Performance Evaluation of an Enhanced Hybrid Wireless Mesh Protocol (E-HWMP) Protocol for VANET

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Abstract— In this paper we evaluate Enhanced Hybrid Wireless Mesh Protocol (E-HWMP), an enhanced version of HWMP based on IEEE802.11p and IEEE802.11s standards, especially created for Vehicular Ad-hoc Networks (VANETs). An enhanced gateway selection algorithm for multi-hop relay in VANET- LTE integration network is proposed. In the proposed algorithm the gateway selection is implemented using the E-HWMP protocol. The proposed gateway selection algorithm aims to improve the handoff efficiency and increasing the data rate while minimizing the average delay and overhead. Therefore, a multi-hop routing over the VANET network is designed. NS2 simulator is used to evaluate the system performance of the proposed gateway selection algorithm (E-HWMP). The results show that, compared to conventional methods, the proposed algorithm significantly improves the system performance in terms of packets delivery ratio, overhead and average end-to-end delay.

Keywords- Vehicular Ad-hoc network (VANET), HWMP, Gateway Selection, LTE, NS-2.35.

I. INTRODUCTION

Every year thousands of people across the world died in car accidents as we all know, therefore vehicular safety is going to be a big challenge. Vehicular Ad-hoc Networks (VANETs) is the one of the most promising applications of Ad-Hoc networking technology. VANET is a special type of mobile ad hoc network (MANET) with some individual characteristics such as, dynamic topology, mobility speed, and predictable movement of vehicles [1]. VANETs are not suitable for safety applications only but also for traffic management and entertainment and commercial applications [2]. Figure 1 show VANET application. VANET is categorized based on vehicles location and speed and is classified into two major categories namely, Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communication.

Types of nodes which are used in VANET are mobile nodes and static nodes. Static nodes are also called Road-Side Units (RSUs), which are set near the road, parking lots and at intersections. Mobile nodes are called On-board Units (OBUs). OBUs are located on each vehicle in the network [3].

VANET is a dynamic network topology which consists of high-speed vehicles that moves in a specific direction. There are many services provided by VANET to improve road safety and transportation efficiency, as well as to reduce the impact of transportation on environment [4].

There are several efforts are made to integrate Vehicular Ad hoc Network with multiple wireless technologies, such as 3G cellular systems in order to provide seamless connectivity and efficient data propagation even in sparse-traffic scenarios [5]. In such heterogeneous network protocols for data dissemination and delivery still represent a challenge.

In this paper, we provide a performance evaluation of an Enhanced Hybrid Wireless Mesh Protocol (E-HWMP) in VANET scenario to estimate the packets delivery ratio, the rate of packets lost, overhead and average end-to-end delay. The proposed gateway selection algorithm which is used VANET scenario is a combination of reactive and proactive mechanism.

This paper is organized as follows. Related works are described in section II, the proposed algorithm described in section III. In section IV we present the simulation result and analysis of our observation. Finally conclusion is given in section V.

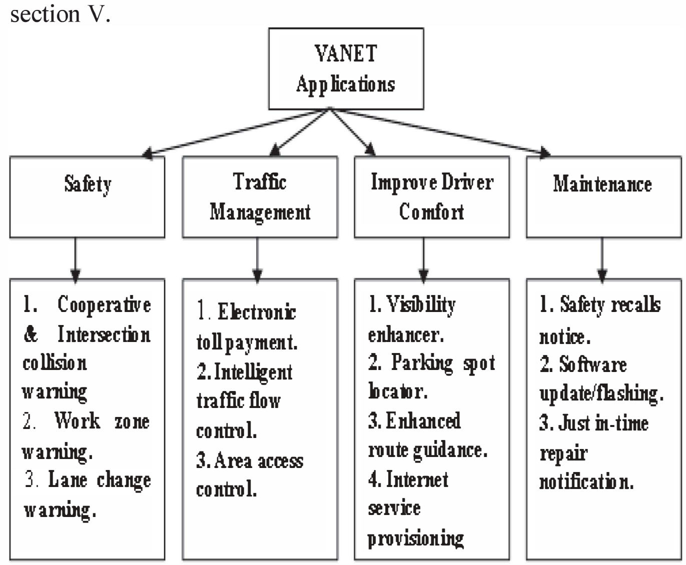

Figure 1. VANET Application

II. RELATED WORKS

Variable mobility of vehicles lacks of connectivity due to quick disconnections and rapidly changing network topology is the main issues related to a vehicular network [6].

In [7], the use of hybrid protocols has been considered by Cataldi et al. I2V2V is the proposed scheme, where vehicles

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can connect with infrastructure network (V2I) and other neighboring vehicles (V2V) providing collaborative approach between vehicles, since a relay vehicles receive the messages from the infrastructure and forward it to target vehicles. This method improves the packet delivery ratio and data reconstruction provided in a rapid way with low overhead.

A multi-hop protocol has been used for a diversity of communication modes (i.e., V2V, V2I). In [8], Resta et al. deal with multi-hop V2V where a probabilistic approach is used to disseminate emergency message whereas the probability of a message that receives correctly by a vehicle within a fixed time interval is lower bounds on that interval.

In [9], C. T. Barba et al proposed and evaluate GBSR-B routing protocol, GBSR-B based on GPRS that intend to improve VANETs performance over urban scenarios. A new mechanism included in their proposal to select the next –hop node. The proposed GBSR- B compared with AODV and GPSR using NCTUns 6.0 network simulator, the result is better in term of packet losses.

In [10], Mohammad Al-Rabayah et al proposed a novel hybrid location-based routing protocol which is designed to classify the issue Vehicular ad hoc networks (VANETs) that is a high mobility wireless networks which are designed to support vehicular applications. The proposed protocol combines the attributes of location-based geographic routing with reactive routing in technique that all available location information efficiently used. The simulation result show that the proposed protocol is scalable and has an optimal overhead.

In [11], Pavlos Sermpezis proposed a novel routing technique designed for VANETs and display some initial performance results. The new mechanism called Junction-based Multipath Source Routing (JMSR). The main characteristics of JMSR include the junction-centric logic, the multiple routes towards the destination and the adoption of source routing mechanisms.

III. AN ENHANCED GATEWAY SELECTION ALGORITHM FOR MULTI-HOP RELAY IN VANET- LTE INTEGRATION NETWORK

In VANET routing strategy is a challenge task due to deficient in resources [12]. To control this problem, an efficient routing algorithm is required to manage the resource requests and at the same time dynamic topology change take into consideration.

Traditional gateway discovery algorithm is reactive or proactive in nature. In this paper a hybrid one is proposed which is a combination of both reactive and proactive algorithm.

A. Proactive gateway discovery algorithm

In proactive algorithm, gateway discovery is initiated by the gateway itself. The gateway periodically broadcasts a gateway (GW_ADV). The GW_ADV message includes a time to live (TTL) that determines the number of hops the message traverse. All mobile nodes residing in the gateway's transmission range receive the advertisement. Less delay and good connectivity is the main advantage of this algorithm. But the major problem in this algorithm is increasing in signaling overhead.

B. Reactive gateway discovery algorithm

The reactive gateway discovery [13] is initiated by a mobile node that is to initialize or update information about the gateway. The mobile node broadcasts (GW_REQ). When the (GW_REQ) message reaches a gateway or any intermediate node that have a roué to the gateway, (GW_REP) send back to the mobile node. Less overhead is the main advantage of this algorithm. But the major problem in this algorithm is increasing in delay.

C. Hybrid gateway discovery algorithm

The hybrid gateway discovery scheme [14] is the combination of both proactive and the reactive approaches. Firstly the gateway broadcasts the Gateway Advertisement message proactively to an area confined to a limited number of hops which is called as the TTL value of the message. The TTL is set to advertisement zone so that the advertisement message can be forwarded only up to this maximal number of hops through the ad hoc network. This area is called as the proactive zone. The nodes that are outside the proactive zone establish connection to the gateway reactively.

A proposed Hybrid gateway discovery algorithm is used to allow source vehicle to connect to LTE network through Gateway. The proposed algorithm minimized the disadvantages of proactive and reactive gateway discovery, where the two approaches have been combined. In the proposed algorithm the gateway discovery is implemented using the E-HWMP protocol. E-HWMP is a combination of IEEE802.11p (AODV Routing Protocol) and IEEE802.11s (HWMP Routing Protocol.

The main purpose of this approach is to reduce the control overhead due to the reactive discovery scheme when there are many source nodes in the VANET. This approach also aims to reduce the overhead of the proactive protocols when the number of gateways increases. In this approach, the determination of the best TTL is therefore not straightforward because the network conditions change frequently.

Architecture of VANET- LTE integration network where the proposed algorithm implemented is cluster based. The clusters are formulated only at LTE cell edges.

Message exchanges of the E-HWMP protocol are:

I. Gateway Announcement (GANN)

Active GW periodically broadcast GANN to all Gateway candidates (GWCs) in the cluster. At each GWc when GANN is received a route to the GW is created and updates its E-HWMP routing table.

IF (route entry for GANN node exists)
update route entry
ELSE
create route entry for GANN node
ENDIF

II. Gateway Request (GREQ)

SV sends a message for multi-hop cluster. The message includes time to live (TTL) value, which specifies the number of hops needed to connect with the GW that can forward the source vehicle to the LTE network, If the neighbour vehicle is a GWc cluster then the source vehicle send multi-hop cluster request.

IF (the neighbour vehicle is a GWc)
sv send multi-hop cluster request
IF (receives OK)
send their packets
Else
IF (the neighbour vehicle within multi-hop cluster)
updates the HWMP table and sends multi-hop cluster request
IF (receives OK)
send their packets
Else
IF (the neighbour vehicle is not GWc cluster nor within multi-hop cluster and reply time out)
SV search for hop to UMTS
Else
SV buffer packet for available hop to LTE
ENDIF
ENDIF
ENDIF
ENDIF
ENDIF

III. Gateway Replay

GREP message send by the nearest node of the source vehicle.

IF ((nearest vehicle is GWc or within multi hop cluster)
nearest vehicle send ok to the SV
ELSE
SV send GREQ to other nearest node.
ENDIF

When the source vehicle receives the GREP it will update the E-HWMP routing table and start to send its packet.

IV. Message Error (MERR)

Notify the source of the broken link, it's propagated to all the affected destinations.

IV. Simulation and Performance Evaluations

The proposed algorithm performance is evaluated by using ns2.35 in terms of packet delivery ratio, end to end delay and control packet overhead. The simulation was performed into two phases as shown in Figure 2 and Figure 3 , Phase I was based on simulating the mobility model which is closed to the real behavior of vehicles traffic and for this task VanetMobiSim was used, the resulted trace file was then passed to the network simulator as the waypoint file. VanetMobiSim developed to simulate the movement of objects along a road network. It is a free and open sourced simulator. Along with being able to model small areas, also capable of modeling traffic in large networks, such as cities or highway networks, without any changes.

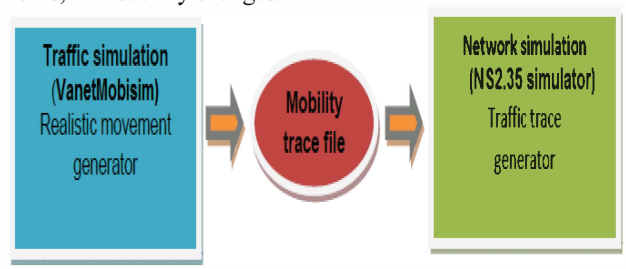

Figure 2. Integration of VanetMobiSim (traffic simulator) and ns-2 interoperation

Figure 4, Figure 5 and Figure 6 show the mobility model of vehicles moving in highway scenario, the scenario considers two different tracks over a particular road (e.g. Highway). Each direction consists of two lanes and numbers of vehicles moving along these lanes.

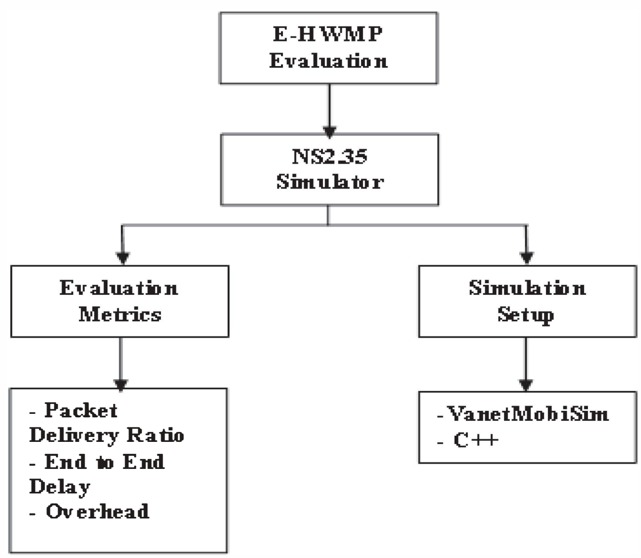

Figure 3. Routing Algorithm Evaluation

Phase II focused on collecting the network information and analyzing it. An enhanced gateway selection algorithm evaluated when implemented with AODV and when implemented with E-HWMP protocol and compared the result.

TABLE1. SIMULATION PARAMETERS

Parameters	Value
Area	8000*1000
Channel	Channel/wireless channel
Propagation Model	Propagation/TwoRayGround
Network Interface	Phy/WirelessPhyExt
Mac Interface	Mac/802 11Ext
Peak Wireless Transmission Range	300m
Seed	0.0
Interface Queue Type	Queue/DropTail/PriQueue

Interface Queue Length	20 packets
Antenna Type	Antenna/OmniAntenna
Routing Protocol	E-HWMP
Total Number of VANET Vehicles	50
Applications	FTP
Peak Mobility speed	50 ms−1
Mobility Model	VanetMobiSim
Simulation stop	500
LTE RSS Threshold	-94 dBM
Uplink Frequency	1.925
Downlink Frequency	2.115
Peak E-UTRAN UL Channel Bit Rate	5.2
Peak E-UTRAN DL Channel Bit Rate	10.3
Transmission Range of eNodeB	10
Node B Interface Queue length	20 packets

As indicated above, the main measured parameter is:

- Packet Delivery Ratio (PDR): The ratio of the total number of the data received to the number of the data packets send from the source to destination.
- End-to-End delay: This term includes all the time required for a packet to be generated, transmitted through the network, and received by the destination.
- Control Packet Overhead: measures the ratio of the total number of control packets to the total number of packets generated within the VANET-LTE integration.

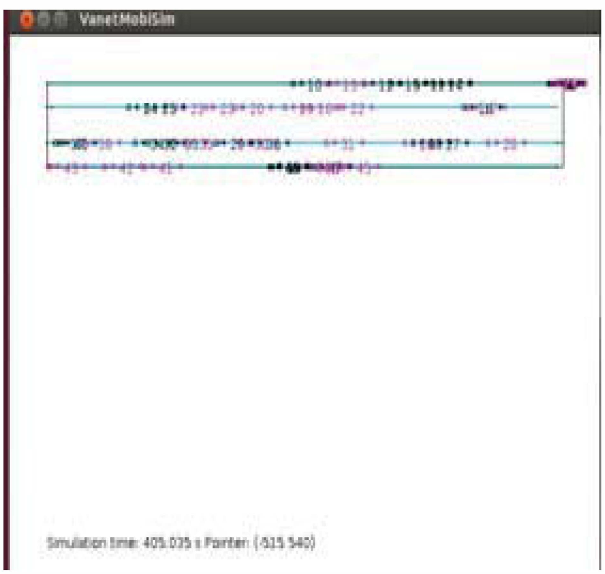

Figure 4. Highway Scenario 1

In Figure 4, fifty vehicles moving on a highway road.

Figure 5. Highway Scenario 2

In Figure 5, thirty vehicles moving on a highway road.

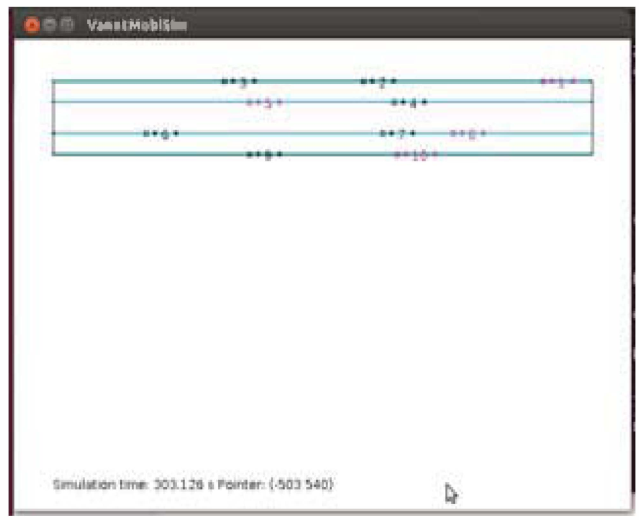

Figure 6. Highway Scenario 3

In Figure 6, ten vehicles moving on a highway road.

In Figure 7, control packets overhead of SGSS with E-HWMP compare with, SGSS with AODV in a range of variation of ieee802.11 transmission range of vehicles. The result that we obtained from the simulation shows, a good performance of the implemented E-HWMP in terms of less control packets overhead compared to the implemented AODV.

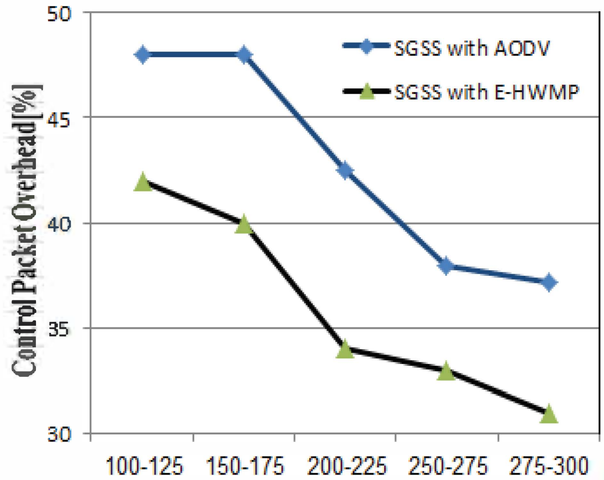

Figure 7. Compare Control Packets Overhead of SGSS with E-HWMP and with AODV in a range of Variation of IEEE802.11 transmission range of vehicles

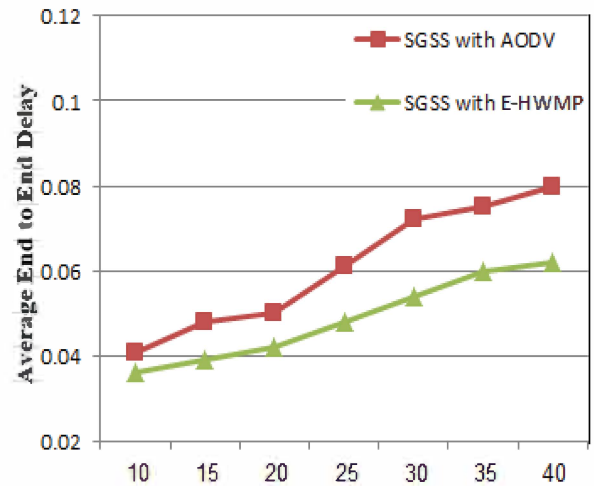

Figure 9. Compare average End - to-End Delay of SGSS with E-HWMP and with AODV in a range of Variation of Number of Vehicles Source in VANET

In Figure 8, packet delivery ratio of SGSS with E-HWMP compare with SGSS with AODV in a range of variation of the mobility speed of VANET vehicles. The result that has been obtained from the simulation shows, a good performance of the implemented E-HWMP in terms of higher packet delivery ratio compared to the implemented AODV.

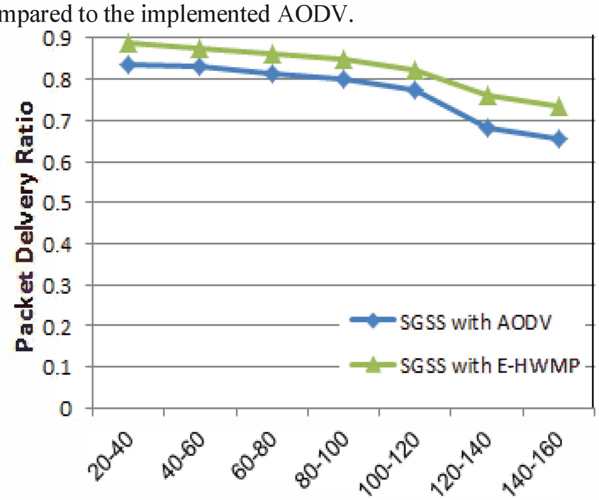

Figure 8. Compare Packet Delivery Ratio of SGSS with E-HWMP and with AODV in a range of Variation of The Mobility Speed of VANET Vehicles

In Figure 9, average end - to-end delay of SGSS with E-HWMP compare with SGSS with AODV in a range of variation of number of vehicles source in VANET. The result that has been obtained from the simulation shows, a good performance of the implemented E-HWMP in terms of less delay compared to the implemented AODV.

V. Conclusion

This paper described a performance evaluation and comparison between E-HWMP and AODV for vehicular ad hoc network. Both protocols were simulated using ns2.35 and were compared in terms of packets delivery ratio, control packet overhead and average end-to-end delay. From the simulation result in section we can conclude that average end to end delay of E-HWMP is much better than AODV and packets delivery ratio of E-HWMP is much higher than AODV and in terms of control packet overhead of E-HWMP is much lower than AODV routing protocol.

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