Comprehensive Survey and Comparative Experimental Performance Gain of AODV, DSR and OLSR in MANETs

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Abstract*: *Routing is a crucial issue in MANET due to the absence of fixed infrastructure and centralized administration. Many routing protocols like Adhoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR), and Optimized Link State Routing (OLSR) have been proposed to find the optimized path from source node to destination nodes. This paper analyzed the performance of AODV, DSR and OLSR on the basis of sent packets, received packets and Quality of Service (QoS) metrics like throughput, end to end delay, packet delivery ratio, packet loss ratio with varying network load and network size.

Index Terms: AODV, DSR, MANET, OLSR, QoS, Routing Protocols.

I. INTRODUCTION

A MANET [1] is a continuously self-arranging connected mobile and wireless network through radio communication where every node goes about as host as well as the router as shown in figure 1. 1, 2, 3, 4, 5, 6, 7 are nodes in which node 1 is the source node and nodes 4, 5, 6 are the destinations nodes whereas 8, 9, 10 are routers.

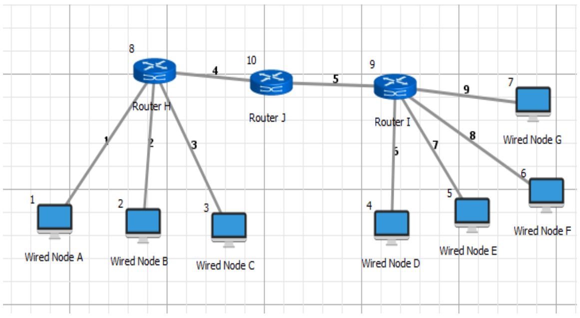

Fig. 1. Conceptual Organi zation of a Multicast Routing.

Due to the mobility of nodes in the network i.e. nodes can change their location anytime and in any direction, there are a number of issues arise within ad hoc networks like routing,

Quality of Service (QoS), resource management, power control and security which are the important active research area for MANET since last few years. Due to flexible infrastructure, MANET has wide new applications [2] as shown in figure 2.

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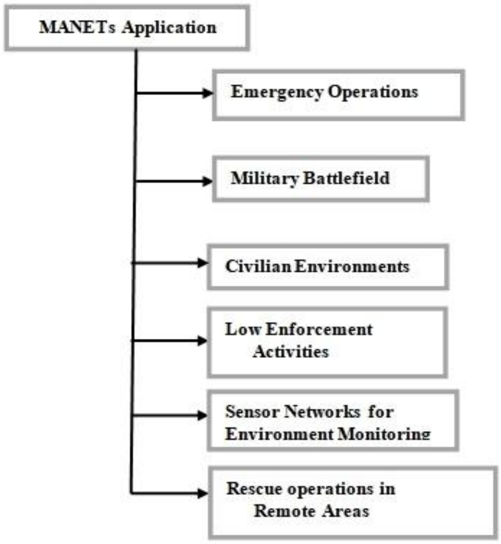

Fig. 2. Applications of MANET.

There are multiple hops between the routes of two nodes through other nodes in the network. That's why searching efficient routes at the network layer and improving QoS at the transport layer in MANETs is very challenging work.

The point of this paper is to access the best exertion of proactive and reactive routing communication protocols AODV, DSR, OLSR on the basis of QoS frameworks like throughput, delay, packet delivery ratio (PDR), packet loss ratio (PLR) by changing network load and network size. This work can give inspiration to additionally look into enhancing the present conventions or potentially make new ones to address the difficulties in MANETs.

The organization of the paper is as per the following: Section 2 discusses the routing protocols in MANETs. Further, there is a complete depiction of related work in Section 3. An overview and general comparison of the three main ad hoc routing protocols AODV, DSR, OLSR present in section 4. The simulation environment and performance metrics are described in Section 5 along with simulation results. Section 6 concludes the paper and presents future work.

II. ROUTING PROTOCOLS

Routing is the process of finding the shortest route from the source node to the destination node to exchange the data packets. Basically, routing mechanisms are divided into two types:-Static Routing and Dynamic Routing. In static routing, routing information is previously stored in the routing table whereas, in dynamic routing, routes are generated when there are changes in network topology because routes may also change. Link/node failure cannot recover in static routing. Dynamic routing overcomes this limitation of static routing. RIP, OSPF and EIGRP are some conventional routing protocols which do not support MANETs.

Based on routing information update mechanisms, Routing Protocols are characterized into three types which support MANETs. Figure 3 shows the taxonomy of existing MANET Protocols [3]. In Reactive Routing (On-Demand) [4] routes are maintained on demand only and routing data is not kept in routing tables while in Proactive Routing (Table-Driven), routes are maintained periodically and routing data is kept in routing tables. Because of these reasons, reactive routing conventions are loop-free, less routing overhead and high delay. While there are the loop, more routing overhead and low delay in the proactive routing protocol. Hybrid routing protocols are hybrid of both routing protocols. So routes availability and storing of routing depend on the location of destination and requirements.

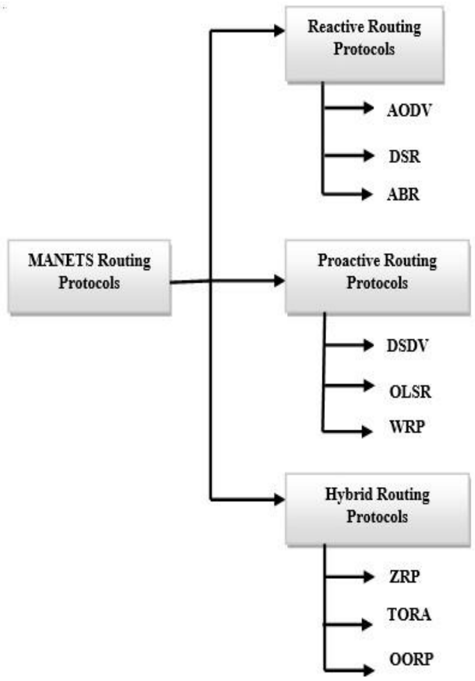

Fig 3. Taxonomy of MANETs Routing Protocols.

III. RELATED WORKS

Over late years, major work has been directed to assess the performance of routing protocols in wireless networks.

Broch, Maltz and Johnson [5] evaluate the performance of multiple routing protocols (AODV, DSR, OLSR and DSDV) based on PDR and routing overhead. They analyzed through experiment that Temporally Ordered Routing Algorithm gives the worst performance in terms of routing overhead and AODV outperforms DSR in terms of routing overhead whereas the other performance metrics of AODV and DSR are almost same at all mobility rates.

Perkins C. et al. [6] presented the performance studies between two reactive routing protocols AODV and DSR for ad hoc networks by changing network load, mobility, and network size. They evaluated AODV and DSR on the basis of PDR. They observed that DSR performs better than AODV in smaller network size, lower load and lower mobility whereas it is not true in larger network size, more load and higher mobility. The routing load generated by DSR is less than AODV.

S. Ahmed and M.S. Alam [7] presented the analysis of AODV, DSR and TORA by varying network loads. They have considered throughput, delay, PDR and routing overhead QoS performance parameters. The simulation results showed that TORA outflanks other routing protocols under specific simulation parameters.

Ahmed and Mohamed [8] assessed the execution of AODV, DSR and OLSR in the existence of self-similar traffic. They have considered throughput, PDR, delay, and routing overhead as QoS performance metrics. The simulation results showed that the performance of DSR is better in terms of above motioned QoS performance metrics at a speed less than 10 m/s.

B. Divecha et al. [9] accessed the execution of AODV and DSR routing protocols by varying node density and hop count. Simulation results showed that DSR gives a better result than DSDV for all scenarios such as varying network node, varying hop count, changing speed on different mobility models.

A. Kumar et al. [10] analyzed on multiple routing protocols (AODV, DSR, OLSR, DSDV) by varying various network parameters such as pause time, burst time, number of nodes. They have considered an average delay, delivery ratio and normalized routing overhead as QoS parameters. They have observed that AODV and DSR outperform OLSR and DSDV. In the case of routing overhead, DSR gives a better result than AODV, DSDV and OLSR whereas the poor performance of DSR in case of average delays.

A. Rahman and A. Zukanain [11] compared the three routing protocols AODV, DSDV, I-DSDV (improved DSDV) by three scenarios: varying pause time, network load and node speed. They have used three metrics: PDR, delay and routing overhead. They have observed that I-DSDV outperforms DSDV when the nodes increased beyond 30. I-DSDV gives a better result than DSDV in terms of PDR and delay at higher rates of node mobility but still, AODV outperforms I-DSDV in higher node speed and number of nodes.

S. Mohapatra and P. Kanungo [12], analyzed of AODV, DSR, OLSR and DSDV. For small network size (up to 600*600 sq. m), DSR outflanks the remaining routing protocols regarding to throughput and PDR whereas, OLSR outperforms AODV, DSR and DSDV for large network.

M. Islam et al. [13] compared the five routing protocols AODV, DSR, OLSR, TORA and GRP for supporting video streaming applications. They concluded that the whole performance of TORA outperforms the other routing protocols. DSR protocol is not suitable for video transmission because its performance is very poor.

M. Gulati and K. Kumar [14] compared AODV, DSR and DSDV by varying mobility speed, network load and data rate. They have considered PDR, delay and jitter as performance metrics. The simulation result showed that AODV outperforms the other routing algorithms.

M. Gupta and S. Kumar [15] performed the comparison between AODV, DSR and DSDV over three

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metrics throughput, packet loss and packet received. They have concluded that the overall execution of DSR is superior to AODV and DSDV.

J. Kumar et al. [16] analyzed on AODV, DSR, DYMO and ZRP. The simulation results showed that DSR outperforms in terms of PDR and delay and DYMO is superior in terms of packet loss for small networks whereas ZRP gives poor performance. Table I shows the summery of the related works to evaluating the performance of the routing protocols.

This paper assesses the most common protocols like AODV, DSR and OLSR based on QoS metrics (throughput, delay, PDR and PLR) by varying network load and network size.

IV. OVERVIEW OF AODV, DSR AND OLSR

a. AODV

AODV [17] is an on-demand (reactive) routing protocol which is based on DSDV and DSR algorithm. It utilizes periodic updates and sequence number strategy of DSDV and a route discovery and route maintenance technique as in DSR, i.e. AODV demands a route only when required and does not require keeping up routes that are not effectively used in communications. Due to the combination of these two techniques DSDV and DSR, AODV utilizes data transfer capacity productively by limiting the network overhead and ensures loop-free routing. There are two phases of AODV as in DSR, but slightly different: -

i. Path Discovery
ii. Path Maintenance

AODV is a successful and proficient routing protocol for all types of ad-hoc mobile communication. It is a loop-free routing algorithm which also avoids count to infinity and congestion problems. In this way, it offers brisk convergence when the ad hoc network topology changes which normally, occur when a node moves in the network. But it does not provide any type of security.

b. DSR

DSR is a loop-free, on-request (reactive) routing protocol that relies upon source routing [18]. It is a self-organizing and self-configuring method. DSR doesn't utilize intermittent updates as it computes routes when there is a need and after that keep up them. In this approach, the sender decides the total sequence of nodes through which the packet needs to travel, the sender attaches this route records in the packet's header. There are three phases of DSR protocol: -

i. Route Discovery
ii. Route cache
iii. Route Maintenance.

DSR gives incredible execution for routing in ad-hoc networks with no infrastructure or administration. Nodes forward packets for one another to permit communication among them. It also reacts rapidly to changes in the network having very low overhead.

c. OLSR

OLSR [19] is a loop-free, table-driven (proactive) link state routing protocol for an ad-hoc network. Multipoint Relays (MPRs) is the key thought of OLSR which lessens control overhead by diminishing the number of broadcasts when contrasted with pure flooding mechanisms. In the network, every node chooses some nodes from its neighborhood which are called multipoint relays (MPRs) of those nodes. The idea of multipoint relays is to lessen the overhead of flooding messages in the network by dropping redundant retransmissions in the same region. Only multipoint relays nodes retransmit their packets. Those nodes which do not lie in any set of multipoint relays only read and process packets, however, don't retransmit their packets. MPRs nodes have also a responsibility to declare link state information in the network. The performance of the routing protocol relies upon the size of multipoint relays, smaller the multipoint relay set gives the more optimal result.

OLSR is effective and efficient for a large dense network where the route requests for destinations occur very frequently. It also does not allow long delays in transmitting data packets. Table II shows the Comparative analysis of AODV, DSR and OLSR.

V. SIMULATION RESULTS AND ANALYSIS

a. Simulation Environment

The simulations were executed by using NetSim Simulator (v10.2). The channel type used in the simulation was wireless and traffic was CBR (UDP). Simulations were done by varying number of nodes from 10, 20, 30, 40 to 50 with varying areas 500*500 sq. m, 1000*1000 sq. m, 1500*1500 sq. m, 2000*2000 sq. m and 2500*2500 sq. m whereas the pause time was kept constant at 10 seconds. The nodes were placed randomly and the simulation time was 200 seconds. Table III gives the simulation parameters used throughout the simulation.

b. Performance Measuring Parameters

The performance of AODV, DSR and OLSR were measured based on throughput, delay, PDR and PLR.

Table I. Summary of the related works to evaluating the performance of the routing communications protocol

S. NO.	Authors, Year	Compared Protocols	QoS Metrics Considered	Simulator Used	Movement Model	Area	# Nodes	Remarks
1.	J. Broch et al. [5], 1998	AODV, DSR, DSDV, TORA	• Packet Delivery Ratio • Routing Overhead • Path Optimality	NS-2	Random waypoint	1500 * 300 sq. m,	50	• TORA gives the worst performance in terms of routing overhead. • The routing overhead of AODV outperforms DSR whereas the other performance metrics of AODV and DSR are almost the same.
2.	Perkins C. et al. [6], 2001	AODV, DSR	• Throughput • Delay • PDR • Routing load	NS-2	Random waypoint	1500 * 300 sq. m, 2200 * 600 sq. m	50,100	• DSR beats AODV in less stressful situation. • AODV beats DSR in a more stressful situation. • Routing load generated by DSR is less than AODV.
3.	S. Ahmed and M. S. Alam [7], 2006	AODV, DSR, TORA	• Throughput • Delay • PDR • Routing overheard • Control packet overhead	OPNET	Random waypoint	10 sq. meters	40	• TORA outperforms other routing protocols (AODV & DSR) under specific simulation parameters.
4.	Al-Maashri A. et at. [8], 2006	AODV, DSR, OLSR	• Throughput • Delay • PDR • Normalized protocol overhead	NS-2	Random waypoint	300 * 600 sq. m	50	• The performance of DSR is better at a speed of less than 10 m/s.
5.	B. Divecha et al. [9], 2007	AODV, DSR	• Throughput	NS-2	Random waypoint, Group Mobility, Freeway Model, Manhattan Models	1000 * 1000s q. m, 2000 *2 000 sq. m	40	DSR gives better results than DSDV for all scenarios such as the varying number of hops, varying network sizes and varying speed on different mobility models.
6.	A. Kumar et al. [10], 2008	AODV, DSR, OLSR, DSDV	• Average delay • Delivery ratio • Normalized Routing Overhead	NS-2	Random waypoint	1000 * 1000 sq. m	---	• The performance of AODV & DSR is better than OLSR & DSDV. • In the case of routing overhead, DSR gives a better result than AODV, DSDV & OLSR whereas the poor performance of DSR in case of average delays.

7.	A. Rahman and A. Zukanain [11], 2009	AODV, DSDV, I-DSDV (Improved)	• PDR • Delay • Routing overhead	NS-2	Random waypoint	1000 * 1000 sq. m	5, 10, 15, 20, 25, 30, 35	• The performance of I-DSDV is better than DSDV when the nodes increased beyond 30. • I-DSDV gives a better result than DSDV but still perform lower performance compared to AODV.
8.	Mohapatra S. et al. [12], 2011	AODV, DSR, OLSR, DSDV	• Throughput • Delay • PDR • Control overhead	NS-2	Random waypoint	200 *200 sq. m, 400 * 400 sq. m, 600 * 600 sq. m, 800 * 800 sq. m, 1000* 1000 sq. m	10, 20,30, 40,50	• DSR outperforms the other protocols in terms of PDR and throughput if the network size is small (up to 600 * 600 sq. m). • OLSR outperforms the other protocols for large network size and high mobility conditions.
9.	M. Islam et al. [13], 2012	AODV, DSR, TORA, GRP, OLSR	• Throughput • PDR • Wireless LAN delay • Packet delay	OPNET	Random Waypoint	800 * 800 sq. m, 1600 * 1600 sq. m	25, 85	• The overall performance of TORA outperforms the other routing protocols. • DSR protocol is not suitable for video transmission because its performance is very poor.
10	M. Gulati and K. Kumar [14], 2014	AODV, DSR, DSDV	• PDR • Delay • Throughput • Jitter	NS-2	Random waypoint	1000 * 1000 sq. m	20-100	AODV outperforms the other routing protocols
11	M. Gupta and S. Kumar [15], 2015	AODV, DSR, DSDV	• Packet Loss • Packet receive • Throughput	NS-2	Random waypoint	600 *600 sq. m	100	• DSR has minimum packet loss than AODV & DSDV
12	J. Kumar et al. [16], 2016	AODV, DSR, DYMO, ZRP	• Average jitter • Delay • Throughput • Hop count • PDR	QUALNET	Random waypoint	700 * 700 sq. m	20	DSR gives better performance in terms of delay and PDR. DYMO gives improved performance in terms of packet loss for small networks ZRP gives poor performance

Table II: Comparative analysis of AODV, DSR and OLSR

S. No	Parameters	AODV	DSR	OLSR
1.	Routing Type	Reactive	Reactive	Proactive
2.	Route Selection	Shortest & update path	Shortest & update path	Shortest route
3.	Multiple Route	No	Yes	Yes
4.	Routing structure	Flat structure	Flat structure	Flat structure
5.	Suited for	Well suited for large network	Well suited for small network	Well suited for large network
6.	Multicasting	Yes	No	Yes
7.	Congestion Handling	Yes	No	Yes
8.	Route maintain in	Route table	Route cache	Routing table
9.	Updates transmitted to	Source	Source	Neighbor
10.	QoS support	No	No	Yes
11	Periodic Broadcast	Yes	Yes	Yes
12.	Advantages	• Adaptable • Higher bandwidth • Lesser routing overhead • Loop-free –Yes • Uses Sequences number to keep the routing info updated.	• Support multipath routing • Less route discovery overhead • Does not require any HELLO message exchange for route maintenance • Loop-free - Yes	• Minimize the overhead. • Improve the transmission quality • Loop-free - Yes
13.	Disadvantages	• Scalability problem • Takes more time to build a routing table • Security - No	• Scalability problem • High route discovery latency • Security - No	• Require more processing power • More bandwidth • Required periodic exchange of HELLO message. • Security – No

a. Throughput

Throughput is the actual data transfer rate which is defined as a ratio of the successful packet. Throughput is affected due to congestion, packet loss, limited resources and dynamic changes in network topology. Mathematically, it is expressed as follow:-

$$Throughput = \frac{No.\ of\ delivered\ packets * packet\ size * 8}{Total\ duration\ of\ simulation}$$

b. Delay

Delay is the complete time taken to arrive the whole message at the destination node. It is equal to the sum of delays of processing time, transmission time, queuing time and propagation time components of all the links of a path.

c. Packet Delivery Ratio:-

Packet Delivery Ratio (PDR) is the ratio of successfully received packets to the total generated packets.

$$PDR = \frac{Total\ Received\ Packets}{Total\ generated\ Packets} * 100$$

d. Packet Loss Ratio:-

Packet Loss Ratio (PLR) is the ratio of lost packets to the successfully received packets by the destination nodes.

$$PLR = \frac{Total\ generated\ Packets - Total\ Received\ Packets}{Total\ Received\ Packets} * 100$$

The simulation results are shown in the following section in terms of throughput, delay, PDR and PLR depend upon

Table III: Parameters for Simulation Setup

Parameters	Used in Simulation
Simulator	NetSim 10.2
Channel Type	Wireless Channel
Movement Model	Random way point
MAC Layer Protocol	IEEE 802.11
Simulation Time	200 sec
Simulation Area (Sq. m)	500*500, 1000*1000, 1500*1500, 2000*2000, 2500*2500
No. of nodes	10, 20, 30, 40, 50
Traffic Type	CBR (UDP)
Pause Time	10 Sec
Maximum Speed	20m/sec
Transmission Range	250m
Packet Rate	4 packets/sec
Protocols Used	AODV, DSR, OLSR
Transport Metrics	Throughput , Delay
Network Metrics	Packet Delivery Ratio (PDR), Packet Loss Ratio (PLR)

network conditions such as network load and network size. Three communications protocols AODV, DSR and OLSR are considered for the comparison.

a. Network Load Analysis: - In this analysis, we performed with the varying number of nodes say 10, 20, 30, 40 and 50 with the pause time, simulation time and network size 10s, 200s and 1000*1000 sq. m respectively. Other parameters of the network are as same as described in Table III. The performance plots for throughput, delay, PDR and PLR with varying number of nodes (Network load) as shown in fig 4 (a), (b), (c) and (d) respectively. From fig 4 (a) it is observed that DSR outperforms the AODV and OLSR but it is very close with the OLSR for the higher number of nodes. From fig 4 (b) it is observed that if the number of nodes increases then delay of all protocols high rate of change whereas the delay of OLSR has a very slow rate of change in comparison to other protocols AODV and DSR.

DSR beats AODV and OLSR in terms of PDR and PLR with an increasing number of nodes which is shown in fig 4 (c) and 4 (d) respectively.

b. Network Size Analysis: - In this analysis, the number of nodes varied with 500*500sqm, 1000*1000sqm, 1500*1500sqm, 2000*2000sqm and 2500*2500sqm whereas the pause time, simulation time and a number of nodes were kept constant at 10s, 200s and 20 respectively.

Other parameters of the network are as same as described in Table III. The performance plots varying throughput, delay, PDR and PLR with network size as shown in Fig 5 (a), (b), (c) and (d) respectively. From Fig 5 (a) it is observed that throughput is maximum for OLSR and minimum for AODV as increasing network sizes. It is also observed that the throughput of OLSR and DSR are almost same for 1000*1000sqm. The delay of DSR increases gradually with an increase in network size as shown in fig 5 (b). The delay is minimum for DSR and maximum for AODV. From fig 5 (c) it is observed that PDR is maximum for OLSR protocol whereas PDR is almost same for AODV and DSR. Similarly, we observed from fig 5 (d) that the PLR is minimum for OLSR whereas the PDR is almost same for AODV and DSR.

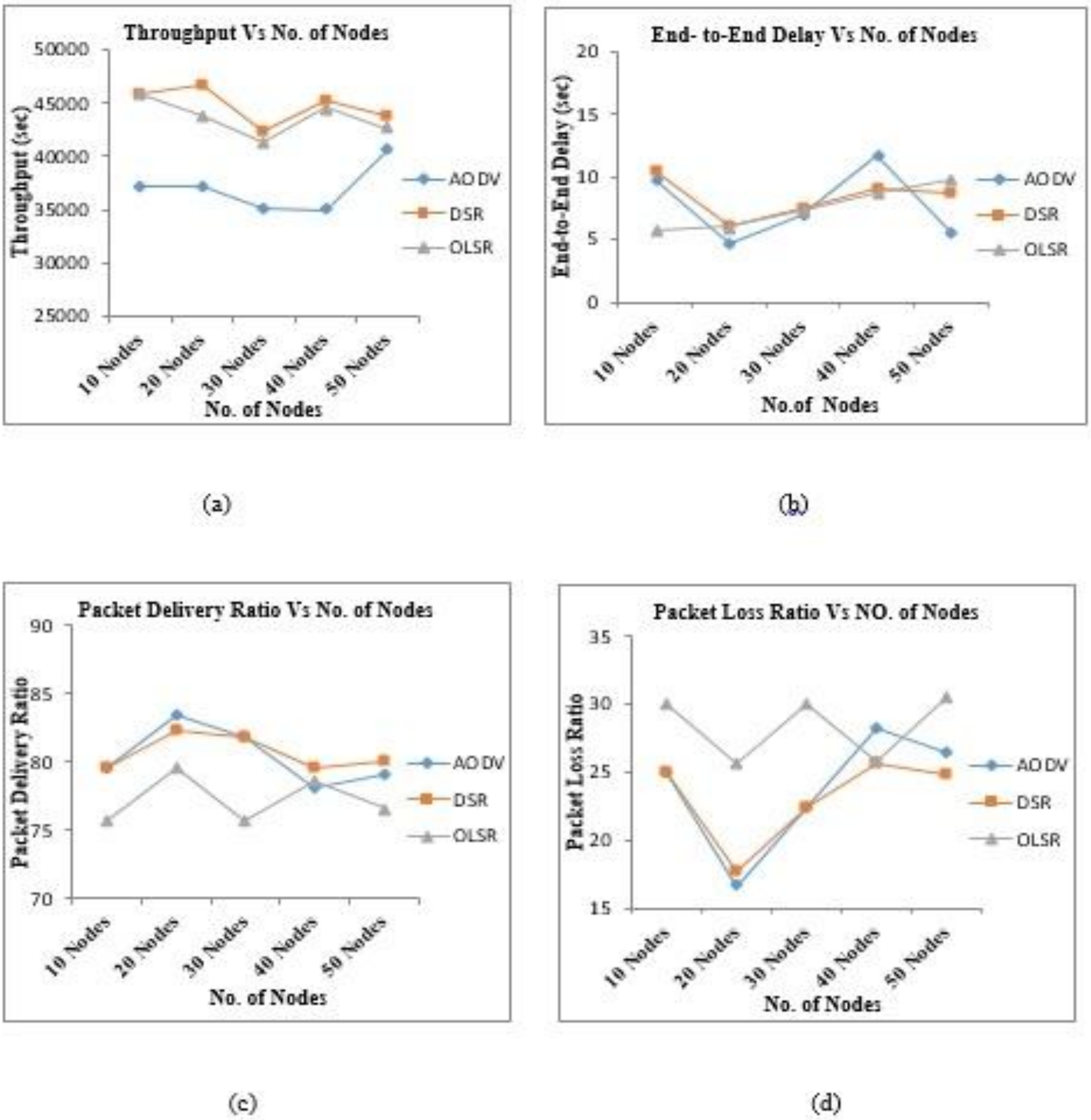

Fig 4: Performance analysis varying number of nodes (a) Variation of throughput (b) Variation of delay (c) Variation of PDR (d) Variation of PLR.

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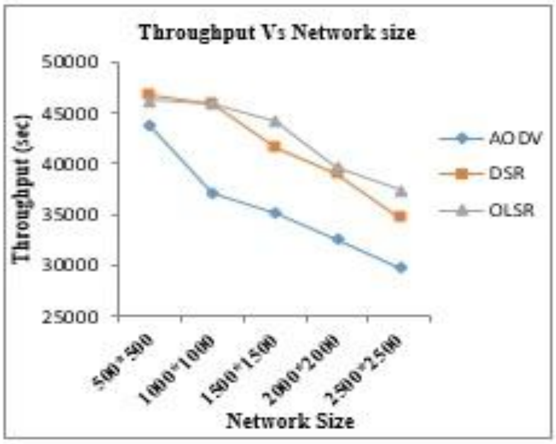
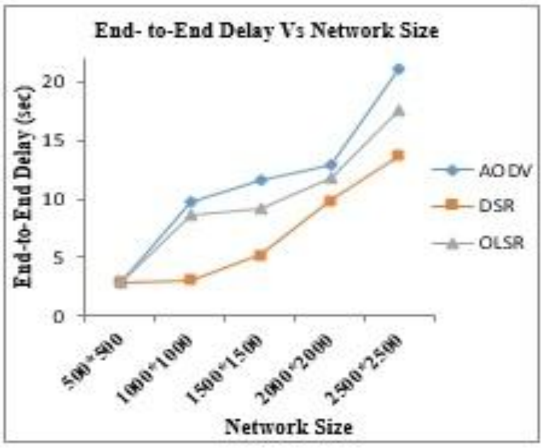


(a)



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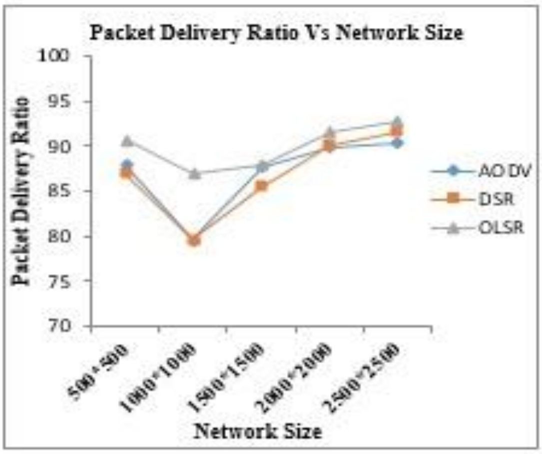
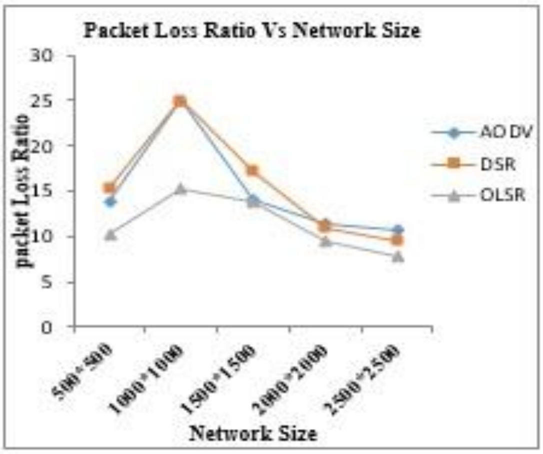


(c)



(d)

Fig 5: Performance analysis varying network size (a) Variation of throughput (b) Variation of delay (c) Variation of PDR (d) Variation of PLR.

VI. CONCLUSION

In this paper, the performance of routing protocol namely AODV, DSR and OLSR were measured with respect to QoS metrics such as throughput, delay, PDR, PLR in two different scenarios: - varying network load and network size. From the result section V, it can be concluded that DSR outperforms AODV and OLSR in terms of throughput, PDR and PLR with varying the number of nodes and network size. With varying the number of nodes the throughput of DSR was almost the same as the OLSR after 30 nodes. With varying the network size, the throughput of DSR is also same as the OLSR if the network size is less than 1000 *1000 sq. m. Finally, we can conclude that the overall performance of DSR is better in terms of throughput, PDR, PLR for network load scenario whereas the overall performance of OLSR is better in terms of throughput, PDR, PLR for network size scenario. Furthermore, modification to the basic DSR and OLSR routing protocols can be possible, so as to make it efficient in large network load and large network size respectively in providing QoS and meet the challenges of mobile ad hoc networks.

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