A Survey of MANET Routing Protocols in Large-Scale and Ordinary Networks

GJCST Classification (FOR) C.2.2. C.2.1

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***Abstract*-An ad hoc network (MANET) consists of mobile nodes that communicate with each other. Routing in ad hoc network is a challenging task because nodes are mobile. Efficient routing protocols have better performance in such networks. Many protocols have been proposed for ad hoc networks such as: Ad hoc on-demand Distance Vector (AODV), Optimized Link State Routing (OLSR), Dynamic Source Routing (DSR), and Geographic routing protocol (GRP). these approaches have not been evaluated for the same conditions in pervious researches. But in this study, the performance of these protocols is evaluated in various network conditions and with different packet size patterns. Also, different MAC layers like 802.11b, 802.11g in ordinary and large-scale networks are considered. For the evaluation, Different metrics like packet delivery ratio, end-to-end delay, Mac delay and Routing traffic received/sent, are applied. All simulations have been done using OPNET.**

I. Introduction

Manets consist of mobile nodes that communicate with each other without any infrastructure and are named as infrastructure-less networks [1]. Nodes in these networks carry out both network control and routing duties; they generate user and application traffics. Routing in ad hoc networks is much difficult because topology of such networks is dynamic. Normal routing protocols which are used in wired networks are not efficient, so, in the past years, many protocols have been designed for ad hoc networks.Routing protocols are divided into four categories: proactive, reactive, hierarchical and geographic routing protocols. The most popular ones are AODV, DSR (reactive), OLSR (proactive) and GRP (geographic). Reactive protocols like DSR, and AODV find the routes only when requested and data need to be transmitted by the source host; These protocols generate low traffic and routing overhead but this will increase delay and are suitable for energy-constrained conditions. They use distance-vector routing algorithms. Proactive protocols like OLSR are table driven protocols and use link state routing algorithms. Proactive protocols generate high traffic and routing overhead but have less delay and can be used when bandwidth and energy resources are enough [2]. Geographic routing protocols use the node position (i.e., geographic coordinates) for data forwarding. A node forwards a packet with considering its neighbors and the destination physical positions. In these protocols packets are sent to the known geographic coordinates of the destination nodes [2]. Some studies considered the evaluation of these protocols, but a little attention have been focused on evaluation and comparison of geographic routing protocols with those three protocols in ordinary and large-scale networks. Data packet size is assumed to be constant in most of the papers, e.g. 512 bytes, [3],[4]. Also, the performance of a network with two constant packet size is considered in others [5]. Evaluation and comparison the performance of ad hoc network simultaneously has not been experienced yet in the two following cases: 1- various size of data packets (uniform distribution) vs. constant size of data packets 2-different MAC layers. An ad hoc network may apply data packet with various size. In this paper, we use OPNET to evaluate these protocols with different packet size and different CBR source-destination pairs. We also evaluate them in large-scale networks; large-scale networks show different behavior in comparison with ordinary networks due to large number of connections and long paths. This paper also compares the use of different MAC layer technologies in large-scale networks. The 802.11 standard was not designed for the multi-hop ad hoc networks but because of widespread availability of 802.11 cards, this technology is the most used one in the MANETs[2]. But using this technology cause several limitation in ad hoc networks. Enhancement in the MAC layer technology (like, 802.11g, the use of OFDM[6], multi-antenna platforms, etc.) can cause these networks to perform better [2]. In this paper, a comprehensive comparison using 802.11b, 802.11g [7] in large-scale ad hoc networks is considered with different scenarios.The rest of the paper is organized as follows. Section 2 is a description of common routing algorithm using for performance comparison. In Section 3 a review of previous literature carried out in this field is provided. In Section 4 we present the scenarios used for comparison. Section 5 describes metrics used in this paper. Section 6 and 7 present the simulation results for ordinary and large-scale network respectively. And finally we provide conclusion in section 8.

II. Description of Routing Protocols

1) *OLSR*

Optimized Link State Protocol (OLSR) is a proactive protocol, so due to it's proactive nature the routes are always available when they are needed [8]. OLSR uses hop by hop routing. It uses MPR (Multi Point Relays) flooding mechanism to broadcast and flood Topology Control (TC) messages in the network. This mechanism takes advantage of controlled flooding by allowing only selected nodes

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(MPR nodes) to flood the TC message. Each node selects an MPR to reach its two-hop neighbors. OLSR uses topology discovery/diffusion mechanism by periodic and triggered Topology Control (TC) messages. TC messages are generated by MPR nodes and carry information about MPR selectors nodes. Neighbor sensing is done by using periodic broadcast of Hello messages. These messages are one-hop broadcasts (never forwarded) that carry neighbor type and neighbor quality information.

2) *AODV*

AODV is a reactive protocol that reduces number of broadcasts by establishing routes on demand basis. This protocol does not maintain the whole routing information of all nodes in the network [9]. For Route Discovery a route request packet (RREQ) is broadcasted whenever a node have a packet to transmit to the destination. It continues forwarding till an intermediate node which has recent route information about destination or the destination itself receive this packet. Then the intermediate node or the destination will send a Route Reply (RREP) message to the source by reverse path of RREQ, therefore AODV uses symmetric link. During forwarding a packet a node records in its tables from which the first copy of the request came. It is needed for establishing reverse path for RREP message. The intermediate nodes are allowed to inform the effected sources from link breakage. Link failure can be due to node's movement or exhausting it's energy. When source node receive the Route Error packet (RERR) packet, it can initiate route again if still needed. To prevent route loops, AODV uses sequence number maintained at each destination to determine how much fresh the routing information is [9]. The sequence numbers are carried by all routing packets[10]. Hello messages are responsible for the route maintenance.

3) *DSR*

DSR is another reactive protocol. The main feature of DSR is source routing. DSR is specially designed for multi-hop ad hoc networks and reduces bandwidth usage by eliminating periodic messages. In this protocol the packet includes a complete list of the all nodes which it should be forwarded towards them. DSR has two main mechanisms: "Route Discovery", "Route Maintenance"[11]. During Route Discovery, a source node broadcasts a RREQ message; and each intermediate node that receives this packet will rebroadcast it, unless it is the destination or it has route to the destination in its route cache. Such a node will send a RREP message to the source [10]. If link failure occur then a route error packet (RERR) will be sent to the source to notify it. The source node then removes that routes consisting failed link from its cache and if there is a new route to that destination in its cache, it will replace it instead of previous one; otherwise it will reinitiate route discovery. Both Route discovery and Route maintenance are on demand. Unidirectional link and asymmetric routes are supported by DSR.[12].

4) *GRP*

A node maintains its list of neighbor nodes by periodically broadcasting Hello messages. If a node does not receive a Hello message from a neighboring node for a period exceeding the specified "Neighbor Expiry Time," it assumes the link to the neighbor is lost. Each node can determine its own position using a GPS. The position of other nodes determined through flooding. When a node moves more than a specified distance, it sends out a flooding message with its newposition. To bootstrap the network, all nodes initiate a full flooding throughout the network. To reduce the overhead caused by flooding updates, the scope of the flooding is limited. This is known as fuzzy routing. In fuzzy routing, when a node sends a position update, only nodes that "need to know" about the change receive the flood.

III. Previous Work

In [13] four different routing protocols like AODV, DSR, DSDV and TORA were compared with each other. It was shown that DSR has better performance due to aggressive use of source cache and maintain multiple routes to the destination. Moreover ,AODV suffers end-to-end delay and TORA generates high routing traffic. In [14] the authors shown that in normal cases AODV has better performance than DSR. But in constrained situation of several CBR traffic sources leading to same destination, DSR outperforms AODV, where the degradation is as severe as (30%) in AODV whereas DSR degrades marginally as 10%. Perkins et all [10] shown that DSR outperforms AODV when smaller number of nodes and lower load/mobility are used in network, however in high mobility or more load and more nodes, AODV has better performance than DSR. It was also illustrated that DSR has poor delay and throughput performances due to aggressive use of caching. Authors in [15] evaluated three routing algorithms like DSR, AODV and FSR. They represented that in city traffic scenarios AODV has a better performance than DSR and proactive protocol FSR. A limited study with considering QOS was conducted in [16] and illustrated that DSR outperforms in packet delivery fraction and routing overhead whereas OLSR shows the lowest end-to-end delay at lower network loads. [17] also discussed proactive and reactive protocols in more realistic environments and illustrated that AODV has better performance than DSR and DSDV. Mbarashimana et all [18] by using OPNET simulator shown that OLSR gets better performance than DSR and AODV. Which is different from what authors shown in [19] and [20]. G.Jayakumar et all [3] compared DSR and AODV with different CBR sources. They shown both DSR and AODV perform better under high mobility simulations. Authors of [12] compared AODV, DSR, OLSR and DSDV for variable bit rate (VBR) and shown that reactive protocols have better performance than proactive protocols. They also illustrated that DSR performs well for the performance parameters namely delivery ratio and routing overhead while AODV perform better in terms of average delay. Authors of [6] and [21] shown that AODV performs better in the networks with static traffic, with the number of source and destination pairs is relatively small for each host and OLSR protocol is more efficient in networks with high density and highly sporadic traffic. Authors of [22] evaluated AODV, DSR, LAR and TORA protocols and compared AODV, DSR and Location-Aided routing (LAR) over a large geographic area. They shown, AODV suffers in terms of packet delivery fraction but scales very well in terms of end-to-end delay; also DSR scales well in terms of packet delivery fraction but suffers an important increase of end-to-end delay. Alexander Klein [19] compared AODV and OLSR and statistic-based routing protocol (SBR) with different traffic patterns and compared them with respect to reliability and routing overhead.

IV. Simulation Environment

1) *Simulation Setup*

The ad hoc networks are implemented using OPNET simulator [23]. For having a comprehensive evaluation of these four protocols in ordinary and also large-scale networks, we use three scenarios that each of them has different geographic size. In each scenario we examined and compared two cases of application layer packets for two MAC layer protocols: 802.11b, 802.11g. The used parameters for simulation are listed in tables 1.

V. Metric

For evaluating these routing protocols we use four different metrics such as End-to-End delay,Packet delivery fraction, Media access delay and Link layer retransmission.

1) *End-to-End Delay (second)*

The End-to-End delay is the time between when the source generates the data packet to when the destination receives it.

Scenario Num.	1, 2	3
Simulation time	600 seconds	150 seconds
Area	1500×500 m²(scenario1)	-- -- -- -- --
Area	1800×800 m²(scenario2)	3000×3000 m²
Node placement	Random	Random
Mobility pattern	Random way point	Random way point
Speed	Uniform(0-10) m/s	Uniform(0-10) m/s
Pause time	0, 50, 100, 200, 300,400,500, 600 (scenario1)	0, 50
Pause time	0,50,100,200, 300,400 (scenario2)	-- -- - -- - -
Application	CBR	CBR
Packet size	1024 bytes, uniform distribution (256,512) bytes	1024 bytes, uniform distribution (256,512) bytes
Packet transmission rate	3 packet/sec	3 packet/sec
Data rate	2 Mbps	2 Mbps
MAC	802.11b, 802.11g	802.11b, 802.11g
#of connections	10, 30	10
Num of nodes	50(scenario1)	100, 150, 200, 250, 300, 350, 400, 450, 500
Num of nodes	100(scenario2)	-- -- --- ----

Table 1: Simulation parameters scenario 1, 2 and 3

2) *Packet Delivery Fraction*

The Packet delivery fraction is the ratio of number of packets successfully delivers to/received by destination to those originated by the sources

3) *Media Access Delay (MAC delay)(second)*

It is providing the result for a received packet with a routing Address Resolution Protocol (ARP) and control packet reply transmitted by MAC layer. For each frame this delay is calculated as the duration from the time it is inserted into the transmission queue, which is arrival time for higher layer data packets and creation time for all other frames types, until the time when the frame is sent to the physical layer for the first time. MAC delay is very useful metric to identify congestion hot spots and measure link interference in ad hoc network [20]. It can be used to improve network throughput in multi-rate networks.

4) *Link layer Retransmission*

Total number of transmission attempts by link layer in the network until either packet is successfully transmitted or discarded as a result of reaching retry limit. Because of large-scale fading [24], signal power attenuation and path loss are observed due to radio propagation over long distance, which itself can cause link layer retransmissions. Number of retransmission in MAC layer can affect loss rate. Retransmission can be due to congestion or internal collisions in the network. So this metric can be a useful metric for these phenomenons.

VI. Simulation Result (Ordinary Network)

1) *End-to-End Delay*

The end-to-end delay parameters are simulated here for 50 mobile nodes with different packet sizes and two different CBR sources as shown in figures (1,2 , 3, 4):

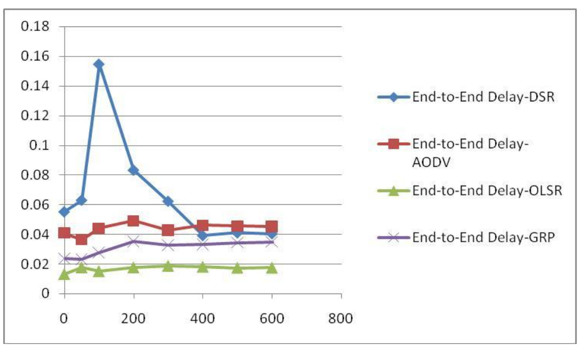
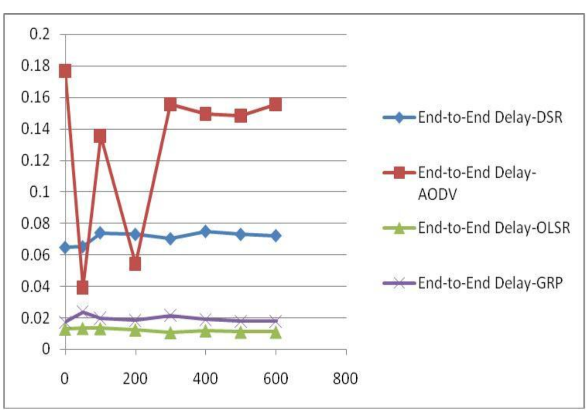


Fig. 1 packet size_1024-10



source **Fig. 2** packet size_uniform-10 source

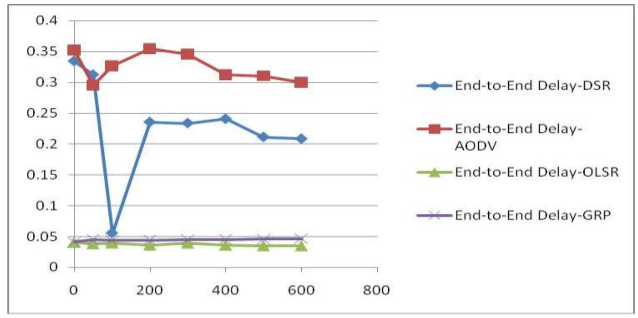


Fig. 3 packet size_1024-30 sources

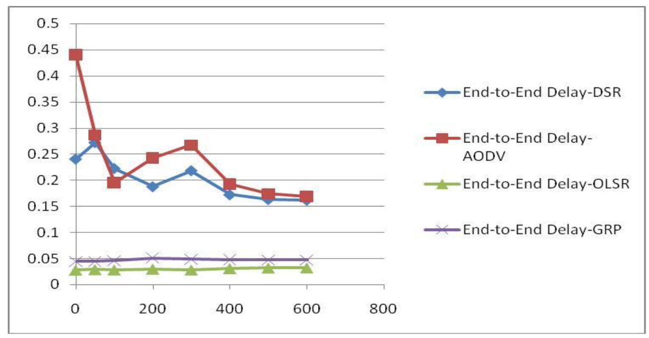


Fig. 4 packet size_uniform-30 sources

comparing figures 1 and 2, we can see that for 10 sources, if the packet size be in uniform pattern, DSR becomes better with respect to average end-to-end delay for pause time 0 to 200 and has less changes with increasing the pause time and it is more linear, however, its delay becomes slightly worse after pause time 400, but it is not significant ; But delay in AODV increases and loses its linearity. Also in GRP and OLSR delays become better slightly.For 30 sources in uniform packets, DSR and AODV delays become better for almost pause time 0 to pause time 600(except pause time 100). But for AODV in pause time 0 the delay increases about 0.1 seconds. Unlike the previous one in 10 sources, here, the delay for GRP increases slightly but for OLSR it decreases. For 100 nodes with 10 and 30 sources, delays are shown in figures (5, 6, 7, 8):

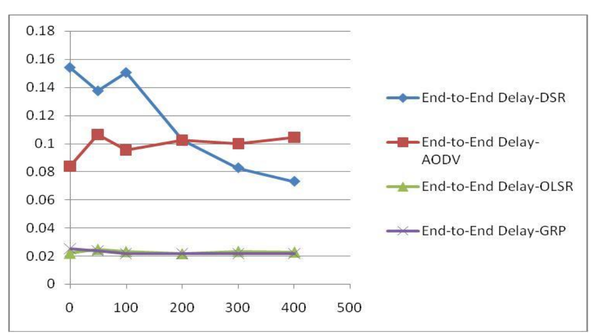


Fig. 5 packet size_1024-10 sources

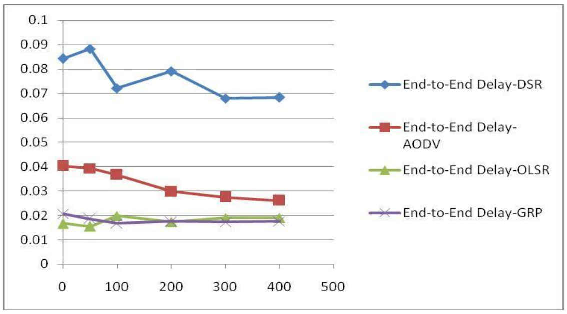


Fig. 6 packet size_uniform-10 sources

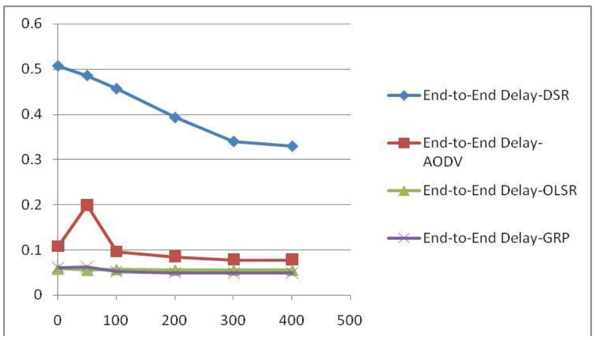


Fig. 7 packet size_1024-30 sources

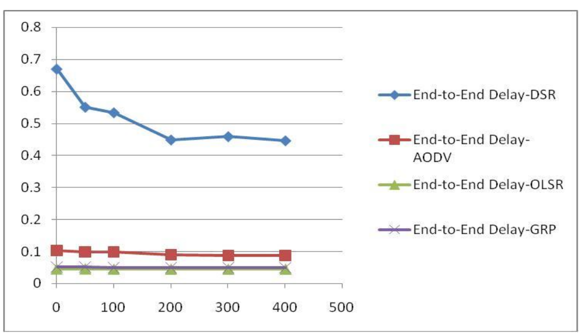


Fig. 8 packet size_uniform-30 sources

It can be seen from figure 6 that for 10 sources DSR delay becomes slightly better and it is more linear, it means that the delay in high mobility (lower pause time) and low mobility (higher pause time) is less than when the packet size is 1024 bytes. With increasing pause time, delay also becomes better in AODV about 0.04 to 0.08 sec. GRP and OLSR delays becomes slightly better but GRP unlike the previous graph has lesser delay than OLSR for pause time 100 to 400.For 100 nodes with 30 sources, for DSR, if we compare each delay in each pause time with the one when the packet size is 1024 bytes, we can see that it increases about 0.1 for every pause time. AODV delay almost does not changes. For OLSR and GRP it does not changes too.From all of these graphs it can be understood that end-to-end delays in OLSR and GRP is much better than the two reactive ones (DSR, AODV).

2) *Packet Delivery Fraction*

When 10 sources exist, in each cases (uniform packet size or 1024 bytes) reactive protocols have better performances than GRP and OLSR. This difference is about 2-3% between reactive and proactive protocols. For 30 source, we can also see that reactive protocols outperforms the others but difference between OLSR and ADV becomes lesser than previous condition (10 sources) and in some pause times their graphs overlapped. But we can see that GRP has the worst performance between these three protocols. However, it should be remind that as we said in previous section GRP has better delay than reactive protocols.

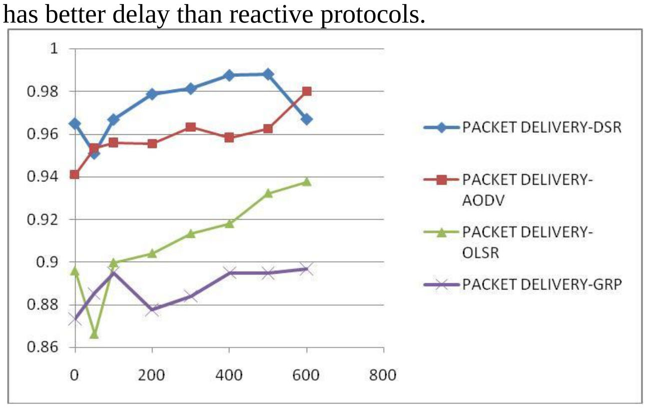


Fig. 9 packet size_1024-10 sources

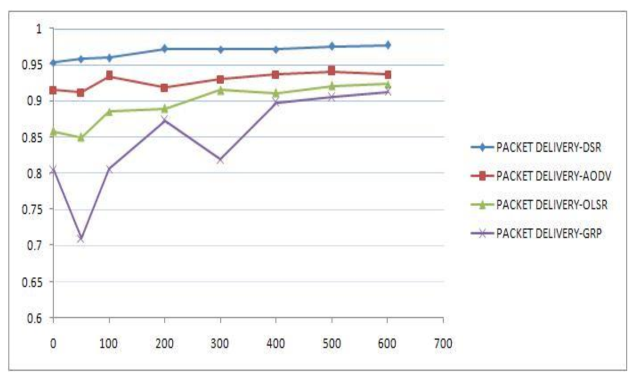


Fig. 10 packet size_uniform-10 sources

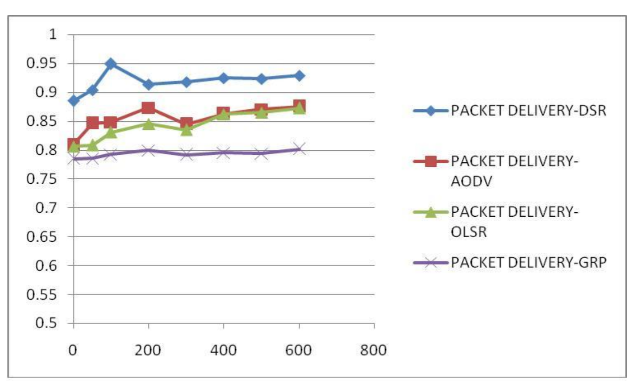


Fig. 11 packet size_1024-30 sources

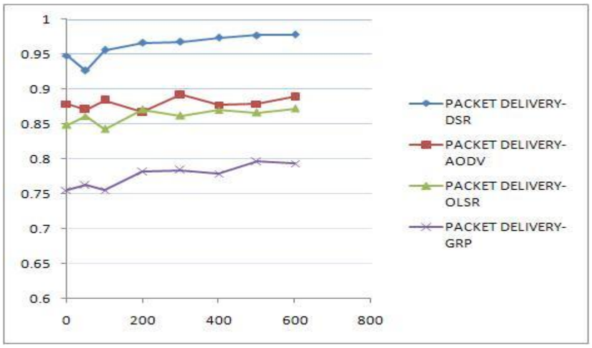


Fig. 12 packet size_uniform-30 sources

For 100 nodes:

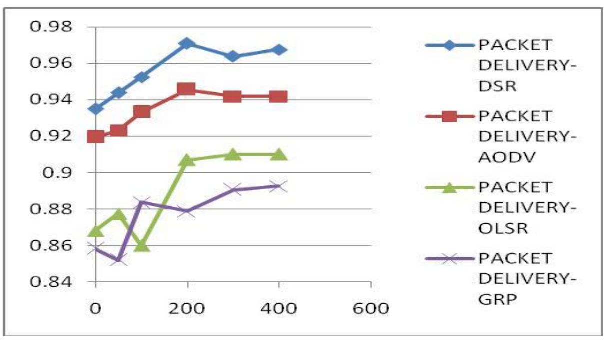


Fig. 13 packet size_1024-10 sources

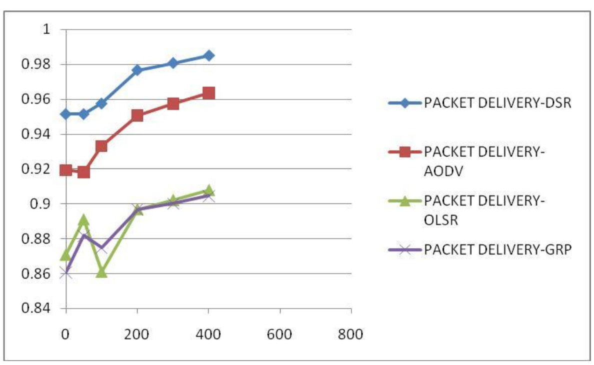


Fig. 14 packet size_uniform-10 sources

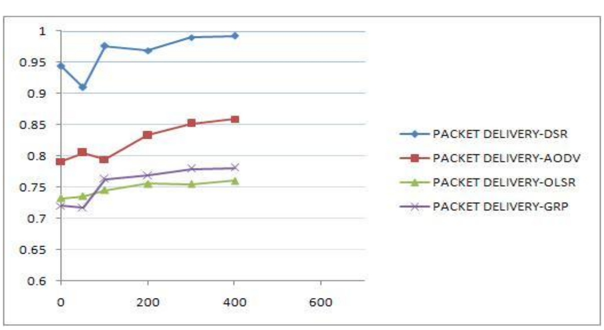


Fig. 15 packet size_1024-30 sources

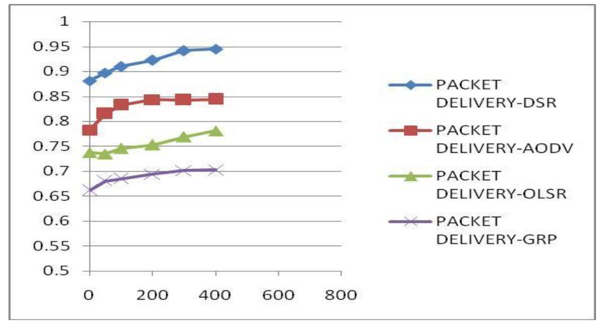


Fig. 16 packet size_uniform-30 sources

From the figures 13 to 16, the packet delivery ratio in reactive protocols (AODV, DSR) is better than OLSR and GRP. There is a little difference between the performances of OLSR and GRP; when the packet size is 1024 bytes, the difference between the performance of OLSR and GRP is about 2% but in uniform packet size(10 sources) these two graphs almost overlapped after pause time 200. Pay attention to the delivery ratios of OLSR and GRP. We can see that GRP performance is worse than OLSR performance in uniform packet sizes but in figure 15, GRP outperforms than OLSR after pause time 100. We can also notify this point that OLSR and GRP performances decreases more than the performances of reactive protocols with respect to increase of CBR connections. As the packet delivery ratio of OLSR protocol decreases about 15-20% and also the performance of GRP decreases about 10-20% for two different packet sizes. The packet delivery ratio in reactive protocols are more stable with respect to number of connections than OLSR and GRP.

3) *Media Access Delay*

MAC delay is an efficient and useful metric for measuring link interference in ad hoc networks and it can be used to improve network throughput in multi-rate networks. So evaluating this metric becomes more important. As it is shown with changes in packet size there is no changes in sequence of graphs in figure (17 to 20). As an other result from this figures, it is clearly shown that DSR has the worst MAC delay between these protocols, vise versa, OLSR has the best MAC delay or indeed, delay resulting from accessing the media during the data communication in OLSR is much lower than other three ones.

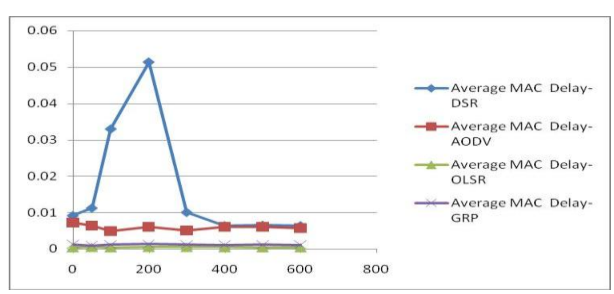


Fig. 17 packet size_1024-10 sources

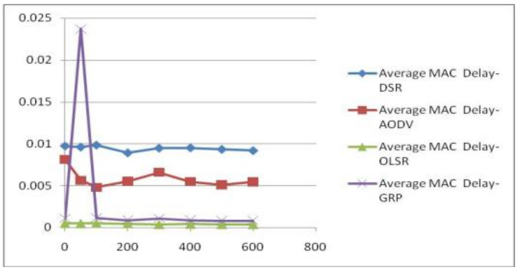


Fig. 18 packet size_uniform-10 sources

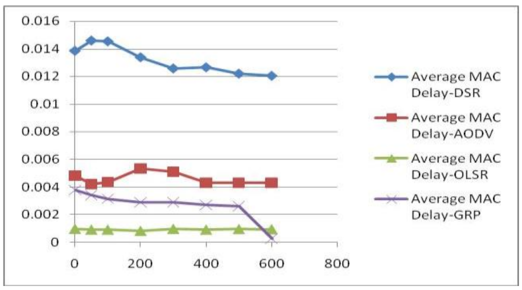


Fig. 19 packet size_1024-30 sources

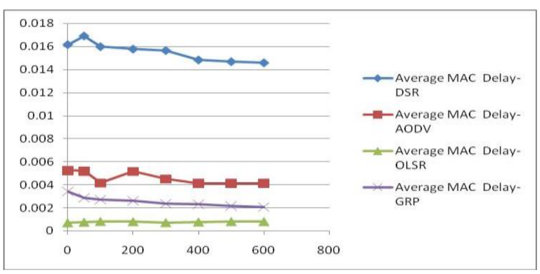


Fig. 20 packet size_uniform-30 sources

For 100 nodes (figures 21 to 24) MAC delay of GRP decreases with increasing in pause time (lower mobility) and its graphs has less changes than OLSR, DSR and AODV. Here, DSR also has the worse and OLSR has the best MAC delay. So we can say that proactive protocols like OLSR has better MAC delay than reactive protocols.

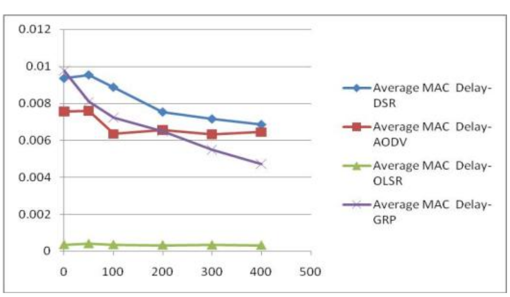


Fig. 21 packet size_1024-10 sources

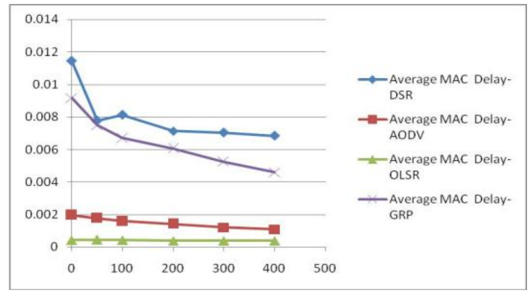


Fig. 22 packet size_uniform-10 sources

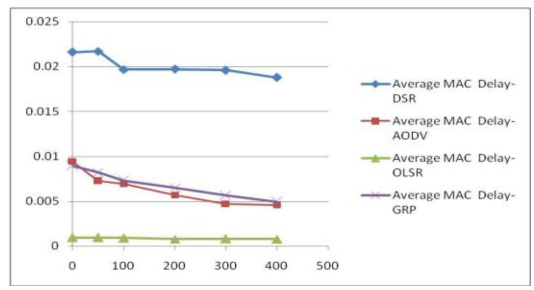


Fig. 23 packet size_1024-30 sources

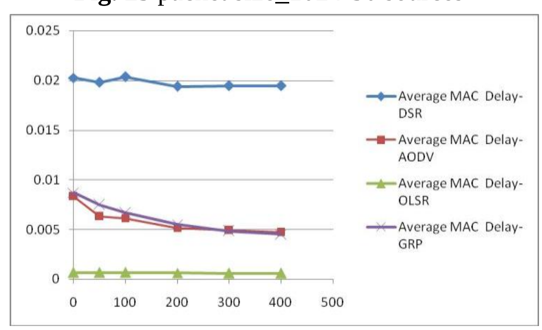


Fig. 24 packet size_uniform-30 sources

4) *Link layer Retransmission*

Total number of transmission attempts by link layer in the network until either packet is successfully transmitted or discarded as a result of reaching retry limit. Retransmission can be due to congestion in the network. Figures (25 to 28) show this metric for 50 nodes.

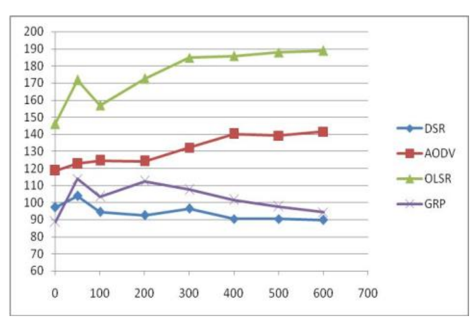


Fig. 25 packet size_1024-10 sources

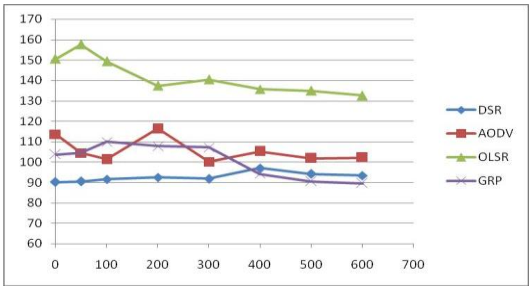


Fig. 26 packet size_uniform-10 sources

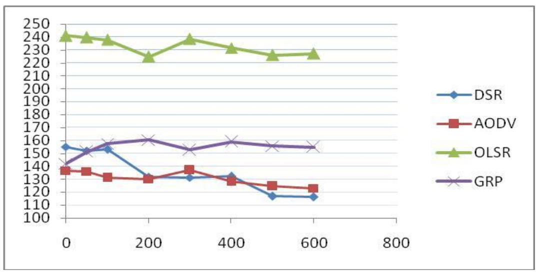


Fig.27 packet size_1024-30 sources

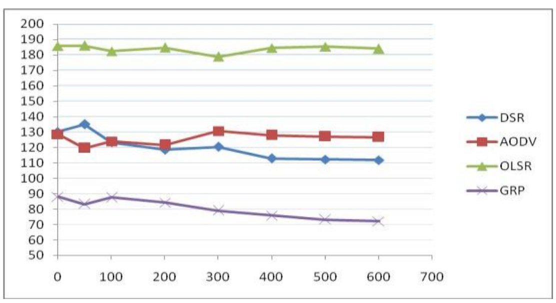


Fig. 28 packet size_uniform-30 sources

Form figures(29 to 32) we can see that OLSR has the most retransmission amount between these four protocols. It may indicate that by using OLSR, congestion increases in network due to high load. Regardless of OLSR, Notify to figures 39 and 40, GRP has the most and the least retransmission amount. So the use of different packet size is more clear in figures 39 and 40.

For 100 nodes:

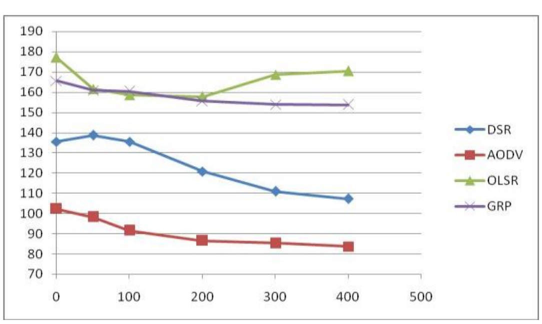


Fig. 29 packet size_1024-10 sources

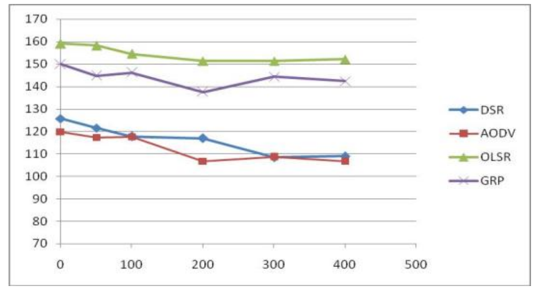


Fig. 30 packet size_uniform-10 sources

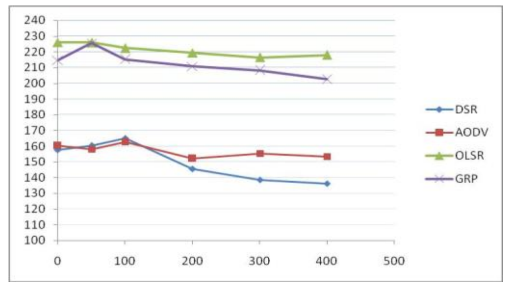


Fig. 31 packet size_1024-30 sources

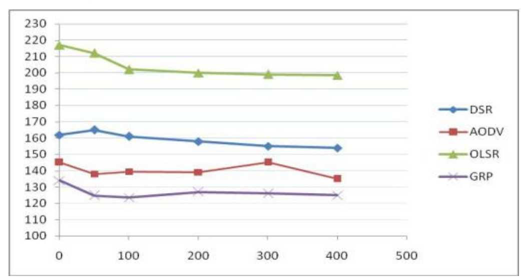


Fig. 32 packet size_uniform-30 sources

VII. Large Scale Network

It is essential to evaluate Large scale ad hoc networks, due to having large number of nodes and much more complexity, with a view to scalability and performance in different conditions like mobility, number of nodes, MAC layer, packet size,… when using different routing protocols. In large scale ad hoc networks because the number of nodes is large and the distance between source and destination may be far, so, routes with large number of hops can be established which itself can result more errors. By evaluating and comparing these four protocols here, we can find three point: 1- if e.g. DSR,… is efficient enough for network application in a special condition 2- which of them has better performance in that case.Our goal in this section is to compare these routing protocols in networks having different number of nodes and topology with respect to the packet size (1024 bytes and uniform packet size), pause time (0,50s) and (802.11b and 802.11g) PHY DSSS (Direct Sequence Spread Spectrum). Behaviour of these protocols has not yet been evaluated for large scale networks with respect to these metrics and different MAC layers

1) *End-to-End Delay*

As we can see from figures(33 to 40), DSR has the largest delay between these four protocols. This is due to aggressive use of caching in DSR. Because number of nodes is large and routes has much more hops than routs in ordinary network, so, the cache size increases which itself can increase delay to choose stale roots. Because OLSR always has routes available due to its proactive nature so it has the best delay.

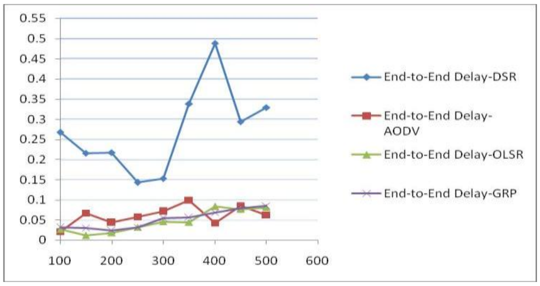


Fig. 33 pt z[1]_1024 -802.11b-p.time[2] 0

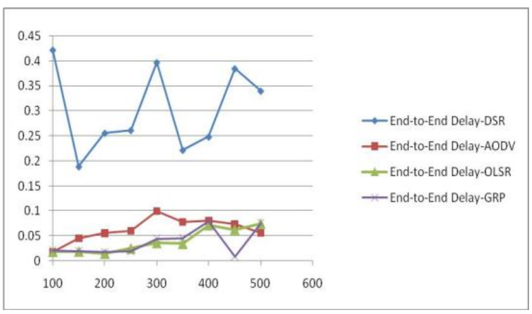


Fig. 34 pt z_uniform-802.11b-p. time 0

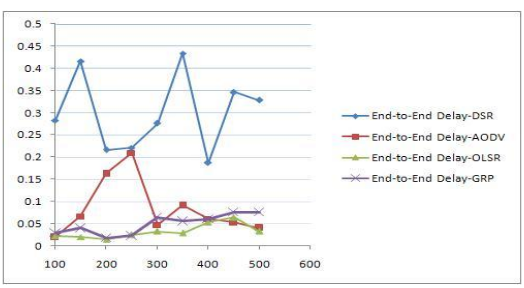


Fig. 35 pt z_1024 -802.11g-p.time 0

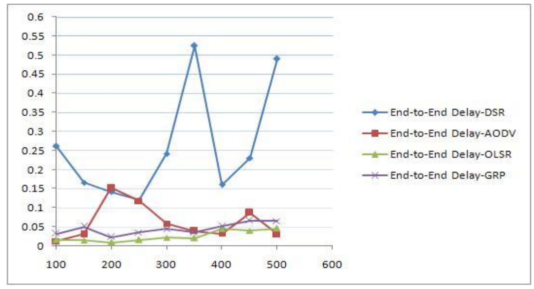


Fig. 36 pt z_uniform-802.11g-p. time 0

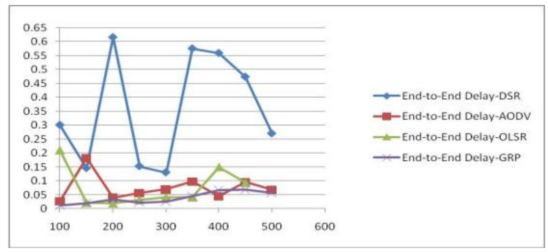


Fig. 37 pt z_1024 -802.11b-p.time50

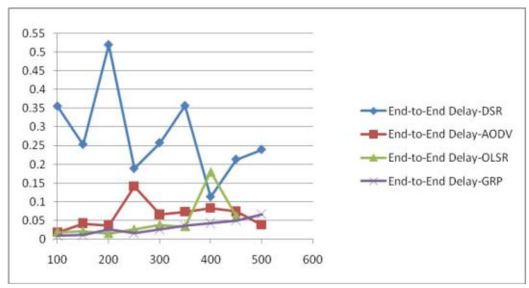


Fig. 38 pt z_uniform-802.11b-p. time 50

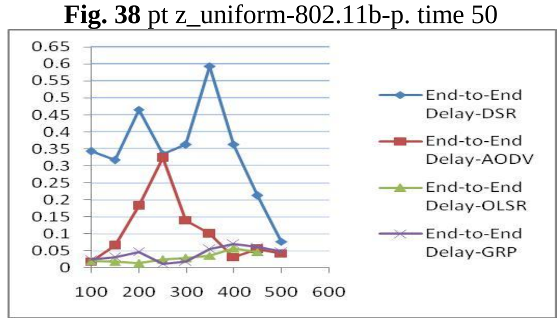
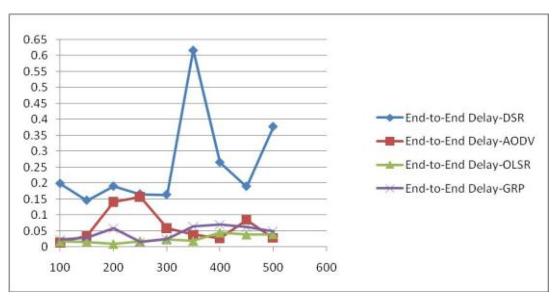


Fig. 39 pt z_1024 -802.11g-p.time 50



[1] Packet size
[2] Pause time

Fig. 40 pt z_uniform-802.11g-p. time50

Notifying figures(33 to 40) when using 802.11b and 802.11g we can see a lot of changes in delay that is so much non-linear, it means it does not increases or decreases linearly. For GRP, it has lower end-to-end delay than reactive protocols like 50 nodes. End-to-end of AODV is less than DSR, because, in DSR the length of a route is a main criterion and it chooses a route between several routes which found by routing discovery process or stored in a node's cache but AODV selects routes having the least congestion due to respond to the first RREQ, also, ignores the length of a route.It should be said that packet delivery and delay also depends on node density in network. Here, we consider networks which have different node density and different number of nodes that varies from 100-500 (as shown in table 3). we compare networks which has same number of nodes and topology and situation of these networks are the same except the pause time and MAC layer which we name below the figures.

2) *Packet Delivery Fraction*

Reactive protocols (AODV, DSR) has better packet delivery ratio than GRP and OLSR. The packet
delivery of OLSR decreases comparing to when the number of nodes is 50 nodes, because, the number of nodes is large and the routing traffic of OLSR is so high causing the congestion in network increases which itself can result to more errors.

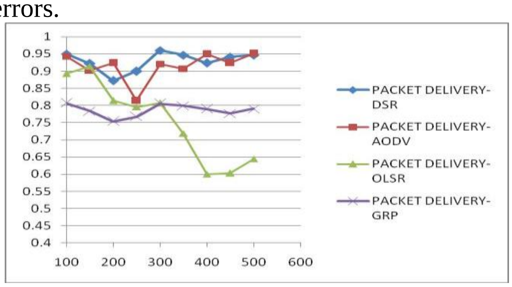


Fig. 41 pt z_1024 -802.11b-p.time 0

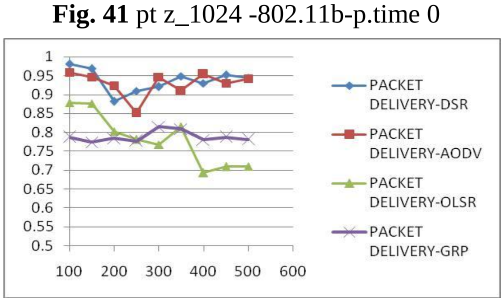


Fig. 42 pt z_uniform-802.11b-p. time 0

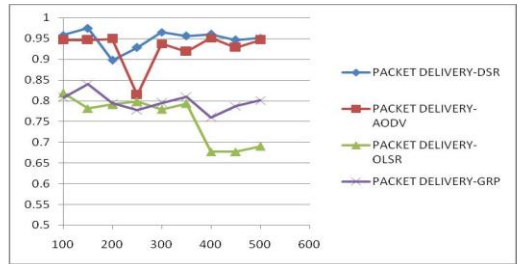


Fig. 43 pt z_1024 -802.11g-p.time 0

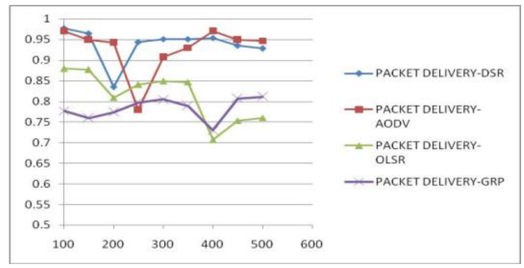


Fig. 44 pt z_uniform-802.11g-p. time 0

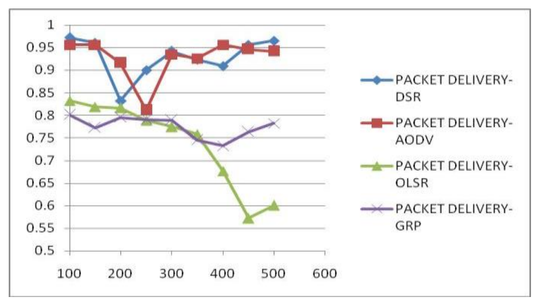


Fig. 45 pt z_1024 -802.11b-p.time50

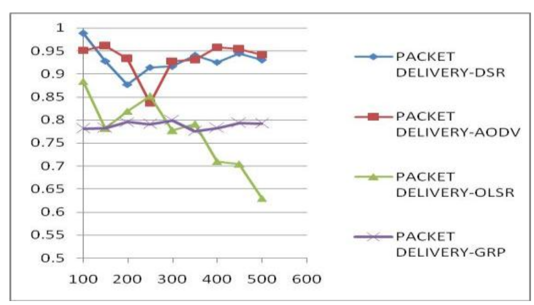


Fig. 46 pt z_uniform-802.11b-p. time 50

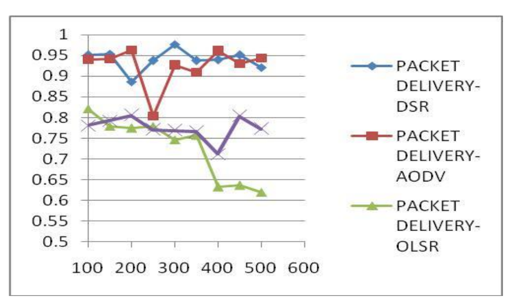


Fig. 47 pt z_1024 -802.11g-p.time 50

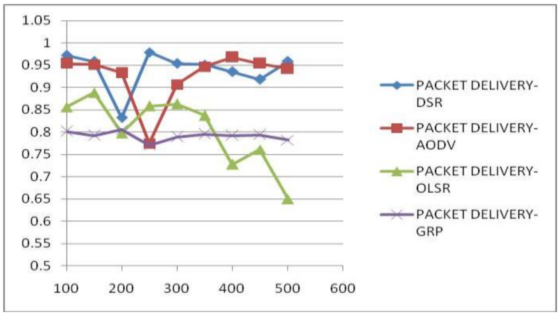


Fig. 48 pt z_uniform-802.11g-p. time50

Also, comparing packet delivery ratio between OLSR and GRP, it can be seen that packet delivery ratio of GRP is more linear and has less changes.

3) *Media Access Delay*

The MAC delay of OLSR is well enough but AODV also has good MAC delay especially when the number of nodes is more than 300.

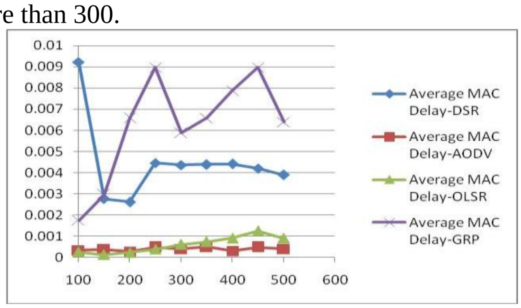


Fig.49 pt z_1024 -802.11b-p.time 0

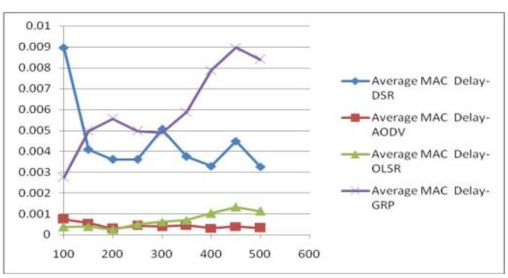


Fig. 50 pt z_uniform-802.11b-p. time 0

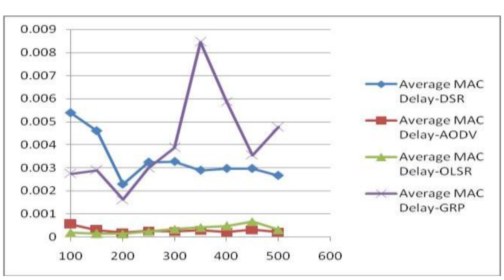


Fig. 51 pt z_1024 -802.11g-p.time 0

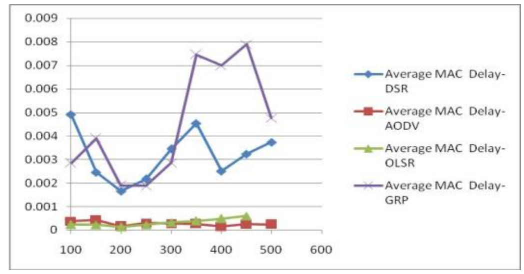


Fig. 52 pt z_uniform-802.11g- p. time 0

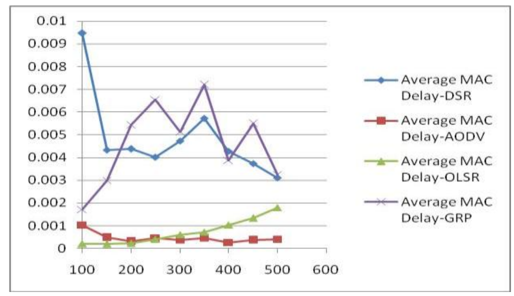


Fig. 53 pt z_1024 -802.11b-p.time50

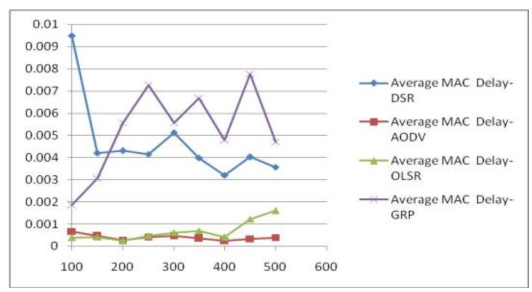


Fig. 54 pt z_uniform-802.11b-p. time 50

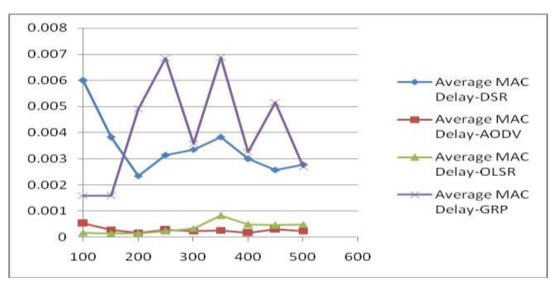


Fig.55 pt z_1024 -802.11g-p.time 50

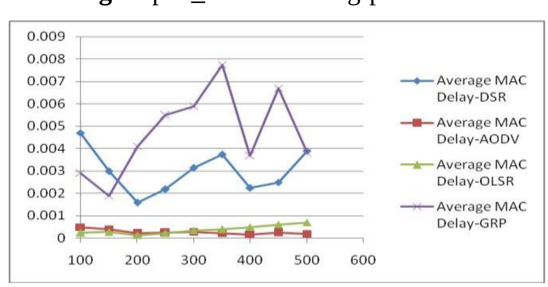


Fig. 56 pt z_uniform-802.11g-p. time50

Comparing MAC delay of one network from figure (57, 59, 61, 63), when we use DSR, the MAC delay of network in 802.11g is less than 802.11b.

4) *Link layer Retransmission*

AODV has the least link layer retransmission and GRP has the most. In large-scale network when we use GRP, the congestion in network increases and its performance become worse. In large-scale network because routes have large number of hops, so, if failure of a link occurs then transmission attempt of DSR increases due to use of source caching.

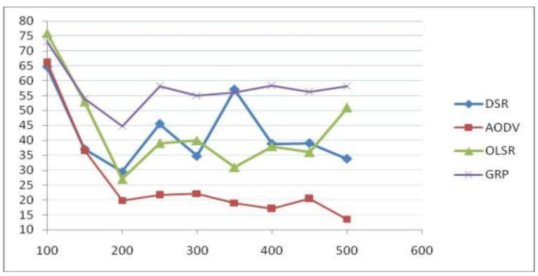


Fig. 57 pt z_1024 -802.11b-p.time 0

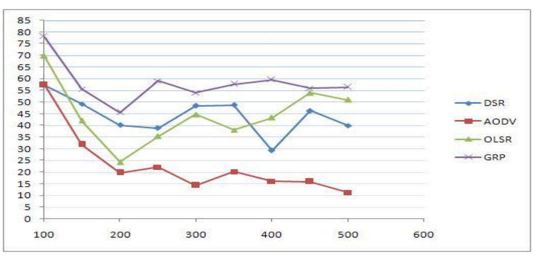


Fig. 58 pt z_uniform-802.11b-p. time 0

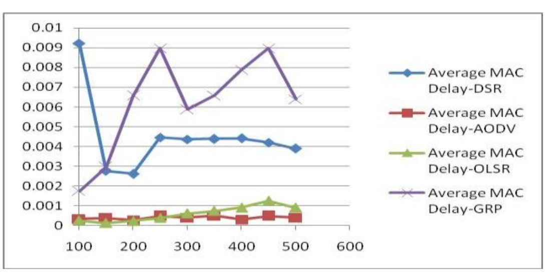


Fig. 59 pt z_1024 -802.11g-p.time 0

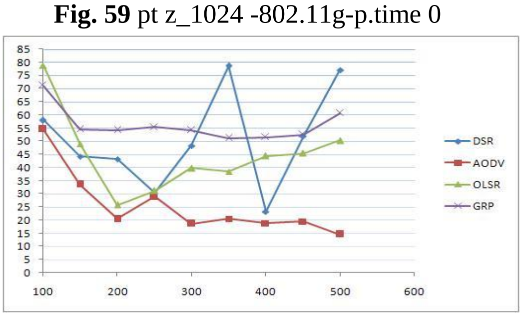


Fig. 60 pt z_uniform-802.11g-p. time 0

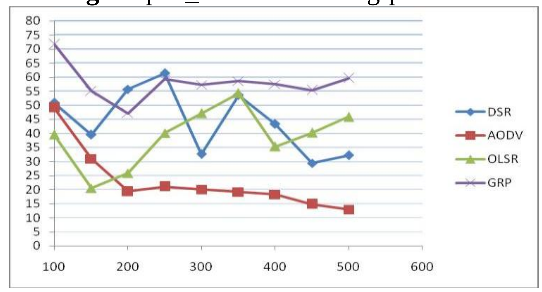


Fig. 61 pt z_1024 -802.11b-p.time50

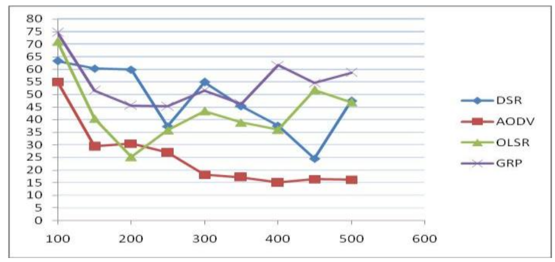


Fig. 62 pt z_uniform-802.11b-p. time 50

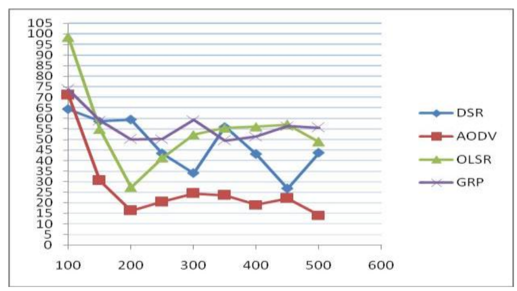


Fig. 63 pt z_1024 -802.11g-p.time 50

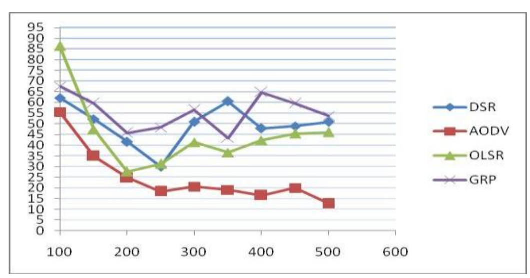


Fig. 64 pt z_uniform-802.11g-p. time 50

VIII. Conclusion

This work is the first attempt towards a comprehensive performance evaluation of four important routing protocols (DSR, AODV, OLSR, GRP) for ordinary and large-scale mobile ad hoc networks. In this paper, using simulation environment (OPNET 14.0) we evaluated the performance of four widely used ad hoc network routing protocols using different packet size patterns (uniform distribution and 1024 bytes) and also, different MAC layer (802.11b, 802.11g) for ordinary and large-scale MANETS. Our work uses four metrics to evaluate the performance of these routing protocols to include additional important performance parameters. For comparative performance analysis, we first simulated each protocol for ad hoc networks with 50 and 100 nodes. In this case OLSR and GRP shows good performance for the End-to-End delay and especially OLSR has the best MAC delay. DSR and AODV outperform OLSR and GRP for packet delivery ratio but reactive protocols show poor performance as compared to OLSR and GRP for the MAC delay. GRP and OLSR performance for End-to-End delay is near together but OLSR. OLSR outperforms GRP for packet delivery ratio, however, GRP has lesser and link layer retransmission.In large-scale network, we evaluate the performance of this protocols for eight different cases (802.11b, 802.11g MAC layer, pause time 0 and 50, different packet size). Our experiment result shows that the MAC layer not only affect the absolute performance of a protocol, but because their impact on different protocols is non-uniform, it can even change the relative ranking among protocols for the same scenario. Detailed characteristics of PHY layer (e.g. Length of signal preamble and header) has a non-negligible effect on the performance of higher layer protocols, and this is true for wireless communication media. From evaluating these four routing protocols, we found that DSR has poor End-to-End delay. The packet delivery ratio of AODV is well enough and also it shows better performance than DSR for End-to-End delay, link layer retransmission and MAC delay. OLSR has the least End-to-end and MAC delay (for most of the time), but its performance for packet delivery ratio decreases more than other protocols with increasing the number of nodes because of more traffic and congestion. GRP has better End-to-End delay than reactive protocols (DSR, AODV).

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