Performance Analysis of Vehicular Adhoc Network Using Different Highway Traffic Scenarios in Cloud Computing

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Abstract. Vehicular Ad-hoc Networks (VANETs) combine intelligent vehicles on highways aim to solve many transportation problems. The performance of VANETs is affected by many parameters due to highly dynamic structure. We assessed the performance of VANETs over different highway's scenarios and investigated that under which circumstances the performance will be better and vice versa. We adopted our experiments in infrastructure environment, where the road side units (RSUs) are connected with cloud server. The RSU periodically gathers spatial-temporal information and upload it to cloud, which could help the drivers to predict the status of road before journey. The experiments carried on two types of highway's scenarios: varying vehicles densities and simulation time. The simulation result shows that selected performance metrics (throughput, E2E delay and packet loss) greatly affect in both scenarios. The simulation time within the interval 200 to 500 is an optimal choice during simulation experiments. The throughput and packet loss increases with increase in vehicle density. The end-to-end delay has an inverse relation with vehicle density. The highway scenarios are generated by SUMO and the actual simulation is done by NS2.

Keywords: Cloud computing · Network simulator · Vehicle density · VANET · Performance analysis · Throughput · Packet loss · End-to-end delay

1 Introduction

The adoption of Vehicular Ad-hoc Networks (VANETs) across industry has increased due to advancements in ad-hoc wireless technology. Vehicular ad hoc networks (VANETs) are classified as an application of mobile ad hoc network (MANET) that has the potential to solve many Intelligent Transportation System (ITS) problems. Recently VANETs have emerged to turn the attention of researchers in the field of wireless and mobile communications. VANET differs from MANET by architecture, challenges, characteristics and applications. A VANET has some particular features despite being a special case of MANET and presenting some similar characteristics as well [1].

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J. Ferreira and M. Alam (Eds.): Future 5V 2016, LNICST 185, pp. 157–166, 2017.
DOI: 10.1007/978-3-319-51207-5_15

VANETs can be widely used in safety, traffic information, and other commercial applications such as a road side restaurant advertisement, digital entertainment, etc. [2, 3]. Based on VANETS, Intelligent Transportation System (ITS) [4] is very efficient to improve safety, and reduce transportation times and fuel consumption. In literature, VANETs have two operational modes such as V2I (vehicle to infrastructure) and V2V (vehicle to vehicle). In V2I mode, the vehicles communicate through a central base station called Road Side Unite (RSU) which collects data periodically and send it to the cloud server for traffic management, road safety and decision making. While in V2V, vehicles are independently communicating with each other. Figure 1 shows the architecture of V2V and V2I.

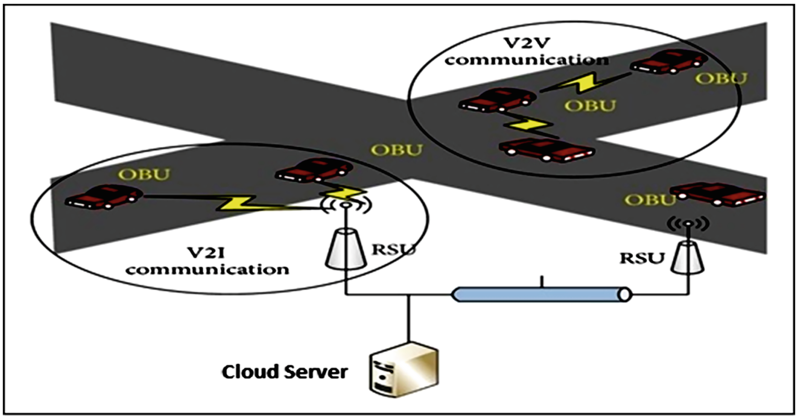

Fig. 1. V2V and V2I operation structure

The high mobile structure of VANET is a challenging task. The existing mobility models are not too dynamic to maintain the highway topology. To get control over the randomize topology structure of VANETs, Vehicle should be enough intelligent to maintain its status. For a consistent and efficient VANET topology, we need two things, a good mobility model that keep track of each vehicle at each moment and second a strong routing algorithm. Routing is the selection of optimal routes for forwarding packets [5]. In this work, we considered a highway of 1 km long for vehicles having RSUs which are further connected with cloud server. The highway mobility model is designed by a prominent simulation framework called Sumo (Simulation of urban mobility) [6]. The highway mobility model is converted to NS2 executable form by MOVE (Mobility Model Generator for Vehicular Networks) [7].

The routing algorithm used in highway simulation is Ad-hoc on Demand Distance Vector (AODV). AODV is a reactive protocol, which discovers routes on demand. AODV can be used in many types' scenarios such as unicast, multicast and broadcast [8]. The different types of control messages used in AODV are Route Request (RREQ), Route Reply (RREP) and Route Error (RERR) [9]. Ahmad *et al.* [9] assessed the performance of OLSR protocol in MANET using different scenarios and performance parameters. We took their work as a motivation and adopted the same scenario cases and performance parameters in VANET Cloud computing. We assessed the performance of AODV protocol in VANET by varying highway topologies and using the same parameters as that of Ahmad *et al.* [9].

We measured throughput, packet loss and End-to-End delay under different highway scenarios and concluded that the given parameters significantly effect by increasing vehicles density. The simulation time after 500 s doesn't significantly affect the performance of highway's vehicles. The statistics of all performance parameters are uploaded to the cloud for efficient traffic planning.

The rest of the paper is organized as follows: Sect. 2 describes the existing work, Sect. 3 having simulation results and discussion, and finally in Sect. 4, we concluded our work.

2 Literature Overview

Das et al. in [10] evaluated the performance comparison of various adhoc routing protocols i.e. LARI, AODV and DSR in terms of Packet Delivery Ratio for VANETs. The performance of these protocols is studied with varying node speeds and traffic density. As a result, the LARI protocol outperforms than AODV and DSR when the network is sparsely populated. The successful delivery of the message was nearly 99.52% in LARI protocol.

The authors in [11] evaluated the performance of reacting protocols namely, AODV and DSR on highly dense and mobile network based on different parameters i.e. Throughput, End-to-end delay and Packet Delivery Ratio. They compared the performance of their selected protocols with newly developed protocol DYMO.

Their simulation shown, that the overall throughput of DYMO is much better than the other two protocols and also end-to-end delay was lowest, when compared with the other (AODV, DSR). However packet delivery ratio of AODV was better than DYMO and DSR. Perdana *et al.* in [12] evaluated the performance of PUMA routing protocol using Manhattan Mobility Model with effect of Nakagami fading distribution in VANET. The performance was analyzed by varying the traffic parameters in the Manhattan mobility model from low to high traffic condition. At the end, they concluded that Nakagami fading and Manhattan mobility model affected the Quality of Service (QoS) in VANET. In [13] the authors analyzed the performance of AODV and GPSR routing protocols in VANET in different scenarios under different traffic conditions with respect to Packet Delivery Ratio (PDR) and average End-to-End Delay (E2ED). Their simulation results showed that AODV performs better with respect to PDR and GPSR outperforms AODV with respect to E2ED. Also, the performance of both the routing protocols depends on scenario and traffic's type.

Shaheen *et al.* [14] examined two routing protocols (AODV and DSR) over two different scenarios (dense and sparse). Both protocols are measured using different performance metrics such as Packet Delivery ratio (PDR), Throughput, End-to-End Delay. According to their simulation results, AODV outperformed than DSR in case of dense scenario, while the DSR protocol is better than AODV, when the network scenario was sparsely populated. Ahmad *et al.* [9] studies the most prominent and widely used protocol i.e. Optimized Link State Routing (OLSR) for MANETS. Their paper presents the performance evaluation of OLSR protocol for TCP and UDP traffic patterns by varying parameters like node density, node speed and pause time. The performance of OLSR has been assessed in terms of performance metrics, such as packet loss, end-to-end delay and throughput under different network scenarios. The results prove that, TCP performs considerably well in terms of throughput, end to end delay and packet loss in different node density and mobility scenarios, while UDP is better in case of pause time.

In this paper, we considered one kilometer long highway and assessed the performance of ad-hoc on demand distance vector (AODV) using the same parameters used in [10]. Our simulation is adopted in real life highway scenario, where the performance is analyzed under different simulation time and vehicle's density. Also the vehicular cloud computing technology is embedded in experiments to minimize traffic congestion, accidents, travel time and environmental pollution. Further our previous work on performance improvement is available [15–19].

3 Simulation Results and Discussions

This is section having information about the simulation environment, tools and results along with discussion. In short, the simulation is carried out on a long highway of length 1 km having vehicles vary from 10 to 100. The ad-hoc on demand distance vector (AODV) works on the top of each vehicle to trace packet transmission. The vehicles will be equipped with communication, computing and sensing devices, and the universal networks will make the internet available during travelling. Thus, the driving experience will be more enjoyable, comfortable, safe and environmental friendly. The performance parameter for assessment VANETs robustness under varies vehicle densities and simulation times are throughput, packet loss, and end-to-end delay.

3.1 Simulation Environment

The high dynamic nature of VANET faces many challenges in real adaptation. The instance change in topological structure of VANET is a big challenge for all existing mobility model [16]. We used three different tools for our experiments. The combo of Sumo and Move are used for designing an operational highway of ongoing vehicles. On the other hand, NS2 is used for actual performance assessment under different scenarios. All the sensed data of highway's vehicles are collected through RSUs, which are further uploaded to the cloud for driver decision making. In this paper we have used Network Simulator version 2 (NS-2) is one of the prominent simulators used to simulate VANETs routing protocols in different scenarios. Manhattan Grid model is adopted in simulation for the movement of nodes [17]. This mobility model is used by NS2.35 to simulate realistic vehicle movement. The simulation parameters for highway traffic design are given in Table 1. We have used Simulation of Urban Mobility (SUMO) [6] is an open source, highly portable, microscopic road traffic simulation package designed to handle large road networks and the Mobility Model Generator for

Table 1. Highway scenario parameters

Parameter	Value
Simulator	Sumo 0.12.3, Move v2.9
Mobility model	Manhattan grid
Simulation time	200, 400, 600, 800, 1000
Highway length	1 km
Number of junctions	3
Number of nodes	10–100
Vehicle's min speed	100 km/h
Vehicle's max speed	120 km/h
Number of lanes	2
Traffic lights	3

Vehicular Networks (MOVE) was recently introduced to make ease of Sumo usage [7]. It is a simple parser for the SUMO and enhances SUMO's complex configuration with a nice and efficient GUI. The simulation parameters are given in Table 2.

Table 2. Simulation conditions

Simulation conditions	Value
Traffic type	UDP
Number of nodes	100
Routing protocol	AODV
Mac protocol	IEEE 802.11p
Packet size	1000

3.1.1 Network Simulator

Network Simulator (NS-2) is one of the prominent simulators used to simulate VANETs routing protocols in different scenarios. Manhattan Grid model is adopted in simulation for the movement of nodes [17]. This mobility model is used to simulate realistic vehicle movement. The simulation parameters are given in Table 2.

3.2 VANETs Performance Analysis on Highway's Vehicles

In this section, we evaluated the performance VANETs over highway with respect to different vehicle density and Simulation time. The performance is assessed by three performance parameters such as throughput, delay, and packet loss. The simulation environment is considered according to Tables 1 and 2.

3.2.1 Simulation Time Impact on Highway's Vehicles

In order to assess the simulation time impact on highway's vehicles, we kept the speed and vehicle density constant to 100 km/h and 50 Veh/km vehicles respectively.

3.2.1.1 Throughput vs Simulation Time

The line graph in Fig. 2 shows that throughput increase with increase in simulation time. Hence we concluded that for an optimal simulation experiments, we have to keep the simulation time in the interval 500 to 1000 s.

A small simulation time causes unrealistic performance, because all the nodes are not participating in short simulation run. Figure 2 also depicts that after a specific simulation interval, the throughput remains constant as shown in simulation time 800 and 1000 s.

3.2.1.2 End-to-End Delay vs Simulation Time

The end-to-end delay in a short simulation run seems quite long duration as shown in Fig. 2. In short, we can say that, delay and simulation time are indirectly proportion to each other. The end to end delay remains constant after specific simulation run time as shown in Fig. 2.

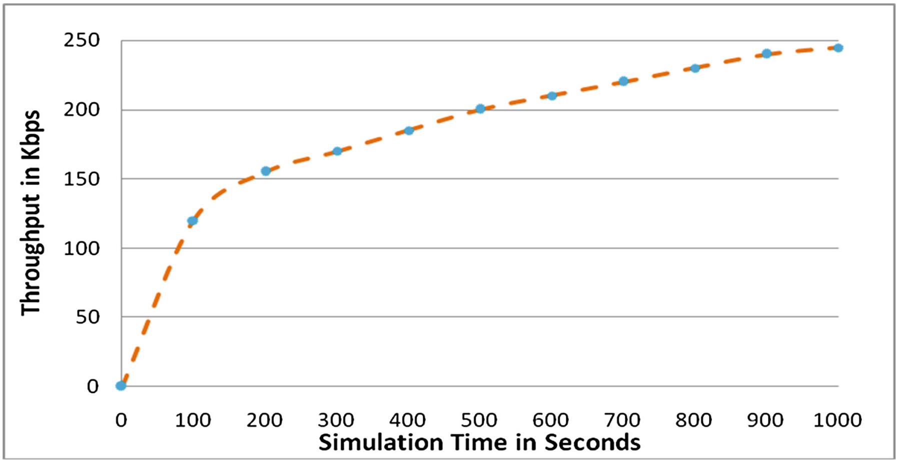

Fig. 2. Simulation time impact on throughput

3.2.1.3 Packet Loss vs Simulation Time

The packet loss has directly proportional relation with simulation time as shown in Fig. 3. But after getting a specific simulation time run, we will experience constant packet loss rate. From Figs. 1, 2, 3, and 4, we concluded that we should keep a moderate simulation time for experiments. Small simulation duration causes to un-realistic results, while too long just waste of time.

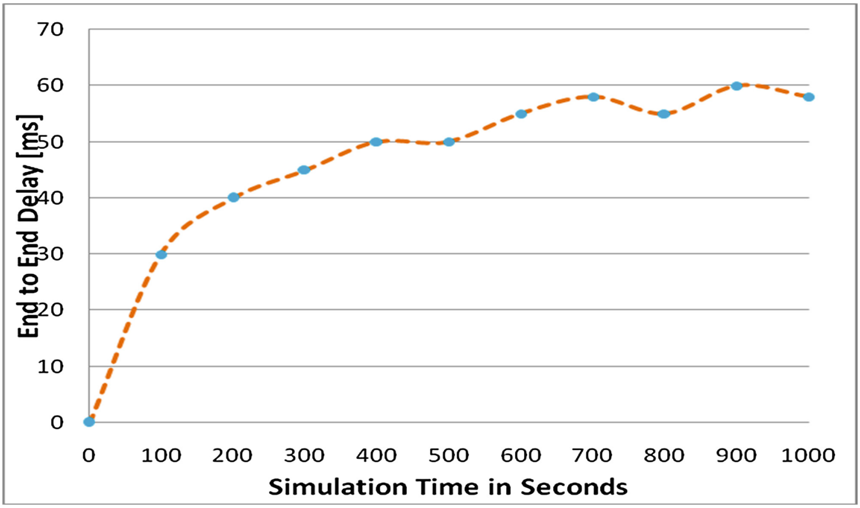

Fig. 3. Simulation time impact on E2E

3.2.2 Vehicle Density Impact on Highway's Vehicle

Vehicle density refers to number of nodes passing through per unit highway's length. In this section, we analyzed the vehicle density impact on highway's vehicles by using throughput, delay and packet loss.

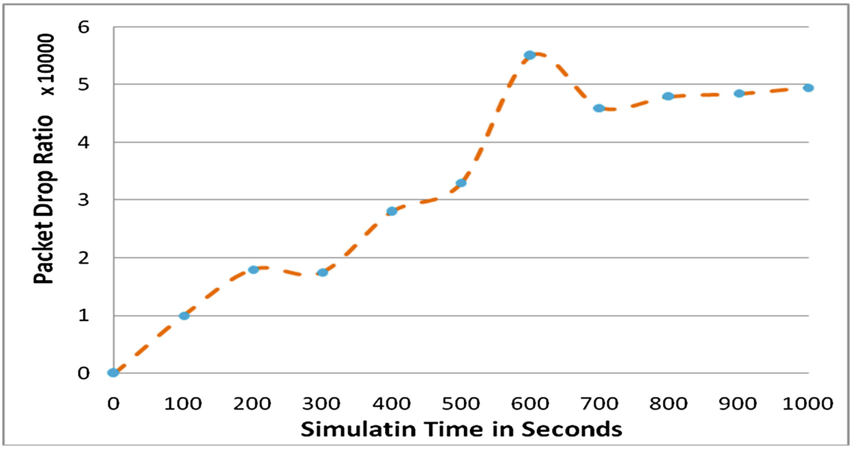

Fig. 4. Simulation time impact on packet loss

3.2.2.1 Throughput vs Vehicle's Density

The average throughput increases with vehicle density as shown in Fig. 5. We kept 10% of the vehicles as traffic agents on highway. Hence with increase in vehicle's density the traffic agents also increases and over all throughput increases.

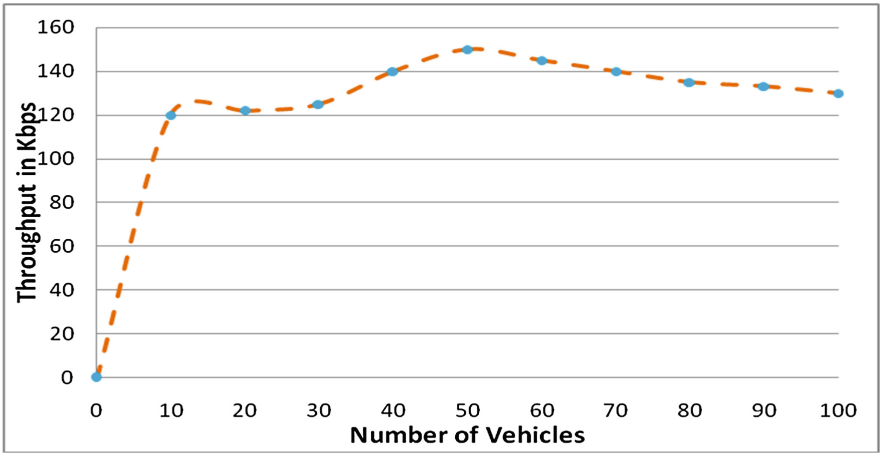

Fig. 5. Vehicle density impact on throughput

3.2.2.2 End-to-End Delay vs Vehicle's Density

The relationship between delay and density is not very clear as depicts in Fig. 6. It has some exponential up and down, which shows that position of communicated nodes also effect the performance.

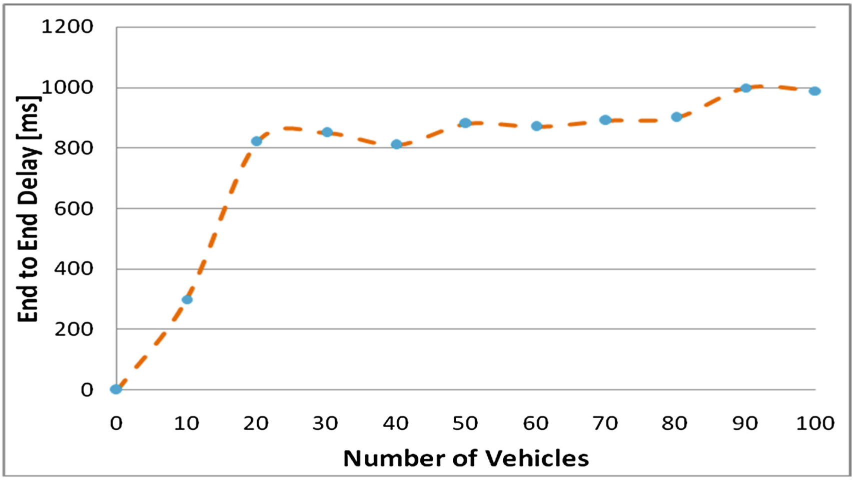

Fig. 6. Vehicle density impact on E2E

3.2.2.3 Packet Loss vs Vehicle's Density

The increase of vehicle's density on highway degrades the performance of packet delivery as shown in Fig. 7. The high packet drop in Fig. 7 is a notification of traffic jam.

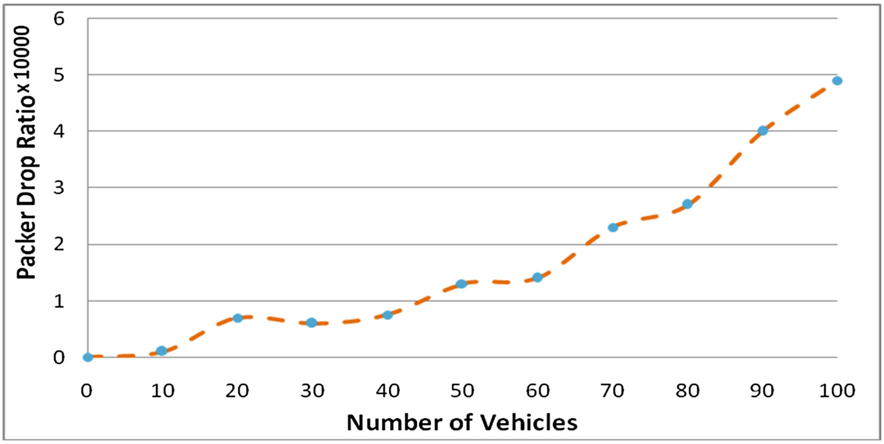

Fig. 7. Vehicle density impact on packet loss

4 Conclusion

In this paper, we analyzed the performance of VANET using different highway's traffic scenarios in cloud computing. From simulation results, we concluded that, Simulation time has significant affect on VANETs performance. A moderate simulation time will be an optimal choice for good results. In a short time interval, all the nodes will not participate in the simulation, which will affect the results. Similarly keeping to much long time has no impact, because after a specific time, the values of all performance parameters become constant. The throughput and packet loss are directly proportional to vehicle density. The throughput and packet loss in a congested condition are significantly more than normal traffic. The relation between End-to-End delay and vehicle density is ambiguous as it has some variability which affects the performance. Our design framework will provide an intermediate platform in the form of cloud server, which could provide the ongoing status of highway.

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