Performance Evaluation of AODV, DSDV and DSR Routing Protocols in Unplanned Areas

N. Saeed[1] , R. U. Amin[2] , A. S. Malik[3], M. K. Kasi[4], B. Kasi[5]

[1]Sardar Bahadur Khan Women's University, Quetta
[2,4,5]Balochistan University of Information Technology, Engineering and Management Sciences, Quetta
[3]Electrical Engineering Department, Engineering College, BZU Multan
[1]nausheensaeed1@hotmail.com

Abstract-It is important to explore how VANET Routing protocols behave in unplanned areas which lacks fixed infrastructure such as Road Side Unit to support vehicular communication. Furthermore, such areas do not possess vehicular traffic regulatory structures such as traffic signals, proper road lanes and traffic planning. These areas show largely unpredictable traffic pattern in means of vehicle speeds and density. This paper presents the simulation results of such scenarios in order to better understand or select the optimal performing Routing protocol among DSDV, DSR and AODV against metrics selected: Packet delivery Ratio, Packet Loss Percentage and Average End to End delay. The results show that AODV out performs DSDV and DSR in unplanned areas. To the best of our knowledge no such routing protocol performance evaluations have been performed for unplanned areas.

Keywords-Vehicular Adhoc Networks, Unplanned Areas, AODV, DSDV, DSR, Routing Protocol, NS-2

I. INTRODUCTION

Integrating wireless technology in vehicles is required as much as required in any other device like smart phones and mobile device.

Word Health Organization (WHO) in a report showed that the road accidents that were fatal has reached to 1.24 million per annum. For road safety Intelligent Transport system VANET would provide means to ensure road safety [vii] and can help in post-accident rescue missions. Automotive companies like General Motors, Toyota, Nissan, Daimler, BMW and Ford promote the term ITS. The rescue vehicles such as ambulances, firefighting trucks, and other vehicles used in rescues are the expected to get VANET technology first [ii].

A. *Unplanned Areas:*

Unplanned areas are defined in the literature [i] as the areas which are infrastructure less i.e. lacks Road Side Units (RSU) for vehicular communication. Such areas do not have traffic regulating infrastructure as well as traffic management plan. In addition these areas present adverse communication problems due to unexpected road curves. Lack of traffic management planning produces unexpected vehicular traffic pattern, and thus leads to unpredictable network traffic congestions for communicating vehicles. These areas could be more prone to traffic accidents and other security hazards thus, implementing VANET in these areas although challenging but will be very beneficial in not only avoiding such incidents but also providing post incident rescue.

B. *Vehicular Ad -hoc Network (VANET):*

Over the years Intelligent Transportation System (ITS) have gained incredible development. Automakers have realized the importance of vehicular communication [iii].

Vehicular ad-hoc networks are special types of MANETS for vehicles. In VANET vehicles acts as mobile nodes [iv] in VANET the drivers are more secure by getting traffic congestion and security messages in advance.

1) Characteristics of VANET:

- **High Dynamic Topology:** Due to high speed nature of VANET, its topology changes frequently e.g. if the speed of two vehicles is around 60 mph the link between these may stay for less than just 10 seconds [v].
- **Frequent Disconnections:** High speed mobility and sparse distribution of vehicles with limited range of transmitters for communication, VANET faces frequent disconnections [v]
- **Mobility Modeling:** VANET mobility is different from rest of MANET mobility patterns as the mobility of vehicles are usually constrained by fixed road geographies and shapes. Thus modeling process requires more efforts to consider streets and high ways.
- **Battery Power:** One of the unique characteristic of VANET to distinguish it from MANET is continuous availability of power/energy in form of vehicle battery.
- **Interaction With Onboard Sensors:** The movements and current position of nodes can be

easily sensed by on board units like GPS etc [vi].

- **Hard constraints:** Applications in VANET exhibits hard QoS constraints. In particular, safety-critical applications in VANET fails completely, if their QoS parameters are not strictly met. One such example is Emergency brake notification application. In this application if a vehicle applies brakes this information shall be shared among neighboring vehicles within strictly defined time threshold to avoid accident. [i, v]
- ***Attenuations:*** DSRC band has some attenuation problems like reflection, deflection, dispersion, propagation delay and other types of fading, packet loses, multipath delays.
- ***Limited transmission power:*** The transmission range for WAVE architecture r is limited, which limits the distance that data can reach up to 1000 m. However in some safety critical applications are allowed to increase the transmission range.
- ***Anonymity of the Support:*** The best part of VANET unlike other wireless networks is that any node with transmitter can join in without any authentication and use the transmission band

2) Goals of VANET

1. To make Roads and Vehicles Safer and smarter.
2. Provide connectivity to users on road to the internet and other VANET services
3. ITS provides Cooperative Traffic Monitor, Blind Crossing (crossing without control), Vehicles Collision Avoidance and other available services [i, vii, xvii].

II. BACKGROUND

A. Vanet Applications:

VANET V2V a V2I communication can use diverse application for a lot of purposed. The three major categories of applications are:

1. Safety Oriented.
2. Commercial Oriented.
3. Convenience Oriented.

1) Safety Oriented Applications:

These applications include road monitoring, surface monitoring road curves information. These applications can be further classified into:

Real Time Traffic: These applications can give and record real time traffic information which can be used to avoid traffic jams and traffic congestion. And can give traffic accidents alerts.

Post-Crash Notification: The vehicles around a crash or the vehicle involved in the crash can send warning that will help the high way patrolling authorities to send in in time and the rest of the traffic could avoid the area.

Cooperative Message Transfer: Vehicles whose speed is slow or that are at a halt will and contribute to transfer messages to other vehicles. It may also automate brakes in case of emergency

Road Hazard Control Notification: These Applications can help to notify the traffic about land sliding or any sudden curves on the roads.

Cooperative Collision Warning: These can warn the drivers who can potentially be on the way to have a crash due to which they can change their paths to avoid any mishap.

Traffic Vigilance: RSU cameras can be used to monitor traffic and check any law traffic law violation.

2) Convenience Applications:

Route Diversions: These Applications Could be very helpful to plan routes in case of traffic congestion.

Electronic Toll Collection: These applications can be help in electronically collecting toll and identifying the vehicles uniquely.

Parking Availability: Parking information can be collected and sent to the divers desiring to park their vehicles at certain parking lot. These application can really increase Drivers satisfaction and even lessen mental stress.

Active Prediction: the drivers knowing the geography of the road can easily adjust speed before the ascending or descending road.

3) Commercial Applications:

Remote Vehicle Personalization/ Diagnostics: It can help in downloading personalized setting of the vehicle the diagnostics can be shared over the network.

Internet Access: Internet can be accessed by vehicles through RSU. Drivers Passengers can browse or do video streaming while on the go

Digital Map Downloading: Digital Maps can are very useful as required in any other Maps. Driver can download maps of certain area for routes etc.

Real Time Video Relay: real time videos streaming can be used for entertainment purposes such watching movies etc.

Value-added advertisement*:* Over the VANET the business advertisements can be disseminated such as that of petrol pumps food point on the routes.

Productive Applications

Environmental Benefits: Research project such as for green transportation with collaboration with ITS projects are working on making green transportation choices to minimize environmental pollution.

Fuel Saving: Applications at toll booth collects toll without stopping the cars this can save considerable amount of fuel.

Time utilization: With the internet Access passengers /drivers can stay connected to work or family and utilize their time in a traffic jam or just during the journey [viii].

These applications can be categories into the following Application families:

1. Road Safety Application. The applications include emergency brake, hazard alerts, road accident avoidance alerts, road information etc.

2. Driver Assistance Application. For driver assistance applications like routes info, congestion information, Maps, information about facilities like car workshops, petrol pumps
3. Applications of passengers comfort*:* applications mostly for entertainment purposes are for passenger comforts [ii, xvii].

B. Types of communication in VANET:

1. Vehicle to vehicle communication (V2V)
2. Vehicle to Infrastructure communication (V2I) In V2V only on board units (OBU) installed into the vehicles are involved the vehicles can communicate with each other without any road infrastructure

   In V2I communication the vehicles communicate with the Road side units (RSU) also knows as access points such as UMTS, WiMax, GSM networks [iii].

C. Routing in VANET:

VANET routing protocols can be divided into Major two categories

1. Topology Based Routing Protocol
2. Position Based Routing Protocols [vi]
3. Hybrid Routing protocols

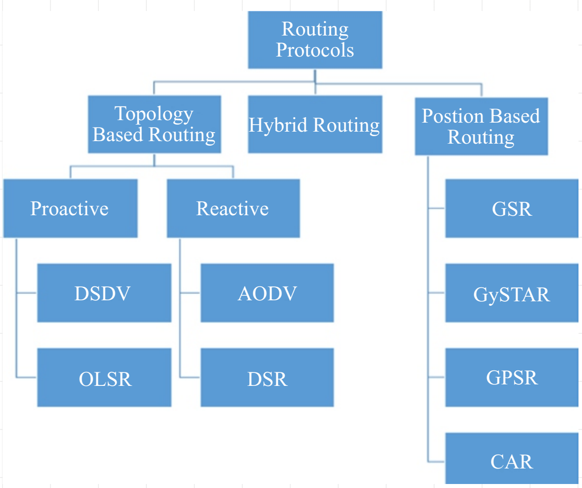

Fig. 1. Vanet Routing Protocols

Ad hoc On-Demand Distance Vector Routing (AODV): AODV is a Topology based Reactive Protocol**,** by minimizing the routing tables which keep only entries for recent active routes, also keeps next hop for a route rather than the whole route. AODV as a reactive protocol uses routing tables, an entry for each destination. To prevent routing loops and to identify whether the routing table is up-to-date or not sequence numbers are used. It supports both in unicasting and multi casting. AODV Uses <RREQ, RREP> in pair to find the route. The Source node broadcasts RREQ (Route Request) to the nodes in its surroundings to discover the destination node. The RREQ comprises of the life span of the message, address of source and destination, Request ID acting as Unique ID. The most recent address receives is considered to be that of the destination and this sequence number is updated in the routing Table [ix].

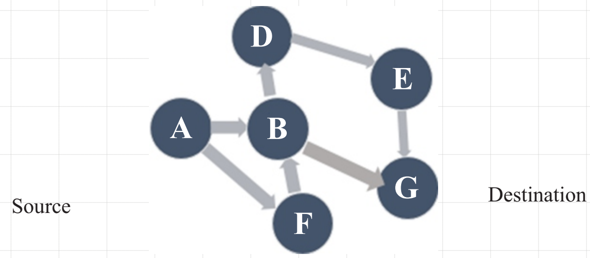

Fig. 2. RREQ Broadcast

Dynamic Source Routing Protocol DSR: It is also a reactive protocol. It decreases the network overhead by reducing periodic messages. This protocol has two main processes: route discovery and route Maintenance. DSR saves the whole path from source to destination in its routing table unlike AODV where its saves only the path to the next hop. DSR starts route discovery only on demand. The packet sent through DSR has all the intermediate node address in the packet header through which the destination node will be reached this is called Source Routing. Similar to AODV it also used RREQ and RREP as a pair and is broadcasted if the destination address is not discovered the intermediate node rebroadcasts it and adding its address into the source routing address.

Destination-Sequenced Distance-Vector Routing (DSDV): It is a table driven routing protocol. DSDV solves the routing loop problem as it store A sequence number with each entry in the routing table if the connection is present the sequence number is in even numbers or ale in odd numbers .Destination nodes generates and broadcasts these numbers until the next updates. Incrementally the router tables are updated instead of updating the whole routing table all together saving the extra bandwidth that would be required otherwise [x].

RELATED WORK

Performance Evaluation of AODV, DSR and swarm intelligent routing protocol is done in [xi]. With varying number of nodes and speed and using Random Way mobility model their findings were that AODV and DSR may not be that suitable for VANET and SWARM proved to perform better in terms of Latency throughput and packet delivery ratio.

In [x] efficiency of AODV DSDV and DSR is evaluated according to the results AODV performs better than DSDV and DSR when talking about throughout packet delivery ratio and latency Number of RSU's used in their study is 11 .

In [xii] AODV and DSR performance has been compared in a city traffic scenario with traffic signals.

The results shows that AODV outperforms DSR with the speed increasing.

[xiii] Results show that in Realistic Vehicular Mobility Model AODV and DSR are Suitable for implementation in terms of through put and delay.

The research in [xiv] evaluates ADV DSR and GOD routing protocols and results show that ADV is more suitable for high way scenarios and GOD for city scenarios on basis of parameters (throughput and packet drop)

III. METHODOLOGY

There are different types of methodologies selected for research studies: such as

1. Mathematical Models
2. Real Test Beds
3. Simulation
4. Emulation

Each one has its pros and cons. The method that is selected in this study is simulation based. Simulation modeling is the combination of putting real life scenario to some extent with mathematical modeling. Real test bed are very expensive and complex to be adopted in case of vehicular Adhoc Networks. Although the simulation study is assumed to not give as good result as the real life traffic but still it could give to some degree results close to real world scenario result. Simulation allows researchers to study a particular scenario in well understood environments repeatedly. For all the simulations the types of application used and the types of traffics produced has been limited to one.

NS 2.35: There are a lot of network simulators available such as OMNeT++ OPNET , GloMoSim, NS2.35 is selected as the network simulator for this study as large number of institutes and people use NS2 in development and for research use to sustain and develop new routing protocols and also for their evaluation [xv]. NS-2 is highly acceptable in research community when talking about VANET research studies.

NS-2 is an open source Software developed by Using C++ and oTCL.

Cbrgen.tcl script included in NS-2.35 is used to generate traffic files and node movement scenario files are generated by Bonnmtion v2.13. Bonnmotion Is a java based tool, used to create scenario files which can be exported into different simulators such as MiXiM, GloMoSim/QualNet, ns-2, ns-3, ONE.and COOJA. Bonnmotion supports different mobility models including Manhattan mobility model [xvi] Due to its support to Manhattan Mobility Model the tools is selected for the study. Both Traffic and node movement files are exported in ns-2 simulation *.tcl files. After simulation run the network communication traces are logged into trace files (having extension *.tr) the results of are extracted by programing awk scripts according ling and exported to MS Excel 2013 for graphs generation.

All the simulations have been performed in NS2 running on Linux based machine, although change of execution environment can have some effect on results, still this effect is not significant, thus can be ignored. Furthermore these effects are beyond the scope of this research given that performance of all the routing protocols has been evaluated on the same system.

There are 27 different scenarios designed according to low, medium and high mobility and node density with three routing protocols AODV, DSDV, DSR simulated for each scenario, Packet sending rate has been Varied from 2Mbps to 100 Mbps at different time in the scenario to simulate unexpected traffic congestion in unplanned areas.

TABLE I
SIMULATION PARAMETERS

Simulation Parameter	
Network Simulator	Ns-2.35
Simulation Time	900 Sec
Simulation area	1000 x 1000 m
Speed	1-20 Km/h ,10-50 Km/h,50-80 Km/h
Average Speed	10.5 Km/h, 37.5km/h, 65 Km/h
Packet Sending Rate	Varied from 2 Packets per Second to 100 packets per second
Data Traffic type	CBR
Mobility Model	Manhattan Grid
Source & Destination Selection	Random
Mobility Model	Manhattan
Channel Type	Wireless Channel
Antenna Model	Omni Directional

Simulation area of 1000 x 1000m for 900 sec and with nodes density of 20 for low 60 for medium and 100 for high density and for low speed average speed 1 km/h to 20 km/h with average speed 10.5 km/h, medium speed 20 to 50 with average speed 37.5 km/h and high speed 50 km/h to 80 km/h having average speed 65 km/h is assumed for the study scenario description is given in Table II

TABLE II
SCENARIOS AND THEIR PARAMETERS

Scenario	Mobility and Density	No. of Nodes	Speed Range (m/s)	Average Speed (m/s)	Protocols Evaluated
Scenario 1	Low Mobility Low Density	20	1-20	10.5	AODV
Scenario 2		20	1-20	10.5	DSDV
Scenario 3		20	1-20	10.5	DSR

Scenario 4	Low Mobility Medium Density	60	1 -20	10.5	AODV
Scenario 5		60	1-20	10.5	DSDV
Scenario 6		60	1-20	10.5	DSR
Scenario 7	Low Mobility High Density	100	1-20	10.5	AODV
Scenario 8		100	1-20	10.5	DSDV
Scenario 9		100	1-20	10.5	DSR
Scenario 10	Medium Mobility Low Density	20	20-50	37.5	AODV
Scenario 11		20	20-50	37.5	DSDV
Scenario 12		20	20-50	37.5	DSR
Scenario 13	Medium Mobility Medium Density	60	20-50	37.5	AODV
Scenario 14		60	20-50	37.5	DSDV
Scenario 15		60	20-50	37.5	DSR
Scenario 16	Medium Mobility High Density	100	20-50	37.5	AODV
Scenario 17		100	20-50	37.5	DSDV
Scenario 18		100	20-50	37.5	AODV
Scenario 19	High Mobility low Density	20	50-80	65	AODV
Scenario 20		20	50-80	65	DSDV
Scenario 21		20	50-80	65	DSR
Scenario 22	High Mobility Medium Density	60	50-80	65	AODV
Scenario 23		60	50-80	65	DSDV
Scenario 24		60	50-80	65	DSR
Scenario 25	High Mobility High Density	100	50-80	65	AODV
Scenario 26		100	50-80	65	DSDV
Scenario 27		100	50-80	65	DSR

The number of connections are 21 for low density, 61 for medium and 101 for high density that means each node in the scenario as at least one connection to any other node. Communication here is totally vehicle to vehicle keeping in view the unplanned area infrastructure less circumstances.

With the combination of certain mobility and density all three routing protocols mentioned earlier have been simulated for evaluation. These key performance indicators are defined as follows:

Average End to End Delay: Average End to End Delay is the sum of time at which the packets received subtracted from the sum of time at which the packets are sent by the source divided by the sample size.

Average End to End Delay =

$$\frac{\sum(\boldsymbol{Revieved\ Packets\ time\ stamp} - \boldsymbol{Sent\ Packets\ Time\ Stamp})}{\boldsymbol{Sample\ Size}}$$

Packet Delivery Ratio (PDR): PDR is the ratio of sum of packet received divided by the sum of Packets sent. **Formula for PDR is as under:**

$$\textbf{PDR} = \frac{\sum(\boldsymbol{Packets\ Recieved})}{\sum(\boldsymbol{Packets\ Sent})}$$

Packet Loss Percentage (PLP): Packet loss is define as those packets that are sent by the source and failed to be received by the destination. Packet loss percentage is defined as sum of packets dropped divided by packets sent PLP can be calculated by formula as below:

$$\textbf{PLP} = \frac{\sum(\boldsymbol{Packets\ Dropped})}{\sum(\boldsymbol{Packets\ Sent})}\ \boldsymbol{X\ 100}$$

IV. Results and Findings

*A. Packet delivery Ratio of AODV***:**

The results show packet delivery ratio of AODV gets better as the mobility decreases and number of nodes increases .this is obvious that with the speed the number of disconnections increases and results in low packet delivery ratio whereas lower speed the AODV shows better results as shown in Fig. 3.

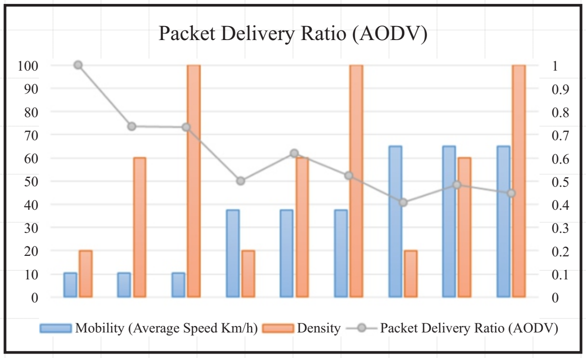

Fig. 3. Packet Delivery Ratio (AODV) Vs. Density & Mobility

Packet Loss Percentage of AODV: Packet loss ratio of AODV shown by graph in Figure 3 tends to increase as the mobility increases. The packet loss is highest when the mobility is medium with medium density

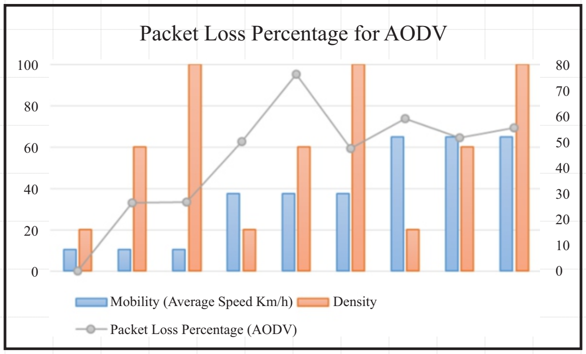

Fig. 4. Packet Loss Percentage (AODV) Vs. Density & Mobility

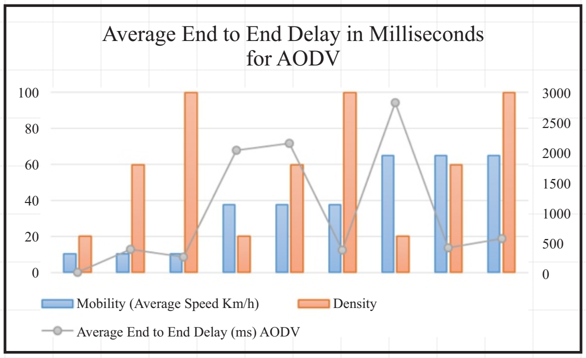

Fig. 5. Average End to End Delay (AODV) Vs. Density & Mobility

Average End to End Delay in AODV: Average end to end delay in AODV tends to increase with medium mobility and is least with the low mobility and low density and high mobility and low density scenarios.

DSDV: Packet loss percentage Analysis of DSDV shows that there is no packet loss with low mobility and low node density but as the node density and mobility increases the packet loss increases too but then later with high mobility and high node density the packet loss decreases.

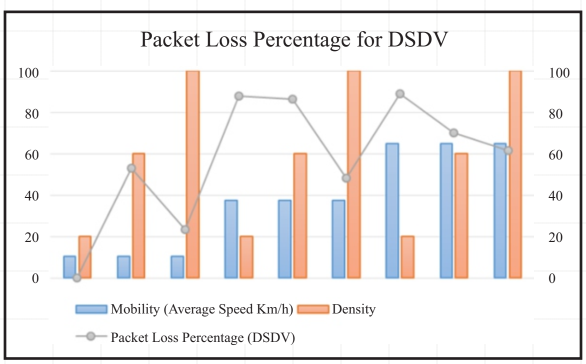

Fig. 6. Packet loss percentage (DSDV) Vs. Density & Mobility

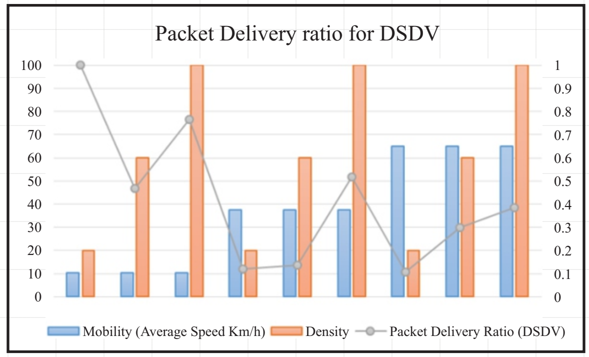

Fig. 7. Packet Delivery Ratio (DSDV) Vs. Density & Mobility

Packet delivery ratio of DSDV trend as shown in Fig. 7 increases with low mobility and low density.

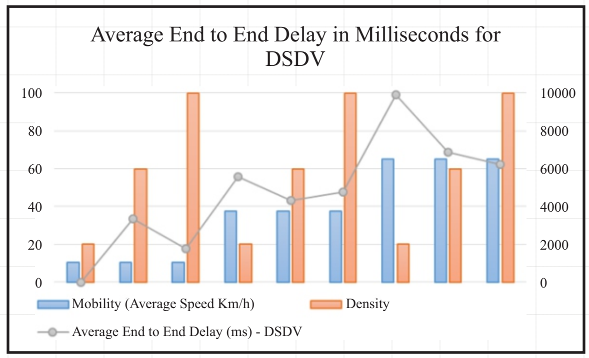

Fig. 8. Average End to End Delay (DSDV) Vs. Density & Mobility

Average End to End delay of DSDVincreases with mobility and node density.

DSR: The simulation results for the DSR protocol are Fig. 9.

DSR Packet Delivery Ratio: Packet Delivery Ratio of DSR tends to increase with decrease in mobility and node density and vice Versa as shown in the graph in Fig. 9.

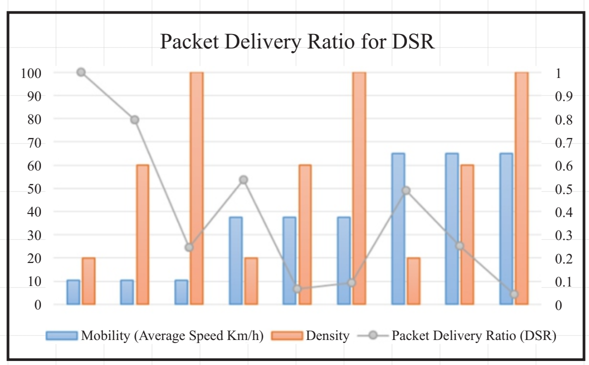

Fig. 9. Packet Delivery Ratio (DSR) Vs. Density & Mobility

Average End to End Delay: Average end to end delay shown in the Fig. 10. Tends to increase with the mobility and density there for the value is highest when both of the values for density and mobility are taken high.

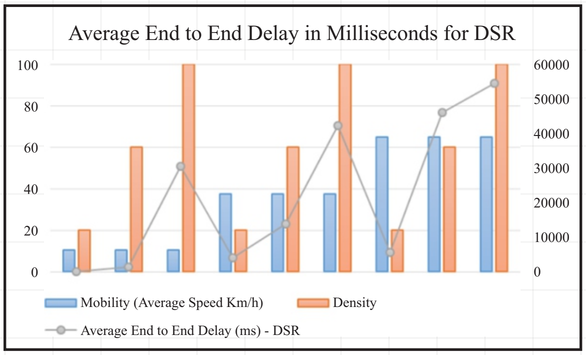

Fig.10. Average End to End Delay (DSR) Vs. Density & Mobility

Packet Loss Percentage for DSR: The trend in packet loss percentage of DSR protocol shows in Fig. 11 that the packet loss percentage increases with the mobility and density and is again highest high average speed and node density in unplanned scenarios.

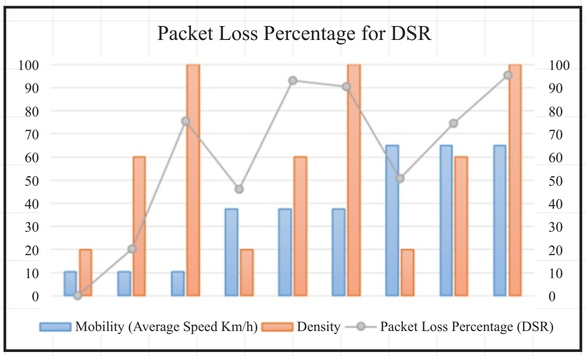

Fig. 11. Packet loss percentage (DSR) Vs. Density & Mobility

V. Comparative Analysis:

When comparing the results of the three routing protocols select that are DSDV, DSR, and AODV for unplanned areas. Performance of AODV how better results than DSDV and DSR. AODV gives better packet Delivery ratio, the least Packet loss Percentage and average end to end delay among the three.

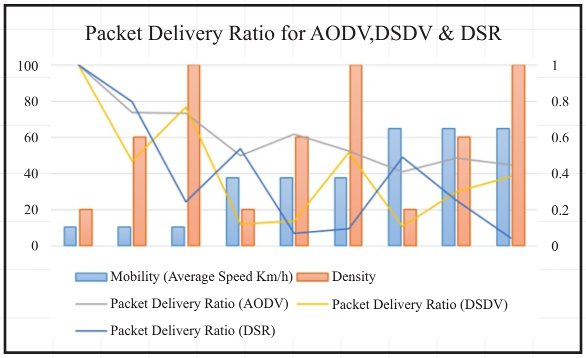

Fig. 12. Packet Delivery Ratio (DSDV, AODV, DSR) Vs. Density & Mobility

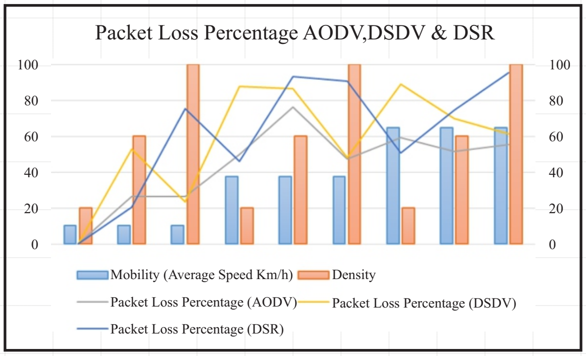

Fig. 13. Packet loss Percentage of DSDV, AODV and DSR Vs. Density & Mobility

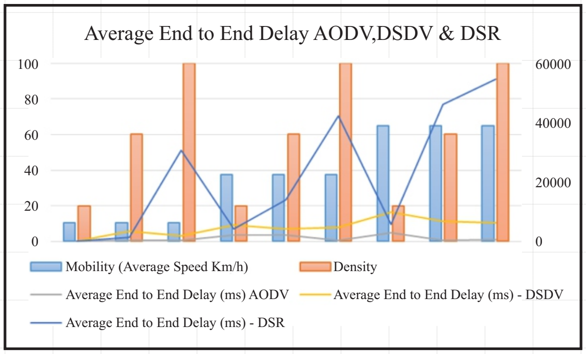

Fig. 14. Average End to End Delay of DSDV, AODV and DSR Vs. Density & Mobility

VI. Conclusion

Routing Protocols DSDV, DSR and AODV were simulated in the scenario of unplanned areas. AODV proves to performance better in terms of Packet Delivery Ratio, End to End delay and packet loss percentage therefore, it is recommended for implementation in the unplanned areas. The results of this paper can be used to further study of routing protocols behaviors in unplanned areas.

VII. Future Work

The work can be extended to the evaluation of other VANET Routing protocols and more metrics can be considered as well. Other characteristics of unplanned areas can be added to the simulation and changes in the mobility model code to make the it closer representation of unplanned areas

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