Performance Comparison of Routing Protocols in VANETs using Network Simulator-NS3

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***Abstract*—**Vehicular communication is the area of interest for researchers and automobile industry for providing intelligent transportation. In this paper the performance of different routing protocols has been observed in a vehicular scenario using network simulator NS3. The performance evaluation parameters are Average Goodput, MAC/PHY overheads and basic safety message packet delivery ratio (BSM PDR). AODV proves a good routing protocol in the simulations for low density vehicles but in high density scenario DSDV surpasses other protocols

Keywords— *AODV; DSDV; NS3; OLSR; VANET.*

I. INTRODUCTION

Many researchers, automobile industries and transportation department of different countries are involved in providing secure and safe communication between vehicles [1] [2]. Vehicular Ad hoc networks (VANET) is an emerging field that can provide communication between vehicles over a large geographical area with or without the aid of infrastructure [3]. VANET provides three types of vehicular communication such as vehicle to vehicle (V2V), vehicle to infrastructure (V2I) and hybrid. The information related to transportation, road traffic, driver's message, natural disaster alert, media sharing and safety messages are shared between the vehicles [4]. Despite having many features VANET faces challenges like frequently disconnected network, high moving speed of vehicles, dynamic topology etc. [1]. Vehicular communication started with a short and middle range Dedicated Short Range Communication (DSRC) service which is based on the IEEE 802.11a physical and MAC layer. Due to the various challenges of VANETs, now it is migrated to IEEE 802.11p and IEEE 1609 which is standard for wireless access in vehicular environments (WAVE) [1] [5].

A plenty of vehicular ad hoc networks (VANET) projects are running to facilitate this approach with the aim to provide the society a relief from traffic jams and fuel wastage. Connected Vehicle working with the U.S. Department of Transportation's, CODECs, Car2Carcommunication consortium, AdaptIVe, ROADART, MAVEN etc. [1] [6][7] are some of the major projects working presently on vehicular communication.

II. RELATED WORK

Some of the work on performance comparison of VANET routing protocols has been carried out in the past. The paper [8] presents comparison of Ad hoc on demand distance vector (AODV), Ad hoc on demand multipath distance vector (AOMDV) and Destination Sequenced Distance Vector (DSDV) comparison on the basis of simulation carried out in a realistic scenario. A highly fading urban realistic environment was used for the simulative comparison of AODV and Optimized link state routing (OLSR) by [9]. Routing protocols are compared by [10] using IEEE 802.11b as MAC layer protocol and Friis Model as path loss model. Vehicular Multi-hop algorithm for Stable Clustering (VMASC) performance is compared with other routing protocols in a realistic environment [11].

The objectives of this paper is to compare the performance of routing protocols AODV, OLSR and DSDV on the basis of simulations carried out with a highway scenario in network simulator NS3[12] using basic safety messages (BSM) broadcasted by every vehicle. The simulation set up has been varied in terms of number of vehicles, vehicle speed in order to find better comparison results.

The rest of the paper is organized in the following sections. Section 3 provides the introduction of routing protocols used. The details of simulation scenario are provided in Section 4. Section 5 presents the performance evaluation parameters for routing protocols. Section 6 is simulation results that provides the comparison of different routing protocols. Section 7 is the conclusion of this paper.

III. ROUTING PROTOCOLS USED

As the vehicles move with different speeds and different destination location, the topology of VANETs is frequently changing and highly mobile [13]. Routing protocols are required for providing routes to the packets carrying routing as well as data information. We used three different routing protocols AODV, OLSR and DSDV for performing simulations. Ad Hoc On Demand Distance Vector (AODV)[14] establishes new links by broadcasting route request messages and establishes connection only when required. It also repairs the broken links faster. Optimized Link State Routing (OLSR) is a proactive protocol that comes in table driven category. This protocol uses multi point relay (MPR) scheme for communicating the routing information with the immediate nodes. The MPR reduces the network load arises during the broadcast of same messages by different nodes [15][16]. Destination sequenced distance vector routing (DSDV) is also a table driven routing protocol that has the routing information of the full network always. It updates the routing table at a particular interval of time using full dump method or incremental update method. Incremental update only increment the data with that of previous update sent [16].

IV. SIMULATION SCENARIO

For analyzing the performance of routing protocols in vehicular ad hoc networks a straight highway scenario of 300 × 1500m is used. The experiments are performed with consideration of low as well high density of vehicles with the variation in speed of vehicles. The routing protocols used are AODV, DSDV and OLSR. Basic Safety Message application is used for broadcasting 10 messages of 200 byte from each node per second at 6Mbps rate. The Table 1 shows the details of simulation setup.

Table.1 Simulation Setup

Parameter	**Specifications**
Platform	Ubuntu16.04 LTS
Simulation TOOL	Network Simulator-3.28
IEEE Scenario	VANET(802.11p)
Mobility Model	Random Way Point
No. of Vehicles	30,60,90,120
Speed of Vehicles	14,17,20 m/sec.
Traffic Type	TCP
Path loss Model	Two ray ground
MAC Layer	IEEE 802.11p
Routing Protocols	AODV, OLSR, DSDV
Transmission Max. Delay	10 ms
Simulation Area	250m*3000m
Transmission Power	7.5 dBm
Channel	Wireless Channel
Simulation Time	20,40,60,80,100,120 sec.

V. PERFORMANCE EVALUATION PARAMETERS

The routing performance of various protocols used has been evaluated on the basis of Average Good put, MAC/PHY layer overhead and Basic safety Message Packet delivery Ratio (BSM PDR).

Average Goodput: It is considered as an evaluation parameter over throughput in VANET as it considers only useful data that is in the form of basic safety messages. It is calculated as the ratio of information file size over the time needed to transfer it. It is considered as the throughput of application layer. Goodput can be measured in bits per second (bps), kilo byte per second (kbps) or megabyte per second (Mbps) [11].

MAC/PHY overhead: In this paper we have used basic safety messages (BSM) that are broadcasted every second. BSM is an application used in vehicular ad hoc networks for sharing useful information. Routing protocols generate routing packets for information related to route update in the network. These packets do not contain any information related to application. The network bandwidth is shared by both types of packets (routing and application). Therefore routing packets are known as overheads in the network and these should be less for better performance of a routing protocol [17]. It is calculated with the formula shown below:

$$\text{MAC} \therefore \text{PHY layer overhead} = \frac{\text{total physical bytes} - \text{total application bytes}}{\text{total physical bytes}}$$

Basic Safety Message Packet Delivery Ratio (BSM PDR): In this work, every second each node broadcasts 10 BSM. The overall packet delivery ratio for individual BSM is calculated for the full simulation time. It is observed that a high PDR provides more reliable communication in the network. It is calculated with the formula shown below:

$$\text{BSM PDR} = \frac{\text{Received BSM Packets}}{\text{Transmitted BSM Packets}}$$

VI. SIMULATION RESULTS

Four analysis have been made from the simulations performed on NS3.

Analysis 1: The simulations using routing protocols AODV, OLSR, DSDV has been carried out to find the average good put, packet delivery ratio for basic safety messages (BSM PDR) and routing overheads using constant vehicle speed of 14m/s and varying the number of vehicles from 30, 60, 90, 120. As shown in Fig. 1.1 the AODV shows highest good

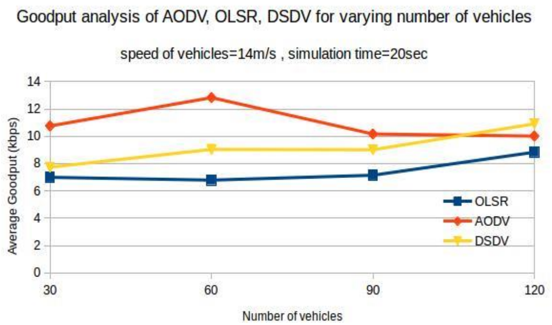


Fig. 1.1 Goodput analysis with vehicle speed 14m/s

put of 10.75, 12.83, 10.16 kbps when the number of vehicles are 30, 60, 90 respectively as compare to the other two. But when the density of vehicles is raised to 120 it fall down to 10kbps with that of 10.91kbps obtained from DSDV. The good put performance of OLSR is least among the AODV and DSDV.

For the calculation of MAC/PHY layer overhead using the same scenario the performance is almost similar to that of good put analysis as shown in Fig. 1.2.

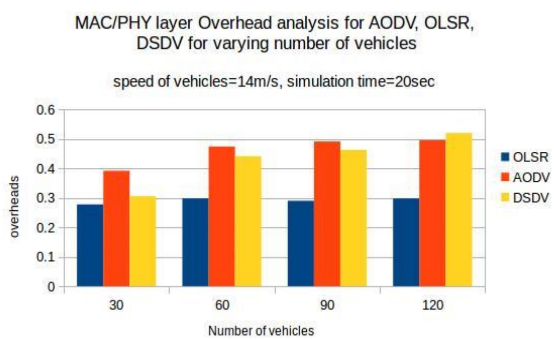


Fig. 1.2 MAC/PHY overhead analysis for vehicle speed =14m/s

The overheads are least in OLSR routing for all the four vehicle densities. DSDV routing provides the maximum overheads 0.520397 with the highest density of 120 vehicles, while in the first three vehicle densities 30, 60, 90) it provides less overheads to that of AODV.The BSM PDR is also calculated for all the four node densities and represented by graphs as shown in Fig. 1.3, 1.4, 1.5 and 1.6.

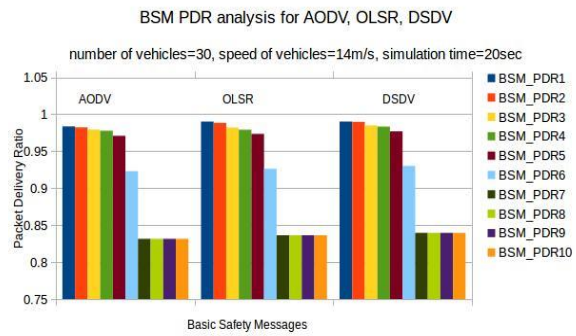


Fig. 1.3 BSM PDR analysis for 30 vehicles with speed =14m/s

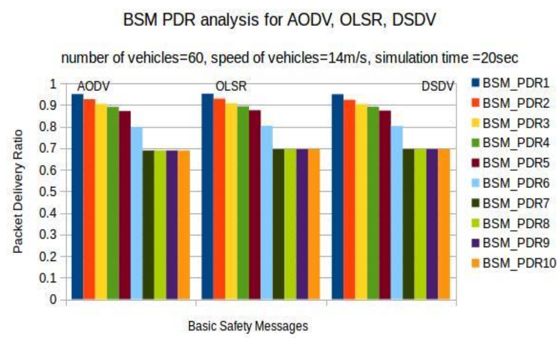


Fig. 1.4 BSM PDR analysis for 60 vehicles with speed =14m/s

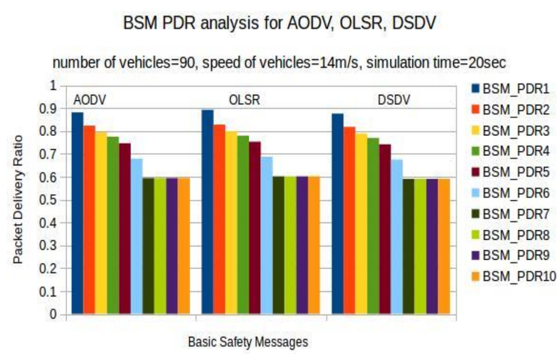
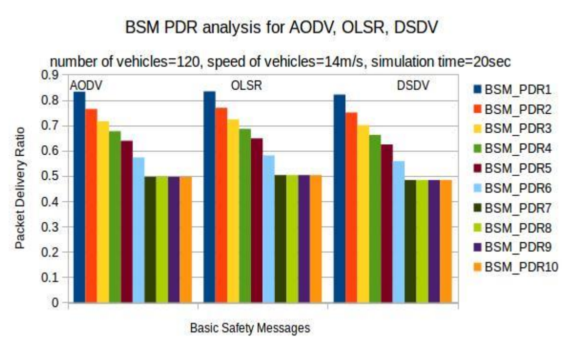


Fig. 1.5 BSM PDR analysis for 90 vehicles with speed =14m/s



.**Fig. 1.6** BSM PDR analysis for 120 vehicles with speed =14m/s

The results shows that the PDR for all 10 basic safety messages is very close for the three routing protocols used. The highest PDR is achieved by the DSDV for all the 10 messages and AODV shows the least PDR. While the performance of OLSR is between DSDV and OLSR.

Analysis 2: The similar simulations are carried out in this analysis as in analysis 1 with the change in speed of moving vehicles changed to 17m/s from 14m/s. The average good put calculated from the three routing protocols is displayed in Fig. 2.1 with the help of graph. The good put shows that AODV is the best protocol for all the four vehicle density scenarios. However the good put (11.8784 kbps) for DSDV in case of 120 vehicles is very close that of AODV (11.9808 kbps). The good put achieved using OLSR is the least from that of AODV and DSDV.

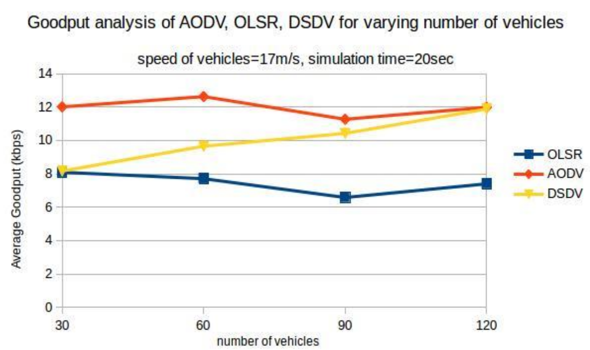


Fig. 2.1 Goodput analysis with vehicle speed 17m/s

The MAC/ PHY layer overhead calculated in this analysis are represented in Fig. 2.2.

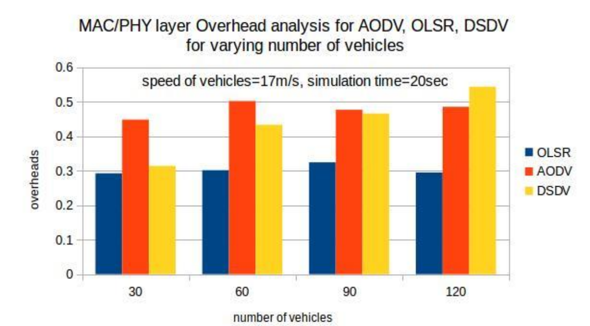


Fig. 2.2 MAC/PHY overhead analysis for vehicle speed =17m/s

The overheads calculation shows the similar performance results to that of in analysis 1 with the speed of 14m/s. The least number of overheads are obtained using OLSR in all the four vehicle density (i.e. 30, 60, 90 and120). The DSDV provides less number of MAC/PHY layer overhead as compare to AODV except in the case of 120 nodes (i.e. highest density).The basic safety messages communicated during this simulation are analyzed via Fig. 2.3, 2.4. 2.5 and 2.6. The observations shows OLSR provides better packet delivery ratio as compare to AODV and DSDV.

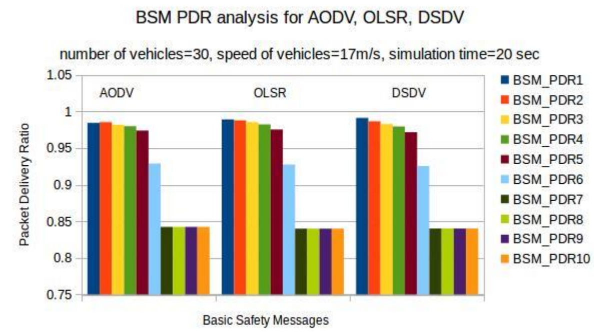


Fig. 2.3 BSM PDR analysis for 30 vehicles with speed =17m/s

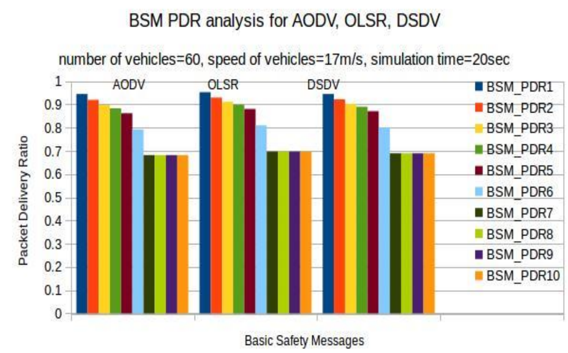


Fig. 2.4 BSM PDR analysis for 60 vehicles with speed =17m/s

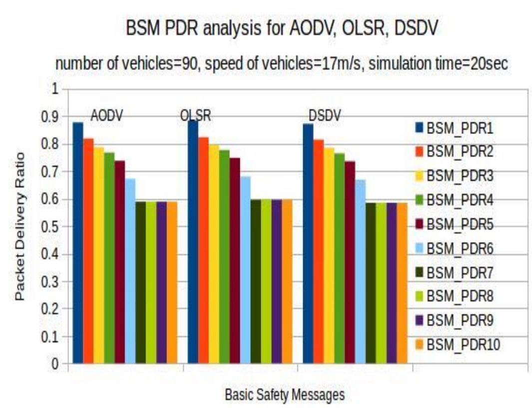


Fig. 2.5 BSM PDR analysis for 90 vehicles with speed =17m/s

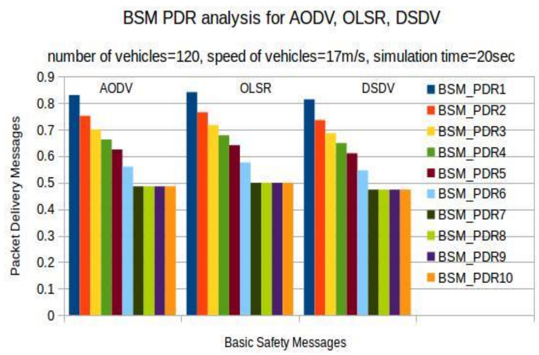


Fig. 2.6 BSM PDR analysis for 120 vehicles with speed =17m/s

Analysis 3: In this analysis the speed of vehicles is further raised to 20m/s from 14m/s and 17 m/s as in analysis 1 and 2 respectively. The Fig. 3.1 represents the

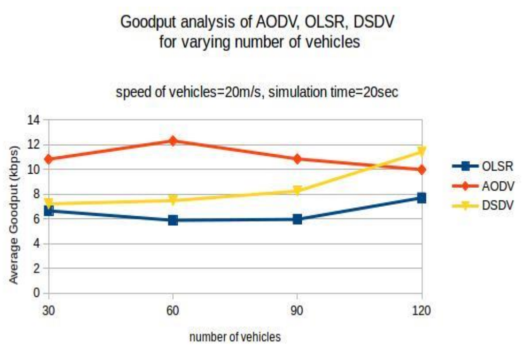


Fig. 3.1 Goodput analysis with vehicle speed 20m/s

graph for average good put calculated from the three routing protocols. The graph shows that AODV is the best protocol for the vehicle density of 30, 60 and 90.

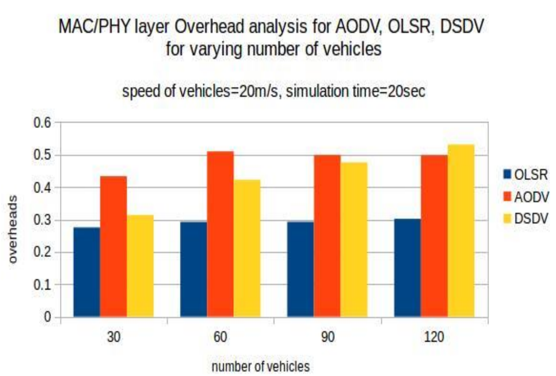


Fig. 3.2 MAC/PHY overhead analysis for vehicle speed =20m/s

However the good put for AODV has been observed low to that of DSDV for high density scenario of 120 vehicles.The good put of 9.984 kbps for AODV is quite below to that of 11.4176 kbps of DSDV. The OLSR provides good put near to that of DSDV in low density of 30 and 60 vehicles. Overall the good put is observed to be the least from that of the other two routing protocols. The MAC/ PHY layer overhead calculated in this analysis are represented in Fig. 3.2.The overheads calculation shows the similar performance results to that of in analysis 1 and 2 with the speed of 14m/s and 17m/s. The least number of overheads are obtained using OLSR in all the four vehicle density (i.e. 30, 60, 90 and120).

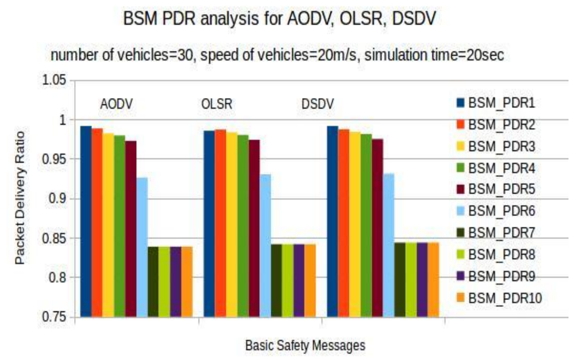


Fig. 3.3 BSM PDR analysis for 30 vehicles with speed =20m/ s

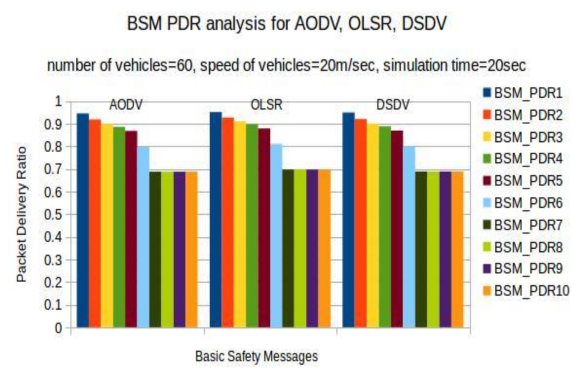


Fig. 3.4 BSM PDR analysis for 60 vehicles with speed =20m/ s

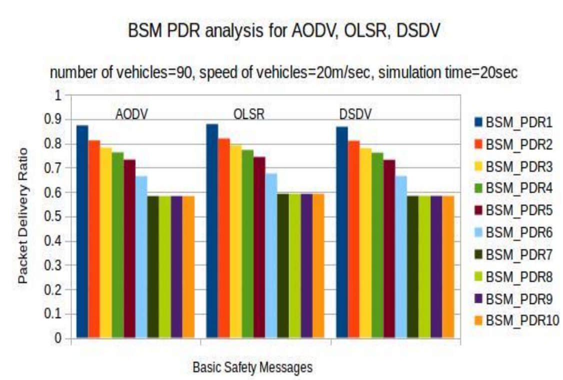


Fig. 3.5 BSM PDR analysis for 90 vehicles with speed =20m/ s

The DSDV provides less number of MAC/PHY layer overhead as compare to AODV except in the case of 120 nodes (i.e. highest density). The basic safety messages communicated during this simulation are analyzed via Fig. 3.3, 3.4, 3.5 and 3.6.The observations shows OLSR provides better packet delivery ratio as compare to AODV and DSDV.

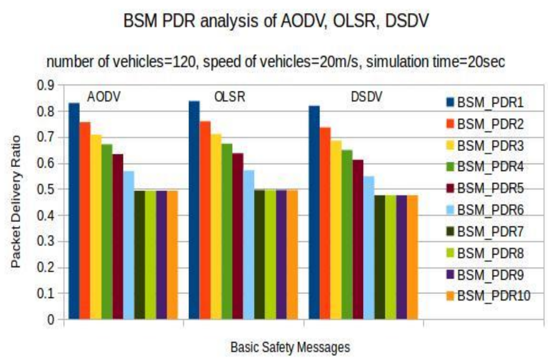


Fig. 3.6 BSM PDR analysis for 120 vehicles with speed =20m/ s

Analysis 4: The above three analysis are made on the basis of variation in vehicle density and the average good put, MAC/PHY layer overheads and BSM PDR are the parameters on the basis of which the performance of AODV, OLSR and DSDV are calculated and plotted in graphs. From the above experiments speed of vehicle is another parameter effects the routing protocol performance.

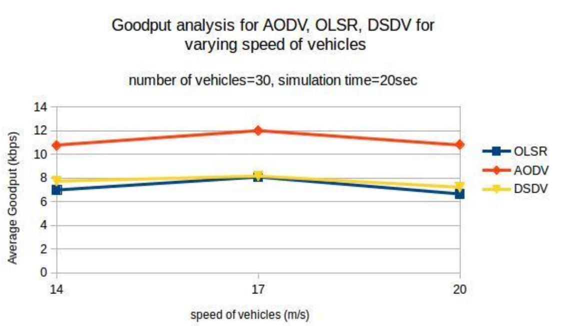


Fig. 4.1 Goodput analysis for 30 vehicles with speed=14, 17, 20m/s

The speed of vehicle is kept between 50 to 72 Km/hr i.e. 14, 17, 20 m/sec. The Good put is analyzed with 30, 60, 90 and 120 vehicles for varying vehicle speed and is plotted in graphs shown in Fig. 4.1, 4.2, 4.3 and 4.4 respectively.

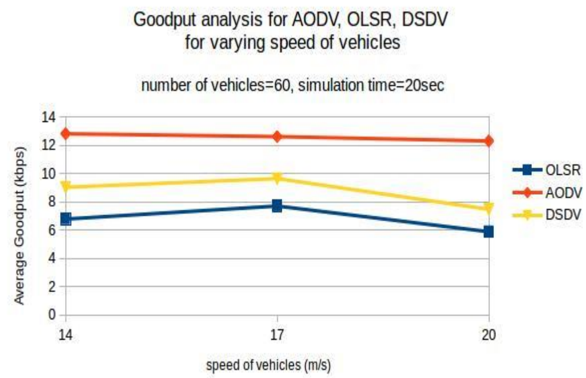


Fig. 4.2 Goodput analysis for 60 vehicles with speed=14, 17, 20m/s

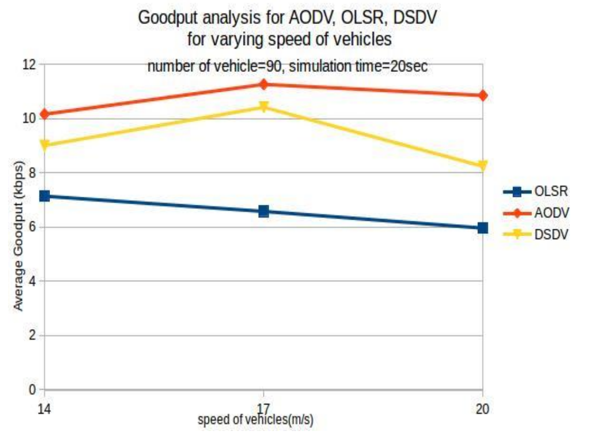


Fig. 4.3 Goodput analysis for 90 vehicles with speed=14, 17, 20m/s

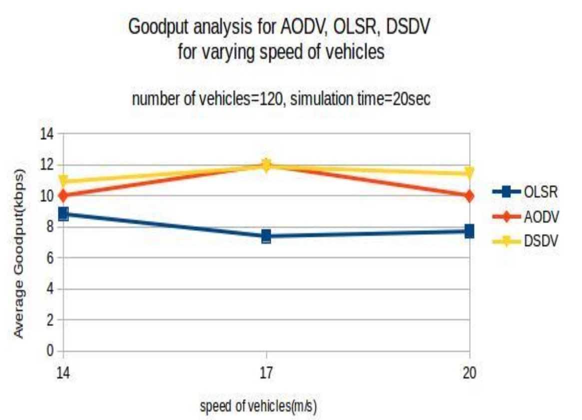


Fig. 4.4 Goodput analysis for 120 vehicles with speed=14, 17, 20m/s

The first observation from the below four good put graphs shows that for the speed of 17m/sec the highest good put is achieved by all three routing protocols in low to high density vehicle ranging from 30, 60, 90 and 120. The second observation is that OLSR provides the least average good put as compare to AODV and DSDV in all three speed variation in low to high vehicle density. The third observation is that AODV performs better than the OLSR and DSDV in 30, 60 and 90 vehicle scenario for all three speed variations. But in case of high vehicle density of 120, DSDV leads the AODV and provides good put of 11.4176 kbps as compare to 9.984kbps at a speed of 20m/s.

MAC/PHY layer overheads are analyzed with 30, 60, 90 and 120 vehicles for varying vehicle speed and is plotted in graphs shown in Fig. 4.5, 4.6, 4.7, and 4.8 respectively.

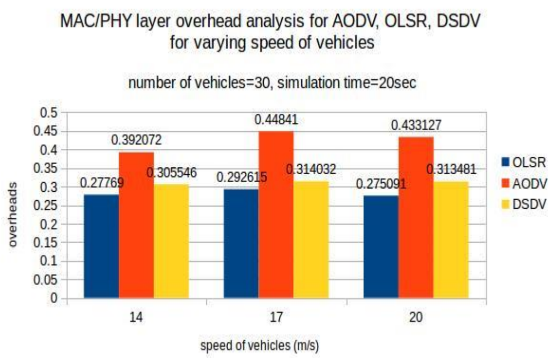


Fig. 4.5 MAC/PHY overhead analysis for 30 vehicles with speed =14, 17, 20m/s

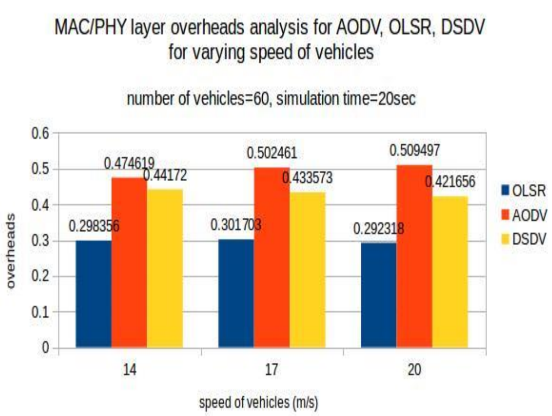


Fig. 4.6 MAC/PHY overhead analysis for 60 vehicles with speed =14, 17, 20m/s

The AODV had maximum number of overheads in node density of 30, 60 and 90. The DSDV has maximum overheads than the AODV and OLSR in 120 vehicles. In all four observations OLSR's performance is below that of DSDV and AODV

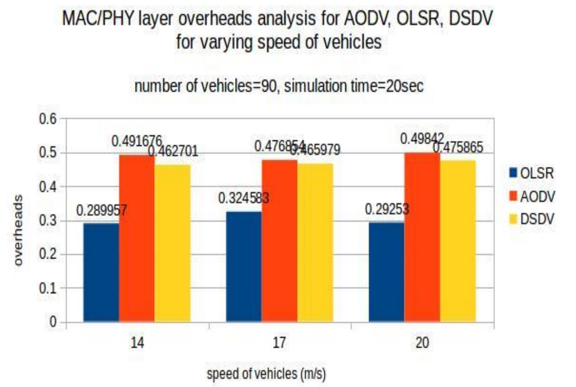


Fig. 4.7 MAC/PHY overhead analysis for 90 vehicles with speed =14, 17, 20m/s

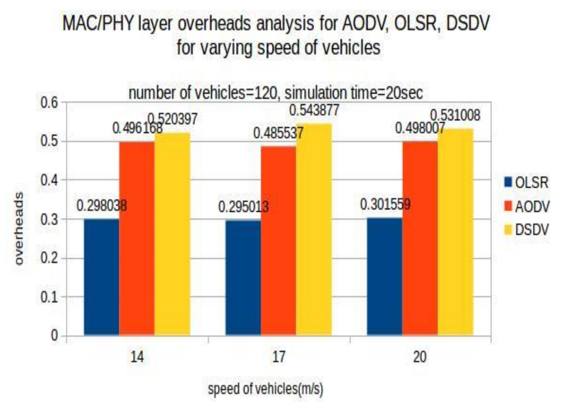


Fig. 4.8 MAC/PHY overhead analysis for 120 vehicles with speed =14, 17, 20m/s

VII. CONCLUSION

In this paper, we have compared the performance of the three routing protocols AODV, OLSR and DSDV in VANET scenarios. In every second 10 Basic safety messages are used to broadcast important information among the vehicles. The average goodput, MAC/PHY layer overheads and packet delivery ratio of basic safety messages are the parameters used for the evaluation of the performance. For obtaining a fair goodput AODV shows the better results in case of vehicle density up to 90 and for 120 vehicles DSDV provides a better goodput than AODV. Since the goodput is best in AODV upto 90 vehicles thus it provides the MAC/PHY layer overheads larger than the OLSR and DSDV. At high density DSDV provides the larger number of overheads. Overall the number of overheads are very less. OLSR shows the BSM PDR to be more promising than AODV and OLSR. Among the three speed used for simulations the mid-range speed of 17m/s provides the best results for the parameters selected for performance evaluation. Finally, it can be concluded from this paper that for low density vehicular scenario AODV will be advantageous and DSDV should be preferred when the simulation are to be carried out with a denser scenario. The average speed of 17m/sec provides the more reliable link establishment between different vehicles.

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