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A comparative study on routing protocols for VANETs

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ABSTRACT

Vehicular Ad Hoc Networks (VANETs) is an emerging area of research and have been gaining significant attention over recent years due to its role in designing intelligent transportation system. It includes vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) message flows, supported by wireless access technology such as, IEEE 1609 WAVE and IEEE 802.11p. One of the major scientific challenge in VANET implementation, is the design of routing protocol that could provide efficient and reliable node-to-node packet transmission. Routing in VANETs is a complex task in urban environment. This paper reports the overall performance evaluation of two existing routing protocols namely, Ad hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR) for VANETs. This study aims at optimizing the selection of best possible routing protocol for providing reliability to data packet dissemination in an efficient way. The impact and effectiveness of existing topology based routing protocol for VANETs application has been evaluated through the use of NetSim software tool. The simulated results shows that a combination of proper channel model together with an efficient routing protocol enhance the link throughput of the VANET for a fixed network size. Further, performance evaluation also demonstrate the impact of network sizes and routing protocols on packet loss, packet delivery ratio, average end-to-end delay and overhead transmission.

1. Introduction

As per the report published by the World Health Organization (WHO), the road traffic injuries and deaths are predominantly caused by accidents due to increasing population, driver carelessness, heavy traffic congestion, violation of traffic rules and lack of information about street [1]. Hence, there must be an intelligent traffic and transportation facility to avoid these incidents. VANET is such an advance network technology solution that pursuits to offer Intelligent Transportation System (ITS) services to the end users and is useful for reducing traffic congestion [2, 3, 4, 5, 6].

VANET offers many features of Mobile Ad Hoc Networks (MANETs) with additional services which includes inter-vehicular communication (IVC): to exchange information among vehicles, roadside units and nearby pedestrians within the defined range. In other words, it is an advanced class of applications of intelligent transportation system. In VANETs, vehicle can communicate within a range of 100–1000m. So, there are two communication units in the design of this networks: a) An on board unit (OBU) b) road side unit (RSU), where OBUs are fixed inside the vehicles and RSUs are stationary node placed close to the intersection of street or traffic signal. RSUs act as an access point and vehicle is used as router, source or destination to disseminate the messages [3, 7].

Considering all the above fact, Federal Communication Commission (FCC) in United States has proposed a frequency range of 5.850–5.925GHz to support V2V communication and V2I communication. The allocated frequency band of 5.9GHz is separated in 7 non-overlapping 10MHz channel bandwidth. In order to support high mobility condition, minimization of communication delay, high data rate and quick link establishment dedicated short range communication (DSRC) is developed [8]. Moreover, Wireless Access for Vehicular environment (WAVE) is a set of special standards which has been developed by IEEE research group for VANETs. CSMA/CA protocols for medium access control (MAC) are utilized by WAVE standard which permits high mobility and dynamic adjustments of network topology. As a results of this the routing information turns to be a challenging task [9, 10, 11]. VANETs deal with two wireless access standards: (i) IEEE 802.11p manages the physical and MAC layer, and (ii) IEEE 1609 manages higher-layer protocols [12]. In addition, AODV and DSR are considered as routing protocol to efficiently detect route from source to destination vehicles.

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In the literature, MPR-OLSR protocol with GSA-PSO technique has been proposed to evaluate the performance in terms of delay, packet drops, channel utilization, packet delivery ratio and throughput of the cognitive radio based VANET [13]. Similarly, a robust architecture in VAVET is proposed using MMPR-OLSR protocol for maximum channel utilization and optimum data transmission [14]. The effect of fading channel model and velocity of the node were not considered in their studies. The performance analysis of the EAACK-MANET has been studied with FDCRP and AODV (cluster and topology based) routing protocols [15]. Moreover, a position based routing approach has been studied for analyzing the performance of VANETs in terms of PDR, delay, route length and control overhead with respect to vehicular density [16]. Similarly, a comparative study of routing protocols has been carried out in [17, 18, 19] to enhance the performance of VANET without considering the wireless channel model and dense traffic scenario. The effect of channel model along with the propagation model and dense traffic network scenario should be considered for VANET, where network performance significantly degrades.

Therefore, based on the above consideration, we have investigated the impact of topology based routing protocol, channel model and network size for a desired performance level of VANETs. To be more particular, we proposed a model of VANET scenario for Bhubaneswar city (see Fig. 1) and furthermore perform different simulations using NetSim and SUMO software to validate our models.

The main contribution of this paper includes the following;

A critical survey on the state-of-the art practices in VANET design and implementation [20, 21]. Analysis of the impact of wireless channel model, network size and routing protocol on throughput of the VANET network.

In the next step, considering the best effective wireless channel model, we have investigated the impact of performance evaluation parameters particularly packet loss ratio and packet delivery ratio (PDR). We can observe that, as the number of vehicle increases, the PDR and packet loss ratio decreases and increase respectively because of routing protocols (AODV, DSR) [22, 23, 24], channel losses and collisions.

Finally, a set of simulations has been designed and performed to

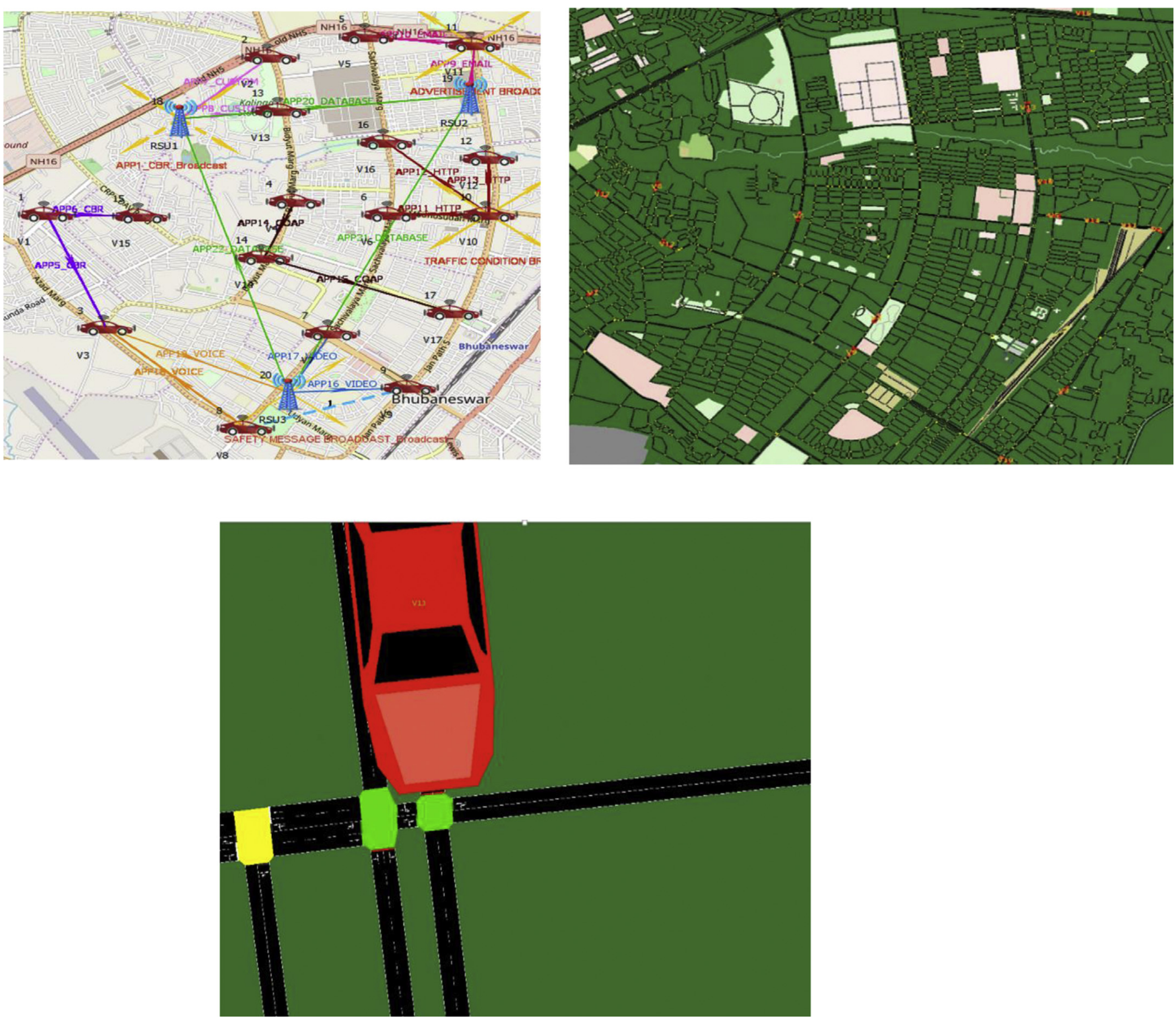

Fig. 1. Typical VANETs traffic scenario of Bhubaneswar city area (courtesy of Oepnstreetmap.com and map.google.com). (a) VANET Traffic scenario in NetSim, (b) Vehicle mobility model in SUMO, (c) Traffic congestion creation in SUMO.

evaluate the overall performance parameter such as delay and overhead transmission of VANET using different network size and routing protocols. Simulated results exhibit that DSR routing protocol with Nakagami-m distribution channel model enhances the performance of VANET.

Rest of this paper is organized as follows: Section 2 introduces the simulation setup, consideration and comprehensive description of the proposed routing protocols and wireless channel models. Section 3 describes all performance evaluation parameters of proposed model. In Section 4, presents the results and discussion related to our simulations and reported the improvement achieved. Finally conclusion is presented in Section 5.

2. Model

In this section, an event based network simulator NetSim10.2 is used along with Simulation of Urban Mobility (SUMO) to have a simulation experiment over a realistic mobility based environment [25, 26]. It permits space-continuous and time-discrete vehicle mobility modelling and simulation with features such as different vehicle types, traffic lights and multi-lane roads with lane changing support [27]. For generating traces and traffic it takes the route assignments which are utilized by the NetSim. By using NetSim platform we have designed VANET user defined traffic scenario with the help of wireless nodes (Vehicles) and Road side unit (RSU) like mobile towers, traffic control rooms. SUMO permits the user to import different sources like open street map. Here, we have designed a VANET scenario for Bhubaneswar city in India as shown in Fig. 1 (a) and bidirectional coupled mobility model in SUMO tool is shown in Fig.1 (b) and (c) respectively.

2.1. Proposed model

In our work, we have created various realistic traffic scenarios like two-way highway, building blocks, road segments with traffic signals etc. Proposed VANET model consists of a number of vehicles and RSUs fairly distributed in the network shown in Fig. 1(a). IEEE 1609 WAVE standard and secondary IEEE 802.11p MAC layer protocol is being used in our work. Previously mentioned two network layer routing protocol, AODV and DSR are applied for the proposed VANET design. It further includes unicast and broadcast message dealing with V2V and V2I. Data packet losses are the reason for the channel characteristics of the network. Therefore, we consider path loss along with fading and shadowing model in the channel characteristics which is shown in Sec. 2.1.3.

Table 1 shows all the simulation parameters and assumptions being used in this paper.

2.1.1. Routing protocols

Routing is a major issue to achieve in VANET, due to high mobility of nodes. Many routing protocols have been reported to establish communication between V2V and V2I in an AdHoc network environment [29]. The principle issue in VANET which need routing protocols, are network and traffic management, mobility, QoS, quick information exchange and so on. In our VANET scenario we adopted existing two topology based routing protocol, i.e. AODV and DSR.

2.1.1.1. AODV (Ad hoc on demand distance vector). It is an on-demand routing protocol for wireless networks that store routing data in conventional routing tables [30]. AODV utilizes the timer at every mobile node and removes the routing table entry after the route is not utilized for a specific time. It performs in two stages: In the first, route has to be found then maintain the route. In this protocol source and intermediate node carries subsequent neighbor message on per flow for information packet dissemination. An introduction message is being transmitted to perform inter nodal communication in the route discovery phase. It sends route-error message when it observed connection failure over any node. Route maintaining stage includes sending a route request message (RREQ) from the communicating node to its neighbors [31, 32]. In this fashion information propagates till it reaches the destination.

2.1.1.2. DSR (dynamic source routing). It is a routing protocol associated to wireless mesh network [33, 34]. It is same as AODV, however, it offers an on-request route when a transmitting node demands one. As well as it utilizes source routing rather than looking forward to the routing table at every intermediate node. It does not require to send introductory messages periodically to inform its presence to neighbors, this features differ from alternative on-demand routing. DSR is a reactive routing protocol, which has two stages for example, route searching and maintenance. To perform the route searching route request packets (PREQ) are provided in the network. Each and every node has to follow some rules:

(a) Any target node only receives packet when it receives PREQ.
(b) If it is not a target node then adds its own particular identification and send the packet to destination.
(c) If identical packet has already arrived at target node, it drops the packet.

In this way, every node retransmits the data packet until it reaches the target. After completion of PREQ sending target node sends a route reply packet (RREP) in the similar path established by PREQ packets. While if any error is arising or link disconnection is happening, then the corresponding node send message to source node by sending request error packet.

2.1.2. Network interfacing protocol

Over the last one decade, the Research and development activities of academic and industry leads to the development of IEEE 1609 WAVE and IEEE 802.11p standard which is used to characterize the physical and MAC layers. In this proposed model, we have utilized IEEE 802.11 PHY/MAC protocol along with the multichannel extensions through IEEE 1609 WAVE standard.

2.1.2.1. IEEE 802.11p standard [35]. The MAC and PHY layers primarily support IEEE 802.11a, IEEE 802.11p standard and it is widely used by

Table 1
Simulation parameters.

Parameters	Values	Parameters	Values
Simulation tool	NetSim10.2	Communication range of vehicles	1km
Mobility model	SUMO	Network Interfacing protocols	IEEE- 1609 IEEE- 802.11p
Simulation area	Bhubaneswar urban area (openstreetmap.org)	Routing protocols	AODV, DSR
Number of vehicles	20, 40, 60	Frequency band	5.9GHz
Simulation time	400sec	Packet size	1420
Channel characteristics	Pathloss, fading and Shadowing models	Message type	Broadcast, Unicast [28]
Fading models	Rayleigh and Nakagami-m model	Performance metrics	Throughput, PDR Average Delay and overhead transmission
Shadowing	Lognormal model	Link mode	Half duplex
Pathloss	47dB	Bit rate	27Mbps
Vehicle speed	20 m/s	Transmitter power	40mw

vehicle manufacturing industries for vehicular communication across the world. This protocol is used for wireless connectivity for fixed, transportable and mobile stations within a local area. It offers the particulars for implementing WLAN communication in the 2.4, 3.6, 5 and 60GHz frequency band. They are implemented and maintained by IEEE LAN/-MAN standard group IEEE 802 [36]. Here, we have considered IEEE 802.11p PHY layer (which is OFDM-based) along with an overall bandwidth of 20MHz with 60GHZ frequency band. IEEE 802.11p MAC protocol completely depend on the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) [37]. This implies once a node needs to transmit an information, the channel should be inactive for a period of short inter-frame space. If the channel is idle it begins to send packets. Once it notices the channel engage, it picks an arbitrary back off period from the interval [0, CW] and send only when the back off timer has lapsed. The parameter CW refers to the span of the contention window. Once the service channel (SCH) is employed; associated node does not get a confirmation for an information, it means that the information packet has affected and is lost, therefore the estimation of CW is multiplied and it will retransmit. In the control channel (CCH) however, packets are broadcasted within the channel and confirmation are not transmitted. This recommends the estimation of CW is never multiplied within the CCH.

2.1.2.2. IEEE 1609 WAVE [38]. This standard family include different network and resource management, network security, administration work and support for multichannel operation. The WAVE consists of many standard and separately these standards perform their functions. The IEEE 1609.1 manages the application field, the IEEE 1609.2 offers a safety and security mechanisms, IEEE 1609.3 deals with WAVE management and the IEEE 1609.4 handles the logical connection control of layers. For each source vehicle, we adopted IEEE 1609 WAVE standard protocol within datalink layer in our network model.

2.1.3. Channel characteristics

Channel characteristics plays an important role in the VANET design for V2V and V2I application. The propagation factors i.e., path loss, shadowing and fading, affect the transmitted signal strength when signal is travelled through wireless channel [38].

A brief about these models are as follows;

2.1.3.1. Pathloss model Frii's free space propagation. In VANET simulation we have considered Frii's Free Space propagation loss model. Path loss may be because of several reasons, such as reflection, absorption and coupling loss of aperture-medium [39]. According to the Friis equation, the general expression by which received power and pathloss is derived is as follows;

$$P_r = P_t \frac{G_t\, G_r\, \lambda^2}{(4\pi)^2 D^n L} \tag{1}$$

Where P_r and P_t are the received and transmitted power respectively. G_t and G_r are related to the antenna gains of transmitter and receiver respectively. L is the system loss. n is related to path loss exponent with the range of 2–5 which is depend on the environment. λ-is the frequency band of the network. In simulations we consider n is 2 due to free space propagation loss model and D is the link range from transmitter to receiver. From Eq. (1), we can also write as

$$P_r = P_t \frac{G_t\, G_r}{\left[\frac{4\pi D}{\lambda}\right]^2 L} = P_t\, \frac{G_t G_r}{P_l L} \tag{2}$$

Where, P_l is the propagation pathloss which is incurred by the transmitted signal during propagation.

$$P_l\,(dB) = 20\,\log_{10}\left[\frac{4\pi D}{\lambda}\right] \tag{3}$$

From Eqs. (2) and (3), we can present receive power in dB as:

$$P_r(dBm) = P_t(dBm) + G_t(dBi) + G_r(dBi) - 20\,\log_{10}\left[\frac{4\pi D}{\lambda}\right] - 10\,\log_{10} L \tag{4}$$

2.1.3.2. Lognormal shadowing model. Shadowing is a processes of attenuation due to various obstacles between transmitter and receiver. In this lognormal shadowing, the shadowing value describes as the random shadowing effects whose distribution is normal with zero mean and log intensity variance σ_I^2 [40]. The PDF under lognormal distribution can be expressed as [41]:

$$PDF = \frac{1}{\sqrt{2\pi\sigma_I^2}}\,\frac{1}{I}\,exp\left[-\frac{\left\{\ln\left(\frac{I}{I_0}\right) - \frac{\sigma_I^2}{2}\right\}^2}{2\sigma_I^2}\right] \tag{5}$$

Where I and I_0 are the irradiance with and without turbulence respectively.

2.1.3.3. Rayleigh Fading models. In wireless communications, fading is the random fluctuation or rapid variations of the envelope of a received signal. The fading may cause by local multipath, slow variation with time, or radio frequency. In simulation, we have considered the Rayleigh Fading channel, which is based on Rayleigh Probability Distribution (PD) with zero mean ($\mu = 0$) and unit variance ($\sigma^2 = 1$). The Rayleigh *PDF* is expressed as [42]:

$$PDF = \frac{r}{\sigma^2}\,exp\left[-\frac{r^2}{2\sigma^2}\right] \tag{6}$$

Where r is the amplitude of received signal and σ is the standard deviation.

2.1.3.4. Nakagami-m fading model. It is a probability distribution related to the gamma distribution. If the received envelope is Nakagami distributed, the corresponding instantaneous power is gamma distributed. In our simulation, we have considered Nakagami fading model which follows gamma probability with m-shape factor parameter of 1 and w-value of 2. The Nakagami PDF is given by [43]:

$$PDF = \frac{2m^m\, x^{2m-1}}{w^m\, \Gamma(m)}\,\exp\left[\frac{mx^2}{w}\right],\ x \geq 0 \tag{7}$$

3. Analysis

Most of the researchers are interested to understand information broadcasting phenomenon in VANET. Which can be presented as: (a) how messages can propagate, (b) how fast the message can be disseminated to all active vehicles. Besides that, to have a reliable V2V and V2I communication and protocols, it is significant to know if the messages are delivered to all the intended nodes. The objective of the presented work is to evaluate the performance, effectiveness and efficiency of the proposed model:

3.1. Average link throughput

It is specific to a link which may be wired or wireless. In case of VANET scenario in NetSim there is a common shared wireless link. It is defined as total data bits transmitted in the link within total simulation time [44].

$$\text{Link Throughput (Mbps)} = \text{Total Bytes transmitted in the link x } 8/\text{Simulation Time } (\mu\ \text{sec}) \tag{8}$$

Table 2
Comparative analysis of Average link throughput.

Parameter		DSR	AODV	No. of vehicle
Average link Throughput (Mbps)	Rayleigh Fading channel	5	3.6	20
	Nakagami Fading channel	10	3.8	20
Average link Throughput (Mbps)		10	4	20
		15	14	40
		32	35	60

Table 3
Comparative analysis of performance metrics.

Parameter	DSR	AODV	No. of vehicle
Packet loss ratio (PLR) %	62	52	20
	69	72	40
	73	76	60
Packet delivery ratio (PDR) %	38	49	20
	31	28	40
	27	25	60
Average End-to-end Delay (ms)	1.82	1.75	20
	0.75	0.88	40
	0.39	0.45	60
Overhead Transmission (Bytes)	430	320	20
	480	360	40
	650	475	60

3.2. *Packet delivery ratio (PDR)*

It is the percentage of data packets that successfully received by all specified vehicles. It is defined as the ratio of the total packets are received by the target vehicles over the total transmitted packets from the source vehicles. PDR should have larger value to ensure better performance of the network. It is calculated as follows [23]:

$$\text{PDR} = \text{Total successful packet received} / \text{Total transmitted packet} \tag{9}$$

3.3. *Packet loss ratio or collision ratio (CR)*

It is defined as the percentage of the MAC collisions packets loss during data transmission per number of broadcast packets. It is given by [45]:

$$\text{CR} = (\text{Total Packet Transmitted} - \text{Total Packet Delivered}) / \text{Total Packet Transmitted} \tag{10}$$

3.4. *Average end-to-end delay (EED) [26]*

It is the average time taken by the information packets to pass through the destination vehicles. Data packets which are successfully delivered and transmitted are counted. Smaller value of delay is required for better network performance. Average EED is calculated as follows [46]:

$$\text{Average EED} = \text{Average time taken to delivered packets} / \text{Total number of packets delivered} \tag{11}$$

3.5. *Overhead transmission (OH)*

The degree of saturation of the network is characterized by this value. It is the ratio between additional routing packets and received packets at target vehicles. The lower OH indicates the better performance of the network. It is given by [23]:

$$\text{OH} = \text{Total number of overhead messages} / \text{Total transmitted data packets} \tag{12}$$

4. Results & discussion

In this section we have presented the simulation results under various condition for each of the performance parameter as described in the previous section using NetSim software tool and MATLAB environment for analysis and plotting. The values of simulated data of proposed model

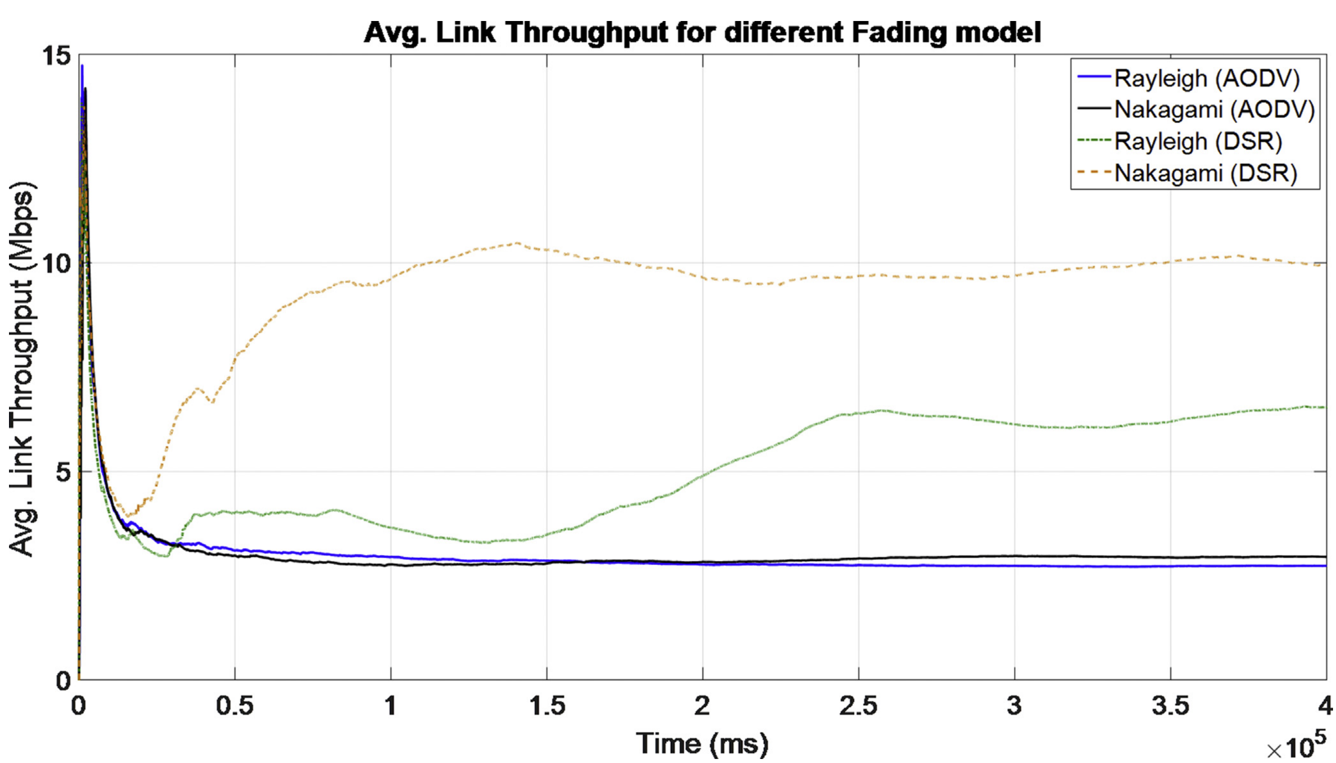

Fig. 2. Average Link throughput For AODV and DSR Routing Protocol in Rayleigh and Nakagami Distribution channel model.

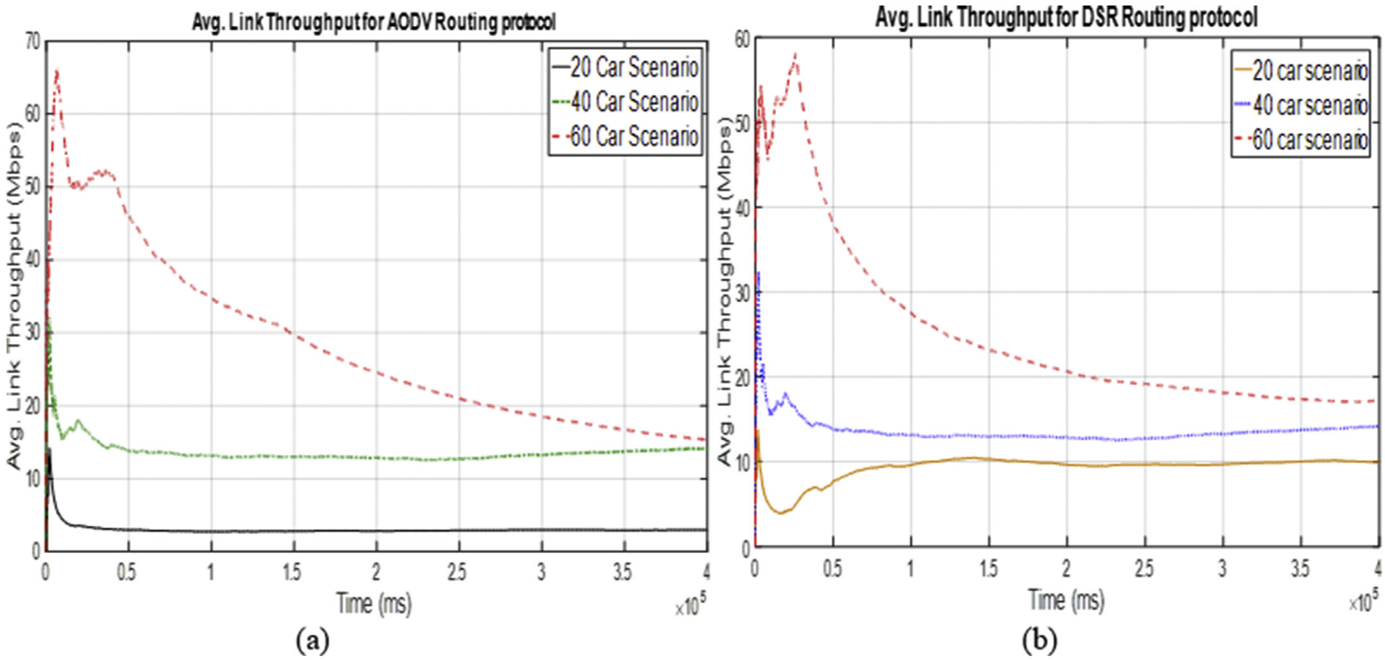

Fig. 3. Average link throughput for different number of car. (a) AODV (b) DSR.

are summarized in Tables 2 and 3.

4.1. Impact of routing protocol on link throughput

Fig. 2 shows the relation between average link throughput and the routing protocols for two specific channel models. During simulations, we have fixed the network size to 20 number of vehicles; in order to compute the impact of AODV and DSR routing protocols. It is clearly depicted that average link throughput with DSR routing protocol is higher as compared to AODV protocol throughout the simulation time. Using the Nakagami-m distribution channel model, among the two considered routing protocols, the highest link throughput was obtained using DSR. Average link throughput of 10Mbps was achieved for DSR, whereas for AODV, it was 3Mbps. In other words, DSR routing protocol require less simulation time than AODV for achieving a higher link throughput.

Under the Rayleigh distribution channel model, it is clear that average link throughput values are approximately 5Mbps for DSR whereas 3Mbps for AODV respectively.

Fig. 3(a) and (b), present results that shows the average link throughput variation within entire simulation time, under different number of vehicles. In this simulation, we have set three different number of network sizes, i.e., 20, 40 and 60 vehicles. As seen in Fig. 3(a), AODV achieves maximum link throughput 50Mbps initially then it decay down to 15Mbps at the end of the simulation for 60 car scenario whereas

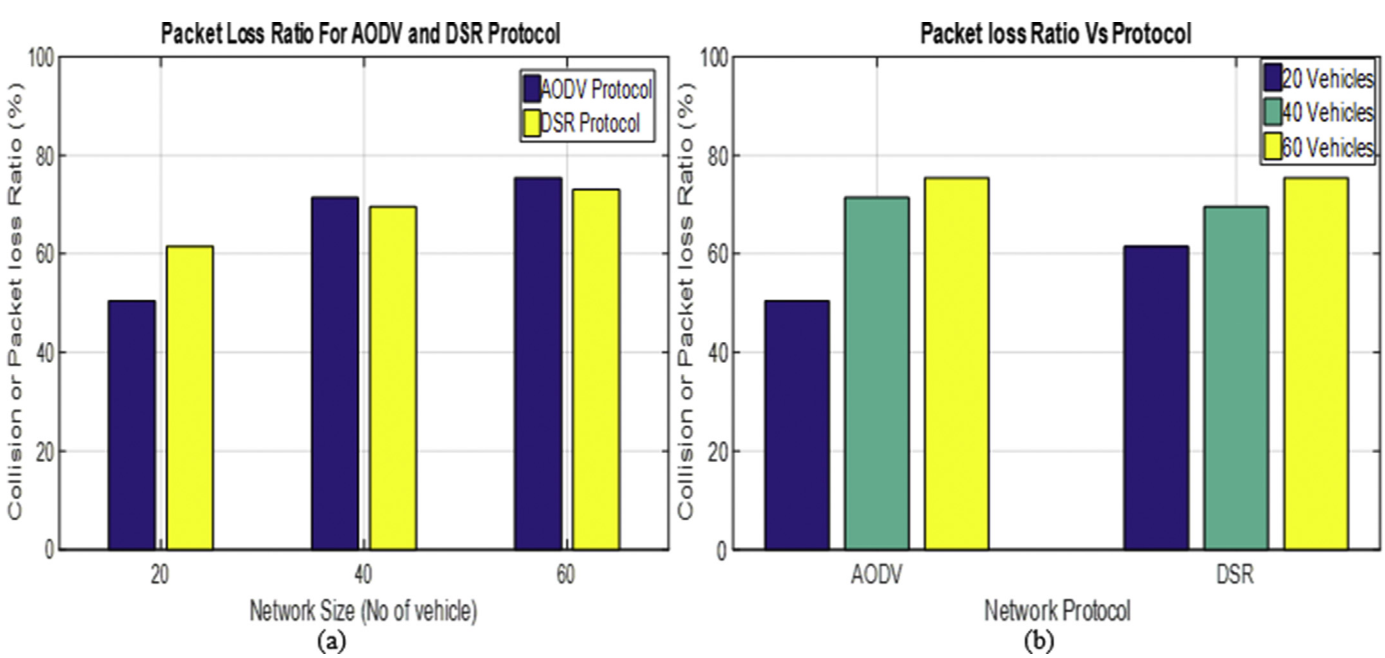

Fig. 4. (a) Packet loss ratio vs network size and (b) Packet loss ratio vs network protocol.

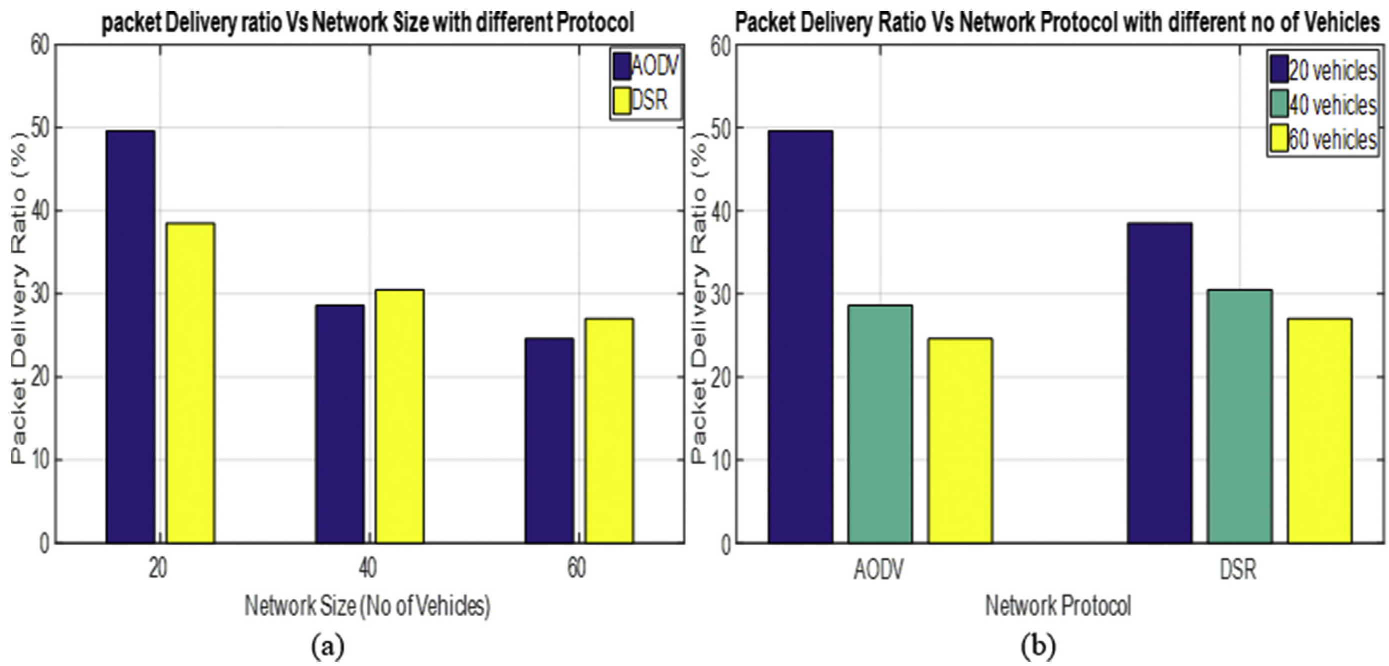

Fig. 5. (a) PDR vs. network size and (b) PDR vs. network protocol.

more or less 13Mbps and 3Mbps link throughput obtained for 40 and 20 car scenario respectively. It is observed in Fig. 3(b) that DSR achieves link throughput variation 50Mbps to 17Mbps for network size of 60 vehicles while it maintained 13 and 10Mbps throughput with 40 and 20 car scenario respectively.

Examining the overall performance evaluation curve, it is clear that higher average link throughput is obtained by DSR routing protocol. For higher network size both routing protocol maintains pretty much same link throughput, however on account of lower number of vehicles such as 40 and 20, DSR outperformed AODV to maintain higher value linked throughput.

4.2. *Effect on collision or packet loss ratio*

Fig. 4(a) and (b) shows the collision or packet loss ratio for the two considered routing protocols and different number of vehicle in the network. We can observe that packet loss ratio is increasing with increased traffic in the network. In AODV protocol it increases from 50 to 75% at 60 number of vehicles scenario whereas DSR protocol it goes up to 73% for same number of vehicles scenario. It is also interesting to note that, the packet loss will be lower for smaller number of vehicles in the network. DSR routing protocol show the lower packet loss ratio compare to AODV for equal numbers of vehicles.

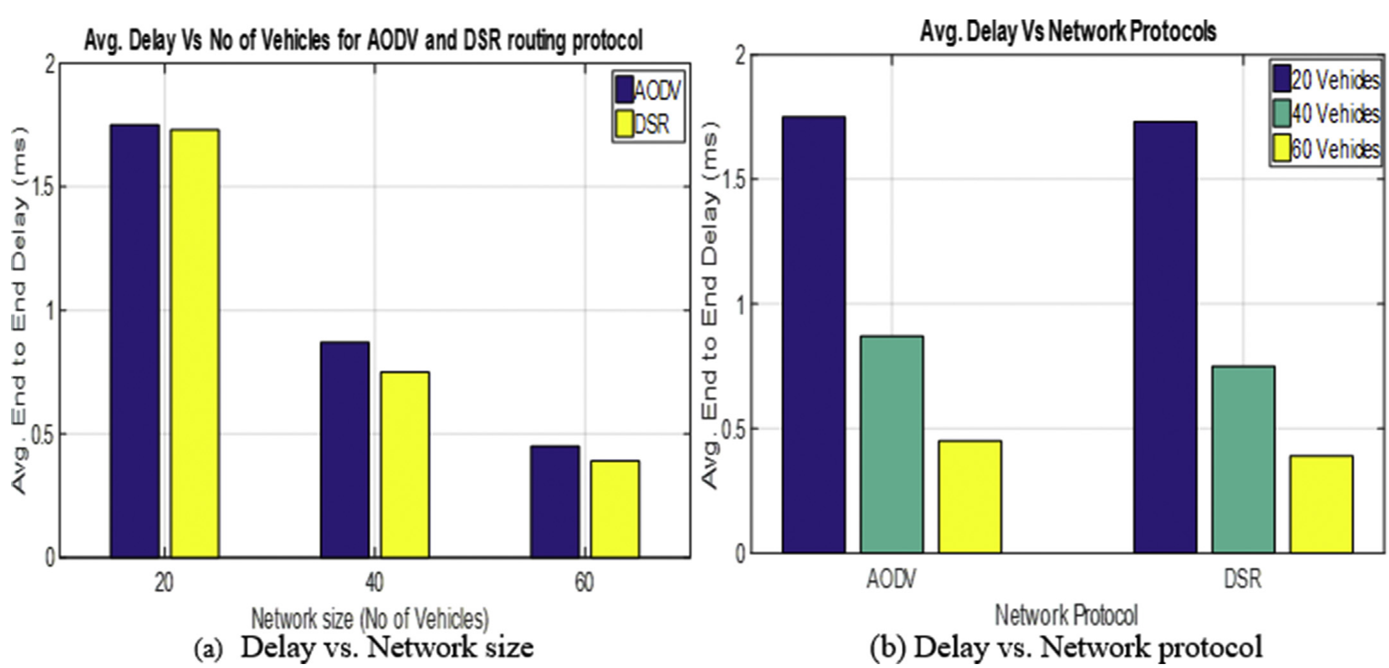

Fig. 6. Avg. end-to-end Delay for AODV and DSR Routing protocol with different Vehicles.

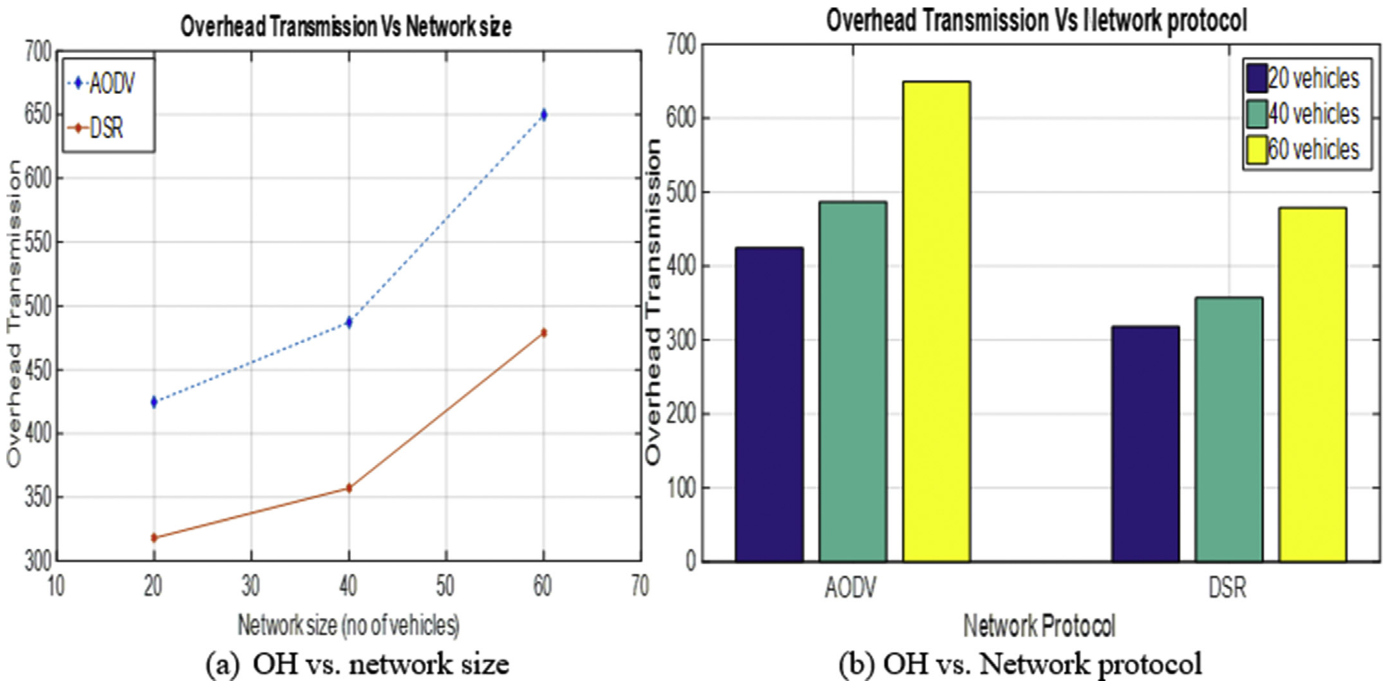

Fig. 7. Overhead transmission over AODV and DSR Protocol with different no of vehicles.

4.3. Packet delivery ratio

Fig. 5(a) and (b) shows the packet delivery ratio (PDR) results for AODV and DSR routing protocol under different numbers of vehicles. It can be observed that DSR achieved 2% and 3% more PDR value than AODV with increased traffic density in the network in terms of 40 and 60 vehicles.

However, in case of 20 car scenario or less than this AODV produce better PDR with 10% more than DSR. This outcome indicates that DSR is an appropriate routing protocol for application that requires reliable packet delivery in the dense traffic network.

4.4. Average end-to-end delay

In Fig. 6(a) and (b), the average end-to-end delay is presented for different number of vehicles and routing protocols. It can be observed that the lowest average delay is taken by DSR which depicts the better performance in comparison with AODV protocol.

Fig. 6(b) demonstrates the delay for DSR protocol is lower than AODV, irrespective of the vehicle's number. This is possible due to short path traveled by the packets.

4.5. Overhead transmission (OH)

The results of the overhead transmission are illustrated in Fig. 7(a) and (b) for different number of vehicles and routing protocols. In Fig. 7(a), we can observe that overhead transmission is increased rapidly with increase in number of vehicles for both AODV and DSR protocol as both protocol generate large number of overhead packets. It is also interesting to see that these two protocols maintain a proportional relationship between overhead and network size. As shown in Fig. 7 (a) and (b), we can conclude that AODV generates more overhead packets and it is not suitable for higher mobility system. Moreover, AODV send more route error message than DSR due to frequent disconnections (intermittent connections) happened on the network.

Compare to AODV, DSR shows lesser number of overhead packet as a result of less number of additional routing packets transmission irrespective of numbers of vehicles.

Based on the above results, we can conclude that DSR protocol is more efficient and more effective than AODV protocol, for our proposed VANET for Bhubaneswar city traffic scenarios. As well as it is a suitable solution for safety applications that require reliable data packet transmission and are delay sensitive. The model can be extended to other cities.

5. Conclusion

In this work, simulation based analysis has been carried out to analyze the VANET system performance using different routing protocols and network size. This work is based on NetSim software platform and SUMO tools which take several considerations of channel models, path losses and wireless access technologies. In this paper, we have presented the performance of AODV and DSR routing protocol for Adhoc routing between V2V and V2I. Our proposed model offers many key insights that can be used to enhance the overall performance of VANET system or for designing suitable intelligent transportation system. Results shows that the performance of the VANET is improved by adopting DSR routing protocol compared to AODV in terms of higher throughput, lower packet loss, improved delivery ratio and reduced delay even for a large network of vehicles. The proposed models, protocols and simulated results may be serve as guidelines for design of modern traffic control mechanisms which follows safety application, faster data packet dissemination and intermittent connection problem in VANETs.

Declarations

Author contribution statement

Suman Malik: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Prasant Sahu: Contributed reagents, analysis tools or data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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