ofa mobility model; vehicle speeds and handoff latency. Each rule provides different equations and transforms them into the EVHO algorithm. EVHO algorithm created a new packet frame for neighboring vehicles for transmission. The experiment of EVHO is conducted using a network simulator, NS-2. The results are compared with existing velocity-based handoff and some significant improvements on packet delay, packet loss rate and network throughput are shown.

Keywords: VANET, Handoff, Velocity, Simulation, Performance

1.0 INTRODUCTION

With the advances achieved in wireless networks and Internet becomes an increasingly significant part of our lives, the idea of having it in our cars became closer to reality. This led to thedevelopment of a VehicleAd Hoc Network (VANET), which is a new type of MANET specifically for vehicles. VANETis a technology that uses moving cars as nodes in a network to create a mobile network [1]. The IEEE 802.11p amendmentwas later introduced to support vehicular networks based on the original 802.11 standards [2].Rather than moving randomly, vehicles tend to move in an organized fashion; movement of the vehicles is constrained to road's structure.There are two types of communications in VANET, vehicle-to-vehicle (V2V), which refers to direct or multi hop communication between vehicles; and vehicle-to-infrastructure (V2I), which involves the communication between vehicles with the base stations that are placed alongside the road [3].One of the greatest benefits of having V2V communication for vehicles is to enable them to exchange important messages regarding road safety (such as emergency warnings, stopped vehicle warnings, collision warning, traffic management, etc.). V2I communication is used to provide the vehicles with Internet access that makes virtually any web technology available in the car.Traditional wireless ad-hoc network routing protocols, such as Ad hoc On-Demand Distance Vector (AODV), are not suitable for VANETs [4]due to end-to-end path selection criteria. To deal with the rapidly changing network topology, routing techniques based on location information are considered more suitable. Greedy Perimeter Stateless Routing (GPSR) [5]selects the node that is the closest to the destination among the neighboring nodes. Data is then forwarded opportunistically without consideration of road topology and network connection status. The Geographical Source Routing (GSR) protocol uses position information and considers the road topology as a connected graph with edges and vertices [6]. Greedy forwarding [7] considered the high mobility and low transmission delay to maintain the neighboring information. Rapid changing of VANET topology and maintaining the connectivity is very difficult with the existing routing protocols. It contributes to the link breakage and decreases VANET reliability.

Improving link breakage and VANET reliability required efficient handoff process. The vehicles' movements are limited to the road structure and therefore, not much freedom on movement as other mobile nodes. In a highway scenario, vehicles are moving in a straight line, andthe next base station (BS) is ahead of them. In this method, the first vehicle that handoff to the new BS, broadcasts the information regarding that specific BS to neighboring vehicles via ad-hoc or V2V communication. The receiving vehicles that are going to perform handoff have the channel and Basic Service Set ID (BSSID) regarding the next station. In this method, no scanning is required to find the next base station unless the authentication fails or the vehicles are outside of broadcasting vehicle. In that case, the vehicle performs normal handoff. However, in high velocity environment, the vehicle users entered the new network (coverage) may be failed to join the network set in time because of fixed threshold value defined in base station. Therefore, the existing handoff algorithm leads to higher delay time in a handoff process.

Therefore, this paper proposes an improvement of link breakage through efficient handoff. The proposed algorithm, enhanced velocity-based handoff (EVHO) solves the problems by considering the velocities of the vehicle and handoff latency (minimizing a scanning time). The results of a simulation performed using NS-2 showed that the proposed EVHO performs much better than existing routing protocol.

The outline of the paper is as follows. Section 2 discusses VANET applications and its importance. In section 3,we describe the related work. We introduce the analytical model and algorithm for velocity-based VANET in section 4. Finally,section 5 analyses the experiment results, and section 6 concludes the paper.

2.0 VEHICULAR AD HOC NETWORK APPLICATIONS

VANETs present an intriguing platform for applications such as Intelligent Transportation System (ITS), Infotainment applications, including but not limited to, live video streaming [8], [9], [10], [11], file sharing, mobile office advertisements and even distributed computer games. Such conceivable ITS and infotainment applications aspire to be a prevalent mode of communication between vehicles while on the road. However, Impact of such anticipated increased communication between vehicles, is bound to have increased contention on communication links, resulting in variable service quality for different applications. As such, discrimination of data becomes imperative and forwarding critical data on appropriate routes becomes decisive. For effective communication between nodes, routing protocols play an essential role in appropriate route discovery.

Providing safety is the primary objective of vehicle communication networks; therefore, V2V is considered as the main communication system for safety applications. Vehicle communications are aimed to provide innovative services to vehicles in order to make better, safer and more coordinated transport network. The safety applications can inform the vehicle's drivers of current traffic, red lights, congested roads, speed limit, accident notification and other similar information. There are also other applications for entertainment and comfort such as drive assistance, cooperative driving, cooperative cruise control, Internet access, map location, automatic parking, automatic toll payment, and location-based services [12].It is expected that inter-vehicle communications will contribute to safer and more efficient roads by providing timely information to drivers.

V2I communication is to provide Internet access to some of ITS applications and the passengers of the vehicle [13]. The GPS navigation system can benefit from Internet access to obtain location maps faster or get better traffic information. Entertainment and comfort applications can provide web navigation, videoconference, TV, weather data, tourist information and many more opportunities that make driving and passenger experience much more enjoyable and less tiresome. The purpose of safety applications is to decrease the chance of accident and enhance driving condition. These applications monitor the vehicle's surrounding environment by several on-board sensors and notify the driver to take appropriate action in time. For example (as seen in Fig. 1), they can inform the driver of road curves and the approaching vehicles to preventaccidents.The roadside sensors are installed on identified areas to provide post-accident investigation.

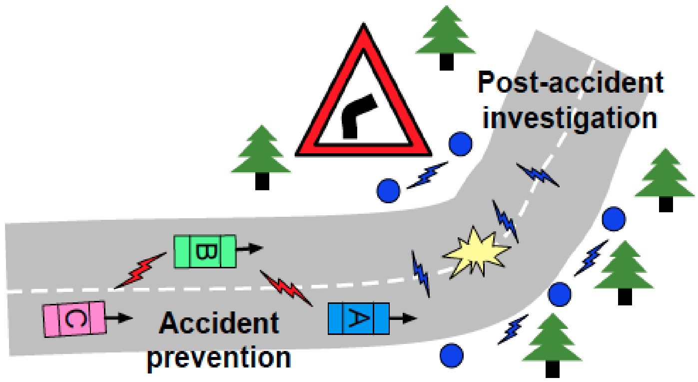

Fig.1V2V and roadside sensor [14]

Safety applications are also categorized based on their usage such as incident management, cooperative collision warning and emergency video streaming. One of the safety applications examples that are currently employed by several cars manufactures such as Ford, is the collision warning with brake support system. The vehicle monitors 325 feet area in front of it and sends feedback to onboard computer. If the driver does not take appropriate action in time, the system will take action and brake.

3.0 RELATED WORK

Various enhanced handoff schemes have been presented recently. This section describes and summarizes these enhanced schemes.Many authors (e.g. [15],[16],[17],[18],[19]) focused on standard mobile WiMAX networks. Boon et al.[15], proposed strategies which a mobile station may employ to reduce the time required for scanning and ranging operations while trying to perform handoff between neighboring base stations. The authors modeled and simulated area of WiMAX coverage utilizing real-world mobility to employ their strategies, which showed a reduction in the time required for scanning and ranging operation. Chen et al. [16], offered a pre-coordination mechanism (PCM) for maintaining fast handoff in WiMAX networks. Simulation results indicated that enhanced disruption time of handoff can reduce to 11 milliseconds. In [18], the authors proposed an adaptive algorithm called Adaptive Channel Scanning (ACS) to allocate scanning intervals in IEEE 802.16. A presented algorithm relies on sharing configuration parameters of neighboring base stations to estimate the required time for a mobile station. The authors found that utilizing the application traffic characteristics reduce communication disruption for all traffics. Authors in [18] concentrated on reducing an inter-cell handoff.The proposed algorithm reduces handover signaling overhead, latency, and also unnecessary handoffs known as a ping-pong effect.

Chen et al.[17][20], and Jo et al. [21] fosuced on cross layer design. Authors in [17] proposed a mechanism that incorporates information from several OSI layers to accelerate the speed of layer twohandoff. Simulation results showed that proposed mechanism can decrease the handoff latency to less than 100 milliseconds in most cases.All aforementioned studies do not consider the characteristics of underlying VANETS. Thereby, Chiu et al. [22]focused on the cross-layer design by consideration of underlying VANETs such as store-carry-forward routing, continuous transition between relay vehiclesand high-speed mobility. Simulation results showed that proposed scheme decreases handoff latency and packet loss as it allows oncoming side vehicles to provide physical layer information of oncoming relay vehicles (RV) to oncoming broken vehicles. Further study by Prakash et al. [23] uses neighboring vehicle assistances to reduce handoff latency and minimizing packet loss during handoff. To accomplish this goal, the authors,firstly,used the vehicle assistance to get the router of the next BS in advance to perform handoff, which leads to reduction in latency, and secondly to receive packets destined for handoff vehicle, resulting minimizing packet loss. The results of aforementioned studies; however, have not shown the throughput of the networks.

4.0 ANALYTICAL MODEL AND ALGORITHM FOR VELOCITY-BASED HANDOFF

This section presents an analytical model and algorithm for handoff decision in VANET. To compute the VANET handoff, we define two rules; i) Vehicle spends times in wireless coverage and ii) the handoff latency.

Rule No. 1 (Vehicle Spends Times in Wireless Coverage)
A vehicle, *V* traverses in an area covered by a wireless coverage, C_w, at a constant velocity, $|s|$. Considering, *V* that connected to a specific base station, *bs1* and moving towards, *bs2*. The distance of the vehicle, *V* between time connected to *bs1* and time disconnected from *bs1*, is denoted as Δd. The time taken of handoff to perform is given as

$$\Delta T = T_{move\text{-}out\text{-}bs1} + T_{move\text{-}in\text{-}bs2} + \frac{\Delta d}{|s|} \qquad \text{Equation (1)}$$

In mobility model, we are referring to a Manhattan model (Refer to Fig.2) [24]. A radius, *r* of omni-directional for wireless coverage is ø, and line of sight of the vehicle with the base station is considered as in Equation (2). V_{max} is the maximum vehicle's velocity in a period, ΔT. The average velocity of the vehicle isgiven in Equation (3).

$$\Delta d = 2(r)(\cos ø) \qquad \text{Equation (2)}$$

$$V_r = \frac{\sum_{i=0}^{n-1} V}{n} \; (i=0 \; ..... \; n\text{-}1) \qquad \text{Equation (3)}$$

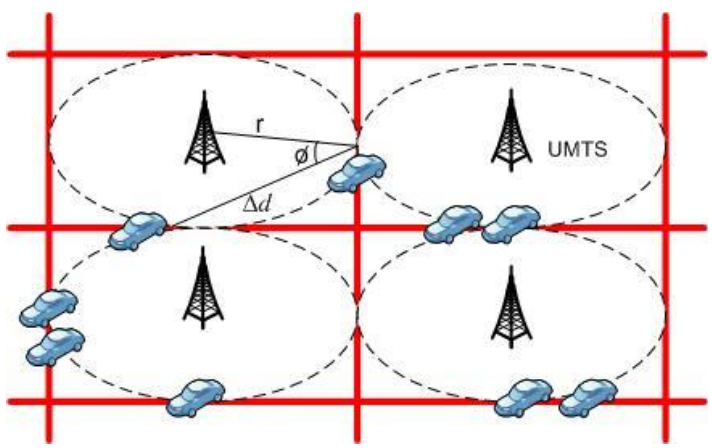

Fig.2Manhattan Mobility Model in VANET

Rule No. 2 (Handoff Latency)

The time moving of *V* in between base station in C_w, *represented as* ΔT. We denote that handoff latency as H_l, and available bandwidth for a new base station is denoted as BW_{bsnew} [bit/s].

$$\text{Ø} (\Delta T - H_l) = \frac{\Delta d \, . BW_{bsnew}}{|s|} \qquad \text{Equation (4)}$$

In a high velocity environment, the larger V_r, the smaller ΔT.When the handoff is performed quicker (less time taken), therefore, the handoff latency is reduced.

4.1 Enhanced Velocity-Based Handoff Algorithm (EVHO)

In vehicular network environment, due to the high velocity of vehicles and short communication intervals,frequent handoff may occur and cause regular disconnection of services. The disruption caused by handoff process results in packet loss and delay in communications. This gap in communication is unsatisfactory, especially to multimedia applications such as VoIP. Since the vehicular network is a sub category of IEEE 802.11 standard, the facts regarding handoff in 802.11 standard also apply to this network. The overall handoff process has three steps; scanning, authentication and association [25].When the receiving signal strength reaches the predefined handoff threshold, the vehicle starts sending probe requests on each channelto the neighboring base stationsand waits *MinChannelTime*for probe responses. If there is any response from any base station(BS) within this period, then it waits until *MaxChannelTime* to receive other possible responses from other base stations. However, if there is no probe response within *MinChannelTime*, it switches to the next channel and starts the same process.

Since scanning phase causes most of the handoff delay, the most intuitive approach is to reduce the probing timeor reduce the number of channels to be scanned.InMANET, the mobile node’s location is changing dynamically towards any direction at any time, which makes prediction of the next best BS very challenging because there is no definite movement pattern.However, in VANET, network topology changes are much restricted because the vehicles are bound to a road structure and they have less freedom in their movement. The BSs are placed alongside the road; this helps to predict the next BSmuch easier when the vehicle is about to perform the handoff. This can be used as an advantage to ourproposed solution to enhance the scanning part of the handoff process.Fig.3 depicts a scenario where the cars at the overlapping coverage have reached handoff threshold and performed handoff to thenew BS.

The proposed work starts here, in Fig.3, the total coverage area of the BS is divided into three zones based on the Received Signal Strength (RSS) [26]. As the name implies, the safe zone is the coverage area where the yellow vehicle is not under threat of imminent handoff. Therefore the vehicle does not trigger the scanning phase as yet and data transfer is carried normally. Next, the grey zone, which is an area where the probability of handoff is high. As the red vehicle enters the grey zone, it starts accepting the blue vehicle’s BS broadcast messages.The blue vehicle has just handoff from BS1 to BS2. After a successful re-association, it broadcasts BS2’s id and channel to neighboring vehicles. Both red and green vehicles receive the broadcast. The red vehicle updates the BS table with BS2 Id and channel information. However, the green vehicle will discard the message since its current BS is the same as the received BS update from blue vehicle.

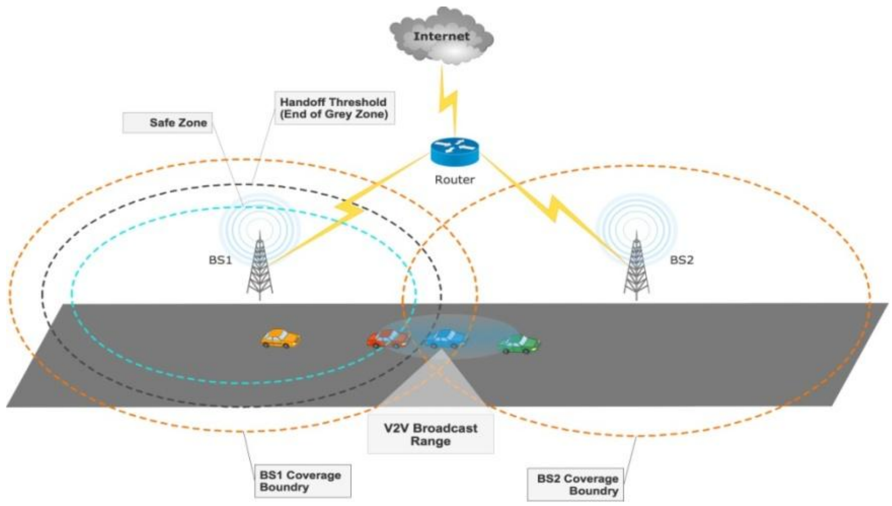

Fig.3 EVHOMechanism in Vehicular Networks

We improved the existing work [5], GPSR routing algorithm by considering the mobility rules defined at the beginning of the section. Fig. 4 consists of two nodes (vehicle_1 and vehicle_2) and two base stations (BS1 and BS2) which connected to a router. Vehicle_1 performed a handoff when it started to move from BS1.As the Vehicle_1 is moving towards BS2 the receiving signal strength keeps dropping until it reaches the handoff threshold (RSSI <RSSI_$_{Threshold}$) and it needs to start active scanning to find the next potential BS for handoff. At this point if Vehicle_2 could know the next BS, it could avoid the scanning part and start re-authentication process with the next BS.

Since Vehicle_1 has already performed the handoff, it has all the information about the next BS for the vehicle behind it. Both vehicles are in a close range to each other; therefore, Vehicle_1 can send a broadcast to its neighboring vehicles, informing them of the next base station's BSSID and the channel it is transmitting on. In this way, when Vehicle_1 reaches handoff threshold, it has the information about its next point of connection. Instead of sending broadcast on each channel to find the next best BS to connect to, it will send a unicast packet on the channel associated with the next BSSID that it has received, requesting for authentication. If the authentication is successful, the scanning phase is not needed; therefore the overall handoff time will be reduced. However, if for any reason the authentication was not successful it will perform the normal scanning process to find the next BS.

A new packet frame is created for the front vehicle to broadcast the BS address, which is very similar to the beacon frame since it must contain the same information about BSSID, channel and supported data rate. An additional attribute, Time-to-Live(TTL),is also needed to limit the broadcast overhead caused by this packet.Three algorithms are presented in related to velocity-based handoff.

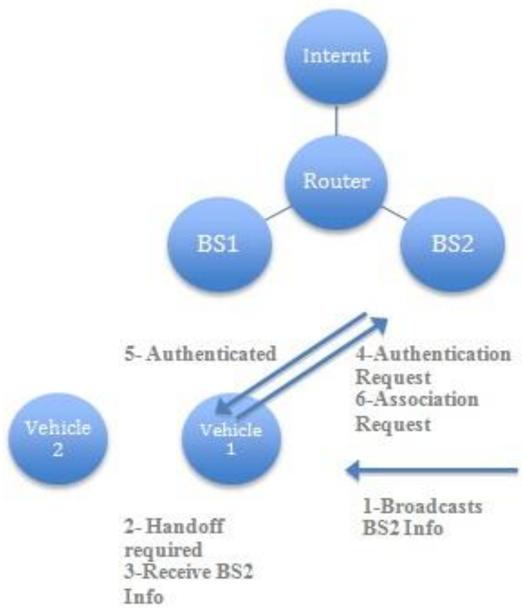

Fig. 4 Schematic View of Enhanced Velocity-Based Handoff Process

Algorithm 1: Enhanced Velocity-based Handoff (Upon Receiving Packet)

Input: $|s|$, $T_{move\text{-}in\text{-}bs}$
Output: H*andoff Threshold*
If (Threshold > Handoff Threshold)
    Discard packet
Else
If (received BSSID = current BSSID)
    Discard packet
Else{
    Update Access point Table
If (handoff requires) {
    Authenticate with BS
    If (authentication successful)
        Associate with BS
    Else
        Start EVHO process }Else
  Continue listening for BS_Update Broadcasts}

Algorithm 2: Base Station Update

Void Mac802_11::recvBSUPDATE (packet)
{
allocate packet
structbsupdate_frame
if (TTL expired)
discard the packet
else
{
check BSSID info from packet
BW_{bsnew}*>min_limit*
if (handoff threshold is reached)
if (current BSSID_add != packet ->BSSID_add)
updateap_table (BSSID, Channel)
else
discard packet
else
discard packet
}}

Algorithm 3: Broadcast

Void Mac8022_11::send_BSUPDATE (destination)
{
allocate packet
structbsupdate_frame
*packet type =**PT_MAC***
*frametype =**MAC_Management***
*frame subtype = **BS_Update_BCAST***
*destination = **MAC_BROADCAST***

...
}

5.0 THE EXPERIMENT

The aim of this experiment is to evaluate the performance of EVHO. To achieve theresults, there are three different scenarios (5 moving vehicles, 10 moving vehicles and 15 moving vehicles) and different velocities; 5, 10, 15, 20, and 25 m/s are compared. The experiments are conducted using network simulation, NS-2. Table 1 shows the simulation parameters used throughout the experiments. For each scenario, three performance metrics (delay, packet loss and average throughput) are presented and compared with theexisting GPSR velocity handoff (VHO) results.Fig. 5 shows a simple scenario that consists of vehicle (as a moving node) and base station (BS) for a simulation implementation in NS-2.

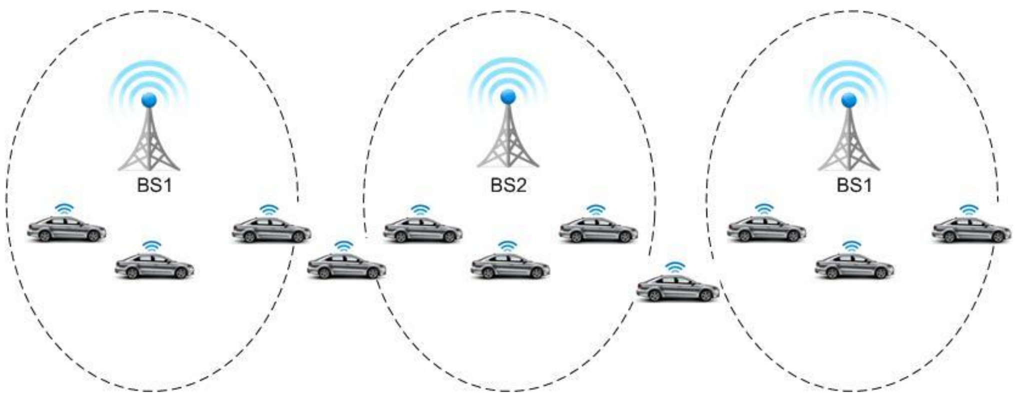

Fig. 5 Scenario Simulation

Table 1.Simulation Parameters

Parameter	Value
Node Types	Mobile node/base station
Network Interface	Phy/WirelessPhyExt
Velocity	5, 10, 15, 20, 25 m/s
MAC Type	Mac/802_11Ext
Area	1000 * 1000
Antenna	Antenna/OmniAntenna
Packet type	UDP
Traffic type /size	CBR/512 bytes
Traffic data rate	600 kbps

5.1 Results and Discussion

The results from the simulation are analyzed in this section. First, the vehicle starts to movefrom 5m/s to 25m/s. Then a comparison of the metrics in different velocities between VHO and EVHO is discussed.

A) Average Packet Delay

The results have shown that as the vehicle velocity is increased, the handoff delay affected in each handoff algorithms. As the velocity increases, it has less time to transmit and scan at the same time; therefore the delay increased by the vehicle velocity. However, inEVHO, the increased in vehicle'svelocity does not affect much on handoff delay. This is because the active scanning is performed before handoff is performed.

Fig. 5, 6 and 7 show the comparison of packet delay for a different number of vehicles, five, ten and fifteen respectively. At velocity of 25m/s, the results have shown that the average packet delay for EVHO in five moving vehicles is 144.56 ms, ten moving vehicles is 160.58 ms and fifteen moving vehicles is 187.27 ms. As the numbers of vehicles are increased, the higher the packets delay. This is because there are too many vehicles to establish the next connection before the signal gets too weak.

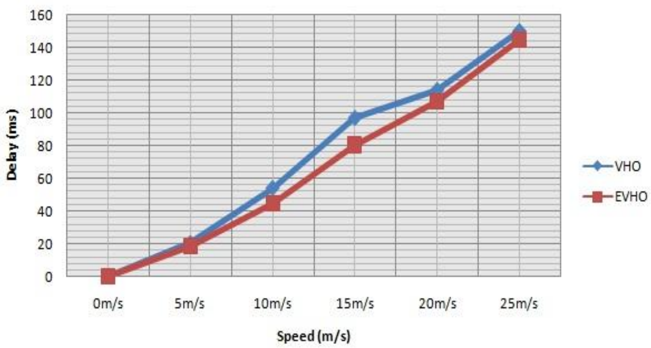

Fig. 5 Packet Delay for five moving vehicle

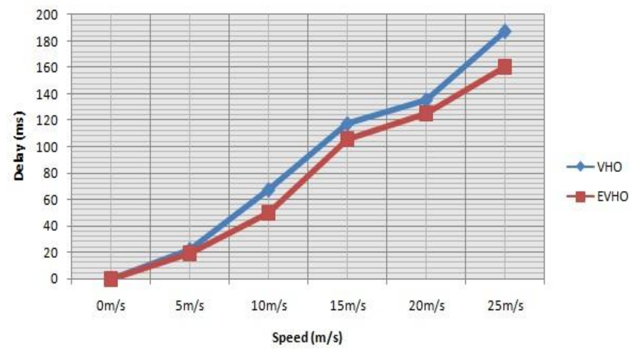

Fig. 6 Packet Delay for ten movingvehicles

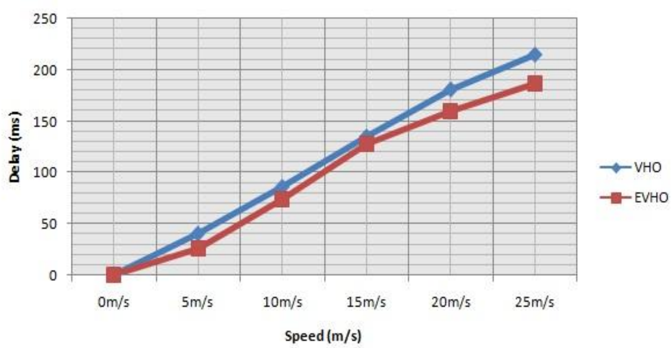

Fig. 7 Packet Delay for fifteen moving vehicles

B) Average Packet Loss

Referring to Fig. 8, 9, and 10, a number of packet loss is increased when velocity of vehicle is increased. In enhanced velocity-based handoff, the vehicle performance is improved compared to the existing velocity handoff. The effectiveness of EVHO is obvious when the vehicle velocity is below 25m/s (the optimize speed limit for highway) where the number of packet losses is below 1000. When there are fifteen vehicles on the road, number of packet losses in VHO is 1277, while EVHO is 765. It has shown that EVHO algorithm improved the network performance.

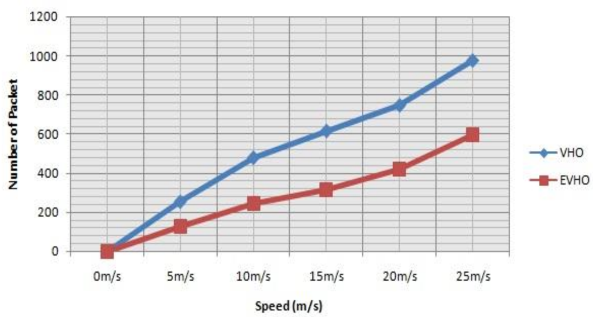

Fig. 8 Packet Loss for five moving vehicles

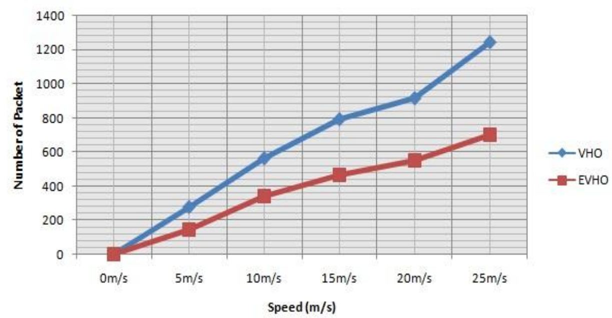

Fig. 9 Packet Loss for ten moving vehicles

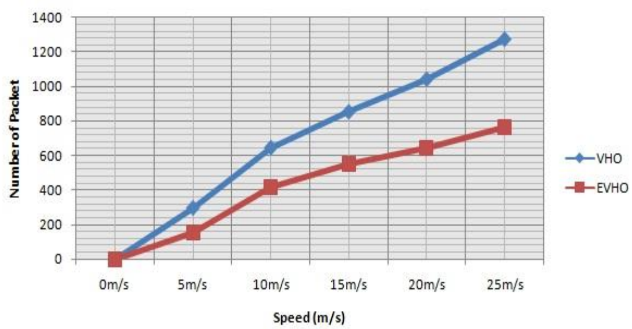

Fig. 10 Packet Loss for fifteenmoving vehicles

C) Average Throughput

The obtained results of average throughputs for different velocities are presented in Fig. 11, 12 and 13. It can be seen in VHO that average throughput is greatly affected as the vehicle velocity increases. The scanning phase in here results in great packet loss and delay which in its own turn is a reason for this behavior and affects average throughput; as the velocity increases more packets get lost and throughput decreases. Fig. 11 shows the average throughput for five moving vehicles and the throughput is decreased when the velocity is increased. However, through our observations of the collected results, we conclude that the authentication and association process time between the vehicle and base station were not affected much by the velocity of the vehicle.

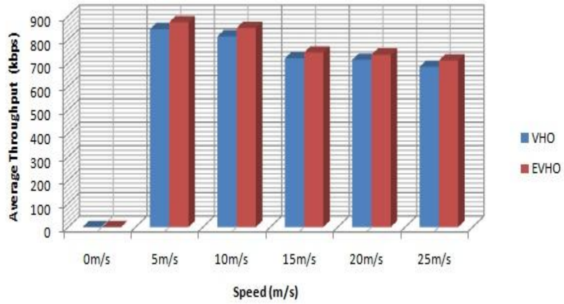

Fig. 11 Average Throughputfor fivemoving vehicle

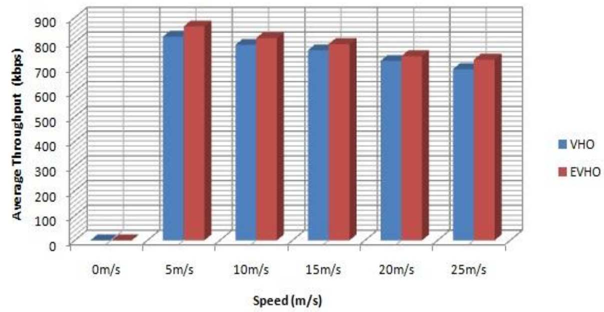

Fig. 12 Average Throughput for tenmoving vehicle

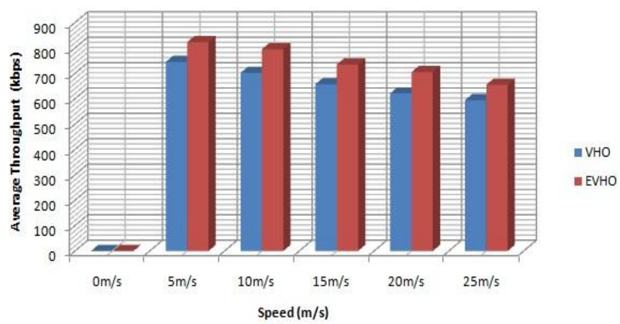

Fig. 13 Average Throughput for fifteenmoving vehicle

6.0 CONCLUSIONS AND FUTURE WORK

The proposed algorithm, enhanced velocity-based handoff (EVHO) is presented in this article. In order to achieve optimal handoff time, the algorithm is improved based on the vehicle's velocity and packet management handoff (handoff latency) before the vehicle performs the handoff itself. The EVHO was performed to meet the objective of the experiment which is to improve link breakage and VANET reliability (efficient handoff). The experiment is divided into three different scenarios with three different vehicle velocities. The performance of the proposed algorithm is measured based on packet delay, loss and throughput. The evaluation results from the experiment conducted are promising and provide many advantages such as:higher accuracy in traffic transmission; improved performance for VANET's applications (safety and non-safety) and improved vehicles connectivity. We are planning to extend the analytical model into more realistic scenarios. The real traffic data will be exported into traffic simulation, SUMO, where more realistic data can be evaluated. Moreover, experiments comparing EVHO with cross layer technology are left for future work.

ACKNOWLEDGEMENT

The authors would like to thank the Ministry of Education, Malaysia for rewarded FRGSGrant (FP030-2012A)for their support.

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