PERFORMANCE EVALUATION OF ROUTING PROTOCOLS IN MOBILE ADHOC NETWORKS (MANETS) USING RANDOM WAYPOINT MOBILITY MODEL

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ABSTRACT
Wide area research has been done in MANETs, with a major focus on the routing protocols in MANETs i.e AODV, DSR, OLSR and so many others. Much research has been done using different tools to study and analyze the performance of the routing protocols in MANET. Different results are shown by the different simulation environments depending on the number of mobile nodes, mobile node speed and varying network load. In this research paper we have studied and analyze the performance of the routing protocols i.e AODV, DSR and OLSR using Opnet Modeler 14.5 and the back end compiler used is Microsoft Visual C++. We simulate different scenarios (varying the no. of mobile nodes, mobile node speed and varying network load). The traffic used is FTP high load traffic. To provide multihop routes from node to the server all mobile nodes were randomly positioned in the network.

KEYWORDS: *AODV (Adhoc on demand distance vector), DSR (Dynamic source routing), OLSR (Optimized Link State routing), MANET (Mobile Adhoc Network),*

I. INTRODUCTION

MANET (Mobile Adhoc Networks) is a robust wireless network which has no infrastructure. The formation of MANET is only possible from mobile nodes or the combination of both i.e mobile and fixed node. In MANETs all the nodes associate randomly with one another and form such topologies which are arbitrary and also they act as host and routers both. The mobile router in MANET do not require any configuration as they have self configuration capability which makes the MANET technology the most suitable for areas where there is no infrastructure or the infrastructure is fully damaged because of natural disasters like floods, earth quakes or in the rescue operations where we require the network connection very urgently. As one of the most important aspect of wireless networks in the mobility, so because of this reason the MANETs working group with in IETF developed consistent IP routing protocols for both type of topologies i.e Static and dynamic. After many years of research, the internet standards were not completely formed MANETs routing protocols, but only they have identified experimental request for comments since 2003 **[1].** The questions regarding the deployment or the implementation of the routing protocols are still unanswered but only the algorithms which were proposed were considered to be used as a trial technology and there are more chances that a standard will be developed from these algorithms **[1].**

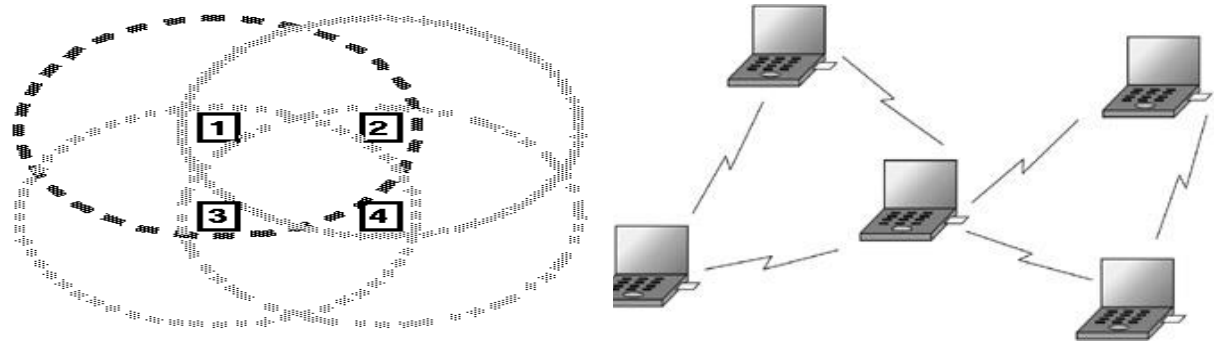

Fig1 Illustration of MANETs

II. PROBLEM STATEMENT

The different IP routing protocols that are developed for wireless networks have different features. All these routing protocols from different routing aspects have different qualities. Because of this reason it is very difficult to choose a correct routing protocol. Three major questions are addressed in this research Paper.

1. Which routing protocol will give us better performance as compared to the other in MANETs?
2. The different factors involved in affecting the performance routing protocols considered under the study in this research paper.
3. And in the last we discuss that what are the major differences between the protocols considered under the study in this research paper?

   For the solution of the above problems we create campus network of size 1000m x 1000m using Opnet Modeler 14.5. The network developed using Opnet Modeler have varying number of mobile nodes, varying network load, and varying the mobile node speed and check the performance analysis of the routing protocols i.e **OLSR** (Proactive routing protocol), **AODV,** and **DSR (**both reactive routing protocols**).** The performance metrics that are evaluated are end to end delay of the packets, throughput, and routing overhead.

III. BACKGROUND

MANETs (Mobile Adhoc Networks) are dynamic in nature, that's why MANETs is an ideal network for a number of applications. The network deployment of MANETs is quick and also it requires very less configuration, that's why MANETs are suitable for emergency situation like natural disasters. MANETs can also be used in conferences. Nowadays most of the people are having laptops having Wi-Fi connection, these people when gathered for meeting or any conference can build MANETs very easy and quickly, that's why MANETs are becoming more and more popular.

Most of the research is done using NS2 network simulator to check the performance evaluation of routing protocols in MANETs, but different simulation environment produces different results, so we need to broaden our spectrum and take into the consideration those effects which are not considered in a particular environment. The performance evaluation two types of flat routing protocols (both reactive and proactive routing protocols) have been checked in this research thesis using Opnet **[2]** under different number of nodes, varying traffic load and varying the mobile node speed**.** The mobility model used in this research report is Random waypoint mobility Model.

The type of routing traffic used in this research report is TCP traffic to study the adhoc routing protocols. In most of the comparison study constant bit rate sources have been used **[3].** Our objective is to discuss few more comparison statistics with unique and different combinations of wireless routing protocols carrying TCP traffic.

IV. RELATED WORK

A detail performance comparison study of the two types of reactive protocols i.e DSR and AODV is done in **[3]** and the simulator used is Network simulator NS2**,** and the results that are derived from NS2 shows that the routing protocol AODV performs better than the routing protocol DSR. Another comparison was done in **[4],** and the results show that the performance of both the reactive protocols AODV and DSR is good in the scenario when medium network load is used in the simulation and OLSR performance is much better than DSR and AODV when the network load used in the simulation is heavy.
In **[1]** a network simulator Glomosim is used to check the performance evaluation the two reactive routing protocols i.e. AODV and DSR, the results showed that when the sources used in the simulation were sending the data to the different destination AODV performance was better than DSR, but when the sources used in the simulation were sending the data to a destination which is a common destination AODV performance was not good as earlier when sending the data to different destinations.

V. AN OVERVIEW OF MOBILE ADHOC NETWORKS (MANETS)

In Adhoc networks there is no fixed infrastructure, that's why adhoc networks are more popular in disaster situation like earth quakes, floods etc because it needs less time to configure and implement. The adhoc network in which mobile nodes are used is referred to as a Mobile Adhoc network. In MANETs we have limited bandwidth and node mobility, so there is need to consider an important feature of the nodes i.e. energy efficiency, changes in topology, bandwidth limitation and unreliable communication in the design.
The mobile nodes in MANETs has dual functionality (routers and host) i.e the mobile nodes have the ability to accept the traffic coming to it and send that traffic from its neighbours to the destination. The self configuration of network becomes more and more pronounced as the network grows with mobility of the nodes.
One most important aspect of the routing protocol is that the protocol should be an energy efficient protocol. The energy efficiency of the protocol is measured by the amount of battery consumption of the node which participates and routing traffic into the network. Here are the few examples of the routing protocols i.e AODV, DSR, OLSR, TORA, WRP, ZRP, IGRP and EIGRP.

VI. APPLICATIONS OF MANETS

MANETs have wide range of application e.g

- Natural disasters
- Group communication in conferences
- Airport hotspots
- Enterprise deployment
  When a natural disaster occurs a radio e.g Wimax link is established to one area and the MANETs network is established in the area which is affected due to the natural disaster, now MANETs network will be connected with established radio link network and will provide coverage to the affected area, and communication will be provided in such situation. Following figure will best explain this scenario.

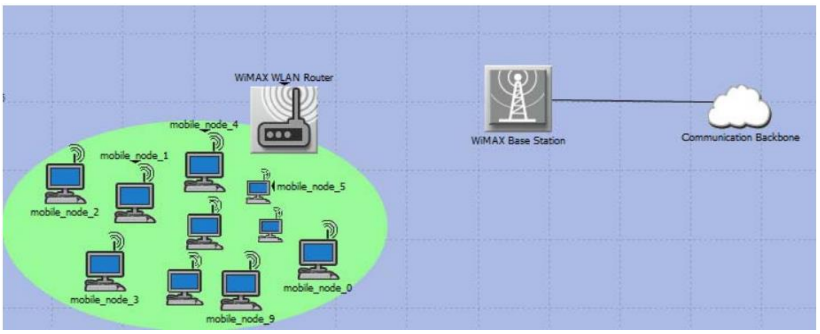

Fig 2 Deployment of MANETs over WiMax

VII. ROUTING PROTOCOLS IN MANETS

Flat routing protocol is discussed in this paper. Flat routing protocol is divided into two main categories.

- Proactive Routing Protocols
- Reactive Routing Protocols

7.1 Proactive Routing Protocols

One of the main features of the Proactive Routing Protocols is that it builds and maintains the information (routing information) to all the nodes in a network whether the route is needed for the sending of traffic or not **[8].** Proactive routing protocols continuously send control messages, even when there is not flow of data that's why proactive routing protocols are not bandwidth efficient routing protocols in Mobile Adhoc Networks (MANETs). These protocols have advantages and disadvantages as well. The main advantage of such type of protocol is that the node can easily get the routing information and a session can easily be established. The disadvantages are that it is not a bandwidth efficient routing protocol; even it will send control messages when there is no flow of data. The other disadvantage can be that for maintenance the nodes will keep too much of data and also restructure process is very slow if failure occurs in any link. In this literature review we have taken **OLSR** as the example of Proactive routing protocols.

7.1.1 Optimized link state routing Protocol (OLSR)

In this research paper we discuss proactive routing protocol used in Mobile Adhoc Networks, and the proactive routing protocol which we have chosen for our study in this research paper is OLSR. OSLR is also used in WiMax Mesh (Backhaul). For the discovery of its neighbour the mobile nodes used in the network uses topology information that are derived from Topology control (TC) messages and Hello Packets.

In OSLR Routing Protocol all the nodes do not broadcast packets but only those nodes broadcast packets which are multipoint Relay (MPR) nodes.

In OSLR routing protocol the routing table is kept by each and every node present in the network. Because of this reason OLSR has higher routing overhead when compared with the other two routing protocols which are considered under the study in this research paper i.e AODV and DSR. With the number of routes the routing overhead does not increase because the new routes are not established when it is needed and due to this that the route discovery delay is minimized.

7.2Reactive Routing Protocols

The type of routing protocols which very efficiently uses the bandwidth of a network is the reactive routing protocols. In a given a signal bandwidth can be defined as the difference of maximum frequency component present in that signal to the minimum frequency component present in that signal. Mathematically we can write. $\mathbf{B.W=f_{max} - f_{min}}$

7.2.1Adhoc on demand distance Vector (AODV)

A type reactive protocol used in MANETs, we have discussed in this research paper is AODV (Adhoc on demand distance vector). A smooth adaptation to the changes in the link condition is facilitated by this algorithm. If a node fails then the notification of the failure is sent to the affected nodes.

AODV form trees which connects multicast group members. AODV is self starting, loop free and also AODV is scalable to large number of mobile nodes.
The messages defined by AODV routing protocol are

- (RREQs) (Route Requests)
- RREPs (Route Replies)
- RRERs Route Errors

These messages are received through a user datagram protocol (UDP) and normal IP header. The request node will use the IP address as the originator IP address of the messages. The IP limited address i.e (255.255.255.255) is used for broadcast messages.

7.2.2Dynamic Source Routing Protocol (DSR)

The second type of reactive routing protocol used in Mobile Adhoc Networks which we have discussed in this research paper is Dynamic source routing Protocol (DSR). Just like AODV it is also on demand routing protocol but the routing protocol DSR unlike AODV is not a table driven routing protocol. The routing protocol DSR is based on source routing. If any node in a network wants to send some traffic, route for that packet is specified. The sender is going to set the whole information of the path for the packets that are traversing from source to the destination **[1]**.
The routing in DSR is different from the routing in AODV and OLSR which is table driven routing protocols (the way the routing decisions are made). In this type of routing source node makes the routing decisions.
When discovering the routes the source nodes collect the information of all intermediate nodes between intended destination and itself **[4]**. The path information will be cached by all the nodes from a source which are involved in the path finding information process. Hop by hop forwarding of packets in DSR is facilitated by flow ID. The following figures will best explain the route discovery in Wireless adhoc network using DSR.

VIII. RANDOM WAYPOINT MOBILITY MODEL

Mobility models are used for the simulation of network i.e for the evaluation of network protocols. In this paper report we have used random waypoint mobility model to check the performance evaluation of the routing protocols in Mobile adhoc network. In this paper we have checked the performance evaluation of the reactive and proactive routing protocols i.e AODV, DSR and OSLR under different scenarios. Johnson and Maltz proposed the random waypoint mobility model. This model is very popular and also easy to implement and also called the "benchmark" mobility model used in MANETs.
In this mobility model all the mobile nodes randomly move without any restriction. In other words we can say that the destination direction and speed of all mobile nodes are chosen randomly and independent of other nodes. The two flavours of this model are.

- Random Walk Model
- Random Direction Model

IX. SIMULATION SETUP

In this research paper we have used Opnet Modeler 14.5 for our simulation and the background compiler used is Microsoft Visual C++. We have used FTP high load for our simulation study. Following table shows the detail of our simulation.

Table1 Simulation Categories

Category	No. of nodes	Speed (m/s)
1	5	10
2	5	28
3	20	10
4	20	28
5	50	10
6	50	28

X. NUMBER OF TRAFFIC SOURCE AND EFFECTS OF MOBILITY ON DSR

In **fig3** we observe that with the number of nodes 5 and 20 the mobility effect is not there on the routing traffic, but in the network which is made up of 50 nodes and the mobility speed of 28 m/s we see the consistent routing overhead, but with the mobility speed of 10 m/s the routing overhead is initially slow but it increases as the simulation progresses.

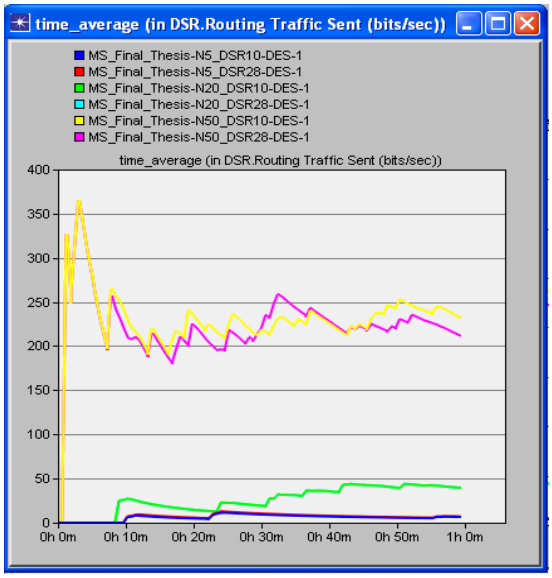

Fig3 Routing Overhead in DSR

XI. NUMBER OF TRAFFIC SOURCE AND EFFECTS OF MOBILITY ON AODV

In **fig4** we observe that the network having number of mobile nodes equal to 5 and 20 the amount of routing traffic is not affected by the mobility, but in the network which is made up of 50 nodes and with mobile node speed of 10 m/s the routing overhead is consistent, but when the mobility speed is increased to 28 m/s the routing overhead is low in the beginning of the simulation and the routing overhead increases with the progress of the simulation. When the speed is low the changes which is due to the node pause and restart can be adjusted by the routing protocols, but at the high speed the routing protocols take some time to adjust themselves and then send the routing traffic. As in case of DSR there is frequent link failure at high mobility and AODV react more frequently.

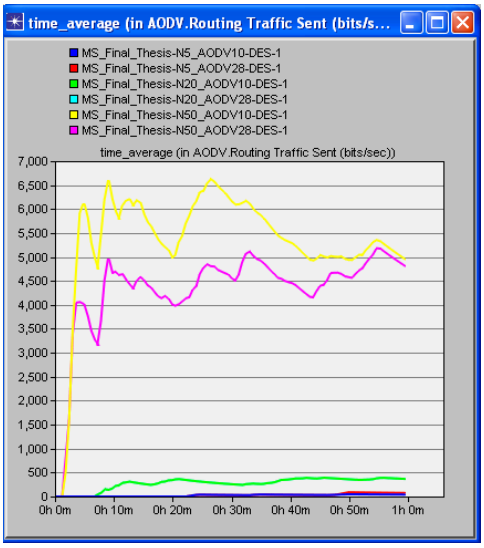

Fig4 Routing Overhead in AODV

XII. NUMBER OF TRAFFIC SOURCE AND EFFECTS OF MOBILITY ON OLSR

Fig5 shows the simulation results of OLSR for the different number of nodes. We observe that the amount of routing traffic is not affected if we increase mobility. As OLSR is a proactive routing protocol therefore it maintains consistent paths due to which the routing overhead is consistent. The routing traffic increases if we increase the number of mobile nodes in a network.

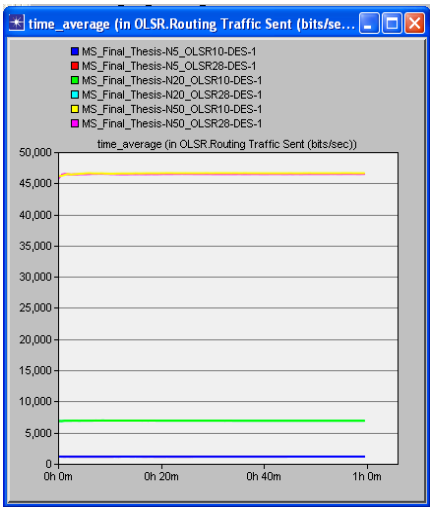

Fig5 Routing Overhead in OLSR

XIII. PACKETS END TO END DELAY

Fig6 to **fig8** shows the end to end delay of packets of all the protocols. We observe that for all the scenarios considered OSLR routing protocol has lowest delay. OLSR is being proactive in nature which means that whenever the application layer wants to send the traffic routes in the network are always ready. If we have a network in which there are more number of nodes the there is a great competition between the performance of OLSR and AODV. But the scenarios considered in this research paper shows that OSLR being proactive in nature has consistent end to end delay.

AODV has very less amount of end to end delay and its number is second after OLSR which has least amount of delay. AODV performs much better the number of mobile nodes in a network is increased. The amount of end to end delay is reduced in routing protocol AODV because of hop by hop initiation in AODV.

We observe that DSR shows consistent performance in term of end to end delay both at low and high mobility speed in the network which is made up of five and twenty mobile nodes, but end to end delay increases in case we have number of mobile nodes equal to 50 both at low and high speed. Retransmission in DSR is the big cause of excessive delay.

To conclude our discussion we observe that OSLR when compared with the other protocols considered under the study has less end to end delay. AODV has less end to end delay when compared with DSR and in the last we observe that DSR had consistent end to end delay for a network having less number of nodes but when the size of the network increases end to end delay is increased in DSR.

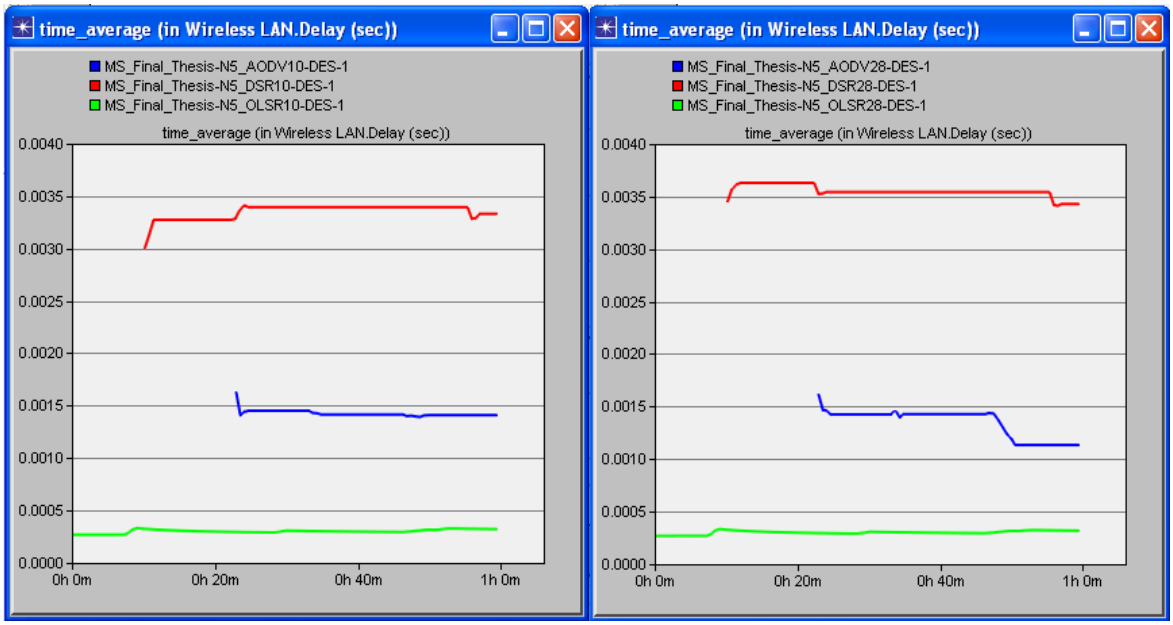

Fig6 Packets End to End Delay of 5 nodes at 10m/s and 28m/s

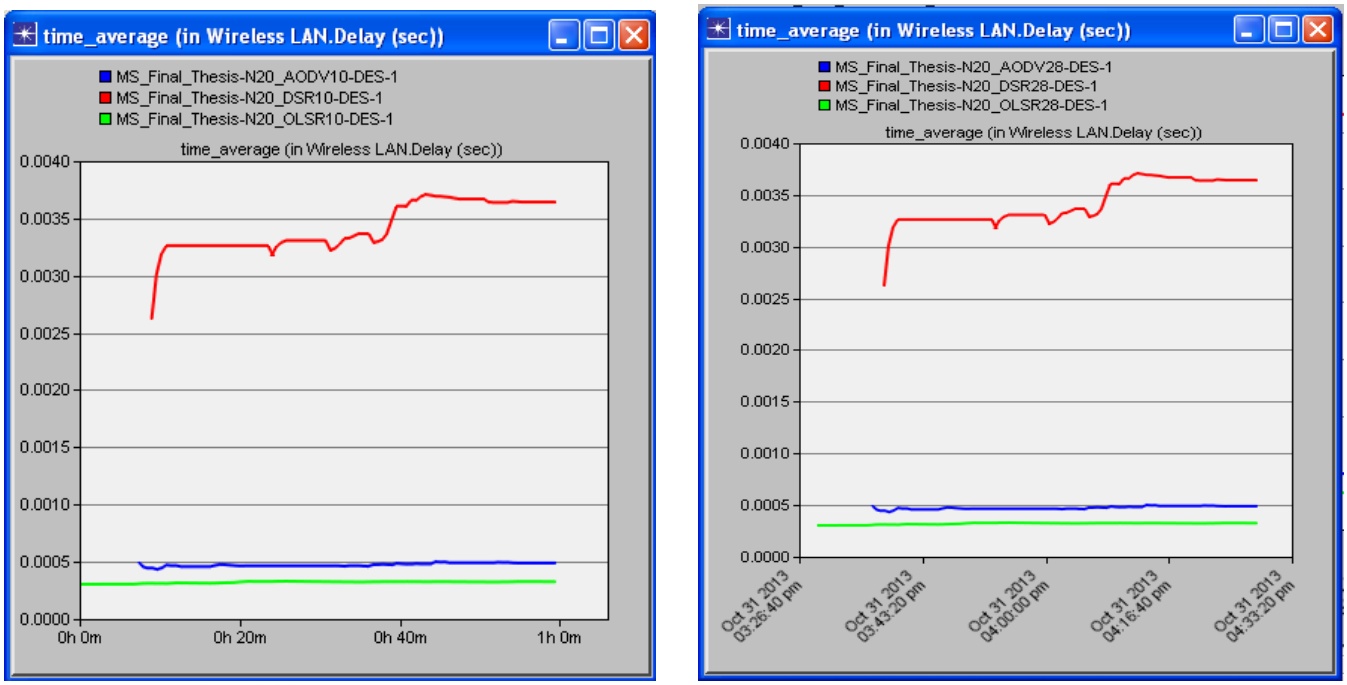

Fig7 Packets End to End Delay of 20 nodes at 10m/s and 28m/s

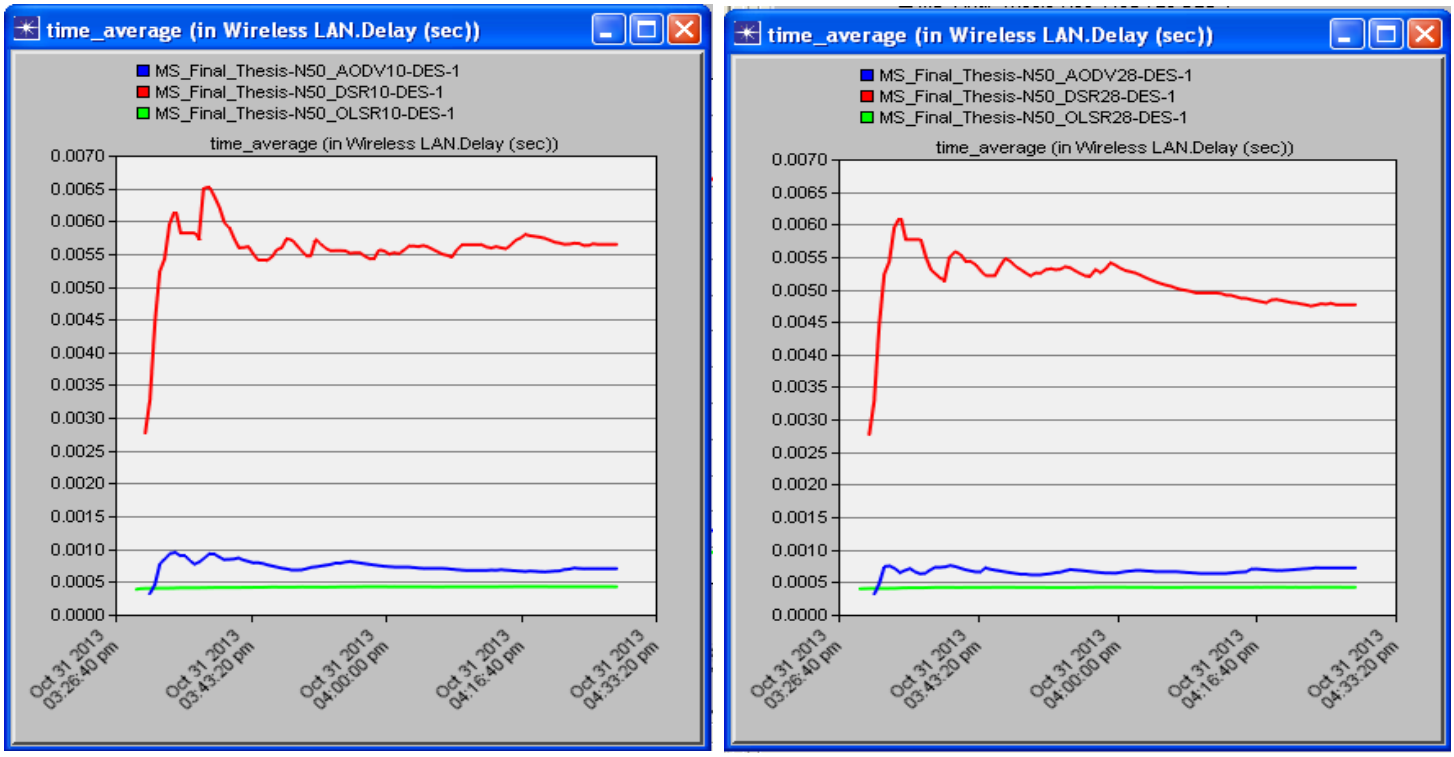

Fig8 Packets End to End Delay of 50 nodes at 10m/s and 28m/s

XIV. THROUGHPUT

Fig9 to **Fig11** shows throughput of all the protocols considered under the study. We observe that the performance of the proactive routing protocol OLSR is much better than all other protocols considered under the study. OSLR being proactive in nature, so all the times routing paths are available for the traffic. OSLR consistently maintains the routing paths in the network which cause least amount of delay. Throughput is the ratio of the total amount of data received at the receiver from sender to the time it takes to receive the last packet from the sender. So less delay in the network means high throughput.

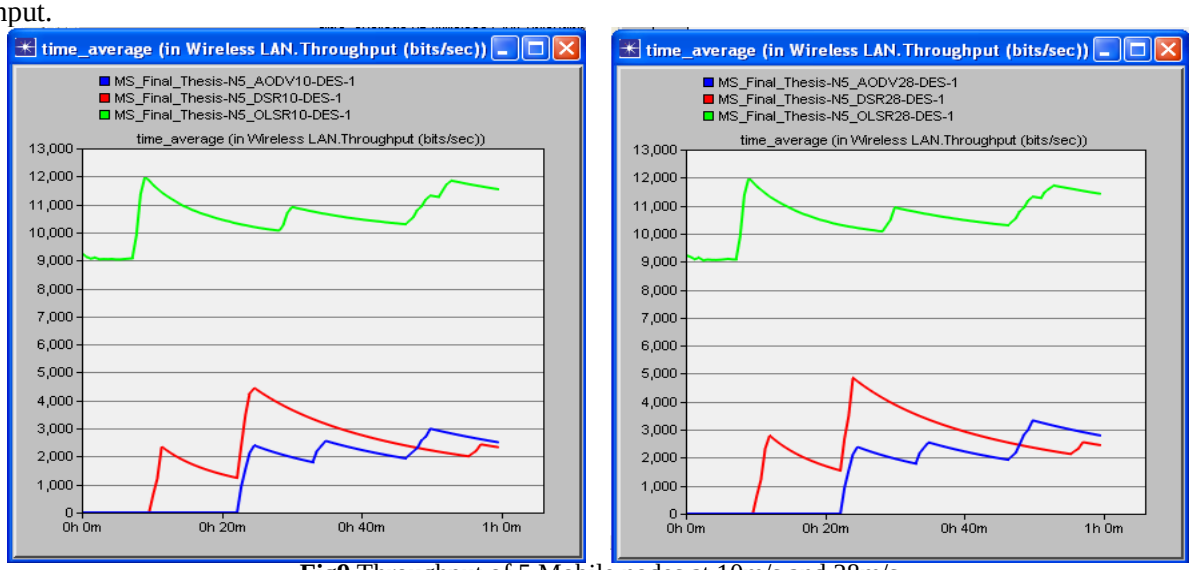

Fig9 Throughput of 5 Mobile nodes at 10m/s and 28m/s

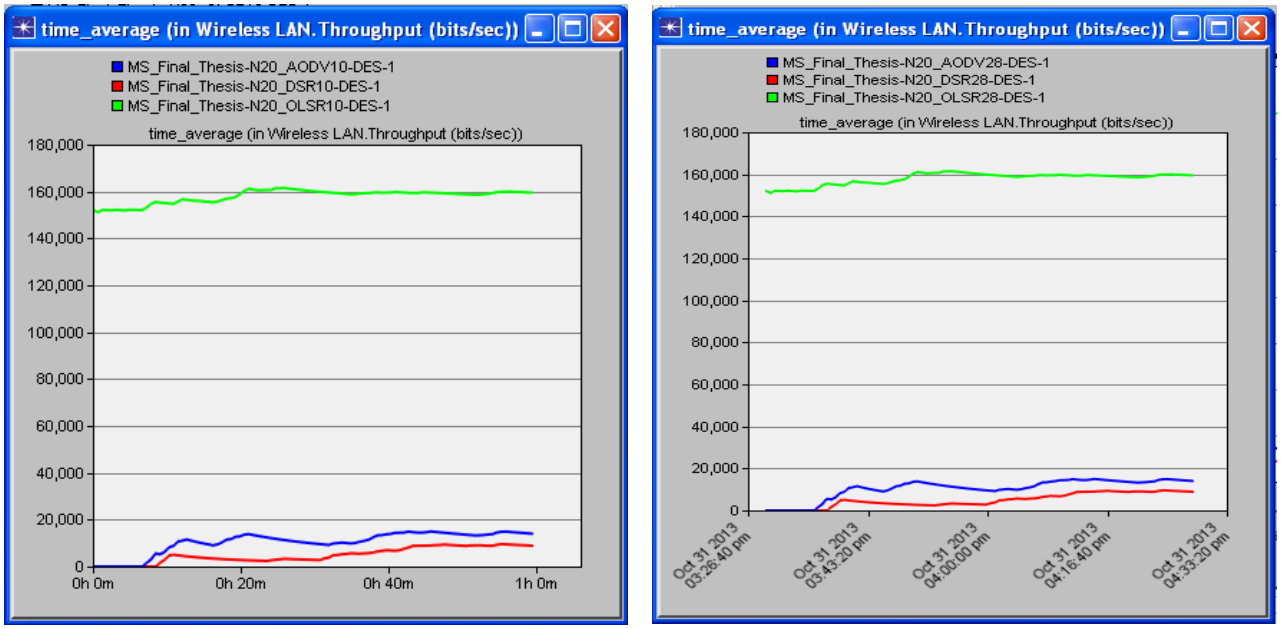

Fig10 Throughput of 20 Mobile nodes at 10m/s and 28m/s

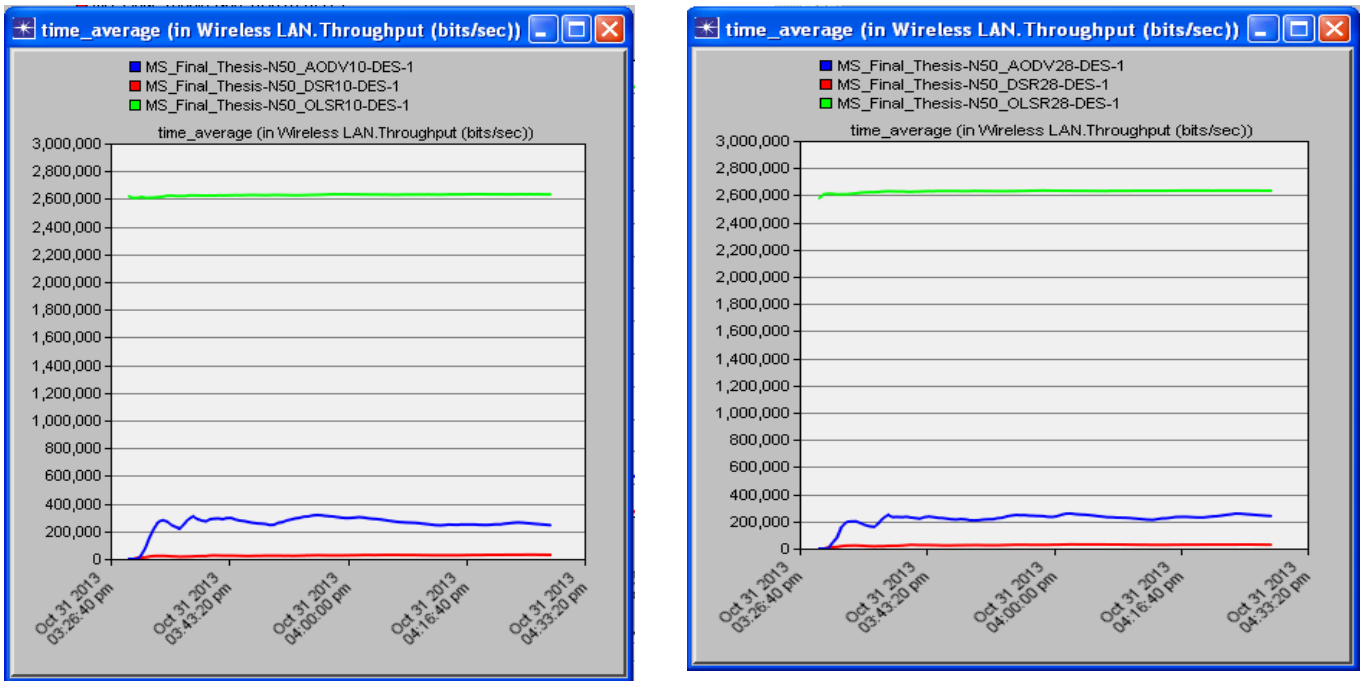

Fig 11 Throughput of 50 Mobile nodes at 10m/s and 28m/s

In the network having five mobile nodes DSR performs better as compared to AODV. This is because routing overhead is least in case of DSR. As the network is small so the hidden node terminal problem, link failure, and network congestion do not come into the consideration. When the network size increases hidden terminal problem, network congestion and network degradation comes into the account. Because of these problems the reaction of the routing protocols is different for the different conditions and delay has major role in measuring the throughput of the network. From the above we observe that the routing protocol DSR does not perform well in the network which is made up of 20 and 50 mobile nodes. But in smaller network DSR performs better than AODV both at low and high speed. But in large network AODV performs better than DSR.

It is concluded from the above discussion that OSLR outperform the other protocols considered under the study.

XV. CONCLUSION

After a details study of all the protocols we have come to know that OLSR outperforms both AODV and DSR in all scenarios including high network load and low mobility but the routing protocol OLSR is not good in term of routing overhead, therefore for high capacity network OLSR is a best routing protocol. As OSLR discovers and maintains routes that's why it is not a good choice for low capacity network. Now talking about DSR, the DSR routing protocol outperforms OSLR in term of routing overhead, but in all other aspects it is outperformed by OLSR, that is the reason OLSR is preferred over DSR.

AODV outperforms both OLSR and DSR in a network having both low and medium load and also at low mobile node speed. AODV also performs better that OLSR and DSR at high mobile node speed with medium and heavy network loads.

After the detail study of all the three routing protocols we have concluded that there in no single routing protocol which is superior among the others. The performance of one protocol may be better than the other in term of routing overhead but that protocol may not be better in term of other performance metrics which are considered under the study in this research thesis, like throughput, packet delivery ratio, and end to end delay of the packets. The selection of the correct routing protocol mainly depends upon the scenario you are working with. Generally we can say that reactive routing protocol performs better in low capacity network while proactive routing protocols performs better in high capacity network.

XVI. FUTURE WORK

Future work in this research paper can be to study the performance evaluation of those protocols that are designed for mobile WiMax in IEEE 802.16 standards. Mobility in WiMax is a feature which was developed as an addition to IEEE 802.16 standard for WiMax. Therefore we must provide all the information to those research scholars who are working in this area and also to the companies that manufacture hardware and also tell them about the advantages and disadvantages of existing standards in this area. We have discussed and analyzed in this research paper that the performance of the routing protocols in MANETs (Mobile Adhoc Networks) is not affected by changing the mobile node speed. By comparing the performance analysis of the routing protocols in Mobile WiMax and in MANETs it can be concluded that how the issue of mobility has been addressed by WiMax.

The other advancement in this research paper can be to develop such algorithms which will address the limitations of the adhoc routing protocols which also came across during this research paper. For example the routing protocol OSLR is better as compared to the other routing protocols discussed in this research paper in many aspects such as end to end delay of the packets but its major problem is that of flooding the network for with the routing traffic due to it proactive nature. It outperforms all the routing protocols discussed in this research paper only in high capacity network but it is outperformed by DSR and AODV in low capacity networks. A new algorithm if developed will try to remove these discrepancies.

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