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Reactive vs Proactive in VANET Scenarios

V.Lakshmi Praba*
Department of Computer Science
Govt College for Women
Sivaganga, India
e-mail: vlakshmipraba@rediffmail.com

A.Ranichitra
Dept of MCA
Sri S.R.N.M College,
Sattur, India
e-mail: ranichitra117@gmail.com

Abstract: Vehicular Ad hoc Networks (VANET) is a new technology that has recently evolved and is widely finding applications on areas such as road traffic, payment collection, tourist guiding information and natural hazards. The main goal of VANET is to provide safety and comfort to passengers.VANET is also an Ad hoc network, the protocols used in Mobile ad hoc network suits VANET. The ad hoc routing protocols can be categorized as Reactive protocols and Proactive protocols. This paper presents architecture for VANET and considers Ad hoc On Demand Distance Vector (AODV) from reactive routing group and Destination Sequenced Distance Vector (DSDV) from Proactive routing protocol. These protocols were simulated using NS-2 package and were compared in terms of packet delivery ratio, end to end delay and number of dropped packets in two scenarios: by varying the maximum number of connections and varying the speed of the mobile node with different number of connections.

Keywords: VANET; ITS; AODV; DSDV; RSU

I. INTRODUCTION

To improve the safety and efficiency of the transportation systems and enable new mobile applications and services for traveling, Intelligent Transportation Systems (ITS) have been developed. The field of Inter Vehicle communication (IVC), including both vehicle to vehicle (V2V) and Vehicle to Road Side(V2R), known as VANET, is recognized as an important component of ITS[1,2]. Recent development in wireless communication technologies also led to the creation of VANET.

The main divergence between VANETs and MANETs is that the nodes move with higher average speed and the number of nodes is assumed to be very large in VANET [3]. Vehicles in the network can communicate in air medium through intermediate vehicles and nearby fixed Road Side Unit (RSU). A special electronic device will be placed inside each vehicle which will afford Ad hoc network connectivity for the passengers. This network tends to operate devoid of any infrastructure or client server communication. Each vehicle equipped with the device will be a node in the network and can receive and relay other's messages through the wireless network.

Automatic payment for parking lots and toll collection are some examples of possibilities inside VANET [4]. And other applications in VANET can be found in [5, 9, and 10]. As the number of vehicles in the road has increased drastically and driving becomes more challenging in the recent years, steps must be taken to have a pleasant journey on the road. In this regard, car manufacturer can incorporate a device in the car to help the drivers on the road to overcome the inconvenience in driving.

This paper is organized as follows. Section 2 provides the VANET architecture and characteristics. Section 3 discusses the various routing protocols for VANET. Section 4 provides the performance evaluation of protocols for VANET and the paper is concluded in Section 5.

II. VANET ARCHITECTURE

Vehicular Ad hoc network is an Ad hoc network in which the vehicles act as a node. VANET has to provide safety journey for the passengers and assist the driver from various hazards. The vehicle in the network should posses' in-built display with keypad, a sensor, digital map and a Geographical Positioning Systems (GPS) system. The sensor is powered by the vehicles battery which is used to store the surrounding happenings such as congestion warning, road maintenance, traffic jam, rail tracks and if needed the information will be communicated to the near by vehicles and Road side Unit (RSU).

The vehicles in the network have high mobility, so, it enters and leaves the network dynamically. Figure 1 shows sample architecture of VANET. Vehicles in the network can communicate in the Ad hoc fashion. The nodes transfer the information to the nearby vehicles and RSU about the events that occur in the coverage area. RSU can also communicate with the nearby RSU to share the information.

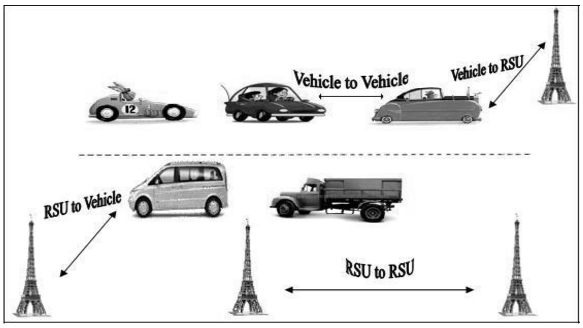


Figure 1. Sample architecture of VANET

The sensor inside the vehicle is responsible for recording the data related to vehicles like speed, height, etc. These data will help in accident reconstruction. RSU also stores the data of the vehicle passing through in the sensors memory installed at the unit. The node in the Vehicular network finds the shortest path to route the packets. If a node fails, the next node in the path has to be assigned the work of the failed node. After recovery, the updated information will be assigned to that node. If there is no nearby vehicle within the coverage area of the failed node, the vehicles can store the information in the Road Side Unit and once a vehicle enters the coverage area the information may be received from the RSU. A vehicle in the VANET can either act as a node or a router. RSU can also communicate with each other.RSU in the network stores the information of all the vehicles crossing the unit like vehicle ID, speed etc. with the help of onsite camera. When there is an interruption in traffic due to collision of vehicles, road maintenance work etc. the information will be sent to RSU and to the nearby vehicles. RSU in turn can communicate the information to the other vehicles to avoid traffic jams. If needed lane switching can be performed prior to the collision. RSU also informs to the nearby fuel station, hospital, fire station, police station. It will also help to locate the missing vehicle and to spot the over speed vehicles.

Vehicular applications depend on the information sent by other vehicles or the information provided by RSU. The driver depends on the application to provide timely and truthful warnings. The application in turn depends on approved information. Once the information is received from the vehicles it has to cross check with the near by vehicles too to evade misbehavior.

III. ROUTING PROTOCOLS

Various Ad hoc routing protocols have been proposed by many researchers. Since most of the characteristics of MANET matches with VANET, the same protocols can be used for VANET also. The Ad hoc protocols can be categorized as proactive protocols and reactive protocols. These protocols help in exchanging the data between source and destination through the intermediate nodes to forward the packets. Proactive or table driven protocols maintains a fresh lists of destinations and their routes by distributing the routing table information. A Reactive or on-demand protocol finds a route on demand by broadcasting the Route Request packets. This paper has considered the protocols one from each category to evaluate in VANET environment: Ad hoc On Demand Distance Vector (AODV)[11,14] from reactive routing group and Destination Sequenced Distance Vector (DSDV)[7] from Proactive routing protocol.

A. Ad hoc on Demand Distance Vector

Ad hoc On Demand Distance Vector (AODV)[6] protocol is a reactive protocol that enables dynamic, self starting, multihop routing between participating mobile nodes to establish and maintain an Ad hoc network. It shares Dynamic source Routing's (DSR) [12] on demand characteristics hence discovers routes whenever needed via a similar route discovery process [13]. The AODV Protocol is designed for Mobile Ad hoc Networks with populations of tens to thousands of mobile nodes. AODV can handle low, moderate, and relatively high mobility rates, as well as a variety of data traffic levels.

Route Requests (RREQs), Route Replies (RREPs), and Route Errors (RERRs) are message types defined by AODV. When a route to a new destination is needed, the node broadcasts a RREQ to find a route to the destination. A route can be determined when the RREQ reaches either the destination itself, or an intermediate node with a 'fresh enough' route to the destination.

A 'fresh enough' route is a valid route entry for the destination whose associated sequence number is at least as great as that contained in the RREQ. The route is made available by unicasting a RREP back to the origination of the RREQ. Each node receiving the request caches a route back to the originator of the request, so that the RREP can be unicast from the destination along a path to that originator. When a link break in an active route is detected, a RERR message is used to alert other nodes that the loss of link has occurred.

B. Destination Sequenced Distance Vector

Destination sequenced distance vector routing (DSDV)[14] is adapted from the conventional Routing Information Protocol (RIP) to Ad hoc networks routing. It adds a new attribute, sequence number, to each route table entry of the conventional RIP. Using the newly added sequence number, the mobile nodes can distinguish stale route information from the new and thus prevent the formation of routing loops.[17].

DSDV is a table-driven routing scheme for ad hoc mobile networks based on the Bellman-Ford algorithm. It was developed by C. Perkins and P.Bhagwat in 1994[7]. The main contribution of the algorithm is to solve the Routing Loop problem. Each entry in the routing table contains a sequence number, the sequence numbers are generally even number if a link is present; else, an odd number is used. The number is generated by the destination, and the emitter needs to send out the next update with this number [7,15].

Routing information is distributed between nodes by sending full dumps infrequently and smaller incremental updates more frequently. DSDV is quite suitable for creating ad hoc networks with small number of nodes [7].

Many improved forms of this algorithm have been suggested. DSDV requires a regular update of its routing tables, which uses up battery power and a small amount of bandwidth even when the network is idle. Whenever the topology of the network changes, a new sequence number is necessary before the network reconverges. [16]

IV. PERFORMANCE EVALUATION

In this paper, two protocols (AODV, DSDV) have been compared to study their performance in a free attack environment using different performance metrics.

A. Simulation Environment

NS-2 (Network Simulator-2)[8] is used for the performance evaluation. Mobility scenarios are generated using random way point model by having 30 mobile nodes in the area of 1000m x 1000m. The following three typical performance measures Packet Delivery Ratio, Average end to end delay and dropped packets have been evaluated.

B. Performance Metrics

The following metrics has been used to evaluate the performance of the two protocols in VANET environment.

1) Packet Delivery Ratio: Packet delivery ratio is important as it describes the loss rate of the packets. It also affects the maximum throughput. It can be defined as the ratio between the total numbers of the Constant bit Ratio (CBR) packets delivered to the destination to the total numbers of packets sent by the source.

$$\Pi\Delta P = \frac{\sum_{i=1}^{n} received\ CBRi}{\sum_{i=1}^{n} sent\ CBRi}\ \Xi\ 100 \qquad (1)$$

2) Average End to End Delay: It includes all delays caused by buffering during route discovery, queuing at the interface, retransmission at the Medium Access Control

(MAC), propagation and transfer times. In simpler terms the average End-to-end delay is the time it takes for a packet to travel across the network from source to destination.

$$End\ to\ End\ Delay = \frac{\sum_{i=1}^{n} CBRi(RT) - CBRi(ST)}{Total\ No.of\ GP}\ ms \qquad (2)$$

RT – received Time, ST - Sent Time, GP – Generated Packets

3) Dropped Packets: In a computer network packet loss occurs when one or more packets of data travelling across a computer network fail to reach their destination. The total number of packets dropped during the transmission is calculated as follows.

$$Dropped\ Packets = \sum_{i=1}^{n} Sent\ CBRi - \sum_{i=1}^{n} Received\ CBRi \qquad (3)$$

C. Simulation Results

The performance of the protocol has been evaluated by considering the following scenarios which consists of 30 vehicles.

Scenario 1: Varying maximum speed with number of connections as 5, 10 and 15 respectively.

Scenario 2: Varying the maximum number of connections.

Table I. Simulation Parameters

Parameter	Value
Simulator	Ns-2
Simulation Time	300 s
Mobility Model	Random Way Point
Number of nodes	30
Maximum No. of connections	5,10,15
Protocols	AODV, DSDV
Traffic model	CBR
Area	1000 x 1000
Antenna	Omni directional

1) Scenario 1

a) Reactive routing protocol (AODV): The experiment uses fixed number of nodes by changing the speed of the mobile nodes (10, 20, 30, 40, 50, and 60) for different number of connections. The simulation parameters are summarized in Table 1.

Table 2 considers the three performance metrics for the maximum number of connections of 5, 10 and 15 respectively by varying the maximum speed from 10 to 60 in steps of 10.

Table II. Simulation Values for AODV

	Maximum Number of Connections								
Max Speed	***PDR %***			***End to End Delay(ms)***			***Dropped Packets %***		
	5	***10***	***15***	***5***	***10***	***15***	***5***	***10***	***15***
10	97.81	97.16	93.07	28.1	96.54	82.77	2.19	2.84	6.92
20	95.16	95.58	95.99	82.3	107.63	129.15	4.84	4.42	4.01
30	91.46	91.87	91.56	151.23	155.2	210.21	8.53	8.13	8.43
40	83.83	82.35	82.38	246.21	377.56	429.54	16.17	17.64	17.62
50	89.32	91.37	91.7	261.02	307.34	282.87	10.67	8.63	8.30
60	80.42	77.36	77.17	480.57	354.77	484.7	19.57	22.64	22.82

Figure 2 shows the performance of AODV protocol with different values for maximum number of connections.

Packet Delivery Ratio: Figure 2.a shows the packet delivery ratio for AODV with number of connections as 5, 10 and 15. From the graph it is clear that the AODV performance does not show good results for the speed greater than 30 ms. The ideal range for PDR is between the speed of 10 and 30 ms irrespective of the maximum number of connections.

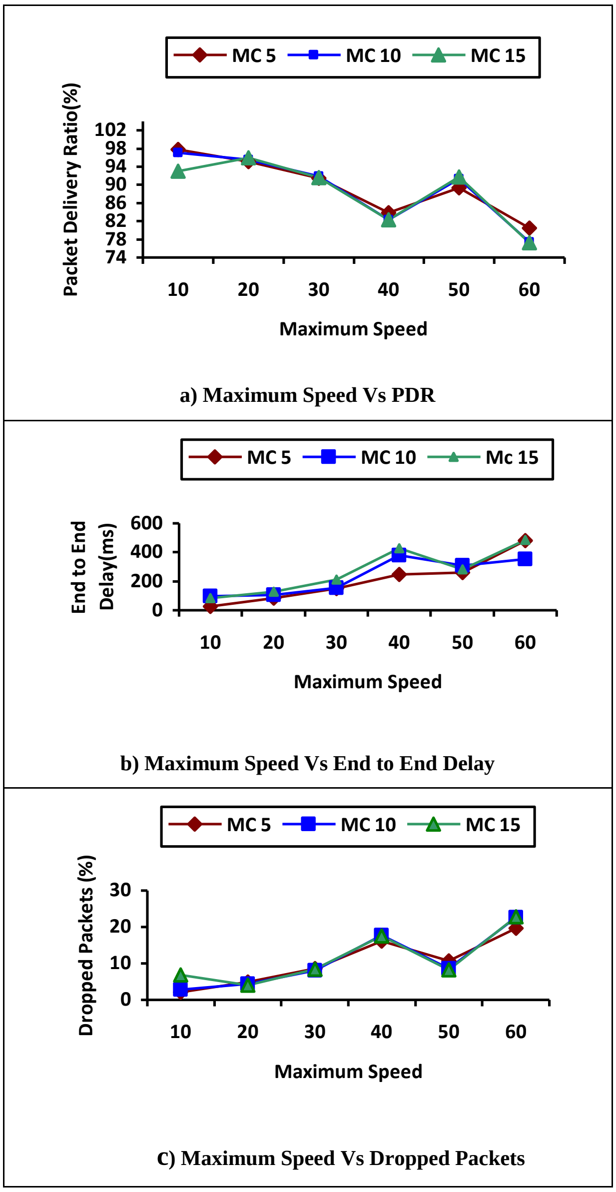


Figure 2. Performance of AODV

Average end to end delay: Figure 2.b shows average end to end delay for AODV protocol. The simulation result shows that end to end delay is high low with the speed greater than 40 ms and does not show good results. Hence the ideal range for end to end delay is between the speed of 10 and 30 ms irrespective of the maximum number of connections.

Dropped Packets: Figure 2.c shows the percentage of dropped packets for AODV protocol. The simulation results shows that number of dropped packets is minimum if the node speed is less than 40 ms as speed.

While evaluating the AODV protocol by varying the speed of the mobile node for different number of connections, results show that the AODV protocol has an average of 94.5% Packet delivery ratio, with a minimum end to end delay and an average dropped packets of 5.5% within the node speed range of 5 and 15.

*Proactive routing Protocol (DSDV):*Table 3 shows the simulation values for DSDV Protocol. Figure 3 shows the performance of DSDV protocol with different values for maximum no. of connections.

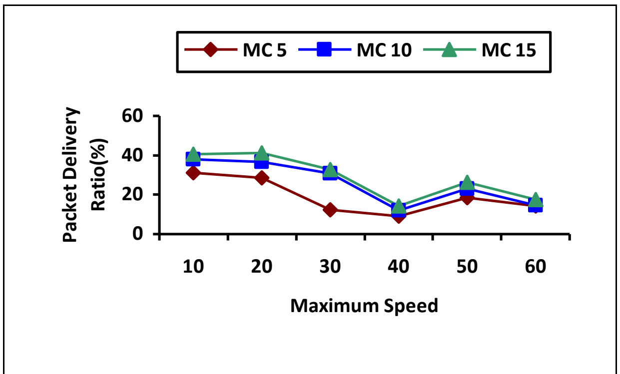
Table III. Simulation Values for DSDV

Max Speed	Maximum Number of Connections								
	PDR %			End to End Delay (ms)			Dropped Packets %		
	5	10	15	5	10	15	5	10	15
10	31.27	38	40.64	3.14	55.1	40.03	46.37	48.31	49.36
20	28.56	36.7	41.09	1.33	59.84	64.73	51.55	49.62	47.67
30	12.44	30.9	32.62	0	72.84	117.39	76.85	55.51	57.67
40	9.17	12.15	14.31	0.93	99.84	251.42	81.75	82.10	81.16
50	18.6	22.92	26.11	239.38	117.07	204.84	65.71	67.78	66.47
60	14.3	14.73	17.32	141.98	313.15	276.21	72.35	78.74	76.93

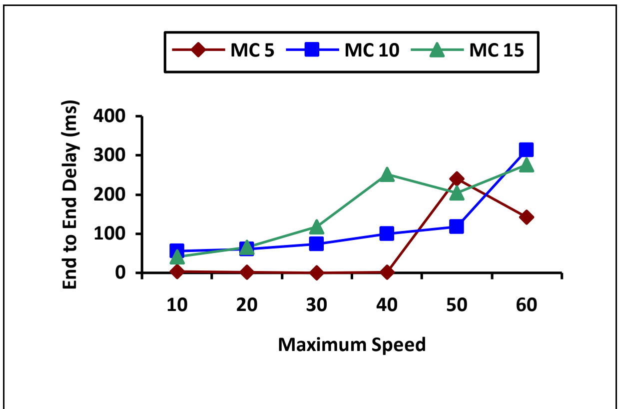
Packet Delivery Ratio: Figure 3.a shows the packet delivery ratio for DSDV with number of maximum connections (MC) as 5, 10 and 15. From the graph it is clear that the PDR is maximum with less speed of the mobile nodes and PDR decreases gradually as the speed is greater than 30 ms as speed. When the speed of the mobile node is 50, PDR gains a sudden increase and again it decreases drastically irrespective of the maximum number of connections.

Average end to end delay: Figure 3.b shows average end to end delay for DSDV protocol. The simulation result shows that end to end delay is less with minimum number of connections and with the node speed less than 30 ms. Hence the ideal range for end to end delay is between 10 ms and 20 ms with number of connections as 5.

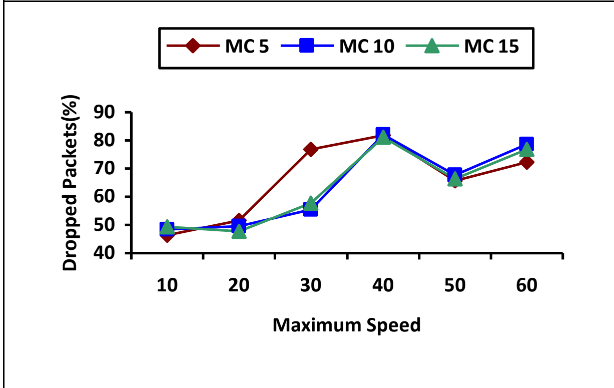
No. of Dropped Packets: Figure 3.c shows the number of dropped packets for DSDV protocol. The simulation result shows that the number of dropped packets is minimum, if the speed of the node is less than 30 ms. The ideal range for dropped packets is between 10 and 30 ms with number of connections greater than 10.



a) Maximum Speed Vs PDR



b) Maximum Speed Vs End to End Delay



c) Maximum Speed Vs Dropped Packets

Figure 3. Performance of DSDV

While evaluating the DSDV protocol simulation shows that an average of 36% Packet delivery ratio, with a minimum end to end delay and with 48% of average dropped packets can be achieved within the node speed range 5 and 15.

2) Scenario 2 - Reactive vs Proactive: The experiment uses fixed number of nodes by changing the maximum number of connections (5, 10, 15, 20, 25, 30, 35, and 40). The simulation parameters are summarized in Table 4 and results are given in the following figures.

Table IV. Simulation Parameters

Parameter	Value
Simulator	Ns-2
Simulation Time	300 s
Mobility Model	Random Way Point
Number of nodes	30
Maximum speed	11
Protocols	AODV, DSDV
Traffic model	CBR
Area	1000 x 1000
Antenna	Omni directional

Packet Delivery Ratio: Figure 4 shows the comparison of the routing protocols on the basis of PDR in free attack environment. The obtained result clearly indicates that PDR for AODV is high whereas the PDR for DSDV increases gradually with minimum number of connections and remains constant when the number of connections is greater than 20. However the performance of AODV is always better than that of DSDV.

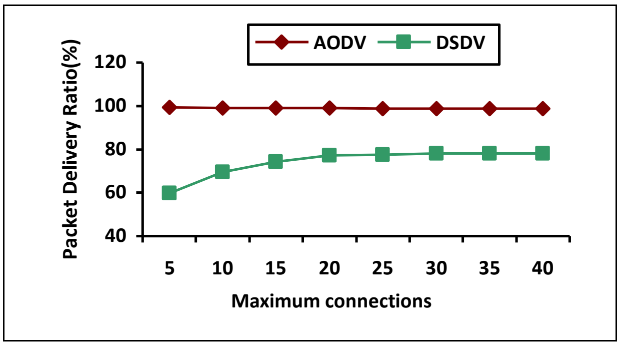


Figure 4. Maximum Connections vs PDR

Average end to end delay: Figure 5 shows the average end to end delay for both the protocols. The simulation results of AODV show that, though the end to end delay is high at initial stage it decreases gradually and remains constant for the number of connections greater than 20. But for DSDV the average end to end delay in the initial stage is less which then increases with number of connection as 10 and remains constant with the number of connections greater than 25. The study indicates that the performance of AODV is always better when the maximum number of connections is greater than 10.

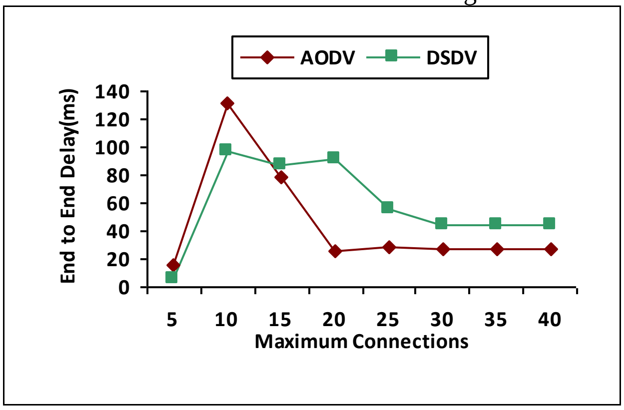


Figure 5. Maximum Connections vs End to end Delay

Dropped packets: Dropped packets versus maximum number of connections are shown in figure 6. From the study it is clear that more number of packets are dropped for DSDV when compared to AODV.

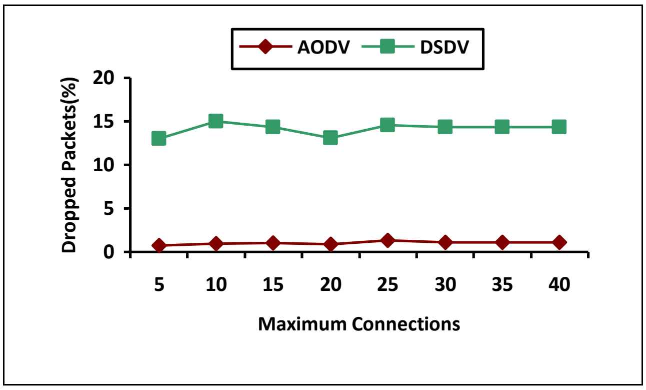


Figure 6. Maximum Connections vs Dropped packets

It is observed that though both the protocols are suitable for VANET, AODV is always better than DSDV.

V. CONCLUSION

In this paper, a sample architecture for VANET was presented and two ad hoc routing protocols AODV and DSDV have been compared in terms of Packet Delivery Ratio, End to End delay and number of dropped packets in two scenarios: by varying the maximum number of connections and number of connections and varying the speed of the mobile node with different number of connections.

VANET architecture was designed for 30 vehicles. The most widely used protocol namely AODV and DSDV were studied, analyzed and simulated using NS2 in a free attack environment for the three important performance metrics of Packet Delivery Ratio, End to end delay and dropped packets.

Two different scenarios were considered and evaluated in this paper. Scenario 1 clearly indicated that the ideal maximum speed for all the considered metrics lies within the range 10 to 30. Scenario 2 analyses by comparing Reactive Vs Proactive protocols by considering AODV and DSDV respectively.

The obtained results clearly indicate that reactive protocol AODV always out performs proactive protocol DSDV for the considered performance metrics under the constrained NS2 simulated VANET Scenario.

Though AODV performs well, there are identified security threats in this protocol too. Research can be concentrated for improving AODV protocol to provide secured VANET environment.

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