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ORIGINAL ARTICLE

Performance evaluation of various MANET routing protocols for adaptability in VANET environment

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Abstract Vehicular ad hoc network (VANET) is emerging as one of the challenging research area because of the heavy dependency of human being into vehicles which tends to develop an intelligent transport system. VANET is treated as an extension of mobile ad hoc network (MANET) due to its behavior and its working mode. VANET is emerging as a new powerful tool to provide safety and security to the human beings during the time of traveling from one place to another. Routing is one of the challenging tasks for both MANET and VANET due to the frequent change in the topology. In this paper, we are evaluating the adaptability of existing MANET routing protocols for VANET. This paper analyze that what is the impact the vehicle density and speed on the packet delivery ratio, normalized routing load, average end-to-end delay, average throughput, average path length and average loss rate, which will help to design a new routing protocol or to have some improvement in the existing routing protocols.

Keywords VANET · ITS · MANET · Routing · Topology · Mobility · Density · Packet delivery ratio · End_to_End delay · Throughput · Routing-load and path-length

1 Introduction

There are many types of infrastructure-less networks, i.e. Ad hoc Network; it is a collection of wireless nodes without any fixed infrastructure. MANET is one of the subclasses of Ad hoc network. VANETs are categorized as an application of MANET that has the potential in advancing road safety and in providing travelers ease (Al-Sultan et al. 2014). The well-known routing protocols like ad hoc on-demand distance vector (AODV) (Perkins et al. 2003), dynamic source routing (DSR) (Johnson and Maltz 1996), destination-sequenced distance-vector (DSDV) (Perkins and Bhagwat 1994), ad hoc on-demand multipath distance vector (AOMDV) (Marina and Das 2001), Optimized Link State Routing Protocol (OLSR) (Clausen and Jacquet 2003) and Zone Routing Protocol (ZRP) (Haas et al. 2002) of MANET are node centric routing which leads to have frequent breaking of links, causing instability in the routing. Usage of these protocols in a highly dynamic environment like VANET may eventually cause many packets to drop and other pessimistic effect in the communication. VANET is highly dynamic in nature in comparison to MANET so we have to deal with more disconnections. In MANET we establish a communication link between the various mobile nodes exist in the network, while in VANET we establish a communication between the mobile nodes (vehicle to vehicle communication) as well as mobile nodes with non-mobiles nodes like road site units (RSU) as shown in Fig. 1. MANET does not rely on any fixed infrastructure, all the communication functionalities like routing, mobility management, etc. are done by the node itself while as in VANET we may have some infrastructure like RSU though the nodes are highly mobile in nature. VANET is comparatively new research area and is gaining a lot of research interest due to several day-to-day challenges occurring in the field of transportation through vehicles regarding the efficiency and security (Darwish and Bakar 2015). VANET is a self-organizing network that connects V-to-V and V-to-RSU. RSU's may

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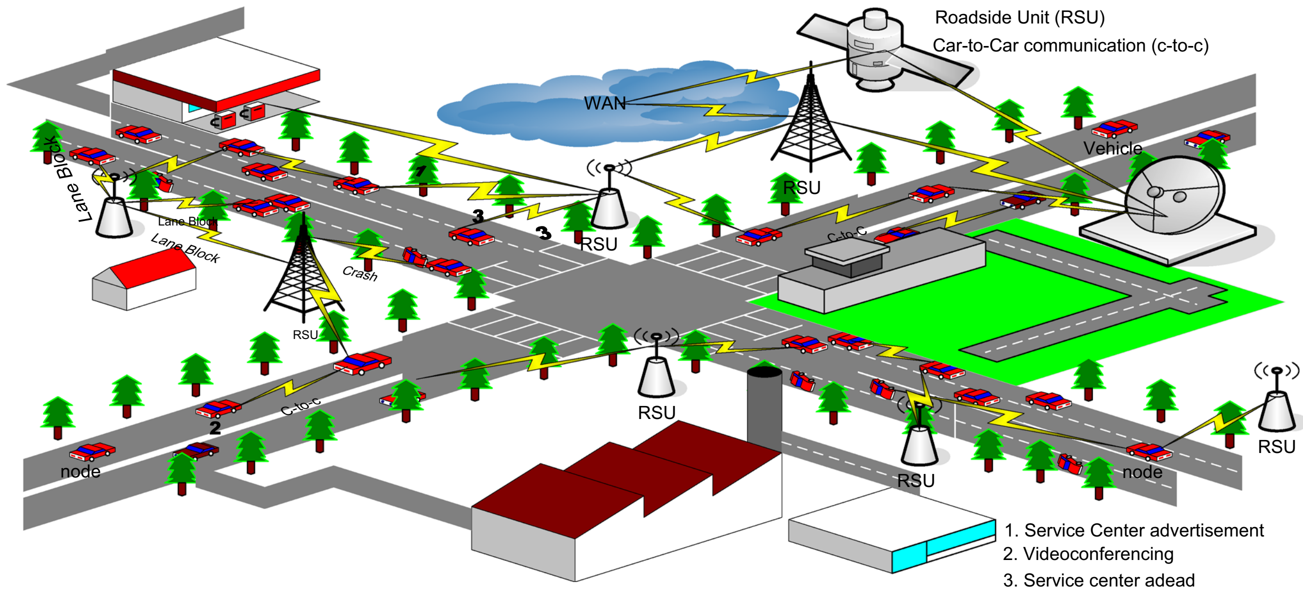


Fig. 1 An illustration of VANET architecture

be connected to some backbone network, to provide the various services like Internet access and many more. Vehicular communications are now the leading genre of conveying information between auto-mobiles (Sharef et al. 2014). The basic goal to develop VANET is to enhance public safety and improve vehicular traffic flow. There is a need for rapid development in the field of wireless communication for independent mobile users, which tends towards the rapid research in the field of Ad hoc Network. In this paper, we are evaluating the adaptability of MANET routing protocols in the VANET environment.

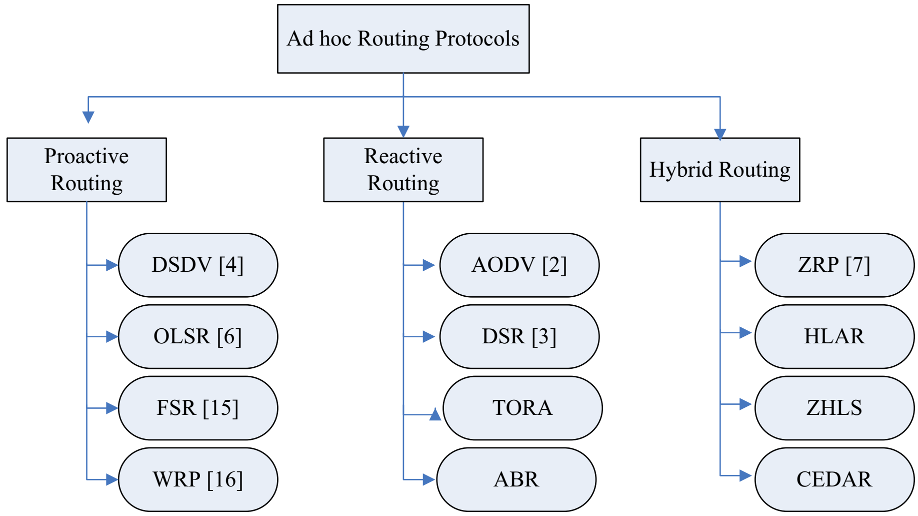
In a wireless ad-hoc network the nodes do not have any predefined fixed infrastructure. Each node in MANET can independently move in any direction that's why its link will break frequently. Also node has to face lots of traffic, which it has to forward to other nodes in the network due to which, the routing task becomes a challenge in MANET environment. Routing becomes more challenging in such networks where the topology is highly dynamic in nature which tends towards frequent link breaking like in VANET. In (Ranjan and Ahirwar 2011) authors have studied an efficient protocol in the category of reactive routing for both MANET and VANET. They found that routing protocol performance varies with node density and traffic conditions. Adaptability issue of routing protocols is also being analyzed in (Raju et al. July 2013), compared DSDV, AODV and DSR for varying the number of nodes and mobility, their study shows that enhanced AODV can be used for VANET. In (Arshad et al. 2013) proposed a framework for distribution of node with respect to connectivity, node density and time for AODV, DSR and FSR. They concluded that MOD-DSR produces the highest throughput in high mobility. The suitability of MANET routing protocols for VANET is also studied in (Chaurasia et al. 2012) and requirement of a specific VANET protocol is determined. A cluster based routing is studied in (Sood and Kanwar 2014), presented a localization technique for both GPS free and GPS based VANETs. They have suggested that cluster based routing is more reliable and provide rapid data sharing between nodes in MANET which can also be modified for VANET. But this approach will face problem since cluster maintenance in VANET is very decisive due to its hilly dynamic environment. Routing protocols for MANET and VANET are also studied in (Kumar and Verma 2015) and suggests that the various routing protocols can be used according to utilization of ad hoc network, objective of the mission, communication and deployment criteria. The performance evaluation of MANET and VANET routing protocols is studied in (Vijayalakshmi and Chezian 2015) which shows that proactive protocols like DSDV shown better results than AOMDV. Only AOMDV and DSDV are being compared using three perameters, which was not providing the clear depiction regarding the adaptability of the MANET protocols in the VANET environment. Thus there is a need for broader study in this field.

2 Background

2.1 Overview of routing protocol for MANETs

Establishing strong routes, maintenance and reconstruction of routes in time are the main tasks of routing protocols.

Fig. 2 Taxonomy of MANET routing protocols



Routing protocols are the pillar of ad hoc networks. They generate complete routes between every couple of nodes from the topology information they are able to perceive (Friginal et al. 2015). MANET routing is broadly categorized into three categories: Proactive, reactive and hybrid. The common taxonomy used to define the mobile ad-hoc network routing protocols is defined in Fig. 2 shown below.

2.1.1 Proactive routing protocols

In proactive routing, the routers construct and maintain updated routing information to all the nodes irrespective of the need. For constructing routing information,periodically they transmit control messages. Usually proactive routing protocols are not fair to utilize bandwidth, because even if there is no data flow, still the control messages are broadcasted. One of the main advantages of proactive routing protocols is that nodes can fetch routing information easily. The problem with such type of routing is that there is too much overhead kept by the nodes for route protection and restructuring is slow when there is a failure in an existing link. DSDV (Perkins and Bhagwat 1994), OLSR (Clausen and Jacquet 2003), Fisheye state routing (FSR) (Guangyu et al. 2000) and Wireless Routing Protocol (WRP) (Murthy and Garcia-Luna-Aceves 1996) are few examples of proactive routing protocols.

2.1.2 Reactive routing protocols

These protocols are the demand-oriented, which find the path whenever it needs. In such types of protocols, to establishing a route there will be a route request (RREQ) and route reply messages sent by source and destination node respectively. For RREQ, source node uses flooding in which it broadcasts a request message to all the connected nodes exist in its range. Nodes maintain only the active route until the destination node becomes inaccessible along every existing path from the source node. The protocols like ad hoc on-demand distance vector Routing (AODV) (Perkins et al. 2003), DSR (Johnson and Maltz 1996) etc. are exist in this category.

2.1.3 Hybrid routing protocols

A hybrid protocols uses the features of proactive and reactive routing protocols in a single protocol. The example of such routing protocol is ZRP (Haas et al. 2002) which combines the proactive and reactive routing approaches.

2.2 Description of routing protocol

This subsection gives a brief introduction of DSDV, OLSR, AODV, DSR and ZRP routing protocols. In MANET computing devises needs to communicate (route packets) in an unfamiliar topology. We have to analyze the performance of these routing protocols as the density of nodes varies. DSDV, OLSR, AODV, DSR and ZRP are the most efficient and popular protocol comes under the category of proactive, reactive and hybrid, thus we selected these protocols for the performance evaluation through simulation in both MANET and VANET environment.

2.2.1 Destination sequenced distance vector (DSDV)

The DSDV (Perkins and Bhagwat 1994) protocol is based on the Distributed Bellman Ford algorithm. Messages are exchanged between source and destination through a single path, which is computed using the distance vector algorithm. To reduce the network overhead, two types of update packets are used: known as a ''full dump'' and 'incremental' packets. The full dump packet contains all the currently available updated routing information and the incremental packet contains only the new changed information since the last full dump message. Frequently, the incremental update packets are sent. However, still DSDV have a large amounts of routing overhead due to the periodic update, and the overhead grows according to O(N^2). Therefore, the protocol will not scale in large network like VANET, since a large portion of the network bandwidth will be used in the updating procedures.

2.2.2 *Optimized link state routing (OLSR)*

OLSR (Clausen and Jacquet 2003) is an optimization of pure link state protocol: all the link information with neighboring node are flooded in the whole network. It reduces the size of control messages by using a technique called multipoint relay: by dropping the duplicate retransmission packets in the same region (Jacquet et al. 2001). It does not request an in-order delivery of packets because each control message has a sequence number of current information. In OLSR each node broadcast *HELLO* message after a fixed interval of time which carries the link status information of neighbors. OLSR works in four phases: neighbor sensing, multipoint relay selection, multipoint relay information declaration and routing table calculation.

2.2.3 *Ad-Hoc on-demand distance vector (AODV)*

AODV (Perkins et al. 2003) uses broadcast mechanism for route discovery. AODV depends on the dynamically establish routing table entries at the various intermediate nodes. To maintain the most resent route it uses the technique of destination sequence number used in DSDV; however each node maintain the sequence number counter individually in an increasing order which will increase the efficiency of bandwidth by minimizing the network load (Perkins et al. 2003). Whenever a node needs to establish a communication, it floods a RREQ (Perkins et al. 2003; Rahman and Zukarnain 2009) message in the network to construct a route. The entire process consists of two procedures: Path Discovery and Path Maintenance.

- Path Discovery (Perkins et al. 2003; Rahman and Zukarnain 2009): Each node maintains two counter a node broadcast_id and a node sequence_no. The source_address and broadcast_id uniquely identifies a RREQ. Broadcast_id is incremented whenever source issues a new RREQ. Each neighbor either gives RREQ to source or broadcast that RREQ to their neighbors after incrementing hop_count. If a node cannot satisfy a RREQ, it can implement a forward path setup as well as the reverse path setup. In the first phase, the source node searches its route table to see whether a valid route to the mentioned destination node exists and if so, then the node starts sending data to the destination node and the route discovery process finishes here. If destination address is not in the route table then the node broadcasts the RREQ packet. When the destination node receives the RREQ packet, it returns the learned or newly computed path to the source node.
- Path Maintenance (Perkins et al. 2003; Rahman and Zukarnain 2009): In this process when a node detects a path failure it broadcast a message to all other nodes exist in that network. It also provides an early recognition of node or link breakdown since wireless networks make use of hop-to-hop acknowledgement.

2.2.4 *Dynamic source routing (DSR)*

DSR (Johnson and Maltz 1996) designed particularly for use in multi-hop wireless ad hoc networks where nodes are mobile. It is totally self-organizing and self-configuring. The source and destination nodes to send out packets to each other and each packet follows the same path. The major motivation behind this protocol is to bound the bandwidth by avoiding the cyclic table updates and long convergence time.

- Route Discovery (Johnson and Maltz 1996; Broch et al. 1998): It is also an on-demand routing protocol, it also looks up the routing information at the time of packet transmission. DSR in its first phase searches a valid route in its own routing table from the transmitting node to the destination node and if it finds the route, then the node starts transmitting to the destination node and the route discovery process end here. If there is no routing information about that destination then the node broadcasts the RREQ packet to reach the destination. When the destination node receives RREQ packet, it returns the learned path to the source node.
- Route Maintenance (Johnson and Maltz 1996; Broch et al. 1998): It is a mechanism of broadcasting a message by an existing node to all other nodes informing the current status or node failure in the network. It provides an early discovery of a node or link failure since wireless networks make use of hop-to-hop acknowledgement.

2.2.5 *Zone routing protocol (ZRP)*

ZRP (Haas et al. 2002; Beijar 2002) reduces the proactive routing range to a zone centered on each node. The nodes out of zone range can be reached with reactive or on-demand routing. IN ZRP all nodes stores, local routing information proactively, RREQs can be performed more efficiently without querying all the network nodes. ZRP significantly reduces the amount of routing overhead as compared to proactive protocols. It has also significantly reduced the initial delay associated with reactive protocols, by faster route discovery. The drawback of ZRP is that for large routing zone like VANET it could behave like a pure proactive protocol, while as for small routing zone it can behave like a pure reactive protocol.

3 Simulation model and performance metrics

For simulating the above mentioned protocols we have used NS2: Network Simulator version 2.35 (Fall and Varadhan 2003) for MANET Fig. 3. For VANET simulation, we have used Simulation of Urban Mobility (SUMO) and MOVE also with NS2.35. SUMO software creates the road maps, edges, curves and vehicle movement with the help of MOVE shown in Figs. 4 and 5.

We have used two types of scenario or mobility model in our simulation one for MANET and another for VANET.

- Designed of a network using a random waypoint mobility model with variable number of nodes for MANET.
- Designed the network using the traffic sign mobility model with variable number of nodes for VANET.

In case of MANET, the Random Way Point Mobility Model (RWPM) is designed to describe the association pattern of mobile nodes randomly. A mobile node waits a specified pause-time at beginning. It selects a random destination after this time in the area and a random speed is distributed uniformly to a node, between the minimum and the maximum velocity. Once a node reaches to its destination point, the nodes waits again for that much of pause-time before choosing a new waypoint and speed.

In case of VANET, the traffic sign mobility model (TSM) that approximates the movement pattern of nodes/vehicles in urban environments to different degrees. All the vehicles are moving towards destination in a fixed predefined path or lane. After a fixed interval of time they all are beginning their journey.

3.1 Performance metrics

In this study, work has been done on the packet delivery ratio (PDR), Average Throughput, Average end-to-end

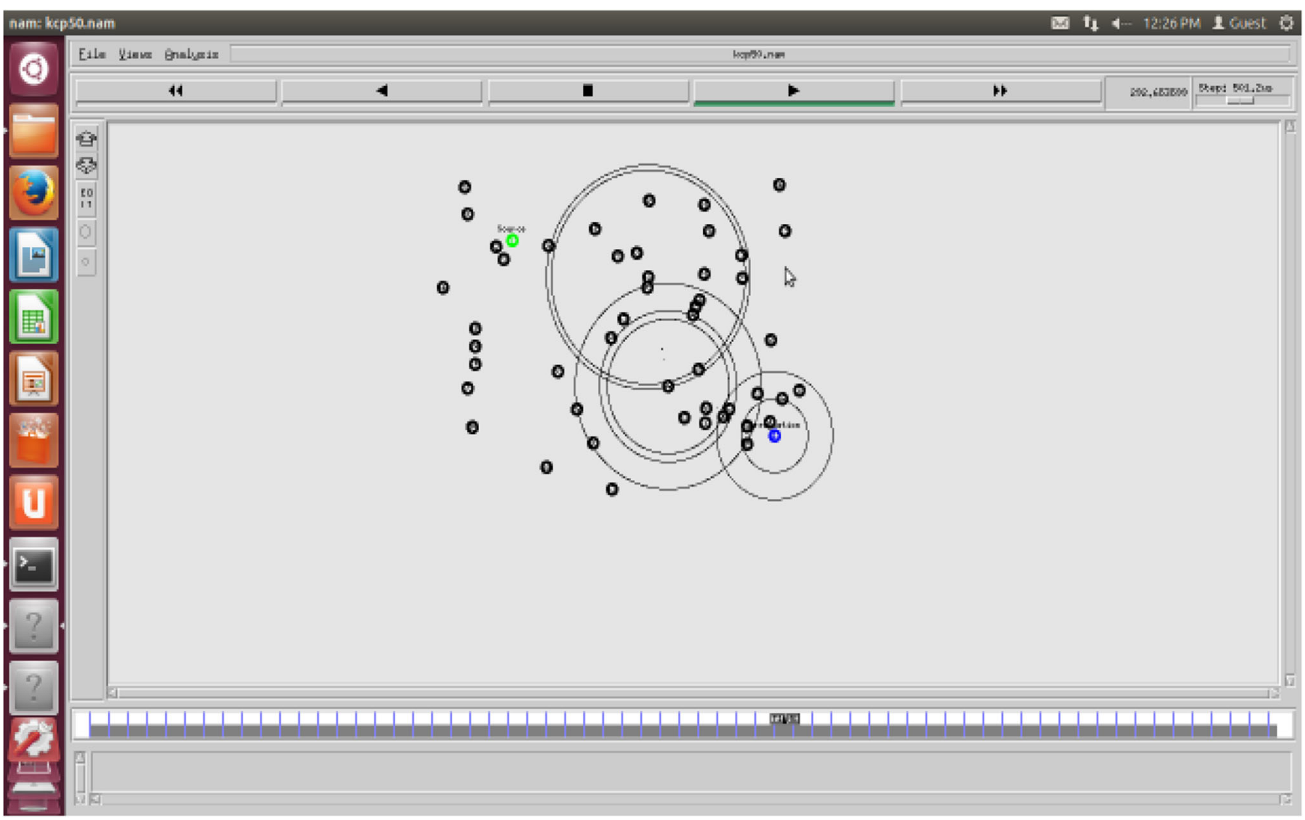


Fig. 3 Simulation of 50 nodes in MANET

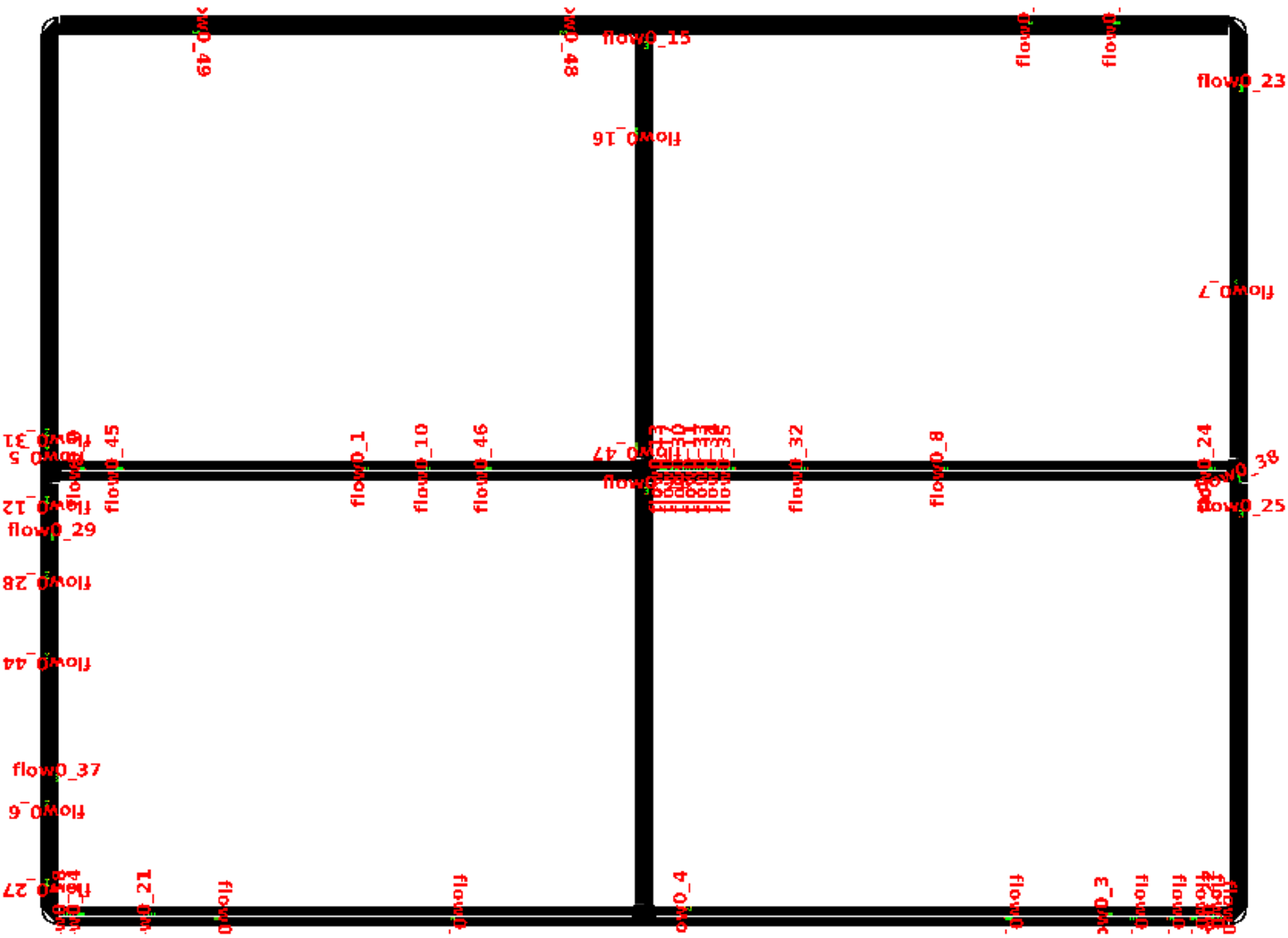


Fig. 4 VANET mobility model with 50 nodes

delay, normalized routing load (NRL) and Average path length as performance metric to evaluate the performance of different routing protocols.

- Packet delivery ratio (PDR): It is the ratio of total number of successfully delivered data packets and the total number of transmitted packets. This parameter metrics give us an idea of how well the protocol is performing in terms of packet delivery (Singh et al. 2011; Maurya and Singh (2010). Mathematically, PDR can define as,

$$PDR = \frac{Total\ number\ of\ successfully\ delivered\ Packets}{Total\ number\ of\ transmitted\ packets} \quad (1)$$

- Average Throughput: The throughput is defined as the ratio of total amount of data a receiver receives from the sender and total time taken to receive the data. The throughput is measured in bits per second (bit/s or bps) (Singh et al. 2011; Maurya and Singh 2010; Li et al. 2010).

$$Average\ throughput = \frac{(Total\ number\ of\ bytes\ received) \times 8}{Total\ time\ taken\ to\ receive\ data} \quad (2)$$

- Average end-to-end delay: The average end-to-end delay is the time interval when a data packet generated from the source is completely received at the application layer of the destination (Singh et al. 2011; Maurya and Singh (2010); Li et al. 2010).

$$Average\ End - to - End\ delay = \frac{\sum (arrive\ time - send\ time)}{Total\ number\ of\ connections} \quad (3)$$

- Normalized routing load (NRL): It is defined as the number of routing packets transmitted by the stations as an overhead with respect to per data packet delivered at

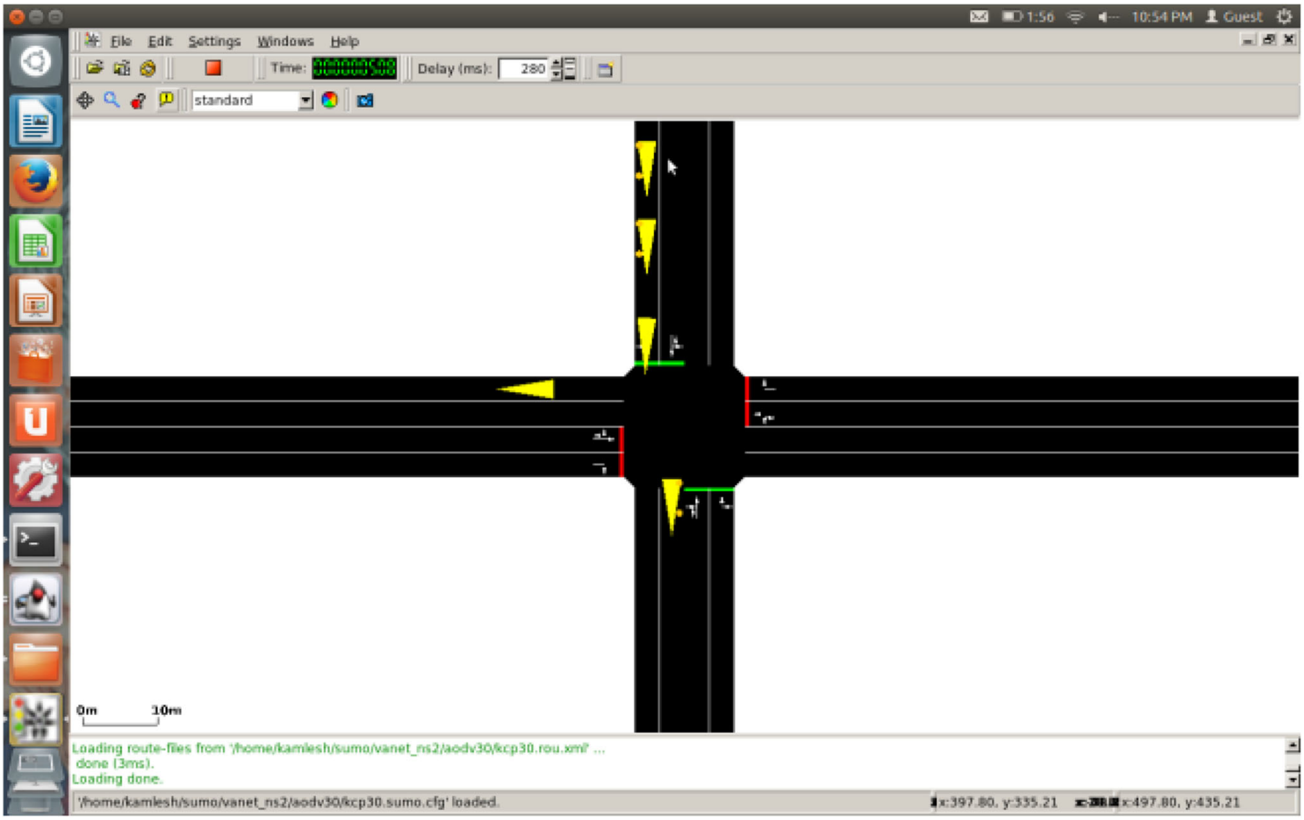


Fig. 5 Vehicle movement and the traffic lights

the destination or in other words, it is the ratio of the total numbers of routing packets sent over the network to the total number of data packets received (Sultana and Raj XXX).

$$NRL = \frac{Total\ number\ of\ routing\ packets\ sent}{Total\ number\ of\ received\ data\ packets} \quad (4)$$

- Average path length: It is defined as the average number steps along the shortest path for all possible pairs of network nodes. It is one of the efficiency parameters for the mass transport in a network (Sultana and Raj XXX).
- Average loss rate: Packet loss is defined as the frequency of loss of one or more packets travelling across a network fail to reach their destination due to the frequent conditions of link failure, buffer overflow, inadequate bandwidth, error fragment or some security related issue.

4 Implementation

The simulation has been performed on Network Simulator version 2.35 (NS2.35). The network is designed using a random waypoint mobility model and traffic sign model (Mahajan et al. 2006) with variable number of nodes for the performance evaluation of AODV, DSR, AOMDV, DSDV, OLSR and ZRP routing protocol in the MANET and VANET environment respectively.

The mobility model used for MANET is a Random waypoint mobility model because it models the random movement of the nodes. For entire simulation, the same movement models are used, the minimum speed of the node was set to 5 m/s and the maximum speed was set to 20 m/s. The source node (1) is communicating with the destination node (4).

The mobility model used for VANET is a traffic sign model (Mahajan et al. 2006) because of the fixed movements of the vehicles onto the roads having traffic lights at the intersection points of the roads. The speed is set to 20 m/s and the source vehicle (1) communicating with destination vehicle (4) shown in Fig. 6.

The simulation parameters for scenario for MANET and VANET are summarized in Table 1. A traffic source for network is constant bit rate (CBR).

In the designed network scenario, node pause time is fixed at 35 s and the number of nodes is varied from 10 to 50 nodes with the difference of 10 nodes, parameters are shown in Table 1.

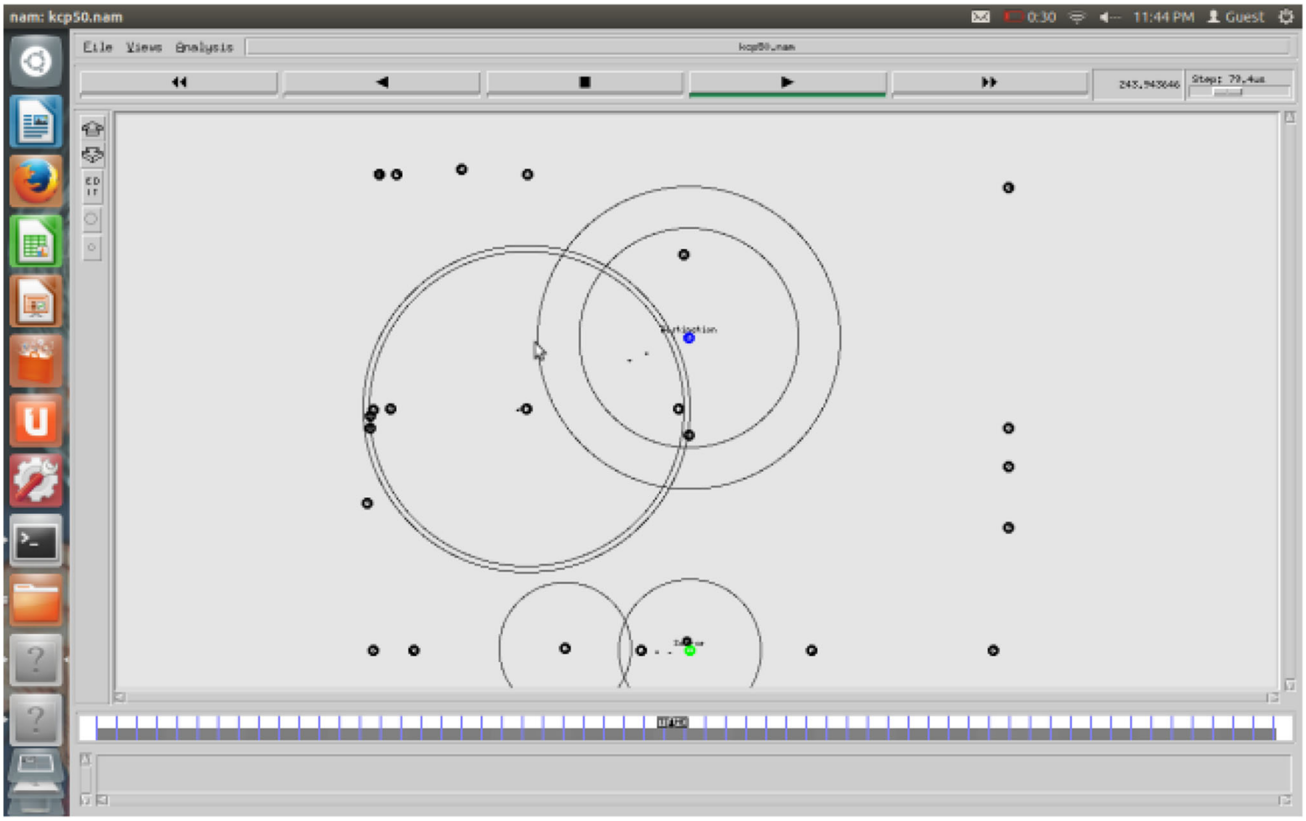


Fig. 6 Communication between source node 1 and destination node 4 in VANET

Table 1 Simulation parameters for MANET

Simulation parameter	MANET	VANET
Simulator	Ns-2 (version 2.35)	NS-2.35, SUMO and MOVE
No. of nodes	10, 20, 30, 40, 50	10, 20, 30, 40, 50
Dimension of space	900 m × 700 m	800 m × 700 m
Minimum velocity (v min)	5 m/s	5 m/s
Maximum velocity (v max)	20 m/s	20 m/s
Simulation time	500 s	500 s
Item size	1000 bytes	1000 bytes
Source data pattern	5 packets per sec	5 packets per sec
Traffic model	CBR	CBR
Node placement strategy	Random	Source of a road
Pause time	35 s	35 s
No. of simulation	10	10

5 Results and analysis

5.1 Packet delivery ratio

In Figs. 7 and 8 we can analyze that the PDR in case of MANET is higher than VANET almost the difference is about 50 %. The best results are given by DSR in MANET environment; while as the best results are given by AODV in VANET environment.

As the number of nodes increasing, the PDR in MANET is decreasing the highest PDR is when the number of nodes is 20. In case of VANET as the number of vehicles is increasing the PDR is also increasing in case of AODV, DSR and AOMDV. Reactive routing protocols have shown

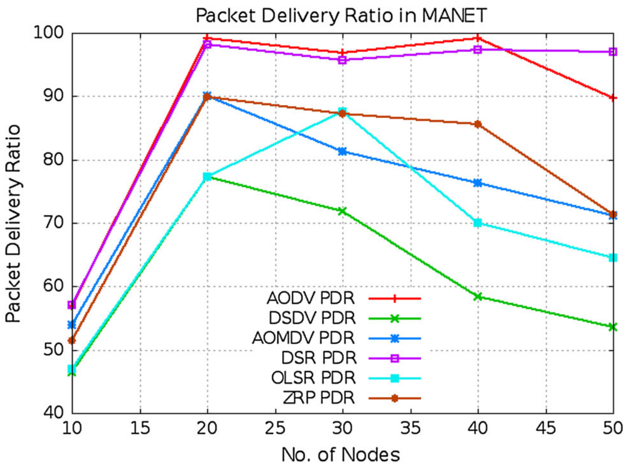


Fig. 7 Variation of the packet delivery ratio for MANET

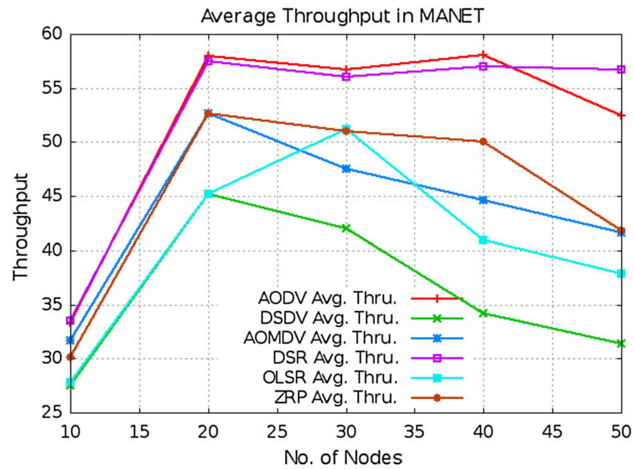


Fig. 9 Variation of the average throughput for MANET

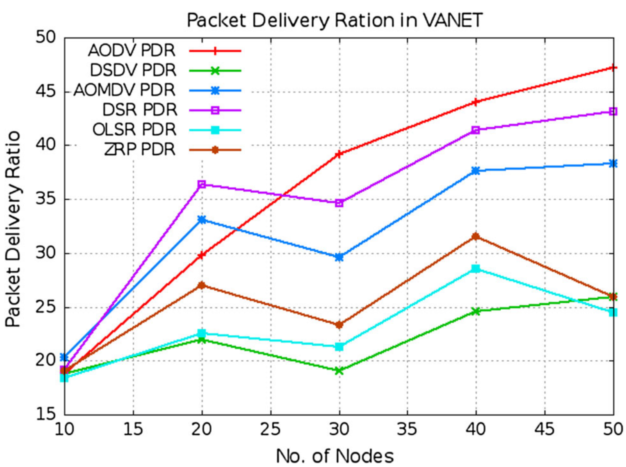


Fig. 8 Variation of the packet delivery ratio for VANET

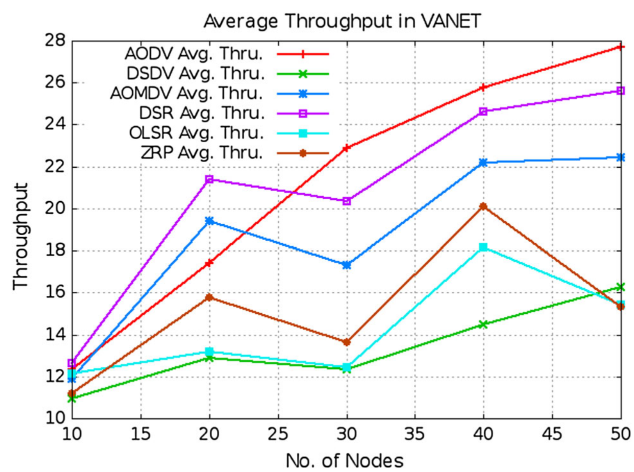


Fig. 10 Variation of the average throughput for VANET

a batter PDR as the number of vehicles is increasing in the network.

5.2 Average throughput

The average throughput in case of reactive protocols like DSR and AODV is relatively high in compression to proactive and hybrid protocols, as the network density is increasing to 50 nodes only DSR has shown better results in compression to rest all.

The average time interval of the number of bits that can be transmitted by each node to its destination is called the node throughput. The sum of the entire node's throughput in the network divided by number of nodes is called the average throughput of the network. As we can analyze the throughput in MANET is almost 50 % greater than throughput in VANET. The best throughput is given by DSR in MANET environment, while as the best throughput is given by AODV in VANET environment, shown in Figs. 9 and 10. Obtained results shows that the performance of reactive and proactive protocols is going down slightly as we are increasing the number of nodes in MANET environment, but in case of VANET the throughput has keep increasing for reactive routing as the number of vehicles is increasing.

5.3 Average end-to-end delay

Using Figs. 11 and 12, we can analyze that the Average end-to-end delay in VANET is much higher than the MANET. The minimum end-to-end delay is given by AODV and AOMDV in case of MANET, while the minimum end-to-end delay is given be OLSR and DSDV in case of VANET. The above results show that the end-to-end delay in proactive protocols like DSDV and OLSR is better than the reactive and hybrid protocols in case of

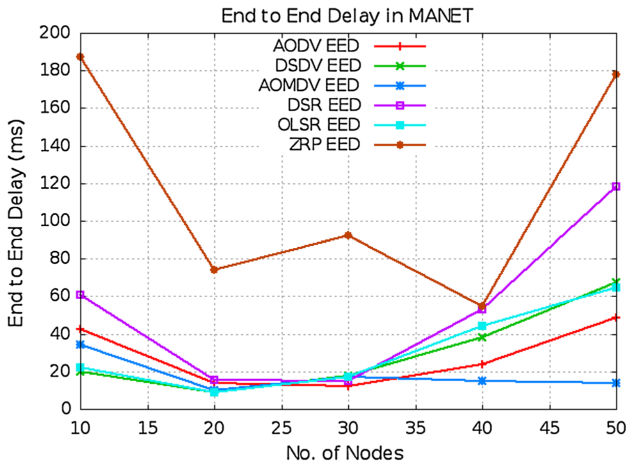


Fig. 11 Variation of the end-to-end delay for MANET

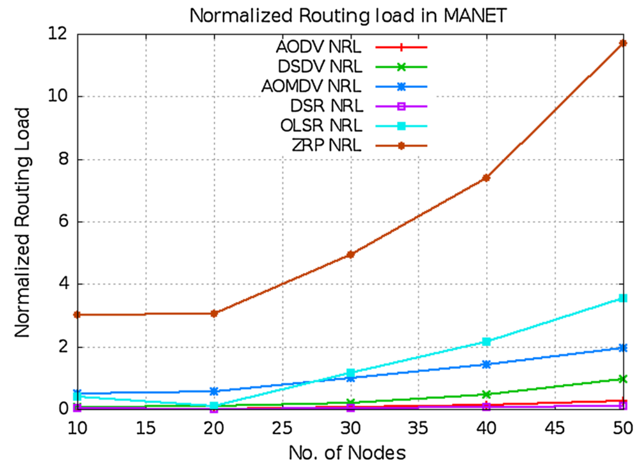


Fig. 13 Variation of the normalized routing load for MANET

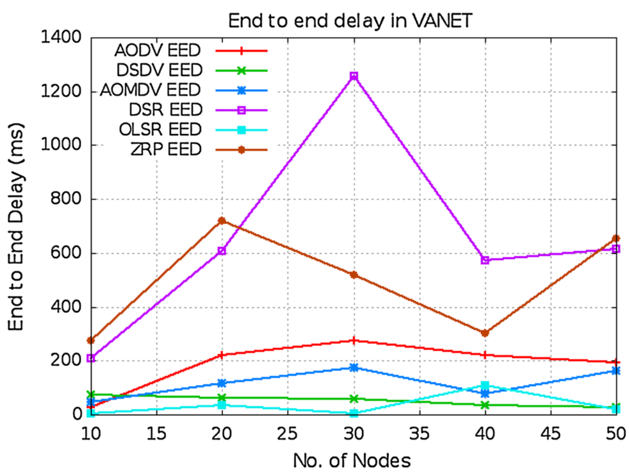


Fig. 12 Variation of the end-to-end delay for VANET

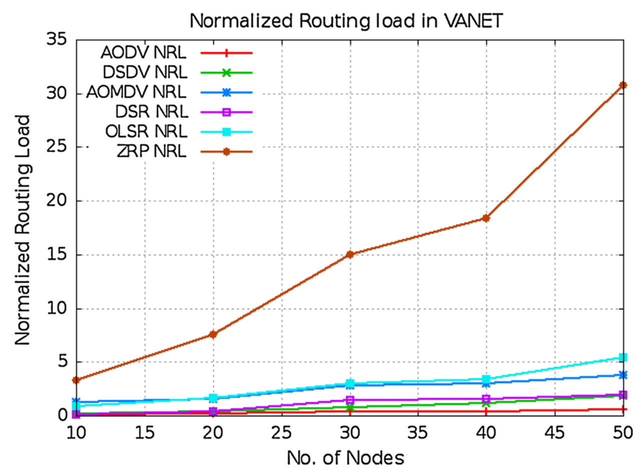


Fig. 14 Variation of the normalized routing load for VANET

VANET. In case of MANET all the protocols are exhibiting the same patters except the ZRP. The end-to-end delay of reactive protocols is slightly higher than the proactive protocols.

5.4 Normalized routing load

Simulation results in Figs. 13 and 14 exhibits the NRL for MANET is slightly less than the NRL for VANET and for few protocol(s) like ZRP the difference is about 50 %. The reactive protocols are having less NRL compare to proactive and hybrid protocols. ZRP has shown the maximum NRL in both cases: MANET as well as VANET. After analyzing results the least NRL we have obtained for reactive routing protocols in VANET environment though it is higher than the NRL in MANET environment. AODV has shown the least NRL for VANET.

5.5 Average path length

The simulation results show's that the average path length for MANET and VANET are very much similar. There is a constant increase in average path length in most of the cases of reactive and proactive protocols for both MANET and VANET environment shown in Figs. 15 and 16. ZRP has a constant average path length for both MANET as well as VANET.

The increase in average path length in case of MANET is higher as the number of nodes are increasing while as in VANET environment the average path length is increasing but not as much as the case of VANET. Especially the result of reactive protocols like AODV and DSR has not shown the amount of increase in the average path length. The obtained results support our claim that the reactive protocols are more suitable than the proactive protocols,especiallyif we analyses the results of AODV.

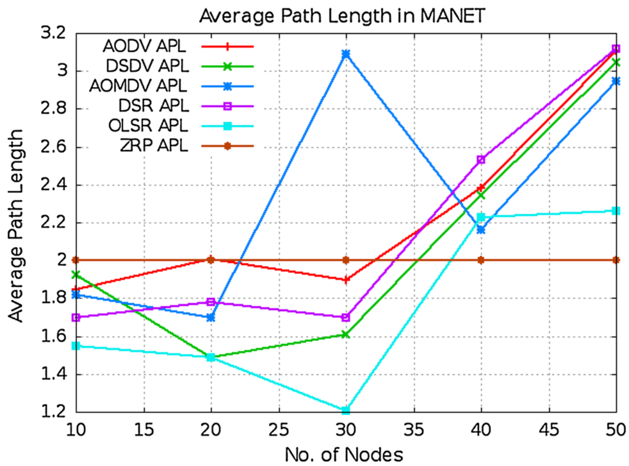


Fig. 15 Variation of the average path length for MANET

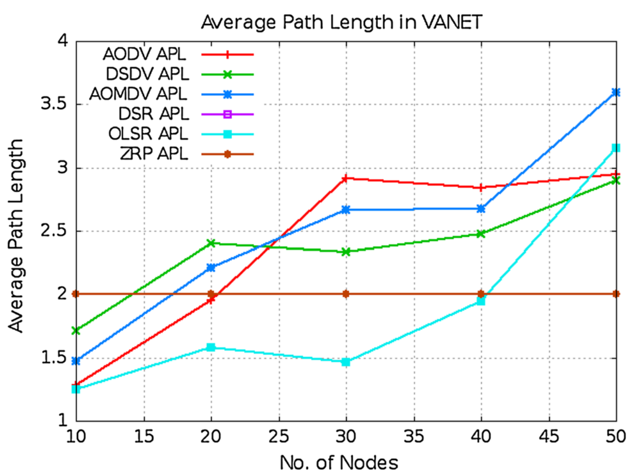


Fig. 16 Variation of the average path length for VANET

5.6 Average packet loss

Packet loss occurs due to fraction of packet lost at MAC layer because of link failure, buffer overflow, inadequate bandwidth, errored fragment or some security related issue. It is more considerable, especially in such types of networks where packet loss is not acceptable. The case considered during the evaluation of various MANET versus VANET routing protocols for packet loss in network layer due to unavailability of buffer space in IFQ and packet drop due to a collision at MAC (DROP_RTR_MAC_CALLBACK).

As the number of nodes increase, the packet loss in VANET is higher than MANET. The proactive protocols have less packet drops in MANET as compared to VANET environment as shown in Figs. 17 and 18.

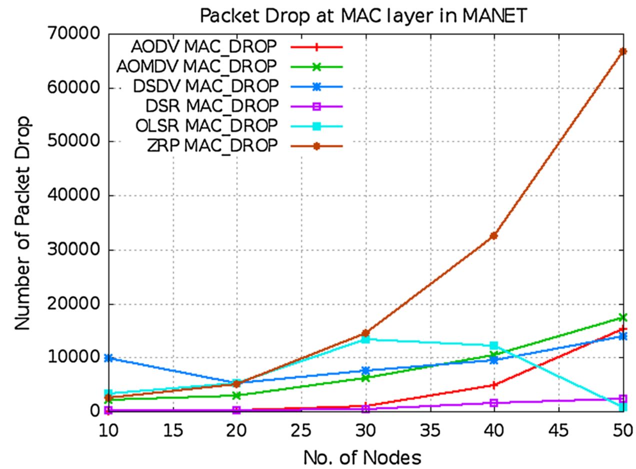


Fig. 17 Packet drop at MAC in MANET

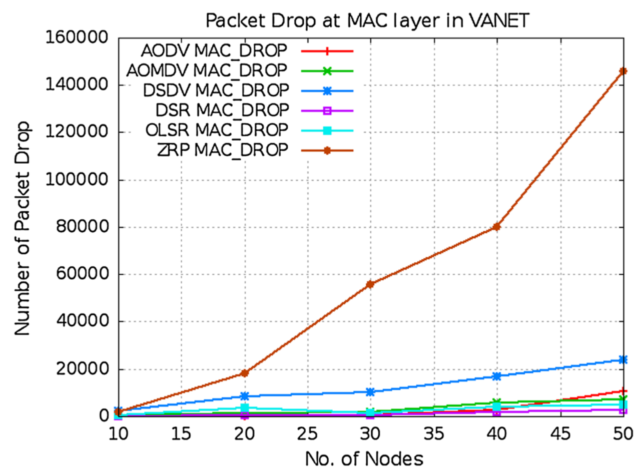


Fig. 18 Packet drop at MAC in VANET

6 Observation

6.1 Effect of network size in MANET

As the number of nodes increased in the network the PDR and the throughput is also increasing. The end-to-end delay is moderate at 20 and 30 nodes but at 10 and 50 nodes it's quite high. The NRL and the average path length are increasing as the numbers of nodes are increasing in the network.

6.2 Effect of network size in VANET

In VANET environment as vehicle density is increasing on the road the PDR and the throughput are also increasing. The end-to-end delay is also showing an increasing pattern as we are increasing the network size. The NRL and

Table 2 Summarization of obtain results

Performance matrices/protocols	AODV		AOMDV		DSR		DSDV		OLSR		ZRP	
	MANET	VANET	MANET	VANET	MANET	VANET	MANET	VANET	MANET	VANET	MANET	VANET
Throughput	H	H	M	M	H	M	L	L	L	L	L	L
Avg. end_to_end delay	L	H	L	H	H	H	L	M	L	M	M	H
Packet delivery ratio	H	H	H	M	H	H	L	L	M	L	M	L
Normalized routing load	L	M	L	M	L	L	L	M	L	M	H	H
Average path length	L	L	L	M	L	L	L	L	L	L	C	C
No. of collisions	M	M	L	M	M	H	L	H	L	L	H	H

average path length have also shown a constant increase as the network size or vehicle density is increasing.

6.3 Admissibility of MANET routing protocol in VANET

After analyzing all these results shown above, we can conclude that the admissibility of MANET routing protocols in VANET environment is not up to the mark due to high mobility and fixed path (Road) movement of the nodes, also for low node density the results are poor.

By successfully implementing the comparison of routing protocols in the MANET and VANET environment, the performance e results are obtained which are shown in Table 2. The results provide an adequate idea regarding the admissibility of MANET routing protocols in VANET environment. Given table also depicts the performance of routing protocols for various performance metrics in the MANET and VANET environment.

7 Conclusion and future work

A comparison study of AODV, AOMDV, DSR, DSDV, TORA and ZRP routing protocols for MANETs and VANET has been made in this paper. The study is based on the PDR, average throughput, average end-to-end delay, NRL and average path length. Which shows that MANET routing protocols are not very well suited for VANET environment, thus there is a need to develop a dedicated or some modification in the existing protocol(s) which can provide better results for VANET environment. AODV has shown slightly better results than others.

As a future work, We can have a protocol which can give more efficient results for both MANET and VANET environments and a new enhanced routing protocol for VANET is needed to be designed for providing better throughput, PDR and to reduce the end-to-end delay, packet loss. An enhancement can be done in on demand routing like AODV for better adaptability in VANET environment.

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