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Performance Reasoning of MANET Routing Protocols Varying Node Density

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Abstract: ***The abbreviation of MANET stands for Mobile Ad hoc NETwork. Nodes in the network can organized and configured by themselves without any kind of permanent infrastructures. All of these extreme features make MANET to be used widely in this contemporary time. In MANET nodes can communicate to each other neither the need of any kind of pre-existing infrastructure like base stations and routers nor any centralized control. Each node be involved in the network can perform both as host along with router. Wireless nodes have the capability of moving freely all over the network at any time. Thus the network topology may reconstruct very quickly over time. This makes the network unreliable and a lot of challenges to the routing of the packets. Routing protocols are used to communicate wireless nodes each other. An efficient protocol will make MANETs reliable. There are three distinct types of MANET routing protocols namely as proactive, reactive routing along with hybrid routing protocols. In these experimentations we have examined all of these categories of routing protocols. We have evaluated Ad-hoc On-demand Distance Vector (AODV) and Dynamic Source Routing (DSR) as reactive, Optimized Link State Routing (OLSR) as proactive, and Geographic Routing Protocol (GRP) as hybrid routing protocols. We have used HTTP traffic over the network designed. OPNET Modeler simulation tool is used to model and simulate the result. In design of the mobility model we have chosen the random waypoint. We have examined delay, network load and throughput of the network varying number of nodes. All of these performance -metrics have considered under light browsing. The comprehensive results show that OLSR has the superior performance for different node density.***

Keywords: MANET, Routing protocol, Delay, Network load, Throughput.

I. INTRODUCTION

Mobile Ad Hoc Network is a collection of moving nodes that forms wireless structure [1]. They are self-structured and self-configuring network. They do not require any predefined infrastructure. Laptops, mobile phones, personal digital assistance etc. are involved in the network as nodes.

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A piece of node can freely go into the network or go away from network immediately [2]. Every single node can performs not only as a host but also as a router in the network. Every single node cooperates in routing data packets. The source node can forward the packet by a direct route to the destination node when it is quite close. If the terminus node is short of radius, than the source node can forward packet traffic to the corresponding destination through intermediate nodes. A network can be constructed at any moment and any place by MANET nodes. That's why MANET network topology is highly dynamic and it makes packet routing too complex. Because of that different routing protocols are required for MANET. These protocols can accommodate to the mobility along with robustly reconstructing structure of the network. Fig.1 shows MANET architecture.

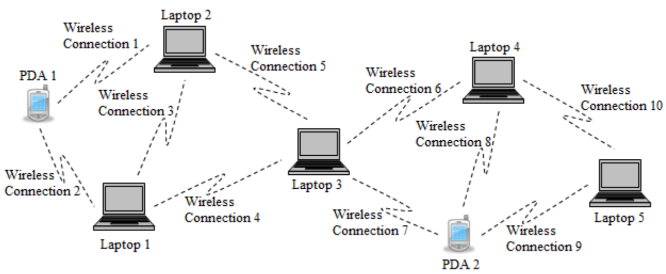


Fig.1. Architecture of a mobile ad hoc network

Internet Engineering Task Force (IETF) has done an extensive research activity on MANETs different routing protocols for their evolution and standardization of routing maintenance [3].

MANET routing protocols have classified proactive protocols as well as reactive protocols. A hybrid protocol is crossing between proactive along with reactive. Proactive protocols are also known as table driven protocols. They detect data traffic paths earlier than they required. However reactive protocols are equally known as on demand protocol. It means that they find the data route immediately after they are required. Hybrid routing protocols give an efficient structure of the packet transmission which can simultaneously draw on the well-being of table driven and on demand routing protocols. Performance evaluation of the most popular routing protocols has done in this article. We have experimented the performance of the different existing routing protocols such as OLSR, DSR, AODV along with GRP, limited to web traffic of light browsing accompanied by performance parameters of throughput, load and delay. All of these experimental results are carried out by OPNET simulator.

We have designed and implemented different network scenario by differing nodes number. These distinct scenarios are employed to study the performance of the defined routing protocols.

II. MANET ROUTING PROTOCOLS

There have a lot of challenges and flexibility in MANETs. These characteristics have given rise to broadly experimentation in routing protocols favored suchlike networks. Routing protocols are normally attracts to governs the packet transmission paths following a collection of rules. This set of rules allows two or more devices to be in touch mutually. They discover the network structure by obtaining the transmitting messages from its adjacent nodes throughout the network as well as acknowledge to correspondingly. The classification of these routing protocols has done according to distinct routing procedures like link state algorithms, pure distance vector algorithms, on demand, and global positioning system. A brief discussion of MANETs different protocols are given below.

A. Adhoc On Demand Distance Vector (AODV)

AODV is the prominent MANET reactive routing protocol. It was developed together by University of California, the University of Cincinnati, Nokia Research Center, and the Santa Barbara in 1991. AODV was advanced to converge several network characteristics like least processing overhead, nominal control overhead, capability of multi-hop data path routing, preservation of dynamic topology and loop avoidance. There are two methods naming route discovery plus route maintenance are used in AODV to communicate packets betwixt source and terminus node [10]. When a source node desires to forward a data packet to it's terminus node it initially searches the routing table. If no data path is present in the table then it derives a source route dynamically through route discovery technique. In route maintenance procedure a data packet route has to be settled at first. After that the source node will preserving or maintaining that route until it requires. In AODV, networks are completely quite since connections are established. A Route Request message (RREQ) is generated while one node desires to forward a message to the destination. After generating the RREQ message it is forwarded over the network to its neighbors. When the neighbor nodes receive these messages, then they send the RREQ message to their adjacent nodes and so on. When one will the route to the terminus node is discovered or an in-between node has route to target node, a RREP (route reply) message is generated. After that RREP message is forward to origin node using backtracking method. When it comes to the source node a data packet route is established. Nodes can transmit data packets with each other after establishing the packet forwarded path from source to destination.

B. Dynamic Source Routing (DSR)

DSR is another popular on demand routing protocol. This is a self-maintaining multi-hop MANET routing protocol. It was developed at Carnegie Mellon University. Dynamic source routing protocol permits network to be thoroughly configure and organize by itself independently [15]. The working principle of DSR is also related to two main components naming route discovery along with route maintenance. Route discovery dictates the finest path for a packet transmission between a given source and destination. On the hand route maintenance assures that the communication route will be optimal and loop-free during the change of network environment.

C. Geographic Routing Protocol (GRP)

GRP is known as position based protocol. Source node collects network information with a compact number of control overheads in GRP. Based on the accumulated knowledge, source node can discover data packet transmitting path. After that it starts constantly broadcast packet even if the connection of the existing route is broken down. This protocol simultaneously uses the robustness of proactive and reactive routing protocols. Due to this property it is generally known as hybrid routing protocol. DQ (special packet name) is applied endlessly to ahead to every one node's adjacent until the target node obtains. Once it comes to the terminus, a NIG (network information gathering) packet is broadcasted towards its neighbor nodes by the destination node. The source node calculates the optimum transmitting path accordance with collected information. Then it begins to broadcast data packets instantly.

D. Optimized Link State Routing Protocol (OLSR)

OLSR is an IP routing protocol for MANET. All data packet routes are loaded and updated in their routing table. When a route is required to packet transmission, it immediately presents the route without any earliest delay. In optimized link state routing multipoint relays (MPRs) are selected. The responsibility of MPRs to forward messages between nodes. They also supervised routing and choosing the actual route from any initiated or source node to any desire termination node. Hop on hop routing is implemented in OLSR. Every single node makes use the uttermost routing information to broadcast network traffic. MPRs can cover every single node which is two hops away. To find out packet routes and transmit data traffic all over the network it utilizes two different types of messages called hello message along with topology control (TC) message. HELLO messages which are forwarded at a particular interval applied to ensure a two way link with the adjacent node. It is used to find its single hop neighbors. Through the response of the one hope neighbors it finds its two hops neighbors and so on. TC messages are used together with MPRs forwarding to communicate adjacent node details all over the network.

III. RELEVENT WORKS

A number of researchers have done several comparative studies as well as evaluated the performance of different routing protocols in MANET.

In their studies they have examined different performance parameters. Some of these related works are discussed below.

Performance assessments of different routing protocols are done in [16].

Researchers have carry out comprehensive performance of proactive and reactive routing protocols. They have used OLSR as proactive and AODV and TORA as reactive protocol. In their work they have showed that in high congestion reactive protocol AODV has better efficiency compared to other protocols. They also proved that during heavily traffic load through the network AODV has more successfully delivering packets compared to OLSR and TORA.

The performance of DSR, AODV as well as OLSR was analyzed in [4]. Researchers were using the performance metrics of data delivery ratio along with delay to carry out the result. Experimental results concluded that the performance of OLSR is superior to AODV including DSR protocols. Due to the tendency of buffer overflow plus packet drops throughout the network layers, the reactive protocols have poor performance.

A comparative simulation research of MANETs OLSR, AODV, TORA, DSR TORA including GRP were deployed in [7]. From their analysis, researchers showed that OLSR has supreme outperform than other routing protocols. GRP has the least MAC delay and network delay.

In [11], distinct network scale is used to evaluate performance of different MANET routing protocols. Researchers show that AODV protocol has better performance according to performance metrics of average delay along with packet delivery fraction. But in terms of routing load TORA has comparatively greater execution over AODV. Relative research of AODV, TORA with DSR were under taken in [9]. In this study performance metric of throughput, delay as well as packet delivery ratio were considered to carry out the result. Researchers showed that AODV protocol performs the finest among three protocols.

Evaluation of GRP performance has been done in [5]. Researcher showed that this protocol has greater performance according to different performance metrics.

Three popular MANET routing protocols (AODV, DSDV including OLSR) are compared utilizing a different numbers of real-life framework in [13]. A various number of performance metrics are evaluated in this work and the most suitable routing protocol is advised.

Multiple scenarios were designed to calculate the performance of OLSR, DSR as well as AODVin [6]. Different TCP protocols were used to execute the experiment. The result concluded that DSR and TORA have extreme delay. TORA has maximum congestion rather than DSR and AOD. This happens due to shallow buffer capacity to control the arriving packet on TCP different forms.

DSR, AODV as well as DSDV routing protocols are compared in [14]. Researchers considered different MANET performance metrics like as throughput, PDR, routing overhead together with total delay to implement the result.

Similarly OLSR, AODV along with DSR routing protocols are compared in [12]. Employing different performance metrics researchers have recommended that proactive routing protocols have superior.

IV. METHODOLOGY

We will discuss regarding the simulation setup of the network along with different parameters that are considered as performance metrics to implement the result below.

A. Network Setup

We have operated OPNET modeler simulation tools to execute the performance evaluation of routing protocols in MANET. We used OPNET version of 14.5 is used in this research work. We have designed different simulation models that were run with varying number of 10, 20, 30, 40, 50 and 60 nodes. In each model we also used a WLAN (Wireless Local Area Network) server. All nodes were selected as randomly assigned in a campus area of 1200 meter × 1200 meter. The node goes with a speed of 5 meter per second following the random waypoint mobility model. It has a property of stopover time. This stopover time is called pause time. We have set the pause time to 100 seconds. We have set the data rate of wireless communication up to 11Mbps. We have used a wireless local area network server in short form WLAN in our network design. WLAN server has many applications. These applications usually execute over TCP. In our network WLAN server keeps up HTTP supported applications. In our experimental network design all the nodes supported a data transmission rate of 3Mbps. The nodes also used 0.005 Watts as their power source. In our network model, we used packet size of 512 bytes. Summary of the network setup given below.

Table I: General attributes for network

Attributes	Assessment
Node density	10,20,30,40,50, and 60
File(data) size	512 bytes
Protocols	AODV, DSR, GRP and OLSR.
Simulation runtime	900 seconds
Simulation area	1200m X 1200m

Table II: Profile configuration

Start time offset	Constant (0)
Duration	End of profile
Start time (seconds)	Uniform (100,200)
Duration	End of simulation

Table III: Application configuration

HTTP	Low browsing
Inter request time(Seconds)	End of profile
Packet size	512 bytes

Table IV: Mobility configuration

Speed (seconds)	Uniform (0,5)
Pause time (seconds)	Constant (100)
Start time (seconds)	Constant (0)

B. MANET Performance Metrics

A brief discussion of performance metrics which are used to analyze the result is given below.

Delay: The overall time required for data traffic to be transmitted or broadcasted through the network taken away any source to target node.

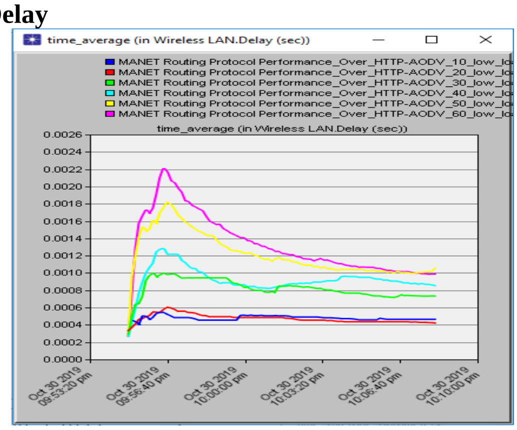
Throughput: Total number of packets transmitted per second through a communication medium or system.

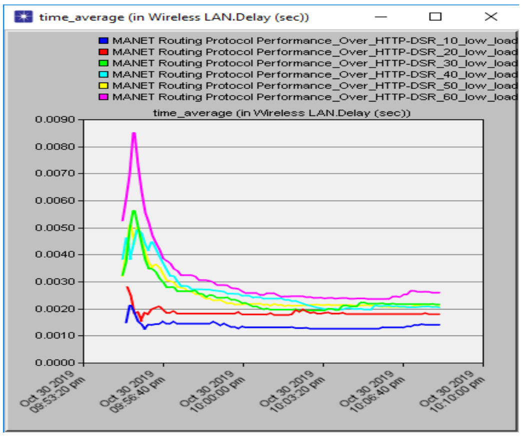
It can also be measured as the amount of packets successfully delivered per second taken away source to terminus node in the network.

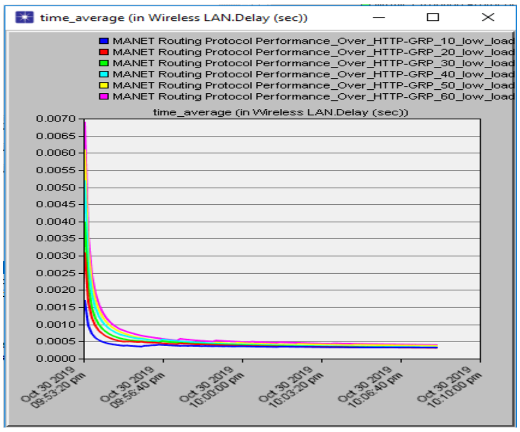
Network Load: It defines the consumption of link capacity across mobile nodes through the network. That means the number of data traffic transmitting through the link per second.

V. SIMULATION RESULT ANALYSIS

A. Delay







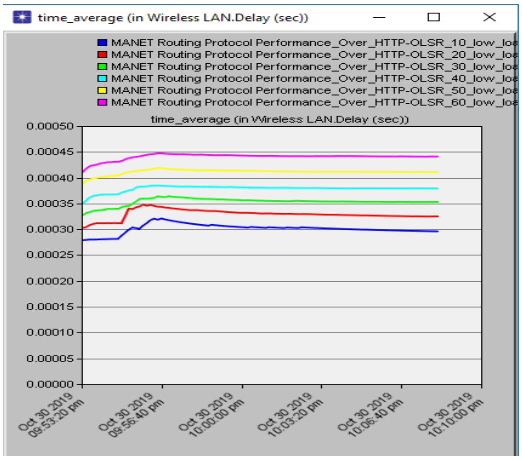


Fig.2. AODV, DSR, GRP and OLSR delay

Table V: Delay scalar values of AODV, DSR, GRP including OLSR

Routing protocol	No. of nodes					
	10	20	30	40	50	60
AODV	0.000421	0.000421	0.00073	0.00082	0.001077	0.00117
DSR	0.001196	0.001618	0.002168	0.002297	0.002194	0.00272
GRP	0.000382	0.000446	0.000488	0.000548	0.000599	0.00066
OLSR	0.000301	0.000329	0.000353	0.000379	0.000411	0.00044

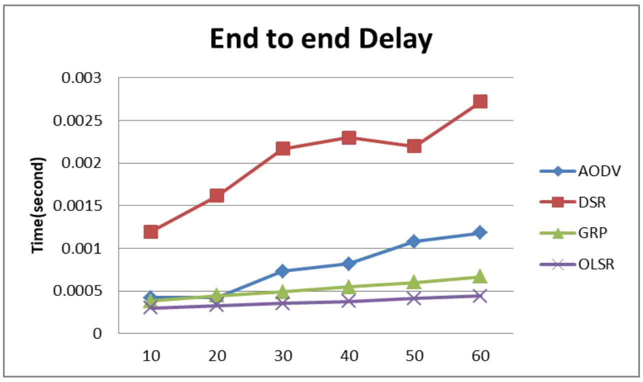
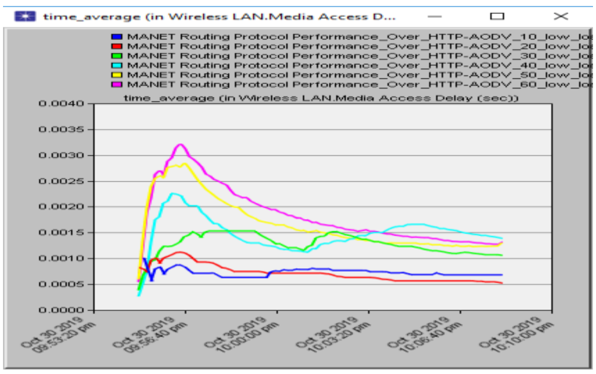


Fig.3. Delay of AODV, DSR, GRP including OLSR

From table V, we can see that the delay of OLSR is too low contrast to DSR, AODV along with GRP. Delay comparison has showed in fig.3. GRP has moderate performance over AODV. DSR experiences the most delay.

B. Media Access Delay



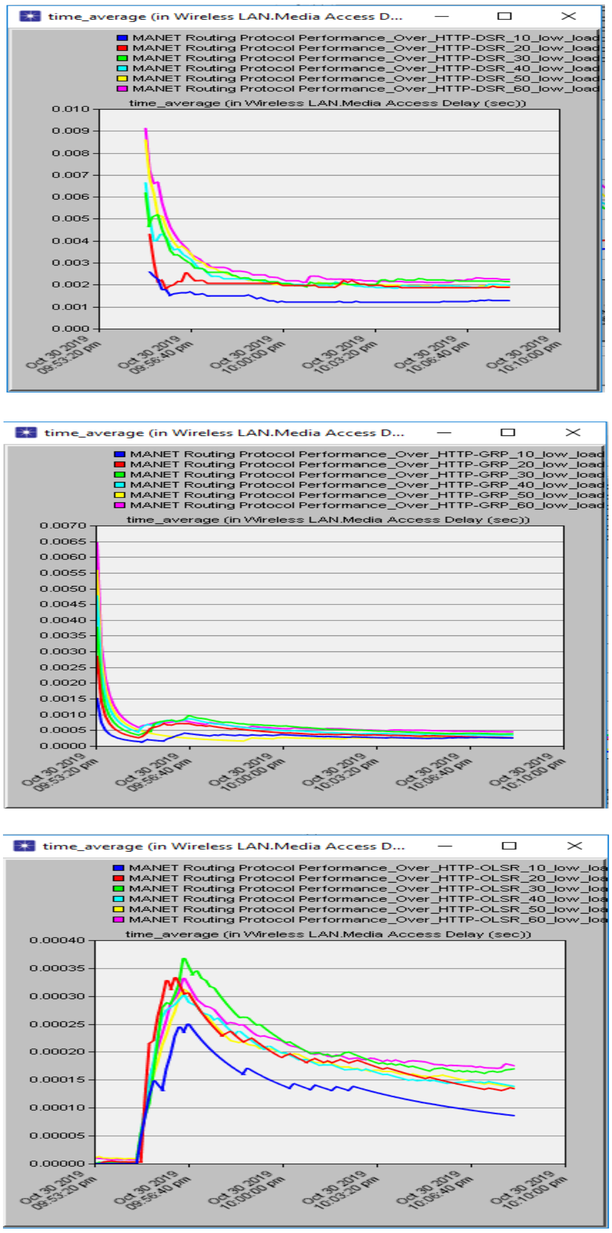


Fig.4. MAC delay of AODV, DSR, GRP, and OLSR

Table VI: Media access delay scalar values of AODV, DSR, GRP including OLSR

Routing protocol	No. of nodes					
	10	20	30	40	50	60
AODV	0.00064	0.000638	0.001139	0.001322	0.001483	0.001637
DSR	0.001195	0.001782	0.002187	0.002076	0.002205	0.00244
GRP	0.000302	0.000461	0.000618	0.000588	0.000396	0.000701
OLSR	0.000123	0.000171	0.000189	0.000167	0.000167	0.000185

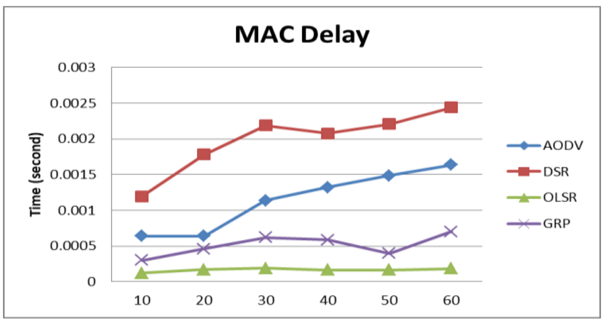
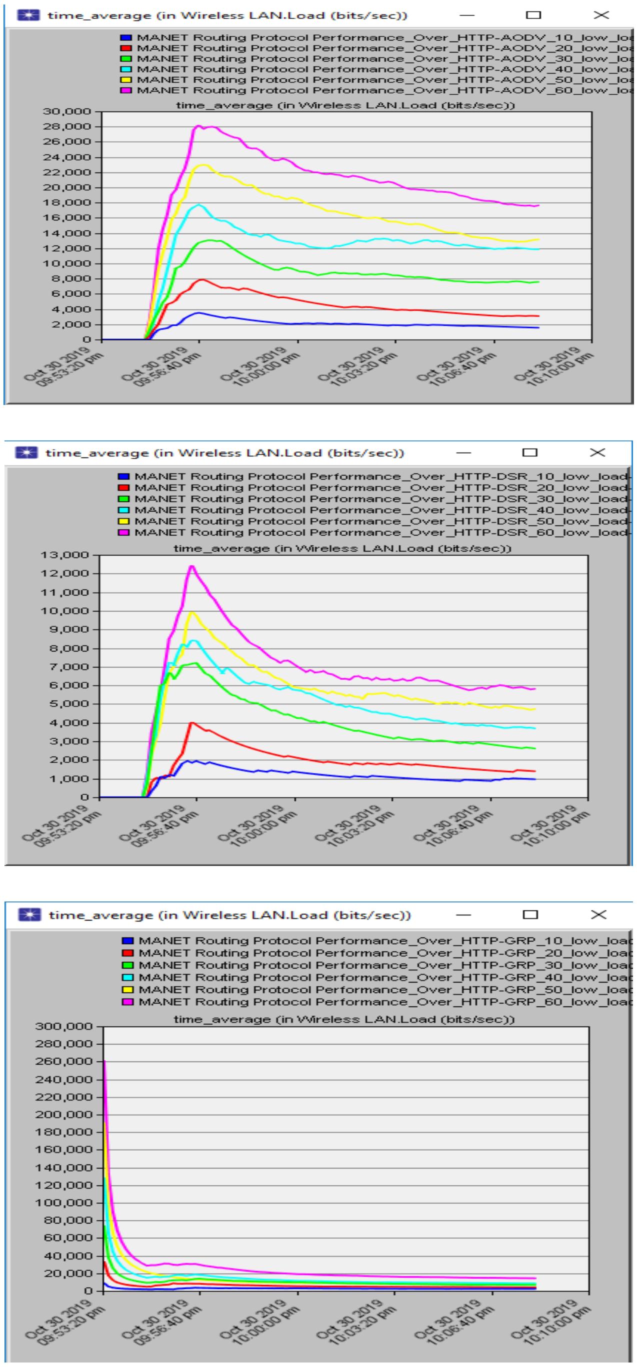


Fig.5 MAC Delay of AODV, DSR including OLSR

Table VI shows that medium access delay of OLSR is very low over other protocols. This is because the data processing at the MAC for OLSR protocol is very fast. That's why MAC delay of OLSR is near to zero. Comparative calculation of MAC delay is plotted in fig.5. From here we concluded that GRP and AODV are much better than DSR.

C. Network Load



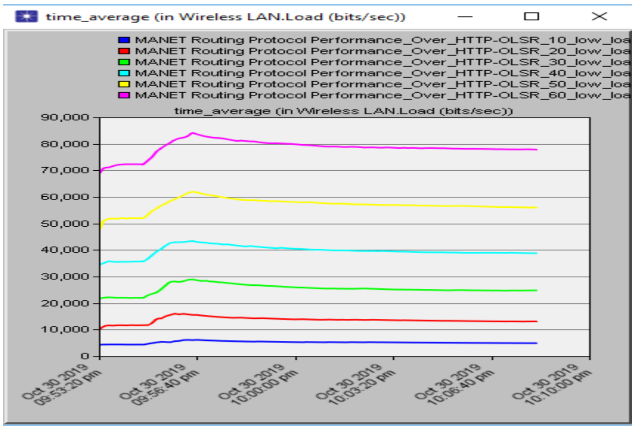


Fig.6. Network load of AODV, DSR, GRP, and OLSR

Table VII: Network load scalar values of AODV, DSR including OLSR

Routing	No. of nodes					
protocol	10	20	30	40	50	60
AODV	1846.302	4065.74	7786.923	11354.44	14490.39	18669.59
DSR	1051.111	1765.02	3633.731	4568.764	5244.713	6321.041
GRP	2670.499	5967.649	10605.46	14588.27	14911.15	25820.23
OLSR	5168.621	13588.71	25371.36	39645.36	56938.16	78489.91

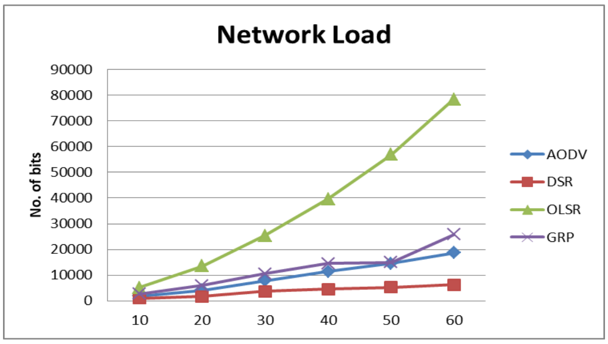
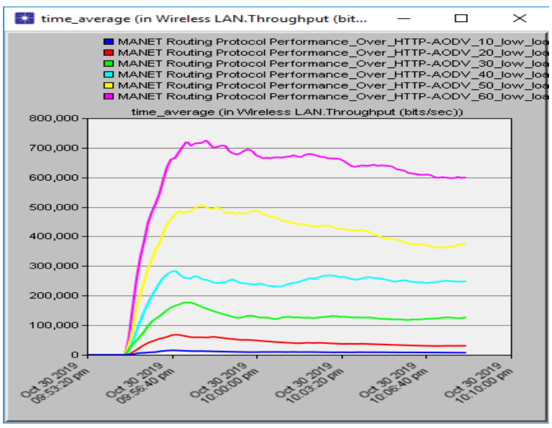
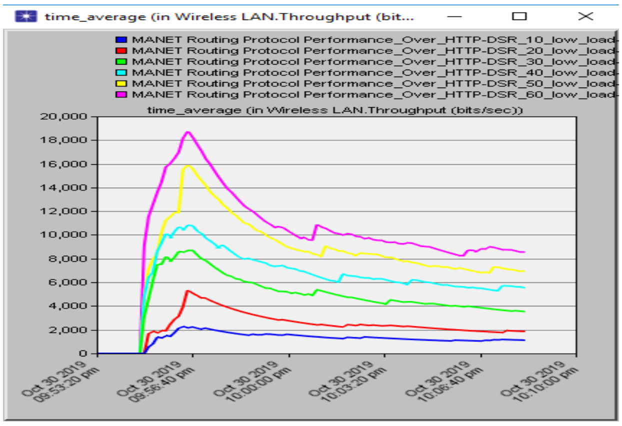


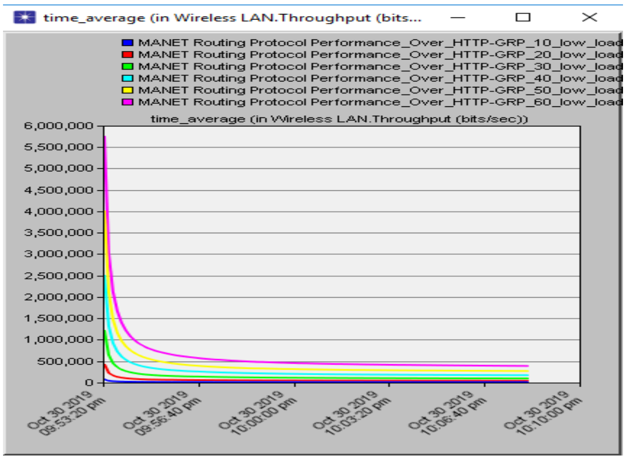
Fig.7. Network load of AODV, DSR, GRP including OLSR

From the table VII we can observe that the highest network load is obtained by OLSR whether DSR obtains the lowest. GRP has a little more than AODV.

D. Throughput







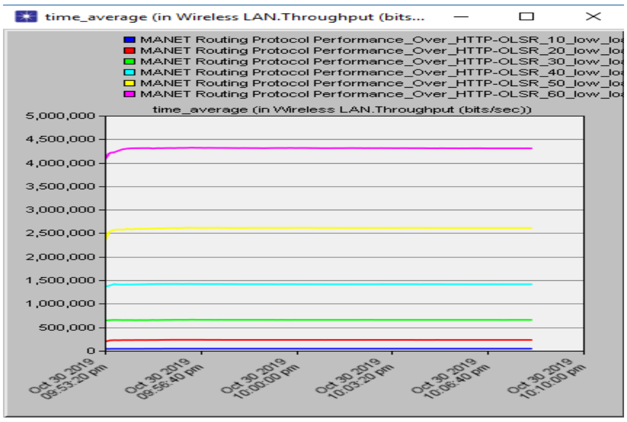


Fig.8. Throughput of AODV, DSR, GRP, and OLSR

Table VIII: Throughput comparison of AODV, DSR, GRP including OLSR

Routing	No. of nodes					
protocol	10	20	30	40	50	60
AODV	8138.57	37240.81	112902.9	214083.3	367880.9	556655.1
DSR	1238.274	2327.187	4660.134	6271.452	8151.339	9826.166
GRP	14744.58	60712.29	146324	273292.5	426881.8	616357.3
OLSR	42917.39	230118.8	657684	1415053	2606477	4305012

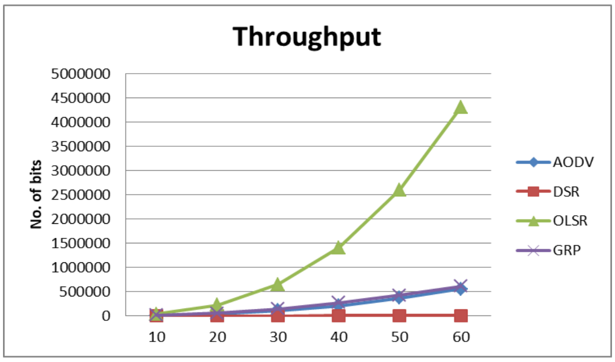
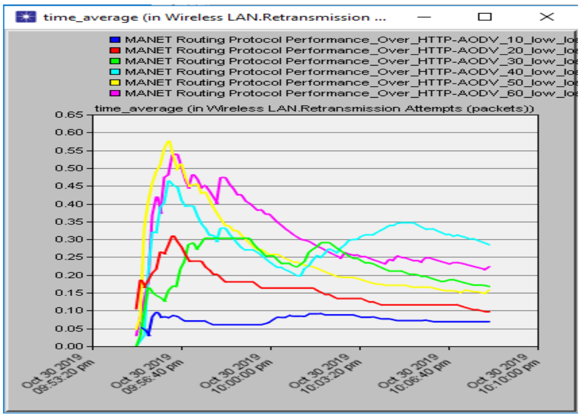
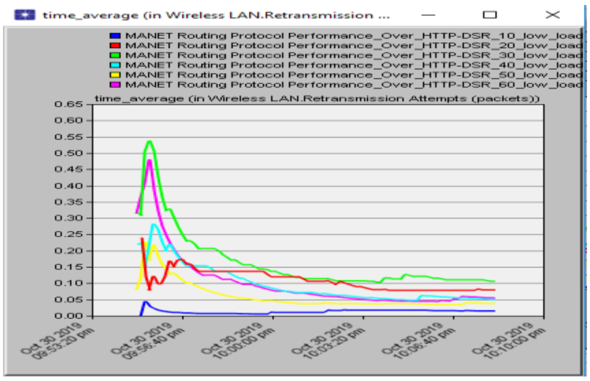


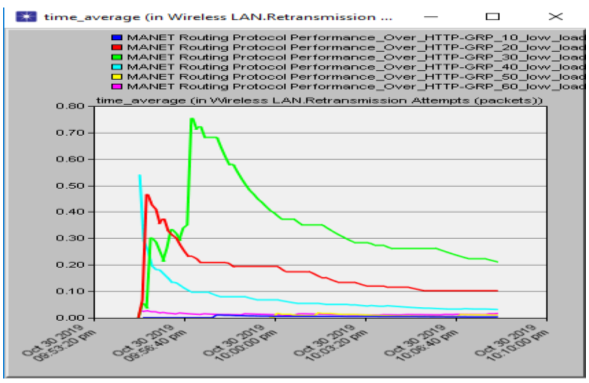
Fig.9. Throughput of AODV, DSR, GRP including OLSR

Throughput of different routing protocols is given in fig.9. We see that the throughput of OLSR performs much better compare to AODV, DSR and GRP. The reason is that in OLSR protocol all the routes are already exist. Thus it does not require discovering a path from source to the destination. For this reason when OLSR routing protocol is applied on the nodes, source nodes are allowed to broadcast more and more data packets through network. AODV and GRP have superior performance over DSR.

E. Retransmission Attempt







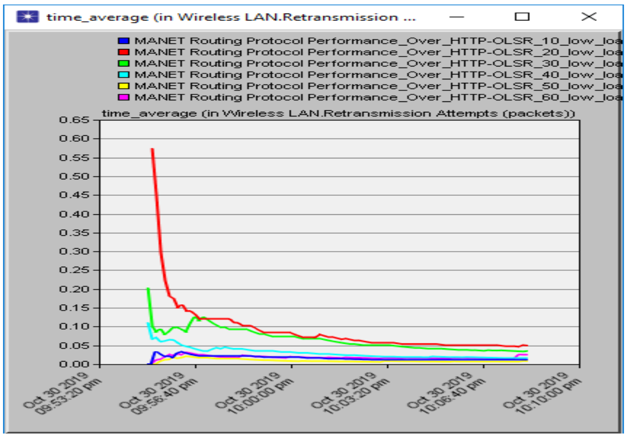


Fig.10. Retransmission attempt of AODV, DSR, GRP, and OLSR

Table IX: Retransmission attempt of AODV, DSR, GRP including OLSR

Routing protocol	No. of nodes					
	10	20	30	40	50	60
AODV	0.064858	0.142189	0.200441	0.262234	0.230448	0.277397
DSR	0.011536	0.095424	0.146689	0.085887	0.052909	0.090773
GRP	0.003584	0.15038	0.306519	0.066606	0.005393	0.011961
OLSR	0.014372	0.080701	0.058871	0.027218	0.00824	0.01609

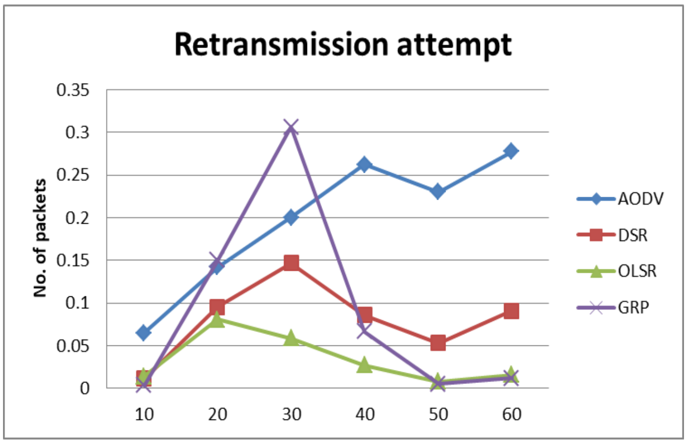


Fig.11. Retransmission attempt of AODV, DSR, GRP including OLSR

Retransmission attempts of distinct number of nodes for selected protocol have given in the table IX. Comparative calculation of these protocols is plotted in figure 10. From the plotted graph we observed that OLSR has the lowest retransmission attempt whereas AODV has the highest. DSR has low attempt for small network. But when the number of node increases, its retransmission attempt also increases. GRP has a high attempt during the small size of network. But when it crosses over 50 nodes, its retransmission attempt immediately goes down.

F. Routing Traffic Sent (packet/sec)

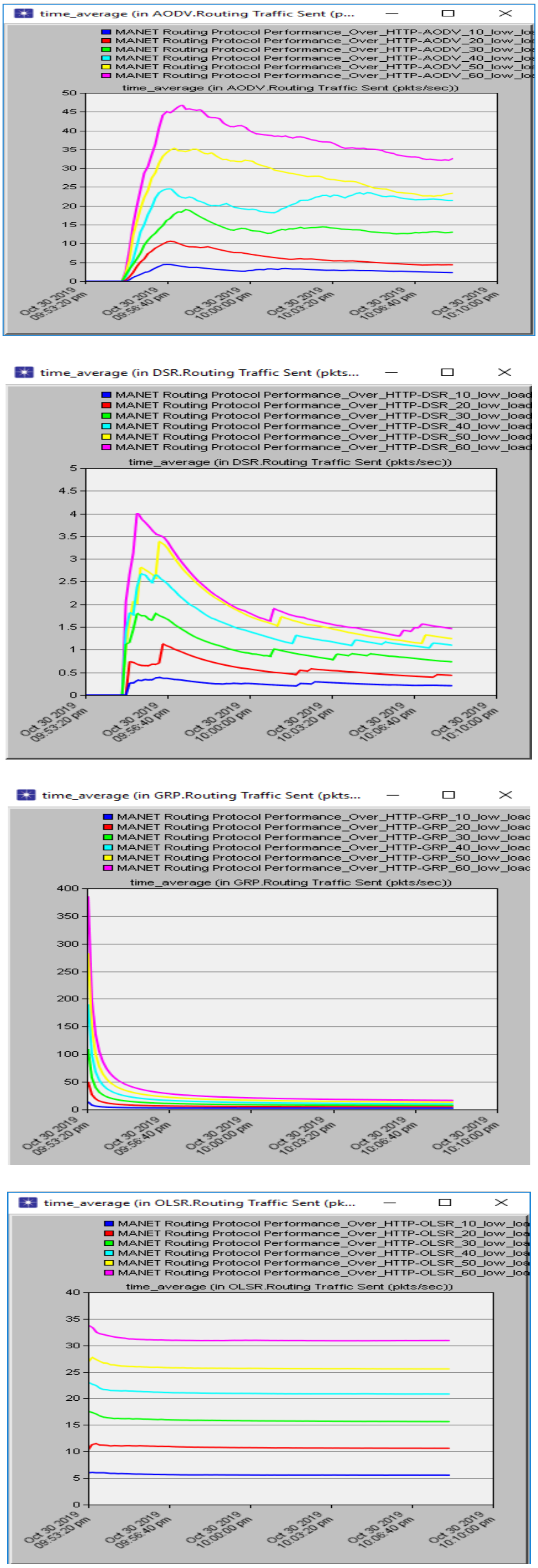


Fig.12. Routing traffic sent of AODV, DSR, GRP, and OLSR

Table X: Routing Traffic sent (packet/sec) of AODV, DSR, GRP including OLSR

Routing protocol	No. of nodes					
	10	20	30	40	50	60
AODV	2.5747	5.556891	11.99549	18.23215	24.33412	32.47517
DSR	0.227126	0.517941	0.92606	1.317315	1.581874	1.787552
GRP	2.863005	6.687272	11.67422	17.79159	24.6307	31.95233
OLSR	5.625155	10.77247	15.87778	21.04758	25.76684	31.0522

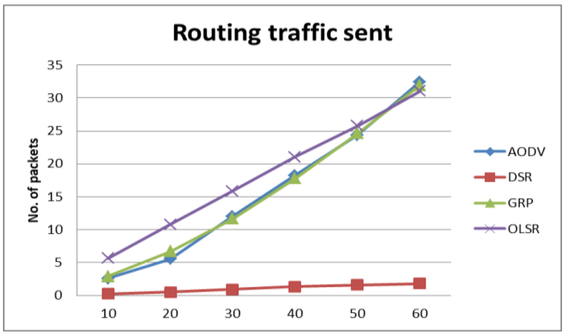
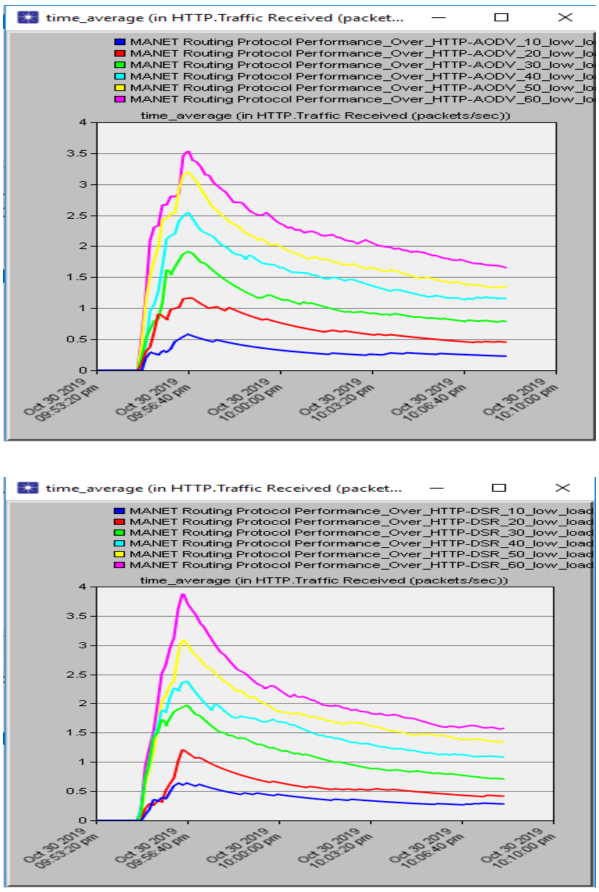


Fig.13. Routing Traffic sent of AODV, DSR, GRP including OLSR

From fig.11 we can say that DSR has the lowest traffic sent rate. OLSR protocol routing traffic sent rate is higher than AODV and GRP. The routing traffic sent rate of AODV along with GRP are almost same where GRP has a little more.

G. Data Traffic Received (packet/sec)



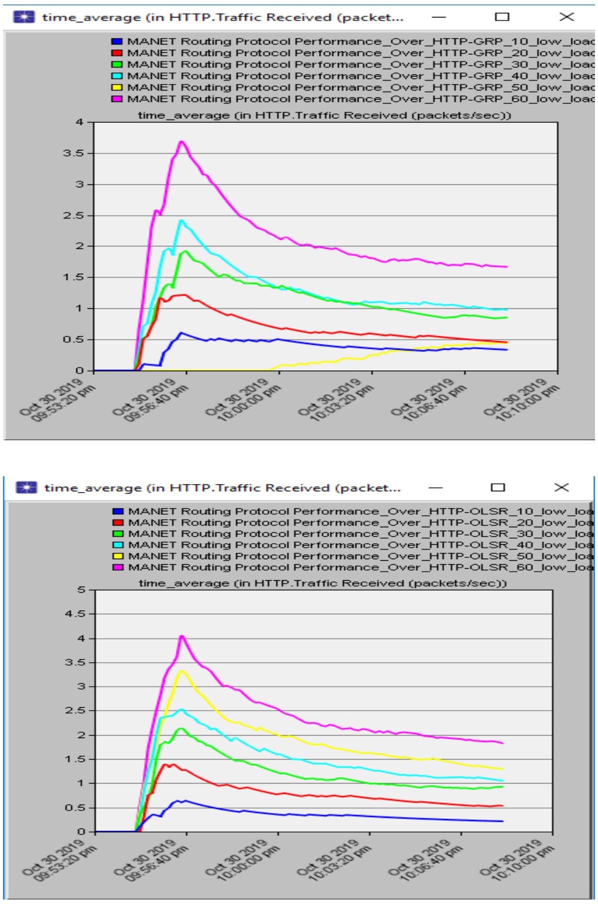


Fig.14. Data traffic received of AODV, DSR, GRP and OLSR

Table XI: Data Traffic sent (packet/sec) of AODV, DSR, GRP including OLSR

Routing protocol	No. of nodes					
	10	20	30	40	50	60
AODV	0.279271	0.609032	0.957394	1.355112	1.664984	1.993587
DSR	0.334709	0.528143	0.994445	1.312875	1.591135	1.881608
GRP	0.344364	0.615602	1.024911	1.167324	0.155522	1.902202
OLSR	0.309456	0.689256	1.067708	1.344085	1.658554	2.121479

Fig.15. Data Traffic received of AODV, DSR, GRP including OLSR

From table X we see that data traffic received rate of different routing protocols are almost same. Fig. 15 shows that OLSR has comparatively a higher data traffic received rate over AODV, DSR and GRP.

H. Normalized Routing Load

Table XII: Normalized routing load of AODV

Nodes	Routing traffic sent (packets/sec)	Data traffic received (packets/sec)	NRL= No. of routing traffic sent/ No. of data traffic received
10	2.5747	0.279271	9.21936
20	5.556891	0.609032	9.124136
30	11.99549	0.957394	12.52931
40	18.23215	1.355112	13.45435
50	24.33412	1.664984	14.61523
60	32.47517	1.993587	16.28982

Table XIII: Normalized routing load of DSR

Nodes	Routing traffic sent (packets/sec)	Data traffic received (packets/sec)	NRL= No. of routing traffic sent/ No. of data traffic received
10	0.227126	0.334709	0.678578
20	0.517941	0.528143	0.980683
30	0.92606	0.994445	0.931233
40	1.317315	1.312875	1.003382
50	1.581874	1.591135	0.99418
60	1.787552	1.881608	0.950013

Table XIV: Normalized routing load of GRP

Nodes	Routing traffic sent (packets/ sec)	Data traffic received (packets/ sec)	NRL= No. of routing traffic sent/ No. of data traffic received
10	2.863005	0.344364	8.313892
20	6.687272	0.615602	10.86298
30	11.67422	1.024911	11.39047
40	17.79159	1.167324	15.24135
50	24.6307	0.155522	158.3744
60	31.95233	1.902202	16.79755

Table XV: Normalized routing load of OLSR

Nodes	Routing traffic sent (packets/sec)	Data traffic received (packets/sec)	NRL= No. of routing traffic sent/ No. of data traffic received
10	5.625155	0.309456	18.17756
20	10.77247	0.689256	15.62913
30	15.87778	1.067708	14.8709
40	21.04758	1.344085	15.65941
50	25.76684	1.658554	15.53573
60	31.0522	2.121479	14.63705

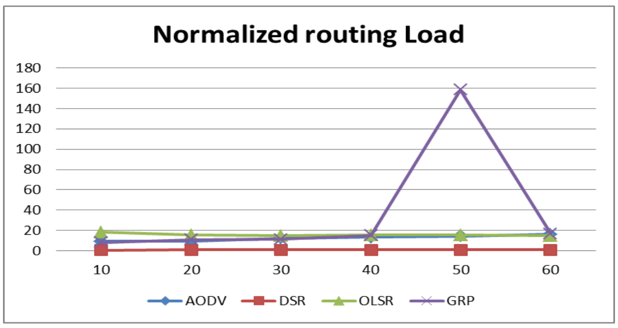


Fig.16. Normalized routing load of AODV, DSR, GRP including OLSR

Normalized routing load for different routing protocols are calculated in table XI, XII, XIII and XIV. After that we have calculated the comparative result in figure 16. We see that DSR has the lowest routing load whereas OLSR has the highest. For 50 nodes network size GRP has the highest NRL. If NRL value is high then the routing packet has higher overhead. This decreases the routing protocols efficiency.

VI. RESULT AND DISCUSSION

Performance of different categories MANETs routing protocols was analyzed in our research. We decided on OLSR, DSR, AODV as well as GRP in our experimental work. We have simulated the network design with different performance metrics with different mobile node density. When all the results were concluded, we can say that the OLSR routing protocol has the foremost execution as contrast to DSR, AODV as well as GRP protocols. Overall evaluation of GRP and AODV are also quite good. We have used HTTP traffic of low browsing over the network design with different node density to carry out the result. We will use different network load with different packet size along with different mobility in our future work.

VII. CONCLUSION

We have evaluated performance of the MANET routing protocols applying HTTP traffic in our experimented work. Since packets are transmitted across the network based on these routing protocols, choosing an ideal protocol for the particular network is a challenging work. Our work will be helpful to choose the ultimate routing protocol for mobile ad hoc network under light browsing HTTP traffic. In future we will be continuing our research to evaluate the performance of MANET routing protocols utilizing heavy browsing HTTP traffic along with Ftp traffic.

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