Modeling of VANET Technology & Ad-Hoc Routing Protocols Based on High Performance Random Waypoint Models

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ABSTRACT

Today, one of the new technologies in the modern era is Vehicular Ad-hoc Network which has taken enormous attention in the recent years. Because of rapid topology changing and frequent disconnection makes it difficult to design an efficient routing protocol for routing data between vehicles, called V2V or vehicle to vehicle communication and vehicle to roadside infrastructure, called V2I. Designing an efficient routing protocol has taken significant attention because existing routing protocols for VANET are not efficient to meet every traffic scenario. For this reason it is very necessary to identify the pros and cons of routing protocols as well as simulation of protocols is essential to understand existing routing protocols behavior. In this research paper, we focus on VANET topology based routing protocols and also measure the performance of two on-demand routing protocols AODV & DSR in the random waypoint scenario.

KEYWORDS: Vehicular ad-hoc network, AODV, DSR, Packet Delivery Ratio, Loss Packet Ratio, Average End-to-End Delay

1. INTRODUCTION

VANET (Vehicular ad-hoc network) is a special form of MANET which is an autonomous & self-organizing wireless communication network, where nodes in VANET involve themselves as servers and/or clients for exchanging & sharing information. Due to new technology government has taken huge attention on it. There are many research projects around the world which are related with VANET such as COMCAR, DRIVE , FLEENET and NOW (Network on Wheels) , CARTALK, CARNET [1-4]. There are several VANET applications such as Vehicle collision warning, Security distance warning, Driver assistance, Cooperative driving, Cooperative cruise control, Dissemination of road information, Internet access, Map location, Automatic parking, and Driverless vehicles [5-7].

In this paper, we mainly focus on VANET topology based routing protocols and we also have evaluated the performance of AODV and DSR based on random waypoint model. The remainder of the paper is organized as follows: Section 2 describes the VANET characteristics. Section 3 describes shortly about VANET topology based routing protocols pros & cons. Section 4 discusses briefly about two on demand routing protocols AODV and DSR procedure. Section 5 describes connection types like TCP and CBR. Section 6 presents

performance metrics and the network parameters. Section 7 presents our implementation. Section 8 presents experimental analysis. Section 9 presents our decisions. We conclude in Section 10 and with the references at the end.

2. CHARACTERISTICS

VANET has some unique characteristics which make it different from MANET as well as challenging for designing VANET applications. They are as follows:

2.1 HIGH DYNAMIC TOPOLOGY

The topology of VANET changes because of the movement of vehicles at high speed. Suppose two vehicles are moving at the speed of 20m/Sec and the radio range between them is 160 m. Then the link between the two vehicles will last $160/20 = 8$ Sec.

2.2 FREQUENT DISCONNECTED NETWORK

From the highly dynamic topology results we observe that frequent disconnection occur between two vehicles when they are exchanging information. This disconnection will occur mostly in sparse networks.

2.3 MOBILITY MODELING

The mobility pattern of vehicles depends on traffic environment, roads structure, the speed of vehicles, driver's driving behavior and so on**.**

2.4 BATTERY POWER AND STORAGE CAPACITY

In modern vehicles battery power and storage is unlimited. Thus it has enough computing power which is unavailable in MANET. It is helpful for effective communication & making routing decisions.

### 2.5 COMMUNICATION ENVIRONMENT

The communication environment between vehicles is different in sparse network & dense network. In dense network building, trees & other objects behave as obstacles and in sparse networks like highway this thing is absent. So the routing approach of sparse & dense network will be different.

2.6 INTERACTION WITH ONBOARD SENSORS

The current position & the movement of nodes can easily be sensed by onboard sensors like GPS device. It helps for effective communication & routing decisions.

3. VANET TOPOLOGY BASED ROUTING PROTOCOLS

Topology based routing protocols use the link's information within the network to send the data packets from source to destination. Topology based routing approach can be further categorized into proactive (table-driven) and reactive (on-demand) routing. Fig. 1 shows a summary of unicast VANEL Routing protocols. Some important categories and sub-categories with their pros and cons are given below:
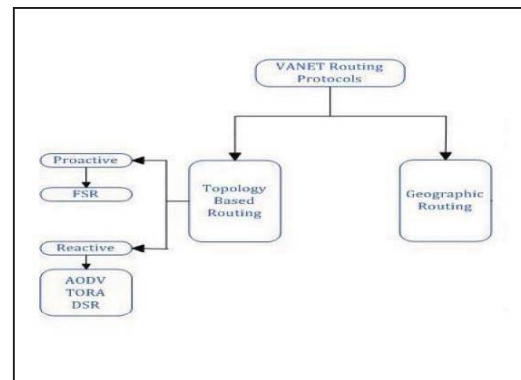
Fig. 1. Unicast routing protocols in VANET

3.1 PROACTIVE (TABLE-DRIVEN)

Proactive routing protocols are mostly based on shortest path algorithms. They keep information of all connected nodes in the form of tables because these protocols are table based. Furthermore, these tables are also shared with their neighbors. Whenever any change occurs in network topology, every node updates its routing table.

Pros

- No Route Discovery is required.
- Low Latency for real time applications.

Cons

- Unused paths occupy a significant part of the available bandwidth.

3.1.1 FISHEYE STATE ROUTING

FSR [7] is a proactive or table driven routing protocol where the information of every node collects from the neighboring nodes. Then calculate the routing table. It is based on the link state routing & an improvement of Global State Routing.

Pros

- FSR reduces significantly the consumed bandwidth as it exchanges partial routing update information with neighbors only.
- Reduce routing overhead.
- Changing in the routing table will not occur even if there is any link failure because it doesn't trigger any control message for link failure.

Cons

-Very poor performance in small ad hoc networks.

-Less knowledge about distant nodes.

-The increase in network size the storage complexity and the processing overhead of routing table also increase.

- Insufficient information for route establishing.

3.2 REACTIVE (ON DEMAND)

The reactive routing protocol is called on demand routing because it starts route discovery when a node needs to communicate with another node thus it reduces network traffic.

Pros

-To update routing table not require periodic flooding the network. Flooding requires when it is demanded.

-Beaconless so it saves the bandwidth.

Cons

- For route finding latency is high.
- Excessive flooding of the network causes disruption of nodes communication.

3.2 .1 AODV

Ad Hoc on Demand Distance Vector routing protocol [8] is a reactive routing protocol which establish a route when a node requires sending data packets. It has the ability of unicast & multicast routing. It uses a destination sequence number (DestSeqNum) which makes it different from other on demand routing protocols.

Pros

- An up-to-date path to the destination because of using destination sequence number.
- It reduces excessive memory requirements and the route redundancy.
- AODV responses to the link failure in the network.
- It can be applied to large scale ad-hoc network.

Cons

-More time is needed for connection setup & initial communication to establish a route compared to other approaches.

-If intermediate nodes contain old entries it can lead inconsistency in the route.

-For a single route reply packet if there has multiple route reply packets this will lead to heavy control overhead.

- Because of periodic beaconing it consumes extra bandwidth.

3.2.2 DSR

The Dynamic Source Routing (DSR) protocol is presented in [9] which utilize source routing & maintain active routes. It has two phases route discovery & route maintenance.

Pros

-Beacon less.

-To obtain the route between nodes, it has small overload on the network. It uses caching which reduces load on the network for future route discovery.

-No periodical update is required in DSR.

Cons

-If there are too many nodes in the network the route information within the header will lead to byte overhead.

-Unnecessary flooding burden the network.

-In high mobility pattern it performs worse.

-Unable to repair broken links locally.

3.2 .3 TEMPORALLY ORDERED ROUTING PROTOCOL (TORA)

Temporally Ordered Routing Protocol [10] is based on the link reversal algorithm that creates a direct acyclic graph towards the destination where the source node acts as a root of the tree. In TORA packet is broadcasted by sending node, by receiving the packet neighbor nodes rebroadcast the packet based on the DAG if it is the sending node's

downward link.

Pros

-It creates DAG (Direct acyclic graph) when necessary.

-Reduce network overhead because all intermediate nodes don't need to rebroadcast the message.

-Perform well in dense networks.

Cons

-It is not used because DSR & AODV perform well than TORA.

-It is not scalable.

4. PROCEDURE OF AODV & DSR PROTOCOL

A routing protocol is necessary to forward a packet from source node to destination in ad-hoc network. Thus for packet forwarding numerous routing protocols have been proposed. In this paper we focus on two important protocols AODV [8] & DSR [9]. AODV & DSR are reactive routing protocols which are also called on demand routing protocol because routes are created only when the source node wants to send a packet to destination.

4.1 AODV

AODV routing protocol mechanism is that if a source node wants to send a packet to a destination node at first the entries in the routing table are checked to confirm that whether the current route exists to that destination node or not. If exists the data packet will forward to the next hop otherwise the route discovery process is initiated. For Route discovery process using Route Request (RREQ) & Route Reply (RREP). The route is

established when receiving RREP message from destination to source. This procedure is called backward learning. Fig. 3 and Fig. 4
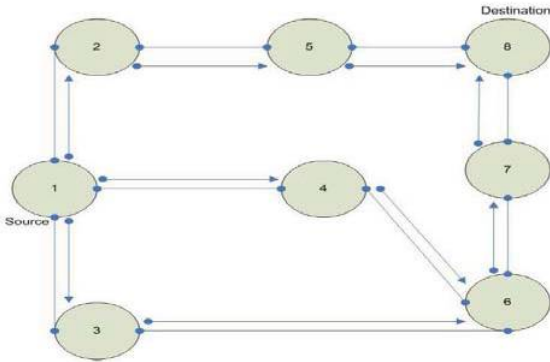

Fig. 2. Propagation of the RREQ for AODV route discovery

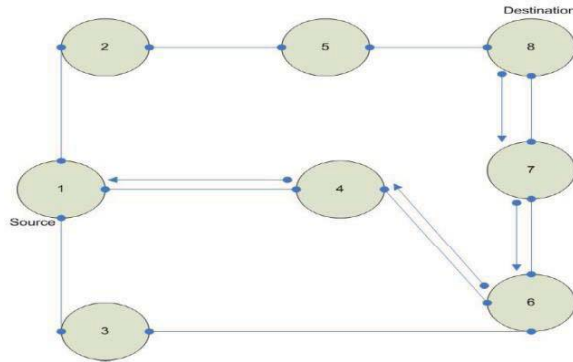shows the RREQ and RREP for the AODV route discovery.

Fig. 3. Path of the RREP to the Source for AODV route discovery

4.2 DSR

The Dynamic Source Routing (DSR) [9] protocol has two phases route discovery & route maintenance. It does not use periodic routing message. All the intermediate nodes ID are stored in the packet header of DSR that it has traversed. Thus when destination occurs then from the query packet it retrieves the entire path information which is used to respond to the source. As a result, establish a path from the source node to the destination node. If there have multiple paths to go to the destination DSR stores multiple path of its routing information. If any route breaks occur in that case an alternative route can be used in DSR. It will generate an error message if there is any link failure. DSR route discovery process shown in Fig. 4.

AODV and DSR have some significant differences. In AODV when a node sends a packet to the destination then data packets only contain destination address. On the other hand in DSR when a node sends a packet to the destination the full routing information is

carried by data packets which causes more routing overhead than AODV.
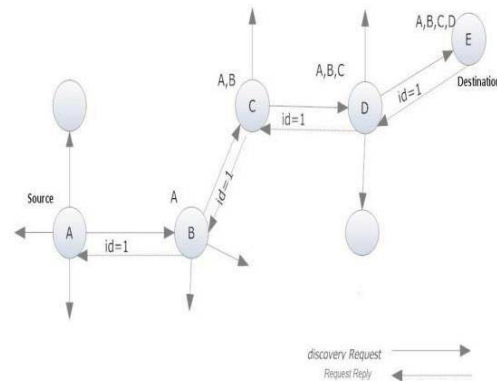

Fig. 4. DSR Route Discovery

5. CONNECTION TYPES

There are several types of connection pattern in VANET. For our simulation purpose we have used CBR and TCP connection pattern.

5.1 CONSTANT BIT RATE (CBR)

Constant bit rate means consistent bits rate in traffic are supplied to the network. In CBR, data packets are sent with fixed size and fixed

interval between each data packet. Establishment phase of connection between nodes is not required here, even the receiving node doesn't send any acknowledgement messages. The connection is one way direction like source to destination.

5.2 TRANSMISSION CONTROL PROTOCOL (TCP)

TCP is a connection oriented and reliable transport protocol. To ensure reliable data transfer TCP uses acknowledgement, time outs and retransmission. Acknowledge means the successful transmission of packets from source to destination. If an acknowledgement is not received during a certain period of time which is called time out then TCP transmit the data again.

6. PERFORMANCE METRICS & NETWORK PARAMETERS

For network simulation, there are several performance metrics which are used to evaluate the performance. In our simulation purpose we have used the below three performance metrics.

6.1 PACKET DELIVERY RATIO (PDR)

The packet delivery ratio is the ratio of the number of packets received at the destination to the number of packets sent from the source. The performance is better when packet delivery ratio is high.

*PDR = (no off received packets / no off sent packets) * 100*

6.2 AVERAGE END-TO-END DELAY (E-2-E DELAY)

This is the average time delay for data packets from the source node to the destination node. To find out the end-to-end delay the difference of packets sent and received time was stored and then dividing the total time difference over the total number of packets received gave the average end-to-end delay for the received packets. The performance is better when packet end-to-end delay is low.

*E-2-E Delay = (time packet received - time packet sent) / total no of packets received * 100*

6.3 LOSS PACKET RATIO (LPR)

Loss Packet Ratio is the ratio of the number of packets that never reached the destination of the number of packets originated from the source.

*LPR = (no off sent packets – no off received packets) / no off sent packets * 100*

7. OUR IMPLEMENTATION

To implement our simulation we used Network Simulator NS-2.34 [11, 12]. Also we used a random waypoint mobility model for our simulation. To measure the performance of AODV and DSR same scenario is used for both the protocols.

7.1 SIMULATION PARAMETERS

In our simulation, we used environment size 840 m x 840 m, node density 30 to 150 nodes with constant maximum speed 15 m/s and variable pause time 50 to 250 s. We did the Simulation for 200s with maximum 8 connections. The network parameters we have used for our simulation purpose shown in the table 1.

Table 1. Network Parameters

Parameter	Value
Protocols	AODV, DSR
Simulation Time	200 s
Number of Nodes	30, 90, 150
Simulation Area	840 m x 840 m
Speed Time	5, 10, 15, 20, 25 m/s
Pause Time	50, 100, 150, 200, 250 s
Traffic Type	CBR, TCP
Mobility Model	Random Waypoint
Network Simulator	NS 2.34

7.2 STANDARD FOR ANALYSIS

For analyzing our experiment we define a standard for simulation results. We consider 30 nodes as low density, 90 nodes as average density and 150 nodes as high density. We also consider 5 m/s as low speed, 15 m/s as average speed and 25 m/s as high speed.
The standard for PDR values (approx.) defined below

For speed & pause time:

High: >=98%

Average: 96% to 97%

Low: <=95%

The standard for E-2-E values (approx.) defined below

For pause time:

High: >=351ms

Average: 151ms to 350ms

Low: <=150ms

For speed time:

High: >=150%

Average: 51% to 150%

Low: <=50%

The standard for LPR values (approx.) define below

For pause time:

High: > 2%

Average: 1% to 2%

Low: < 1%

**For speed time:**

High: > 3%

Average: 1.5% to 3%

Low: < 1.5%

7.3 SIMULATION RESULTS

The performance of AODV & DSR has been analyzed with varying pause time 50s to 250s and speed time 5 to 25 m/s for number of nodes 30, 90, 150 under TCP & CBR connection. We measure the packet delivery ratio, loss packet ratio & average end-to-end delay of AODV and DSR. Based on the simulation result we have generated the graph which shows the differences between AODV and DSR. The graphs are given below.
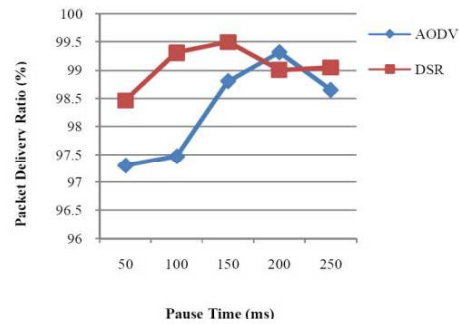
Fig. 5. PDR (w.r.t. Pause) of 30 nodes using TCP
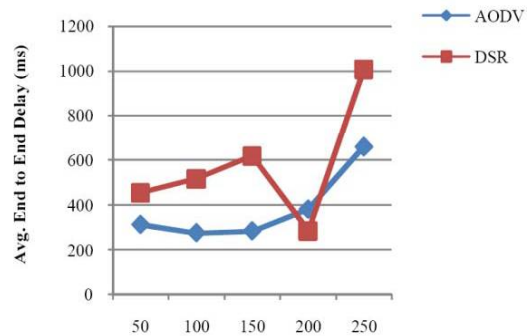
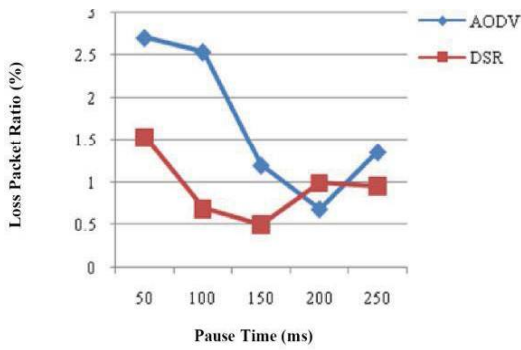**Fig. 6.** Avg.E2E delay (w.r.t. Pause) of 30 nodes using TCP

Fig. 7. LPR (w.r.t. Pause) of 30 nodes using TCP
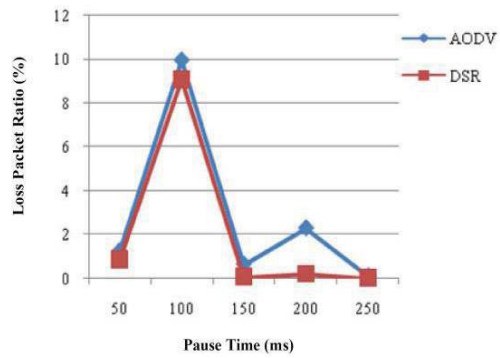

Fig. 10. LPR (w.r.t. Pause) of 30 nodes using CBR
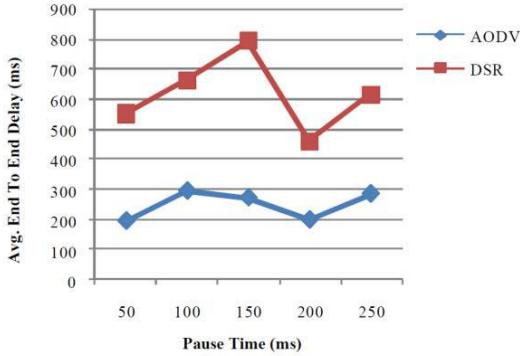

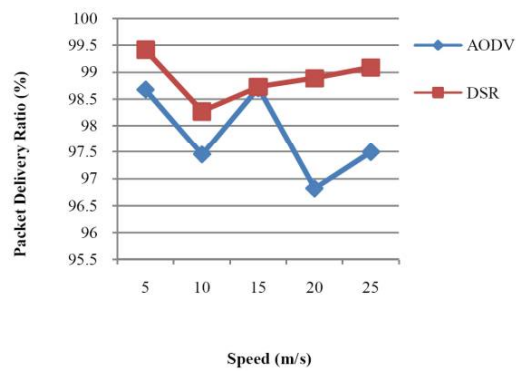**Fig. 8.** Avg.E2E delay (w.r.t. Pause) of 150 nodes using TCP

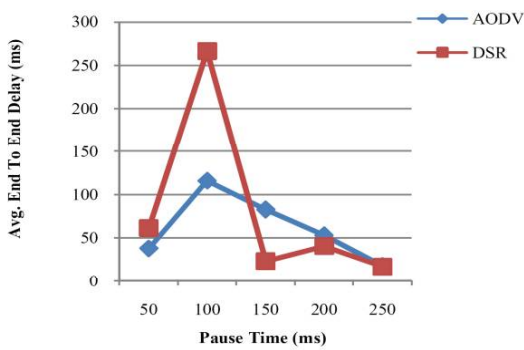**Fig. 11.** PDR (w.r.t. Speed) of 30 nodes using TCP

Fig. 9. Avg.E2E delay (w.r.t. Pause) of 30 nodes using CBR

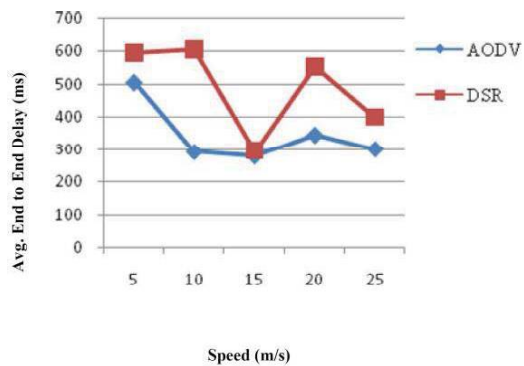**Fig. 12.** Avg.E2E delay (w.r.t. Speed) of 30 nodes using TCP

8. EXPERIMENTAL ANALYSIS

Our simulation area considered is 840 × 840 and simulation run time is 200 seconds. Speed has been varied from 5m/s to 25 m/s. Pause time has been varied from 50s to 250s. Based on our standard in section 7.2 we can summarize the following differences between AODV and DSR based on our estimated parameters.

8.1 PATTERN ANALYSIS OF 30 NODES USING TCP CONNECTION

From our experimental analysis we observe that for TCP connection using pause time as a parameter in low mobility low pause time the packet delivery ratio (PDR) is average for AODV and high for DSR. In that scenario average end to end delay (E-2-E Delay) is average for AODV and high for DSR. The loss packet ratio for the TCP connection is high for AODV and average for DSR. If the pause time is high the PDR for both routing protocols is high and E-2-E Delay for both protocols is high. LPR of DSR is low but for AODV it is average. On the other hand, using speed as a parameter in low mobility low speed the packet delivery ratio for both protocols is high. In that scenario average E-2-E Delay is high, the loss packet ratio is low for both routing protocols. But in low mobility high speed, the PDR for AODV is average but high for DSR. E-2-E Delay for both protocols is high. LPR of AODV is average. But for DSR it is low.

8.2. PATTERN ANALYSIS OF 30 NODES USING CBR CONNECTION

We observe that for CBR connection using pause time as a parameter in low mobility low pause time the PDR of CBR for both routing

protocols is high. In that scenario average E-2-E Delay is low for both protocols .The loss packet ratio is average for AODV and low for DSR. If the pause time is high the PDR for both routing protocols is high and E-2-E Delay is low for both routing protocols. LPR of DSR is low but for AODV it is low. On the other hand, using speed as a parameter in low mobility low speed the packet delivery ratio for both protocols is high. In that scenario average E-2-E Delay and the loss packet ratio are low for both routing protocols. But in low mobility high speed, the PDR for AODV is high but average for DSR. E-To-E for both protocols is low. LPR is average for both routing protocols.

8.3 PATTERN ANALYSIS OF 150 NODES USING TCP CONNECTION

Pause time as a parameter in high mobility low pause time PDR for both protocols is high. In that scenario average E-2-E Delay is average for AODV and high for DSR. The LPR is average for both protocols. If the pause time is high the PDR for both routing protocols is average and E-2-E Delay is average for AODV and high for DSR. LPR is high for AODV and DSR. On the other hand, using speed as a parameter in high mobility low speed, PDR of AODV is average but high for DSR.

Though, E-2-E for AODV & DSR is high. LPR is low for DSR and high for AODV. If the speed is high AODV performs average and DSR performs high. E-2-E is high for both routing protocols. LPR of AODV is high but for DSR it is average.

8.4 PATTERN ANALYSIS OF 150 NODES USING CBR CONNECTION

We observe that for CBR connection using pause time as a parameter in high mobility low pause time the PDR of CBR it is average for AODV and low for DSR. E-2-E for AODV is average but it is high for DSR. The loss packet ratio is high for both protocols. If the pause time is high the PDR for AODV and DSR using CBR is high. E-2-E and LPR is low for both routing protocols.

On the other hand, using speed as a parameter in high mobility low speed the packet delivery ratio for AODV is average but high for DSR, Though E-2-E and LPR for AODV is high but low for DSR. If the speed is high the PDR for AODV and DSR is low. E-2-E is high for both routing protocols. LPR of AODV and DSR is high for CBR connection.

9. OUR DECISIONS

After analyzing the performance of AODV & DSR we now summarize our decisions in the below decision tables based on our standard defined in section 7.2. In Fig. 13 we have shown the performance of PDR, E-2-E and LPR for TCP and CBR connections where speed and node density is varied. In Fig. 14 we have shown the performance of PDR, E-2-E and LPR for TCP and CBR connections where pause time and node density is varied.

Nodes Density	Packet Delivery Ratio				Avg.End to End Delay				Loss Packet Ratio			
	TCP		CBR		TCP		CBR		TCP		CBR	
	AODV	DSR	AODV	DSR	AODV	DSR	AODV	DSR	AODV	DSR	AODV	DSR
Low Density												
Low Speed	High	High	High	High	High	High	Low	Low	Low	Low	Low	Low
Avg.Speed	High	High	High	High	High	High	Avg	High	Low	Low	Low	Avg
High Speed	Avg	High	High	Avg	High	High	Avg	Avg	Avg	Low	Avg	Avg
Avg. Density												
Low Speed	High	High	High	High	High	High	Avg	Low	Avg	Low	Low	Low
Avg.Speed	Avg	Avg	Low	Avg	High	High	Avg	High	High	Avg	High	Avg
High Speed	Avg	Avg	Avg	Low	High	High	Avg	High	High	Avg	High	High
High Density												
Low Speed	Avg	High	Avg	High	High	High	High	Low	High	Low	High	Low
Avg.Speed	High	High	Avg	Avg	High	High	Avg	Low	Low	Low	High	Avg
High Speed	Avg	High	Low	Low	High	High	High	High	High	Avg	High	High

Fig. 13. PDR, E-2-E and LPR for TCP & CBR connections where varying speed & node density

10. CONCLUSION

In this paper we mainly focus on VANET topology based routing protocols. At first, we describe about VANET topology based routing protocols with their pros & cons. We choose two on demand routing protocols AODV & DSR on the basis of the packet delivery ratio, average End-to-End delay and Loss packet ratio for analysis their

performance. We showed the performance of AODV & DSR using decision tables & observe that the performance of AODV and DSR depends based on scenarios. For further development of these protocols the performance evaluation should shed some light in near future.

Nodes Density	Packet Delivery Ratio				Avg.End to End Delay				Loss Packet Ratio			
	TCP		CBR		TCP		CBR		TCP		CBR	
Low Density	AODV	DSR	AODV	DSR	AODV	DSR	AODV	DSR	AODV	DSR	AODV	DSR
Low Pause Time	Avg	High	High	High	Avg	High	Low	Low	High	Avg	Avg	Low
Avg Pause Time	High	High	High	High	Avg	High	Low	Low	Avg	Low	Low	Low
High Pause Time	High	High	High	High	High	High	Low	Low	Avg	Low	Low	Low
Avg. Density												
Low Pause Time	Avg	Avg	Avg	High	High	High	Low	Low	High	High	High	Avg
Avg Pause Time	Avg	High	High	Avg	Avg	High	Low	Low	High	Avg	Low	Avg
High Pause Time	Low	High	High	High	Avg	High	Low	Low	High	Avg	Low	Low
High Density												
Low Pause Time	High	High	Avg	Low	Avg	High	Avg	High	Avg	Avg	High	High
Avg Pause Time	Avg	High	Avg	High	Avg	High	Avg	Low	High	Avg	High	Low
High Pause Time	Avg	Avg	High	High	Avg	High	Low	Low	High	High	Low	Low

Fig. 14. PDR, E-2-E and LPR for TCP & CBR connections where varying pauses time & node density

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