

Analyzing Routing Protocols Performance in VANET Using 802.11p and 802.11g

Rasha Kaiss Aswed and Mohammed Ahmed Abdala

Network Engineering Department,

College of Information Engineering, Al-Nahrain University

Iraq, Baghdad

Abstract—A vehicular Ad hoc Network (VANET) is emerged as new technology to communicate between vehicles without using infrastructure. The characteristics of VANET are high mobility and rapid change of topology, so the routing protocols affected by the rapid changes and symmetric link break. This paper evaluates three routing protocols: AODV, OLSR and DYMO, by analyzing the performance of these routing protocols using two different MAC protocols IEEE 802.11p and IEEE 802.11g. As well as, two different scenarios are considered (highway and city) to measure and evaluate the performance of routing protocols by varying the number of vehicles, vehicles speed using OMNeT++ as network simulator Simulation Urban MObility (SUMO) as a traffic simulator. In addition to that, analysis shows that AODV outperform OLSR and DYMO in terms of average throughput. While in term of end-to-end delay, DYMO has the lowest delay.

Keywords— VANET, Routing Protocols, OMNeT++, SUMO, MAC protocols

I. INTRODUCTION

Vehicular Ad hoc Networks (VANETs) is a subclass of Mobile Ad hoc networks (MANETs). the mobile nodes in VANETs are vehicles endowed with sophisticated on-board equipment, traveling on constrained paths (i.e. roads and lanes) to communicate with each other for message exchange via Vehicle-to-Vehicle (V2V) communication and also between vehicles and fixed roadside such as: wireless and cellular network infrastructure to form Vehicle-to-Infrastructure (V2I) communications [1]. Dedicated Short Range Communication (DSRC) protocol is designed to support high speed and low latency V2V, and V2I communications, using the IEEE 802.11p and WAVE standards [1].

VANETS are emerged as new technology to improve the efficiency and safety of modern transportation systems. For example, vehicles can exchange information such as traffic accident, and congestion to reduce traffic jam and accidents. VANETs and MANETs are characterized by the mobility and self-organization of the nodes. But due to driver behavior, and high speeds, VANETs characteristics are different from MANETs. VANETs are characterized by rapid but somewhat predictable topology changes; frequent fragmentation, small effective network diameter, and no power constrain [1].

There are many challenges in VANETs such as: security, privacy, routing protocols, connectivity, and

quality of services. This paper will focus on routing protocols in VANET by evaluating several selected routing protocols using OMNET ++ network simulation.

The rest of this paper is divided into the following sections. Section II introduces VANET routing protocol. Simulation environment is described in Section III. Section IV discusses the simulation setup. Simulation results are presented in Section V. Conclusion is given in Section VI.

II. VANET ROUTING PROTOCOL

A routing protocol is the procedure to govern the communication between two nodes to exchange information which includes the route establishment, forwarding decisions, and the recovering from routing failure. Many MANET routing protocols have been adapted to suit VANETs' unique characteristics. Routing protocols can be classified into five categories: Topology based, position-based, broadcast based, geocast based, and cluster-based [2]. This paper focused on topology based routing protocols i.e. OLSR, AODV and DYMO.

A. Ad hoc On-demand Distance Vector (AODV)

AODV [4] works in two phases: route discovery and route maintenance. AODV uses route discovery by broadcasting Route Request (RREQ) message to all its neighboring nodes. AODV uses sequence numbers to avoid the possibility of forwarding the same packet more than once. When an intermediate node receives RREQ and if it knows an active route to the requested destination node, it sends a Route Reply (RREP) packet back to the source. Route maintenance is needed when a route fails. RERR (Route Error) is created by the node which closes to the break. RERR lists all the nodes affected by the link failure. When a source node receives an RRER, it can reinitiate route discovery.

B. Dynamic MANET on Demand (DYMO)

DYMO [3] is similar to AODV. It aims to simpler design, helping to reduce the nodes' system requirements and simplify the protocol implementation. DYMO provides enhanced features, such as covering possible MANET-Internet gateway scenarios and implementing path accumulation. The major difference between DYMO and AODV is the routing table entry; AODV only generates route table entries for the destination node and the next hop node, while DYMO stores routes for each intermediate hop.

C. Optimized Link State Routing (OLSR)

OLSR [4] operates as a table driven protocol that exchanges topology information with other nodes of the network periodically. Each node selects a set of its neighbor nodes as "multipoint relays" (MPR) to reduce the number of transmissions required. Each MPR is responsible for forwarding control traffic to declare link state information in the network periodically. The advantages of OLSR are: to provide shortest path routes to all destinations and the available link-state information may be utilized for redundancy. In route calculation, the MPRs are used to form the route from a given node to any destination in the network.

III. SIMULATION ENVIRONMENT

This work is carried out by using two simulators: network simulator and traffic simulator. This section will introduce both simulators.

A. Network Simulator

There are many network simulators that have been used in many VANET research. NS-2 has popular use in many studies but it is not scalable. In this paper, OMNeT++ has selected because of its scalability and powerful GUI. OMNeT++ [5] is an open source, C++ based discrete event simulator. It can be used for simulation of communication networks and parallel systems. Scenarios in OMNeT++ are characterized by a hierarchy of reusable modules. Modules relationships and communication links are stored in Network Description (NED) files and can be modeled graphically. Simulations can be executed interactively in a graphical environment or as command-line applications.

B. Traffic Simulator

There are several traffic simulators available, but the most common one is Simulation of Urban Mobility (SUMO), which have been used by many researches. SUMO [6] is an open source, microscopic, multi-modal traffic simulation. It allows addressing a large set of traffic management topics. It is purely microscopic: each vehicle is modelled explicitly, has an own route, moves individually through the network and each road is modeled by setting its limited speed, number of lanes, etc. It allows to build any road topology, also allow importing different readymade map formats of many cities and towns of the world that helps in generating real world road topology.

IV. SIMULATION SETUP

The routing protocols have evaluated in city and highway. In city scenario, one of the important intersections in Baghdad, Iraq (AL-Hassaneen) has been chosen as shown in Fig.1. However, in highway scenario; the airport highway street which is located in Baghdad, Iraq has been chosen as shown in Fig.2. In both scenarios, the required map has been downloaded from OpenStreetMap and configured to work with SUMO traffic simulator. The evaluation in both scenarios is done using the simulation parameters summarized in Table 1.

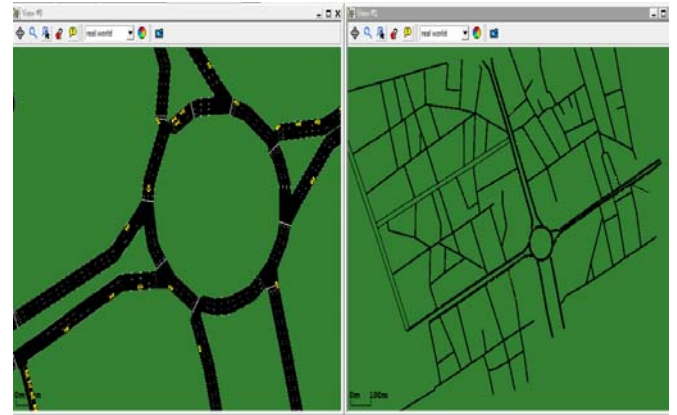


Fig. 1. City Scenario and the Vehicles Movement.

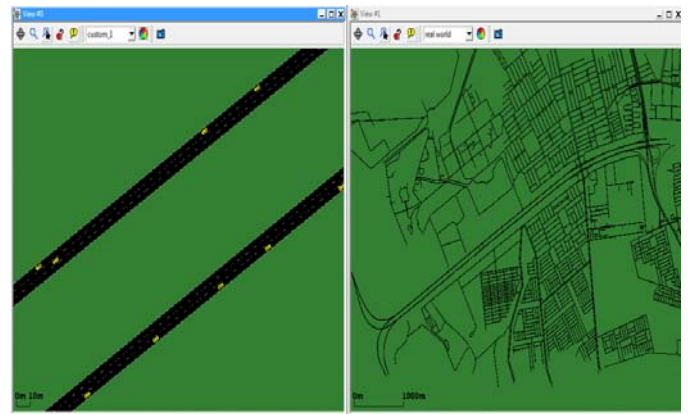


Fig. 2. Highway Scenario and Vehicles Movement.

TABLE 1. SIMULATION PARAMETER

OMNET++ Version	OMNET++ V 4.3.1
SUMO Version	SUMO 0.19.0
Simulation Area	1500 × 1300 m
Highway Length	8 KM
Number of lanes	3
Vehicles Number	City: 50, 100, 150, 200 Highway: 25, 50, 75, 100
Speed	City: 20, 40, 60, 80 Km/h Highway: 80, 90, 100, 110, 120 Km/h.
Simulation Time	600 Seconds
Routing Protocol	AODV, OLSR, DYMO
MAC Protocol	IEEE802.11g and IEEE802.11p
Packet Size	512 Byte
MAC Bit Rate	24 Mbps for IEEE 802.11g 6 Mbps for IEEE 802.11p
Radio Propagation Model	Two Ray Ground

V. SIMULATION RESULTS

The goal of this paper is to analyze the performance of AODV, OLSR and DYMO in city and highway scenarios in term of the following performance metrics:

- 1- Average Throughput: is the number of successfully delivered packets at the receiver in bit per second.
- 2- End-To-End Delay: the time taken to transmit the packet from the source to the destination.

A. City Scenario

In city scenario, the selected routing protocols have been evaluated using two MAC protocols IEEE802.11p and IEEE802.11g. Two cases are evaluated. When the number of vehicles is varied, the max vehicle speed is set to 50 Km/h.

However, when the vehicle speed is varied, the number of vehicles is set to 75. Fig 3 and 4 shows the performance of AODV using 802.11p and 802.11g in terms of average throughput vs. the number of vehicles and vehicle speed.

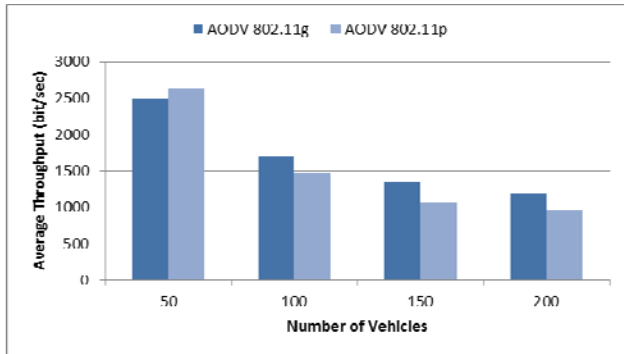


Fig.3 Throughput vs. Number of Vehicles (max. Vehicle Speed=50Km/h)

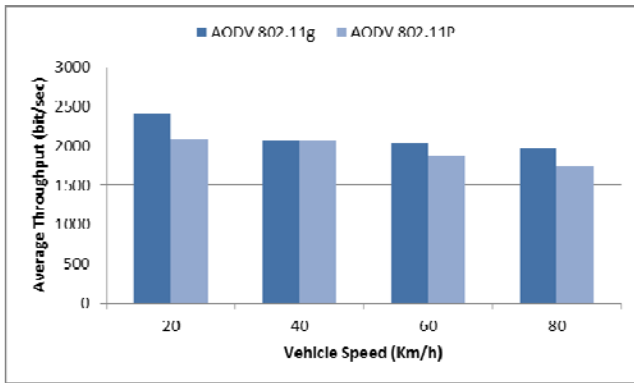


Fig.4 Throughput vs. Vehicle Speed (No. of Vehicles = 75)

From Fig 3 and 4 we can observe that the average throughput of AODV 802.11g is more than AODV 802.11p. The average throughput of AODV using the two MAC protocols is decreased as the number of vehicles and vehicle speed are increased. Figure 5 and 6 shows the performance of AODV using 802.11p and 802.11g in terms of end-to-end delay vs. the number of vehicles and vehicle speed.

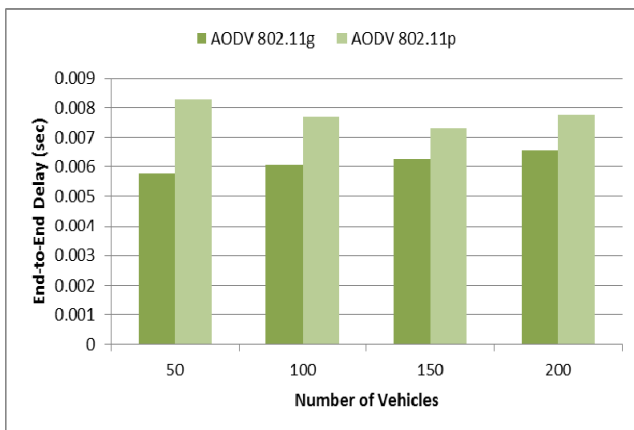


Fig.5 Delay vs. Number of Vehicles (max. Vehicle Speed=50Km/h)

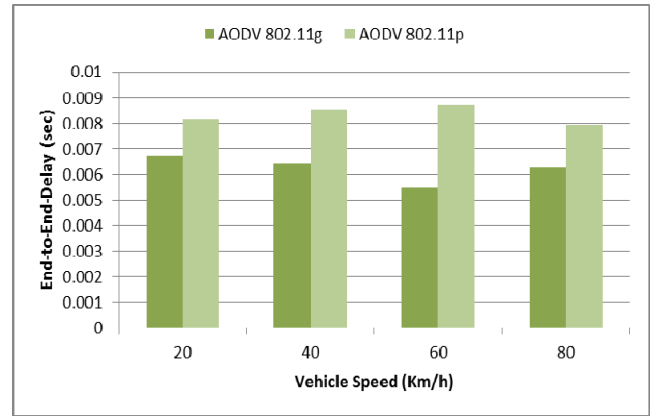


Fig.6 Delay vs. Vehicle Speed (No. of Vehicles = 75)

From Fig 5 and 6 we can observe that the end-to-end delay of AODV 802.11g is less than AODV 802.11p. The end-to-end delay of AODV using the two MAC protocols is increased as the number of vehicles and vehicle speed are increased.

Fig 7 and 8 shows the performance of OLSR using 802.11p and 802.11g in terms of average throughput vs. the number of vehicles and vehicle speed.

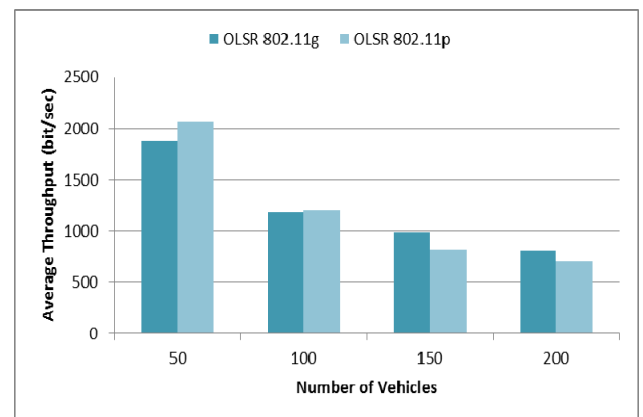


Fig.7 Throughput vs. Number of Vehicles (max. Vehicle Speed=50Km/h)

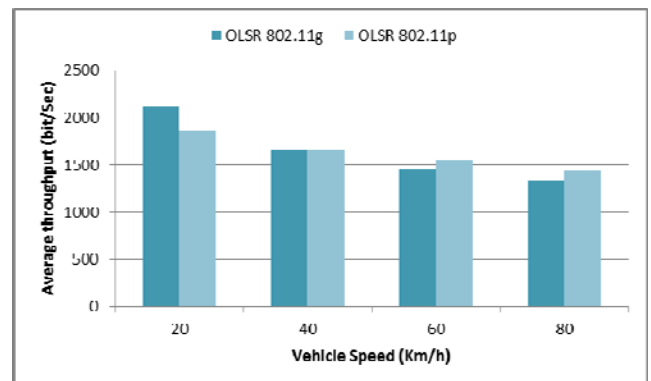


Fig.8 Throughput vs. Vehicle Speed (No. of Vehicle=75)

From Fig 7 and 8 we can observe that the average throughput of OLSR 802.11g is less than OLSR 802.11p when the number of vehicles is low and the vehicle speed is high, but the average throughput of OLSR 802.11g is more than OLSR 802.11p when the number of vehicles is high and the vehicle speed is low. The average throughput of

OLSR using the two MAC protocols is decreased as the number of vehicles and vehicle speed are increased.

Fig 9 and 10 shows the performance of OLSR using 802.11p and 802.11g in terms of end-to-end delay vs the number of vehicles and vehicle speed.

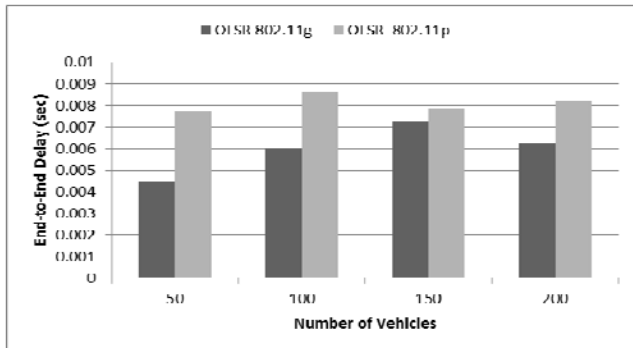


Fig.9 Delay vs. Number of Vehicle (max. Vehicle Speed=50Km/h)

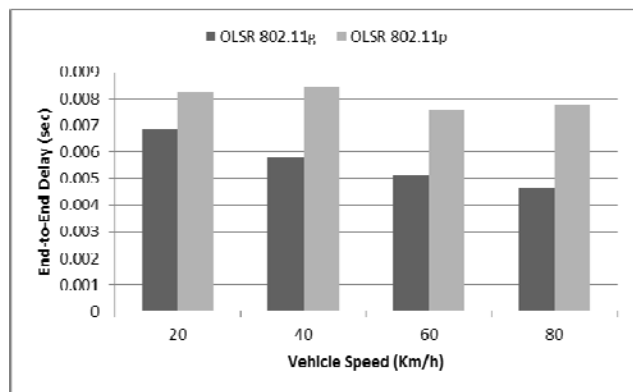


Fig. 10 Delay vs. Vehicle Speed (No. of Vehicle =75)

From Fig 9 and 10 we can observe that the end-to-end delay of OLSR 802.11g is less than OLSR 802.11p. The end-to-end delay of OLSR 802.11g decreases with the increment of vehicles number, but it decreases with the increment of vehicle speed. The end-to-end delay of OLSR 802.11p increases with the increment of vehicles number and speed.

Fig 11 and 12 shows the performance of DYMO using 802.11p and 802.11g in terms of average throughput vs the number of vehicles and vehicle speed.

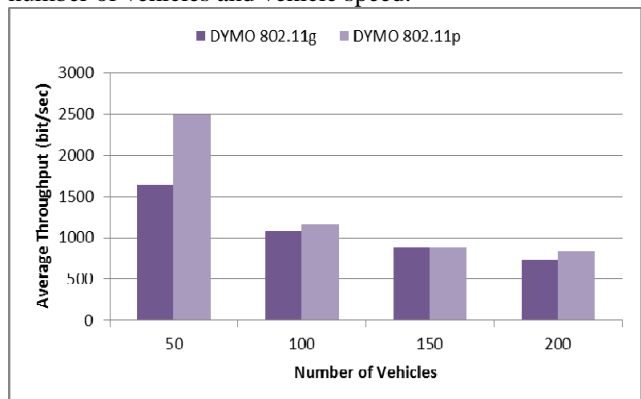


Fig.11 Throughput vs. Number of Vehicles (max. Vehicle Speed=50Km/h)

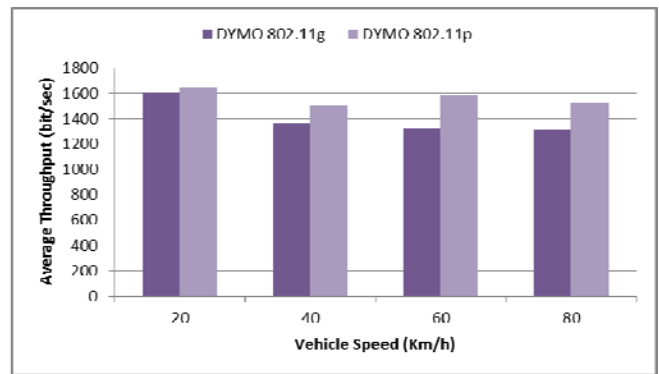


Fig.12 Throughput vs. Vehicle Speed (No. of Vehicle =75)

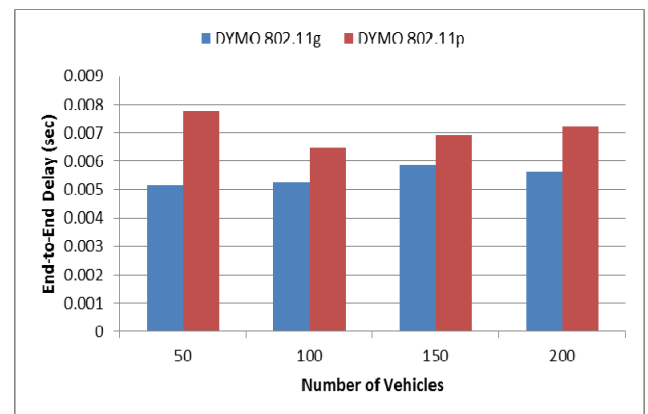


Fig. 13 Delay vs. Number of Vehicles (max. Vehicle Speed=50Km/h)

From Fig 11 and 12 we can observe that the average throughput of DYMO 802.11g is less than DYMO 802.11p. The average throughput of DYMO using the two MAC protocols is decreasing with the increment of vehicles number and speed.

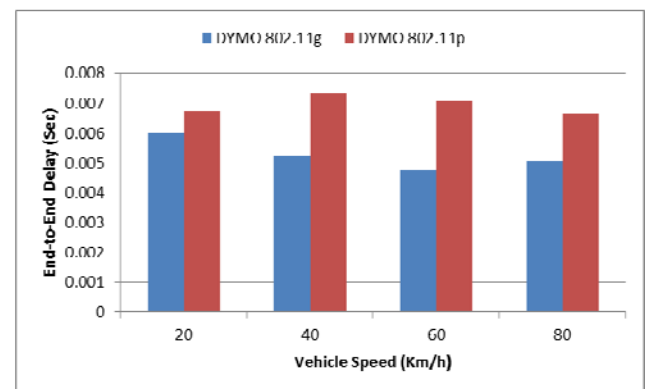


Fig. 14 Delay vs. Vehicle Speed (No. of Vehicle=75)

Figure 13 and Figure 14 show the performance of DYMO using 802.11p and 802.11g in term of end-to-end delay vs the number of vehicles.

From fig 13 and 14 we can observe that the end-to-end delay of DYMO 802.11p is more than DYMO 802.11g. The end-to-end delay of DYMO 802.11g is increasing with the increment of vehicles number, but it is decreasing with the increment of vehicle speed. The end-to-end delay of

DYMO 802.11p is decreasing when the number of vehicle is 100, and it is increasing with the increment of vehicle speed and then it is decreasing when the vehicle speed is 80 Km/h.

B. Highway Scenario

In highway scenario, AODV, OLSR and DYMO are evaluated using IEEE802.11p and IEEE802.11g by varying the number of vehicles for a max speed of 70 Km/h. In addition, the contrast evaluation by varying the vehicle speed has been made the number of vehicle equal to 50 vehicles. Fig 15 and 16 shows the performance of AODV in terms of average throughput vs. the number of vehicles and vehicles speed.

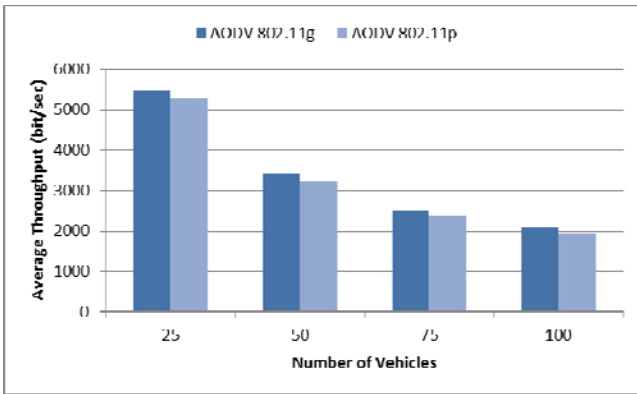


Fig.15 Throughput vs. Number of Vehicles (max.Vehicle Speed=50Km/h)

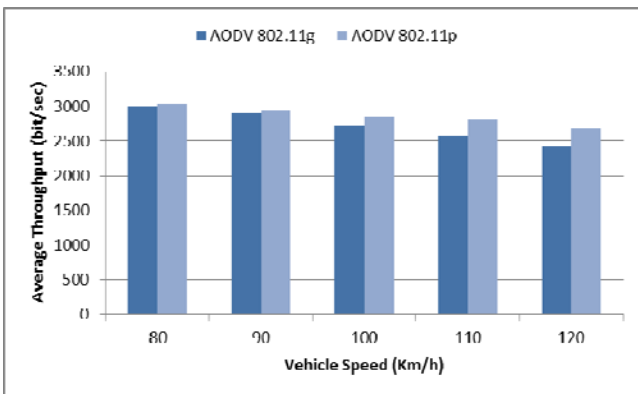


Fig. 16 Throughput vs. Vehicle Speed (No.of Vehicle=75)

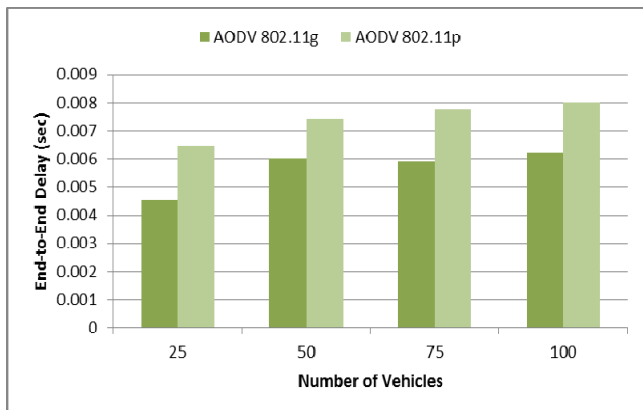


Fig. 17 Delay vs. Number of Vehicles (max.vehicle speed =50Km/h)

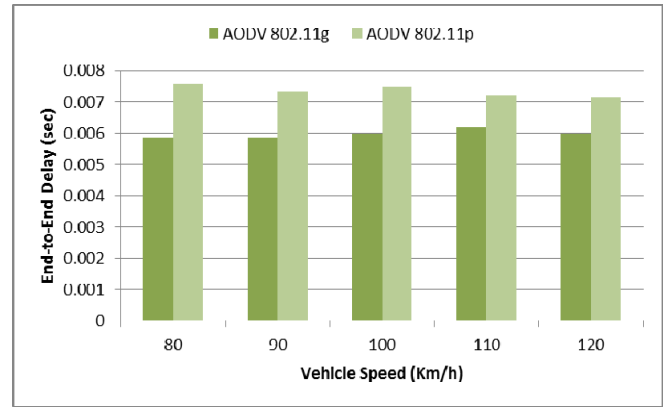


Fig.18 Delay vs. Vehicles Speed (No.of Vehicles=75)

From Fig 15 and 16 we can observe that the average throughput of AODV 802.11g is more than AODV 802.11p when varying the number of vehicles, AODV 802.11p is more than AODV 802.11g when varying the vehicle speed. The average throughput of AODV is decreasing with the increment of the number of vehicle and vehicle speed.

Fig 17 and 18 shows the performance of AODV using 802.11p and 802.11g in terms of end-to-end delay vs. the number of vehicle and vehicle speed.

From Fig 17 and 18 we can observe that the end-to-end delay of AODV 802.11g is less than AODV 802.11g. The end-to-end delay of AODV is increasing with the increment of vehicle speed and the number of vehicle.

Fig 19 and 20 shows the performance of OLSR using 802.11p and 802.11g in terms of average throughput vs. the number of vehicle and vehicle speed.

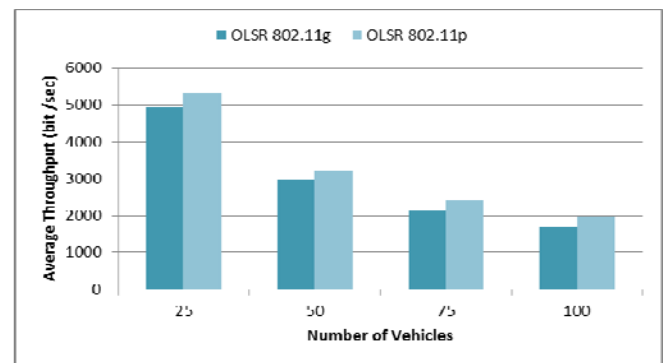


Fig. 19 Throughput vs. Number of Vehicles(max.Vehicle Speed=50Km/h)

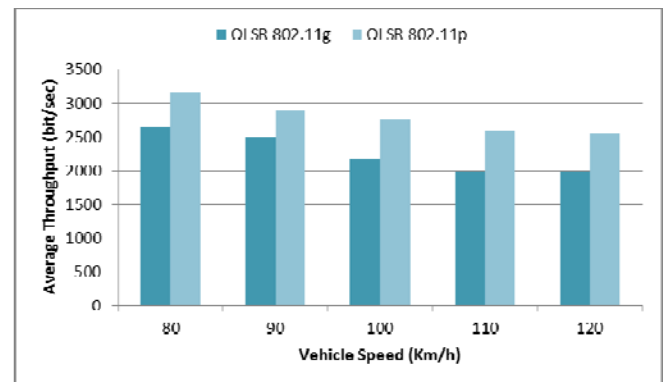


Fig. 20 Throughput vs. Vehicle Speed (No. of Vehicle =75)

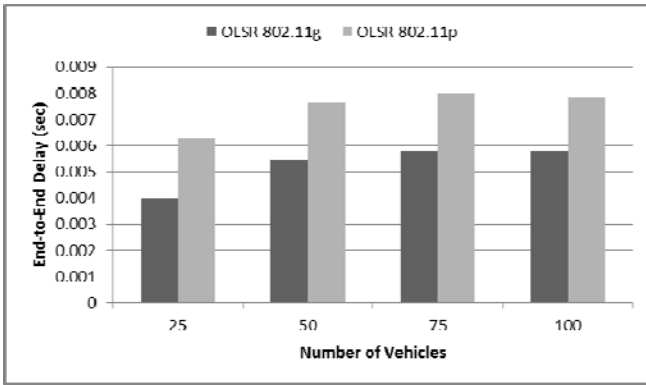


Fig. 21 Delay vs. Number of Vehicle (max. Vehicle Speed = 50Km/h)

From Fig 19 and 20 we can observe that the average throughput of OLSR 802.11g is less than OLSR 802.11p. The average throughput of OLSR is decreasing with the increment of the number of vehicles and vehicle speed.

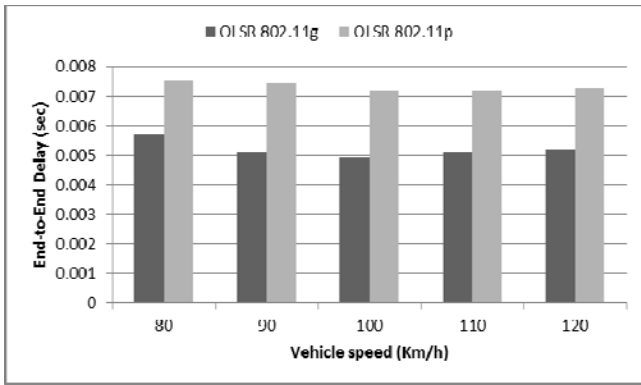


Fig.22 Delay vs. Vehicle Speed (No.of Vehicles=75)

Fig 21 and 22 show the performance of OLSR using 802.11p and 802.11g in terms of end-to-end delay vs the number of vehicles and vehicle speed.

From Fig 21 and 22 we can see that the end-to-end delay of OLSR 802.11p is more than OLSR 802.11g. The end-to-end delay of OLSR is increasing with the increment of the number of vehicle. The end-to-end delay of OLSR is decreasing with the increment of vehicle speed, but then it is increasing when the vehicle speed becomes 110 and 120 Km/h.

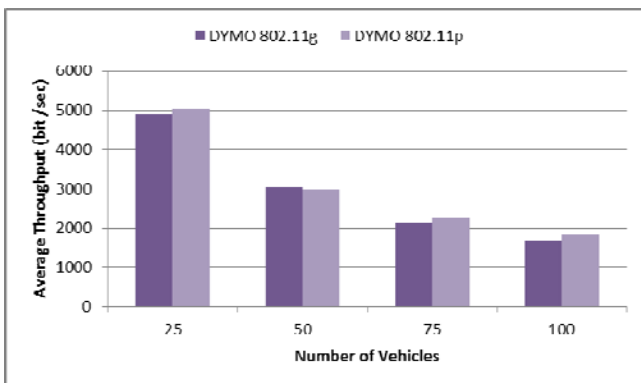


Fig.23 Throughput vs. Number of Vehicles (max. Vehicle Speed =50Km/h)

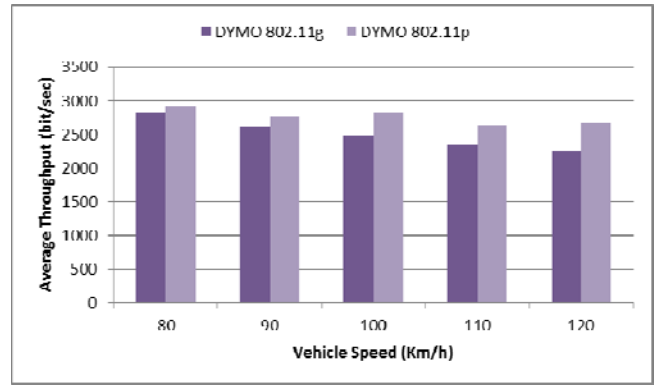


Fig.24 Throughput vs. Vehicle Speed (No. of Vehicle =75)

Fig 23 and 24 shows the performance of DYMO using 802.11p and 802.11g in terms of average throughput vs the number of vehicles and vehicle speed.

From Fig 23 and 24 we can observe that DYMO 802.11g is less than DYMO 802.11p. The average throughput of DYMO is decreasing with the increment of the number of vehicles and vehicle speed.

Fig 25 and 26 show the performance of DYMO using 802.11p and 802.11g in term of end-to-end delay vs the number of vehicles and vehicle speed.

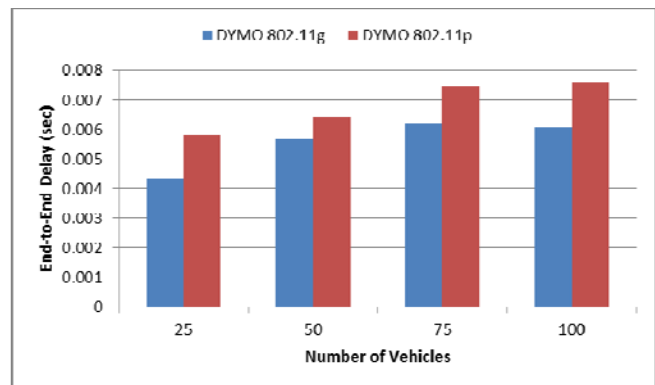


Fig. 25 Delay vs. Number of Vehicle (max. Vehicle Speed =50 Km/h)

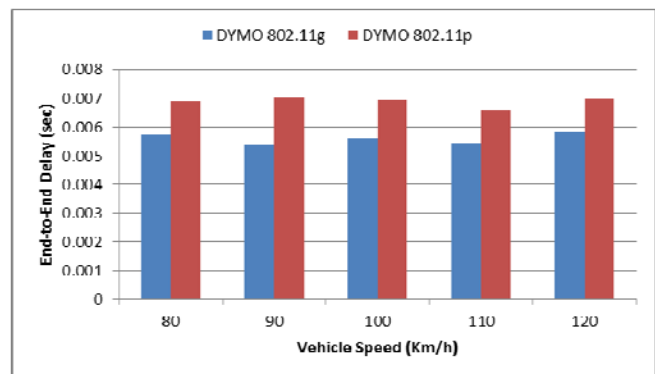


Fig 26 Delay vs. Vehicle Speed (No. of Vehicle =75)

From Fig 25 and 26 we can observe that the end-to-end delay of DYMO 802.11p is more than DYMO 802.11g. The end-to-end delay of DYMO is increasing with the increment of the number of vehicles. But the end-to-end delay of DYMO is varying with the increment of vehicle speed.

VI. CONCLUSION

This paper presented the analysis of three routing protocols AODV, OLSR and DYMO using two MAC protocols IEEE 802.11p and IEEE 802.11g in city and highway scenarios which using the simulation environment OMNeT ++ and SUMO by varying the number of vehicles and the vehicle speeds. However, the simulation results show that AODV outperforms OLSR, DYMO in term of average throughput and OLSR has the lowest throughput than AODV and DYMO. In term of end-to-end delay, however AODV has the highest delay, and DYMO has the lowest delay. However, the performance of all routing protocols using IEEE 802.11p is higher than IEEE 802.11g in terms of end-to-end delay. The average throughput of OLSR and DYMO using IEEE 802.11p is higher than DYMO and OLSR using IEEE 802.11g, but the average throughput of AODV using IEEE 802.11g is higher than AODV using IEEE 802.11p. The future work will concentrate on modifying the AODV in order to decrease the end-to-end delay while keeping the throughput high.

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