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A Comprehensive Performance Analysis of Proactive and Reactive MANET Routing Protocols

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Abstract- A mobile ad hoc network (MANET) is generally considered as a collection of wireless mobile nodes that dynamically form a temporary network and are capable of communicating with each other without the use of a network infrastructure or any centralized administration. During the time large number of ad hoc routing protocols has been developed, but none of these is capable of producing efficient routing of packets in large number of nodes because of their own limitations. In this paper, we have compared the results three MANET routing protocols such as Ad hoc On Demand Distance Vector (AODV), Dynamic Source Routing (DSR) and Optimized Link State Routing (OLSR) by using different web based applications such as HTTP, FTP, E-mail and Video conferencing and hence presented our observation regarding the performance of these protocols. OPNET Modeler 14.0 simulator is used for simulation purpose and performance of these routing protocols is measured using three performance metrics such as throughput, network load and network delay. From experimental results it has been observed that in case of delay AODV and OLSR perform in a similar manner with HTTP, FTP, E-mail traffics, but in Video conferencing AODV performs better than OLSR. In case of network load OLSR routing protocol is quite low as compared to reactive protocols AODV and DSR. However, in case of throughput OLSR outperforms AODV and DSR.

Keywords: - MANET, DSR, HTTP, FTP, E-mail, OPNET.

I. INTRODUCTION

In the last three decades, wireless network has grown enormously. Although, wireless network has made the information sharing and communication very easy but before we can start communication between two systems we have to setup static links. This kind of network is known as infrastructured network. These types of networks can only work in the environment where a fixed infrastructure exists. All such reasons motivate the need of infrastructure less networks which are known as *ad hoc* networks. Ad-hoc means "for some specific purpose only" [1]. So it is clear that such kinds of networks are formed when needed. All available nodes are aware of all other nodes within range. The entire collection of nodes is interconnected in many different ways. Because the nodes in ad hoc network are mobile and independent of each other due to which topology of such networks changes very rapidly. This makes the routing very difficult.

In this paper three widely used routing protocols namely AODV, DSR and OLSR based on different web applications are analyzed and compared. Three parameters such as Network Delay, Network Load and Throughput are chosen as the performance metrics. The rest of the paper is organized as follows: Section II presents the definition of MANET, Routing and protocol classification. Overview of three protocols used in the study is presented in Section III. Section IV describes the simulation environment and performance metrics and then the results are presented in Section V. Finally, Section VI concludes the paper.

II. MOBILE AD-HOC NETWORK (MANET)

MANET [1] consists of mobile nodes interconnected by wireless multi-hop communication paths without any fixed infrastructure. The nodes can be hosts as well as routers. Ad hoc wireless networks are self-creating, self-organizing, and self-administering.

2.1 Routing In MANETs

In order to facilitate the communication between two different systems or within a network routing protocol is used to discover paths between various nodes. The basic goal of the routing protocol is to find a very efficient route between a pair of nodes, so that messages can be delivered in a very efficient and timely manner.

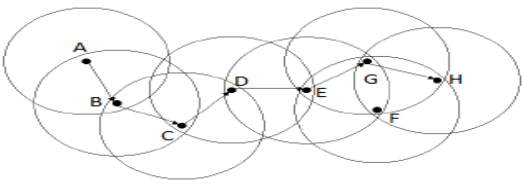

Fig.1 Routing in MANETs

Fig1 shows how routing takes place in MANETs. In this figure a route is created between two nodes A and H using a number of intermediate nodes. This is called multi-hop routing. Bandwidth and power constraints are two important factors to be considered in current wireless network because multi-hop ad-hoc wireless relies on each node in the network to act as a router and packet forwarder. This dependency results in placing the demands of bandwidth and power computation on mobile host to be considered while choosing the protocol for the nodes. Routing protocols which are used in wired network cannot be used for mobile ad hoc networks because of node mobility [2].

2.2 Classification of Routing Protocols

Many protocols have been proposed for MANETs. These protocols can be mainly divided into two categories.

- Reactive/On-demand Routing Protocols
- Proactive/Table-driven Routing Protocols

A. Reactive/On-demand Routing Protocols

In reactive or On-demand protocols, the routing information is not maintained for all the routes but only for the active routes. This means the routes are determined and maintained by a node only when it wants to send data to a particular destination. A route search is needed for every unknown destination. Therefore, the communication overhead is reduced at expense of delay due to route research. Examples of some reactive protocols are Ad hoc On-Demand Distance Vector (AODV), Temporally Ordered Routing Algorithm (TORA) and Dynamic Source Routing (DSR). But in this paper we'll discuss only AODV and DSR as we have simulated these two protocols from reactive category [2].

B. Proactive/Table-driven Routing Protocols

In proactive or table-driven routing protocols, each node maintains up-to-date routing information to every other node in the network. In order to maintain such information routing tables are used in these protocols. Routing information is periodically transmitted throughout the network in order to maintain routing table consistency. However, for highly dynamic network topology, the proactive schemes require a significant amount of resources to keep routing information up-to-date and reliable. Some highly used proactive routing protocols are Optimized Link State Routing (OLSR), Destination Sequenced Distance Vector (DSDV) and Wireless Routing Protocol (WRP) [2].

III. DESCRIPTION OF AODV, DSR AND OLSR

A. Ad hoc On-Demand Distance Vector (AODV)

The AODV joins the mechanism of DSDV and DSR. The hop-by-hop routing and sequence number of DSDV and on-demand mechanism of route discovery and route maintenance from DSR are combined in AODV [3].

Route Discovery[3]: In this route discovery is not used when the route is present in cache. Otherwise the RREQ is flooded in network which contains the last known sequence number, whereas the intermediate nodes in the network store the reverse route to source. When destination gets the RREQ, it sends back RREP that contains number of hops to it and most recent sequence number. All intermediate nodes that forward the RREP backward build a forward path. Because of the hop-by-hop nature of AODV the nodes store only the next hop instead of entire route.

Route Maintenance[3]: To maintain routes each node in active routes check link status of their next hop neighbour. The node sends a route error (RERR) message to each of its upstream node on detecting a link break in order to invalidate this route and the neighbours forward it further. Consequently, these nodes propagate the RERR to their predecessor nodes. This process continues until the source node is reached. When RERR is received by the source node, it can either stop sending the data or reinitiate the route discovery mechanism by sending a new RREQ message if the route is still required.

B. Dynamic Source Routing (DSR)

DSR designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. It is a very simple and efficient routing protocol. The protocol is composed of the two main mechanisms of "Route Discovery" and "Route Maintenance".

Route Discovery [4]: Whenever a source node requires a path to the destination node. First of all, the source node searches for a valid route to the destination in its route cache. If the source node finds a valid route to destination then it puts the route into packet's header and uses this route to send its data packet but if source does not find the same in cache then it initiates the route discovery process by broadcasting a route request (RREQ) message. The route request message contains the address of the source and the destination, and a unique identification number. The intermediate nodes put their address on the header and forward the packet. When the destination node receives the request message then it has the whole hop sequence of path. As a result it sends back the route reply (RREP) message which contains the proper hop sequence.

Route Maintenance [4]: It is used to handle route breaks. When a node encounters any problem regarding transmission at its data link layer, it removes the route from its route cache and generates a route error message which is sent to each originator node that has sent a packet routed over the broken link. The originator node removes this link from its route cache. If one route cache contains another source route, the node sends the packet using this route. Otherwise, it will initialize a new Route Request. Acknowledgment messages are used to verify the correct operation of the route links.

C. Optimized Link State Routing (OLSR)

The OLSR [5] is the proactive link-state routing protocol optimized for the MANETs. In this two types of messages are used to discover and then distribute link state information throughout the network named Hello and

Topology Control (TC). The Hello messages are used by nodes for sensing these changes in neighbourhood and gathering the information about its neighbours along with link status. Now flooding process uses TC messages to communicate with the distant nodes. Each node chooses a set of nodes as MPRs (Multi Point Relays). Nodes select MPRs such that there is a path to each of its 2-hop neighbours via a node selected as an MPR. These MPR nodes then source and forward TC messages that contain the MPR selectors. TC message contains address of its originator and MPR set of that node. The nodes will receive a partial topology graph and shortest path algorithm is applied on this graph to find optimal path.

IV. SIMULATION SETUP

4.1 Simulator

OPNET (Optimized Network Engineering Tool) Modeler 14.0 is selected for performing simulation. OPNET is a discrete event network simulator that provides virtual network communication environment. OPNET Modeler 14.0 is chosen because it is one of the leading environments for network modeling and simulation. It offers easy graphical interface. This tool is highly reliable, robust and efficient. It supports large number of built-in industry standard network.

4.2 Simulation Parameters

This simulation study focuses on the performance of routing protocols with different web application. Therefore, twelve simulation scenarios consisting of nodes 100 are considered for three routing protocols AODV, TORA & OLSR. Different web traffic is generated using the Application and Profile Configuration. Table 1 shows the simulation parameters used in this study. The speed of the nodes is set to 5 meters/sec. We have chosen random waypoint mobility model as this assures that mobile nodes are configured with mobility. Buffer size is set to 1024000 bits as heavy browsing is used for traffic generation.

TABLE1. Simulation Parameters

Attribute	**Value**
Maximum Simulation Time	150 sec
Interface Type	Wireless(ad-hoc)
Network Area	500*500 meters 700*700 meters 900*900 meters
Mobility Model	Random Way Point
Data Rate(bps)	11Mbps
Transmit Power(W)	0.020
Buffer Size(bits)	1024000
No. of Nodes	20,40,100
Protocols	DSR, AODV, OLSR
Traffic Generation Application	HTTP, FTP, Email, VIDEO CONFERENCING

4.3 Performance Metrics

a) *Throughput:* - Total number of data packet is delivered successfully per second of simulation time. We analyze the throughput of the protocol in terms of number of messages delivered per second.

Throughput= (number of delivered packet *packet size)/total duration of simulation

b) *End-to-End Delay:* - The end-to-end delay [6] is the average time it takes a data packet to traverse from the source node to the destination node. This includes all possible delays.

c) *Network Load (bits/sec):* Network Load [7] is a statistic represents the total data traffic received (in bits/sec) by the network from the higher layers of the MACs that accepted and queued for transmission. This statistic doesn't include any higher layer data traffic that is rejected without queuing due to full queue or large size of the data packet.

V. RESULTS AND DISCUSSIONS

This paper presents the performance comparison of three routing protocols AODV, DSR and OLSR by using number of nodes 20, 40, 100. But here, simulation results are shown with 100 nodes only.

A. Network Load:

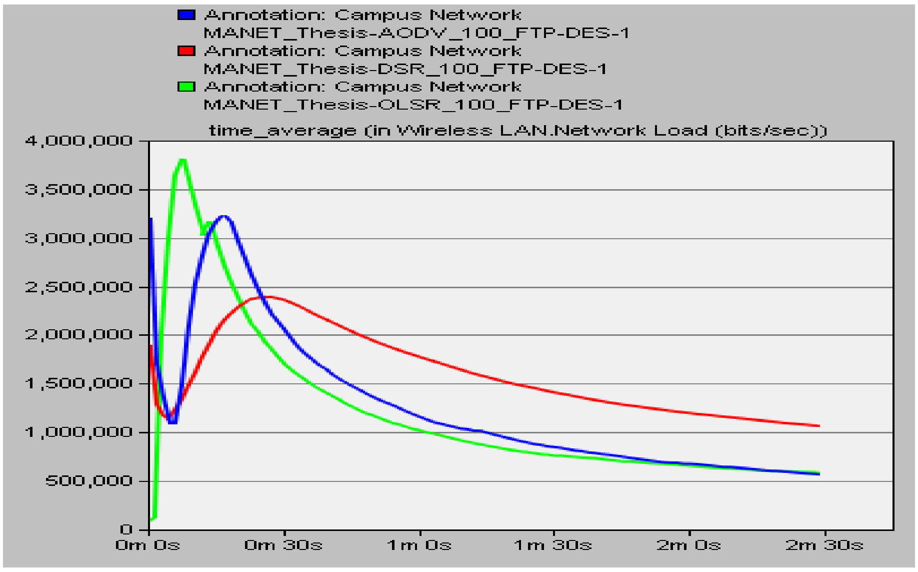

Fig. 2 Network Load for 100 nodes (DSR, AODV and OLSR) with FTP Traffic.

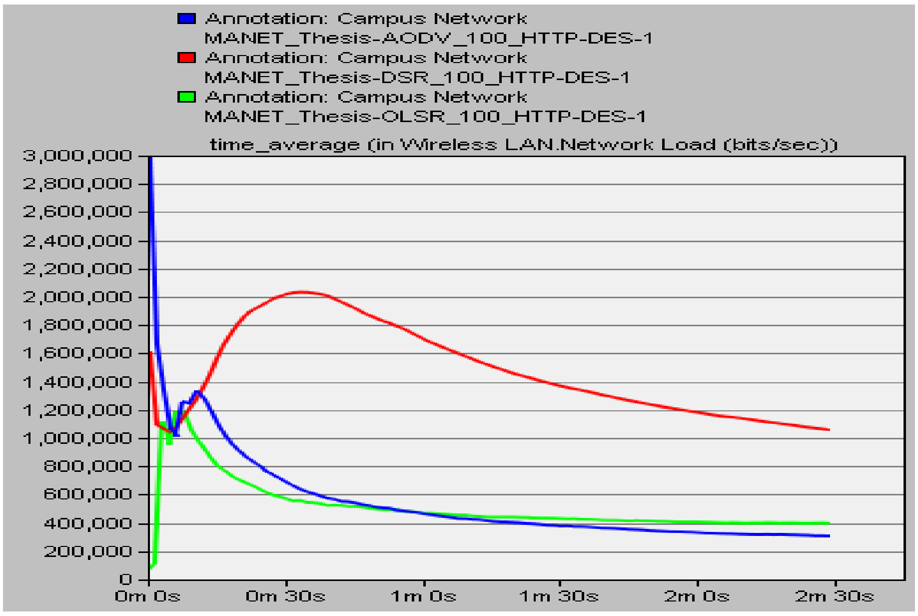

Fig. 3 Network Load for 100 nodes (DSR, AODV and OLSR) with HTTP Traffic.

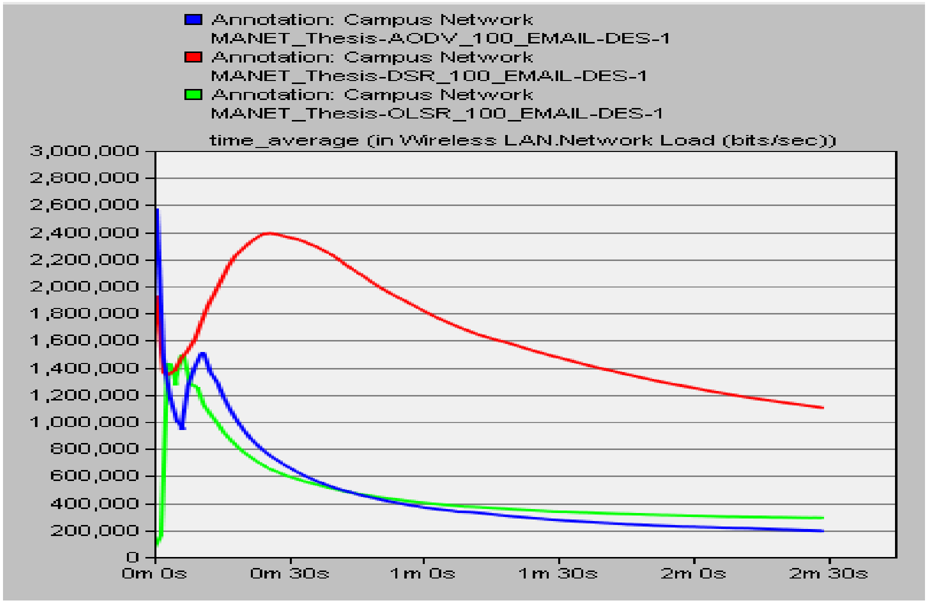

Fig. 4 Network Load for 100 nodes (DSR, AODV and OLSR) with EMAIL Traffic.

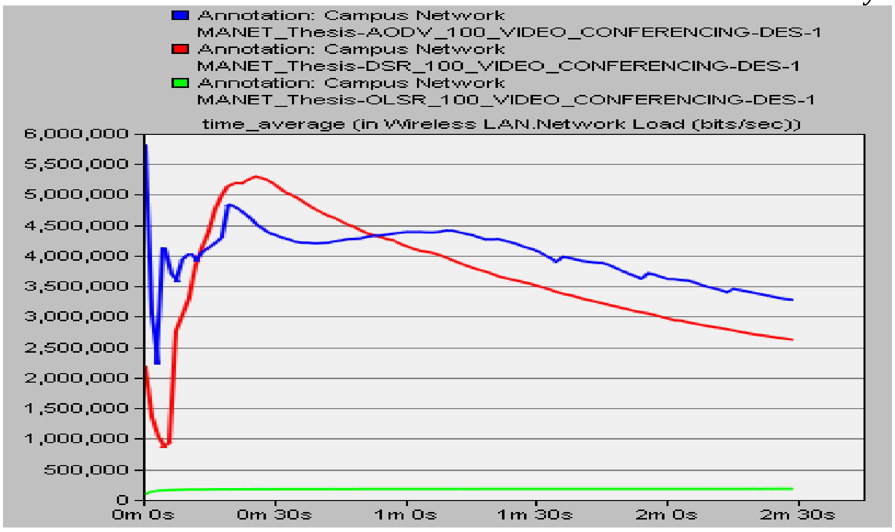

Fig. 5 Network Load for 100 nodes (DSR, AODV and OLSR) with VIDEO_CONFERENCING Traffic

The figure 2 to figure 5 shows the network load in all three protocols AODV, DSR and OLSR over HTTP, FTP, Email and Video Conferencing for 100 nodes respectively. On comparing the graphs it is clearly observed that network load in OLSR routing protocol is quite low as compared to reactive protocols AODV and DSR. The frequent changes in the graph result in changing the link state and MRP nodes due to random mobility. It is table driven approach therefore it maintains route and network load. On the other hand DSR has higher network load as a result of which it store the packet in its cache and find routes on demand. When the traffic is set to video conferencing, signifying heavy traffic, AODV has higher network load.

B. Network Throughput

Network Throughput is calculated for all three routing protocols using100 nodes.

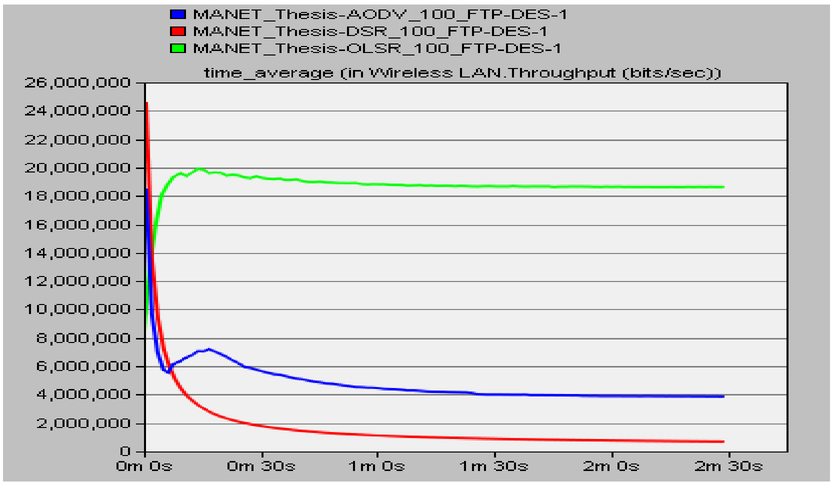

Fig. 6 Network Throughput for 100 nodes (DSR, AODV and OLSR) with FTP Traffic.

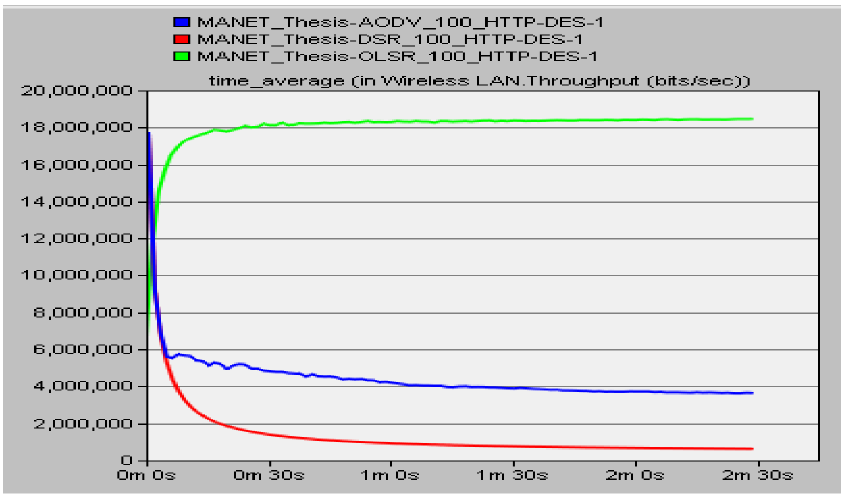

Fig. 7 Network Throughput for 100 nodes (DSR, AODV and OLSR) with HTTP Traffic.

Simulation results in figures 6 to 9 shows the throughput for the routing protocols AODV, DSR, and OLSR protocols over HTTP, FTP and Email and Video Conferencing. It has been observed that for simple HTTP, FTP and Email and video conferencing traffic throughput increases. OLSR is higher in throughput than that of the reactive routing protocols AODV, DSR in case of HTTP, FTP and Email and video conferencing traffics; because of it the OLSR protocol is independent of the traffic and network density compared to AODV, DSR and TORA protocols.

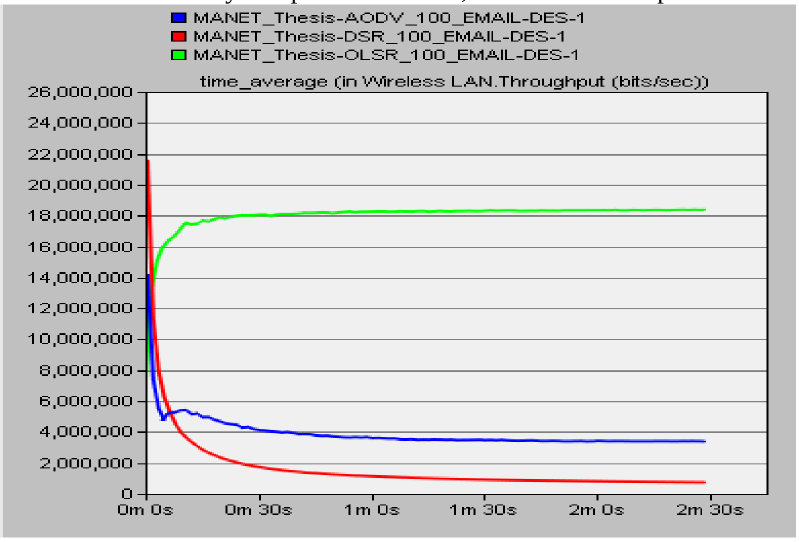

Fig. 8 Network Throughput for 100 nodes (DSR, AODV and OLSR) with EMAIL Traffic.

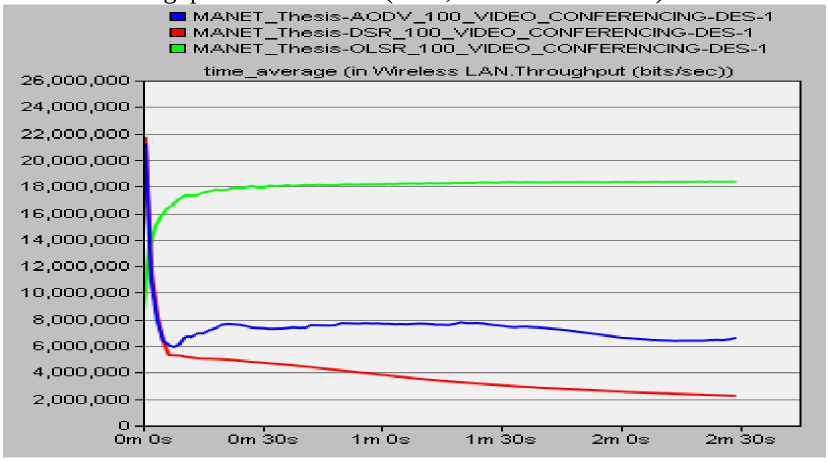

Fig. 9 Network Throughput for 100 nodes (DSR, AODV and OLSR) with VIDEO_CONFERENCING Traffic.

OLSR reduced the control overhead forcing the MPR to propagate the updates of the link state. But the drawback of this is that it has to maintain the routing table for all the possible routes. There is no difference in small networks, but when the number of the mobile hosts increase, then the overhead from control messages also increases. The OLSR protocol work most efficiently in the dense networks.

C. Network Delay:

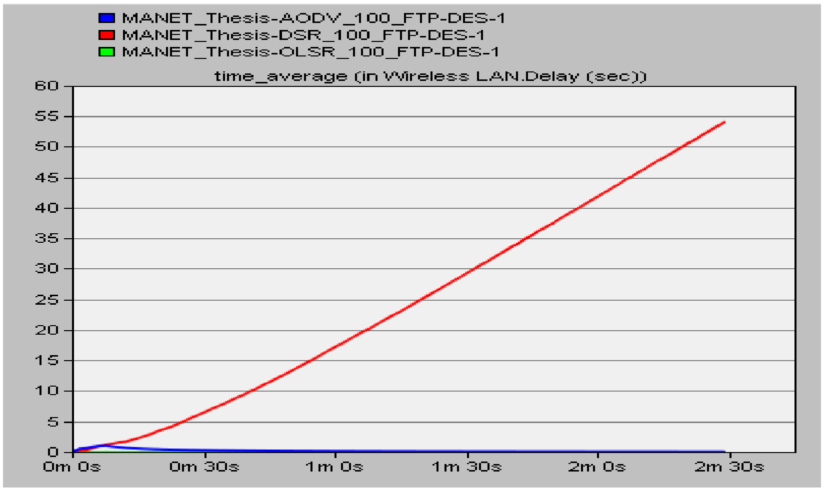

Fig. 10 Network Delay for 100 nodes (DSR, AODV and OLSR) with FTP Traffic.

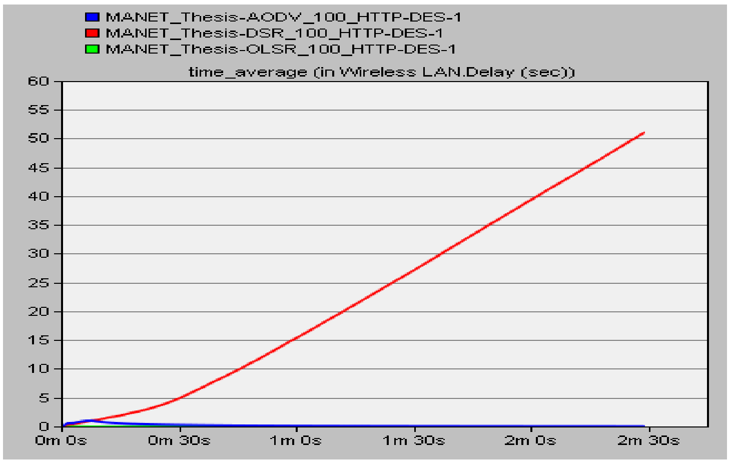

Fig.11 Network Delay for 100 nodes (DSR, AODV and OLSR) with HTTP Traffic.

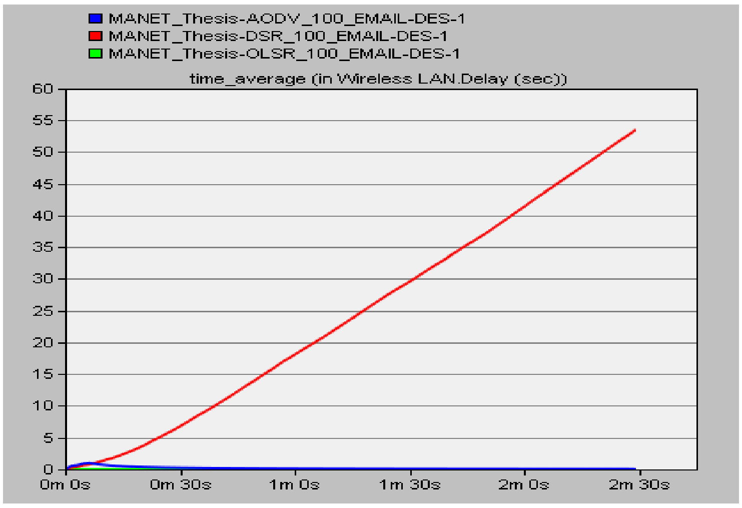

Fig.12 Network Delay for 100 nodes (DSR, AODV and OLSR) with EMAIL Traffic.

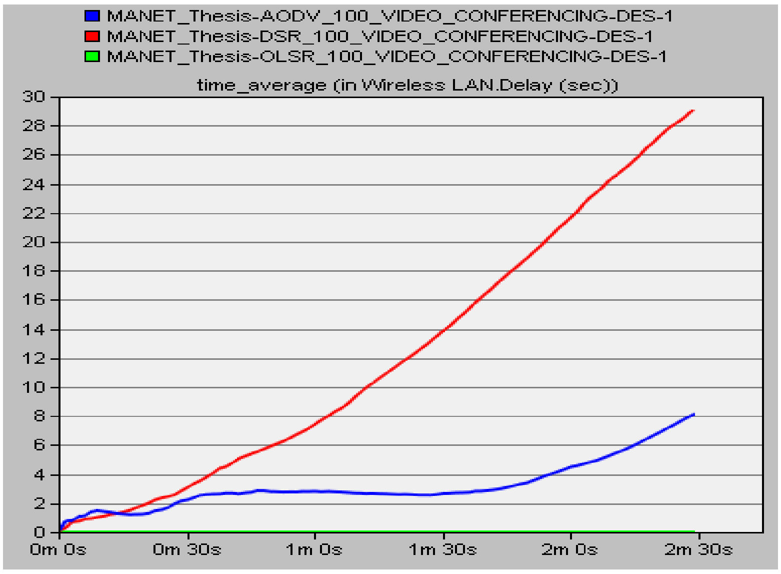

Fig.13 Network Delay for 100 nodes (DSR, AODV and OLSR) with VIDEO_CONFERENCING Traffic.

The figures 10 to 13 shows the network delay in all three protocols AODV, DSR and OLSR over HTTP, FTP, Email and Video Conferencing heavy load traffics for 100 nodes respectively. On comparing the graphs it has been observed from experimental results that delay in OLSR routing protocol is quite less as compared to reactive protocols AODV and DSR. AODV shows lower delays but slightly higher than the OLSR. OLSR protocol performed better as compared to AODV and DSR in case of network delay. This is due to the proactive nature of the protocol. OLSR does not need to do the extra work for the discovery of the route so it provides low single packet transmission latency. AODV also performed well even in the more number of nodes because it reacts to the topological changes quickly. Other reason for the fast delivery of packets by AODV is its loop free nature.

VI. CONCLUSION

In this paper an attempt is made to evaluate the performance of three routing protocols such as AODV, DSR and OLSR and also an effort is made to compare the results of these protocols using MANET. The evaluation consider the impact of scalability, mobility and network HTTP, FTP and Email and Video Conferencing heavy traffic load on different types of routing protocols. In the performance assessment delay, network load and throughput are adopted for the whole scenarios considered. The simulation using OPNET consider different scenarios that attempt to cover all the aspects required for network evaluation. In this paper Experimental results have demonstrated that the delay by using DSR protocol is highest and by OLSR it is lowest. In the case of throughput, OLSR has comparatively good throughput. On the other side network load of OLSR routing protocol is quite low as compared to reactive protocols AODV and DSR.

It has been concluded from observation that average end to end delay is highest in video conf while lowest in HTTP, whereas throughput is highest in HTTP and lowest in video conf and Email, also it has been observed from all our results that network load is highest in video conf while lowest in FTP.

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