International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622
National Conference on Advances in Engineering and Technology
(AET- 29th March 2014)

RESEARCH ARTICLE OPEN ACCESS

Performance Analysis of OLSR and QoS Constraint OLSR in MANET

Mohit Gambhir*, Sapna Gambhir**
*Research Scholar, JamiaMilliaIslamia, Delhi
**Associate Professor, YMCA University of Science & Technology,Faridabad
sapnagambhir@gmail.com

ABSTRACT
Recent developments in the field of wireless networks lead to the development of short-lived networks known as Mobile Ad hoc Networks (MANET). The Routing protocols in MANET are classified into three categories viz. table driven, on-demand and hybrid protocols. OLSR is one example of table driven routing protocol, which is best suited for dense networks which aims at reducing routing overhead. It uses link state routing as its basis and minimum hop count as a metric to find shortest paths. But in dense networks, there may exists number of different paths to reach a destination with different cost metrics therefore some quality of service (QoS) constraints can help to choose better route to a destination. QoS guarantee is very much essential for successful communication of nodes in the network. The different QoS metrics includes throughput, packet loss, jitter, delay, error rate etc. Basic OLSR protocol has certain drawbacks like number of retransmissions, route instability, packet losses, delay etc. In basic OLSR and Qos constraint OLSR, the metric used for calculating shortest path is different. In OLSR, QoS constraint is hop count where as in OLSR-ETX, its expected transmission count which is sum of inverse of probability of successful transmission. In OLSR-ML, QoS constraint is the product of probability of successful Transmission along the path by calculating packet delivery ratios and in OLSR-MD, metric used for QoS consideration is delay. In this paper, OLSR and its Qos Constraint (OLSR-MD, OLSR-ML, OLSR-ETX) are analyzed in terms of various parameters viz. Throughput, Normalized Routing Load, End-to-end delay. These parameters have been simulated on NS-2 simulator and compared by varying the simulation time.
Keywords:Mobile Ad hoc Network (MANET), Optimized Link State Protocol (OLSR), *QoS Constraint OLSR-ETX, OLSR-ML, OLSR-MD*

I. INTRODUCTION

A MANET [1] is an autonomous system of mobile routers connected by wireless links. The union of which forms an arbitrary graph. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. The main characteristics [2] of MANET includes dynamic topology, bandwidth constraints and variable link capacity, self-configuring, energy constrained nodes, limited security, multi-hop communications. To reduce the number of reactions to topological changes and to control congestion, multiple routes could be used. If one route is invalid, then other stored route is active for communication and thus saving the routing protocol from initiating another route discovery procedure. Therefore, a good routing protocol is needed.

Routing protocols of MANET can be categorized [3] into three categories as Table Driven Routing Protocols, Source Initiated On-Demand Routing Protocols and Hybrid Routing Protocols. Table Driven routing protocols attempt to maintain consistent, up-to-date routing information between every pair of nodes in the network by propagating route updates after fixed time intervals. In On-Demand routing protocols, every node needs to maintain a route to every node at all other times. The benefit of this approach is that signaling overhead is likely to be reduced. Third category is hybrid protocol seeks to combine the first two approaches.

Optimized Link State Protocol (OLSR) is a table driven routing protocol, so the routes are always immediately available when needed. OLSR is an optimization version of a pure link state protocol. So the topological changes cause the flooding of the topological information to all available hosts in the network.

The objective of this paper is to select OLSR protocol with different Quality of Service constraint when

MANET has to be created for the small duration. In this paper, comparative analysis between the standard OLSR protocol and QOS constraint OLSR protocols has to be carried out in the simulated environment created in the NS-2 simulator. The parameters taken for consideration during comparative analysis are throughput, normalized routing load and end-to-end delay.

Organisation of the paper is as follows: section I discusses about the basics and working of OLSR; section II explains various QoS constraints of OLSR; section III explains various simulation scenarios of OLSR and its QoS constraint protocols along with analysis of results received from simulations; section IV concludes the paper.

II. OPTIMIZED LINK STATE ROUTING PROTOCOL

The Optimized Link State Routing (OLSR) protocol is based on Open Shortest Path First (OSPF) protocol [4]. The OLSR protocol can be conceptually divided into three different operations, namely neighbor sensing, distribution of signaling traffic and distribution of topological information [5]. Neighbor sensing in OLSR is accomplished by transmitting periodic hello messages that contain the generating node's address identifier, a list of neighboring nodes and the type of link it has with each neighbor (e.g.: symmetric or asymmetric). For the distribution of signaling traffic, OLSR adopts a flooding mechanism where every node forwards a flooded message that it has not forwarded previously. Finally, the distribution of topological information function is realized with use of periodic topology control messages that result in each node knowing the partial topology graph of the network which is then used for computation of optimal routes [6] [7]. To compute the optimal routes, it is necessary to find out network's link information through Link State Routing.

2.1 Working of OLSR

OLSR [8] is independent of the underlying link layer. Each node sends periodic HELLO messages to discover neighbors. The neighborhood of a node A contains all those nodes which are directly linked to A. The links may be symmetric or asymmetric. OLSR also uses a concept called a two-hop neighbor. A node, C, is a two-hop neighbor of A if a node B is a symmetric neighbor of A and C is a symmetric neighbor of B, but C is not a neighbor of A. The HELLO packet contains the node's own address, a list of its neighbors and the status of the links of all its neighbors. These HELLO packets are used by the nodes to generate the immediate and two-hop neighborhood as well as to determine the quality of links in the neighborhood. This information is stored for a limited time in each node and needs to be refreshed periodically. Flooding HELLO packets across an arbitrarily-sized MANET is costly due to the presence of multiple duplicate retransmissions. In order to avoid this, OLSR uses the concept of Multipoint relay (MPR) flooding instead of full flooding. Each node uses its two-hop neighborhood information to select a minimal set of MPRs such that all the nodes in its two-hop neighborhood are reachable. Each node maintains a list of nodes, called the MPR selector set, for which it is an MPR. The node then retransmits only those messages received from nodes which have selected it as an MPR. The MPR flooding mechanism is also used to spread topology information throughout the MANET. All nodes with a non-empty MPR selector set periodically send out a Topology Control (TC) message. This message contains the address of the originating node and its MPR selector set. Thus, each node announces reachability to its MPR selectors. Since every node has an MPR selector set, effectively, the reachability to all the nodes is announced. Thus, each node receives a partial topology graph of the entire network.

There are various issues involved with each routing protocol that need to be resolved like route looping, congestion etc. Some kind of Quality of service can be guaranteed to optimize the routing procedure in MANET and to avoid such problems.

III. QOS CONSTRAINT OLSR

Constraints in Ad-hoc networks usually arise due to low computational and bandwidth capacity of nodes, mobility of intermediate nodes in an established path and absence of routing infrastructure. A routing protocol or a QoS [9] scheme for Ad-hoc networks should focus on these problems and is expected to be:

1) Distributed in nature
2) Computationally inexpensive
3) Efficient in reducing the route discovery and recovery time.

Minimum hop-count is the metric [9] most commonly used by existing ad-hoc routing protocols to calculate optimal routes, including the standard OLSR specification. Minimizing hop count is not enough in a wireless environment, because when the network is dense, there may be several routes with the same minimum hop count and very different link qualities. An arbitrary decision made by minimum hop-count algorithms may not select the best available route.

3.1 QoS Constraint OLSR-ETX

The QoS metric a link quality extension, called ETX (Expected Transmission Count) metric

[10]. This extension aims at finding paths with the lowest number of required transmissions to deliver a packet to its final destination. The ETX of a link is calculated using forward and reverse link delivery ratios. The delivery ratio is the probability that a data packet successfully arrives at the next hop. The expected probability that a transmission is successfully received and acknowledged is the product of the forward delivery ratio (df) and the reverse delivery ratio (dr) of a link. Thus, the expected number of transmissions is given by:

$$ETX=1/(d_f \times d_r)$$

The delivery ratios (d) are measured using modified OLSR HELLO packets sent every t seconds (e.g. t=2). Each node calculates the number of HELLOs received in a w second period e.g. (w=20) and divides it by the number of HELLOs that should have been received in the same period (10, by default). Each modified HELLO packet informs the number of HELLOs received by the neighbor during the last w seconds, in order to allow each neighbor to calculate the reverse delivery ratio. The worse the link quality is, the greater the ETX link value becomes. The ETX value is 1 for a perfect link that loses no packets. If no HELLO packet is received during w-second period, ETX is set to 0 and the link is not considered for routing. Otherwise, ETX is greater than 1.
In the case of a multi-hop path, the ETX value of the complete route is given by the sum of the ETX of each hop. OLSR selects the best route from one source to a specific destination as the one with smallest ETX value. Even though ETX is based on the success probability over a single link, it aims at minimizing the number of transmissions along a given path and not minimizing the loss probability along the path.

3.2 QoS Constraint OLSR-ML

An alternative way to calculate the link quality [11] of a given path in order to select the path with the minimum loss probability. In a multi-hop path, the probability of successful transmission over the complete path should be the product of the probabilities of each path. Thus, in a route from A to C, passing through B, the total probability of successful transmission is given by:

$$P_{AC}=P_{AB} \times P_{BC}$$

In this approach, a multi-hop path link quality value is given by the product (and not the sum) of each link quality. As we are using the probabilities P and not its inverse value (ETX), the best route from one source to a specific destination is the one with the highest probability (P) of successful transmission, i.e., the one with minimum loss probability.
One could argue that if all link qualities were 1 in a given network, then the probability of successful transmission over a multi-hop path between two nodes would be same as the probability over a direct link between them. This is true, but the regular OLSR implementation already has a solution for this scenario. When multiple routes with the same link quality are present, the one with the minimum number of hops is chosen. Thus the direct link would be chosen in that case.

3.3 QoS Constraint OLSR-MD

The main idea behind the Minimum delay is to measure the link delay between the nodes. Therefore, all calculations of routing tables are based upon each neighboring nodes. Therefore OLSR-MD [11] is the protocol with the route selection between the current node and the other nodes in the network which have the lowest sum of different transmission delays of all the links along the path proactive. It used the methodology of AdHoc Probe to obtain the one-way delay on each link. This information was used as a link metric for Optimized Link State Routing (OLSR). The OLSR Minimum Delay (OLSR-MD) was compared against OLSR with the standard hop count. This is simply due to the fact that the one-way delays which are the base for the MD routing metric are determined with small probe packets before setting up the routing topology and do not take traffic characteristics into account. If no other traffic is present in the network, the probes sent on a link experience a very small delay, but larger data packets sent on this link may experience higher delay or retransmission due to congestion. OLSR-MD is an interesting approach of routing with delay assurance.

IV. SIMULATION AND ANALYSIS

OLSR and Quality of service constraint OLSR (with minimum loss (ML), delay (MD) and expected transmission count (ETX)) protocols, when mobile Ad-hoc network has to be created for the small duration, are considered for simulation. The whole scenario comprises of 10 mobile nodes using OLSR and QoS constraint OLSR protocol is simulated in NS-2 simulator with the assumption that all mobile nodes receives packet as well as forward them to all neighboring nodes without filtering them on the basis of destination address. The needed parameters to carry out the simulation and their corresponding values for protocols are specified below in Table 1.

Table 1: Simulation Parameters

Parameter	Value
Number of nodes	10
Topography Dimensions	1000m X1000m
Traffic type	CBR
Radio Propagation model	Two-Ray Ground model
MAC type	802.11Mac Layer
Packet size	210 bytes
Mobility model	Random Waypoint
Antenna type	Omni directional

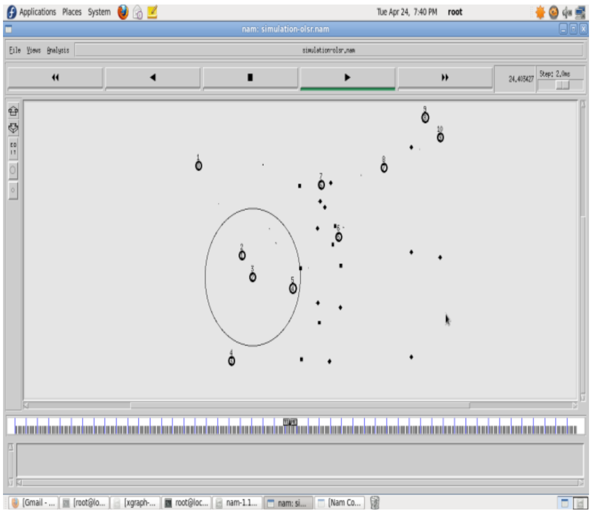

Fig 1: Flow of traffic between the nodes

All the above parameters in the table remain same for OLSR and QoS constraint OLSR protocols. Simulation time is varied and the behavior of protocols is examined by studying the X graph based on following three parameters Average End-to-End Delay, Throughput, Normalized Routing Load (NRL).The traffic flow in terms of exchange of packets between the nodes is read from the script file. Fig 1 represent that after simulation has started the mobile nodes are sensing its neighbors with the help of HELLO messages and TC messages.

4.1 X graph Evaluation of End-to- End Delay

Fig 2 shows the X graph of OLSR protocol when the simulation is carried out for 50 seconds the end-to-end delay is initially zero at the time of start because initially there is no CBR connection. As the CBR connections establish the number of data packets is sent and end-to-end delay is observed.

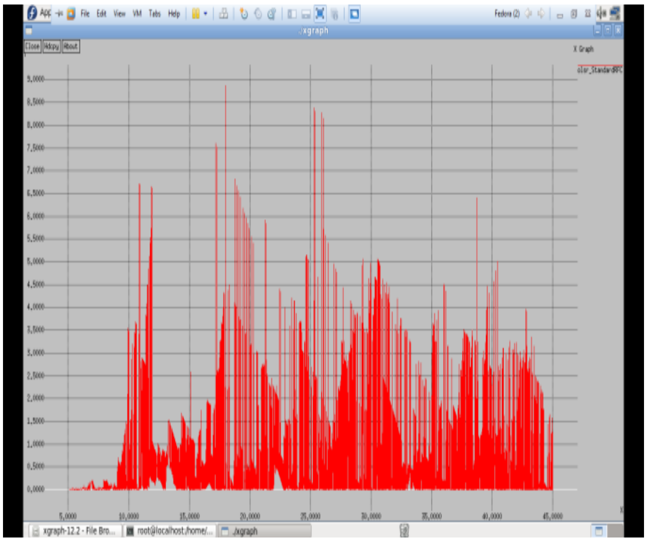

Fig 2: X graph of End-to end delay Vs Simulation time for OLSR protocol

But as the simulation time increases substantially the end-to-end delay increases because of traffic flow exchange. As it can be observed in from the graph that end-to-end delay is changing very frequently because different packets follow different path to reach destination so end-to-end delay is varied at each instant. Fig 3 shows the simulation for 50 seconds simulation time when QoS was applied. The QoS constraint here is transmission link Quality. It can be depicted from the graph that end-to-end delay in OLSR-ETX is very high at most of the points during the network simulation.

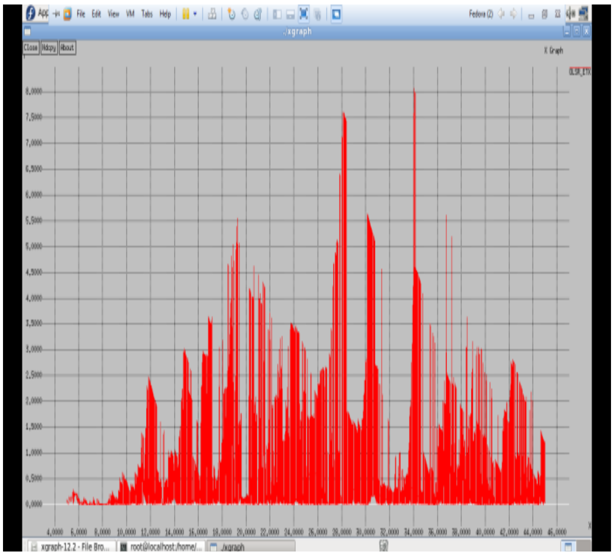

Fig 3: X graph End-to end delay Vs Simulation time for QoS OLSR-ETX

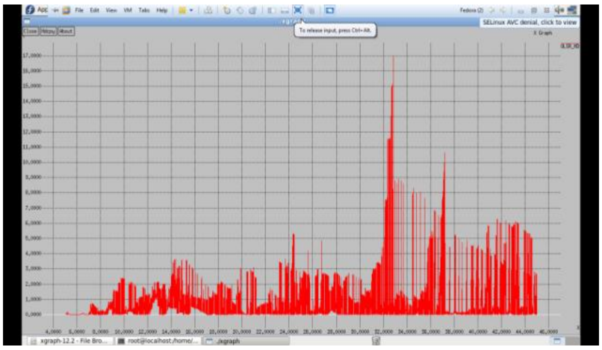

Fig 4: X graph End-to end delay Vs Simulation time for QoS OLSR-MD

Fig 4 shows the end-to-end delay for OLSR protocols when QoS constraint of minimum delay is applied during optimal route selection. The end-to-end delay value is less at most of the instances. This is so because minimum delay metric constrained is applied.

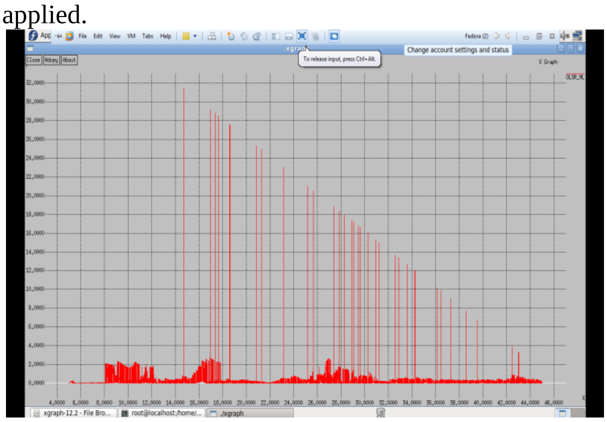

Fig 5: X graph End-to end delay Vs Simulation time for QoS OLSR-ML

Fig 5 shows the end-to-end delay for OLSR protocol when QoS constraint of minimum loss is applied during MPR selection instead of general MPR selection algorithm.

It can be observer that OLSR-MD shows the minimum delay because in OLSR-MD route selection is based on delay of Ad-hoc probes. OLSR-ETX and OLSR-ML are producing large values of delay when traffic increases. MD. Firstly, In order to select paths with lower packet loss rates, OLSR-ML usually selects paths with a larger number of hops compared to OLSR-ETX. This increase in hop count could result in longer delays. Secondly, OLSR-ETX uses the same mechanism to measure the link quality as that of OLSR-ML, i.e., modified HELLO messages. But summing up the individual probabilities and preference of the shortest path reduces the delay of ETX as compared to ML.

4.2 X graph Evaluation of Normalized Routing Load (NRL)

The NRL is the load offered on the protocol under the given scenarios the number of routing packets transmitted per data packet delivered at the destination. This metric gives an idea of the extra bandwidth consumed by overhead to deliver data packet.

NRL = ((cp_sent + cp_forw) / data_agt_rec)*100;

cp_sent = rreq + rrep + rerr;

Terms used in NRL are shown in Table 2.

Table 2: Terms used in NRL

Abbreviations	Description
cp_sent	Control Packets Sent
Cp_forw	Control Packet Forwarded
Data_agt_rec	Data Packet Receieved
Rreq	Route request

Fig 6 shows the normalized routing load for OLSR protocol. Initially NRL value is zero and as the simulation time increases its value also increases because more and more packets are exchanged between the nodes. At an instance during simulation it reaches its peak when all the routing tables are maintained with latest updates with maximum NRL value and then after updating the control overhead decrease therefore NRL value.

Fig 7 shows the Normalized routing load for OLSR and QoS OLSR-ETX. As it can be depicted from the graphs obtained that Value of NRL in OLSR protocol is high as compared to QoS OLSR-ETX. The NRL value increases as the simulation time increases as the packets starts exchanging between the nodes reaches its peak value, peak value here signifies that that all the nodes are done with hello messages and topology control messages in order to attain the whole network topology information. After that this again tends to decrease.

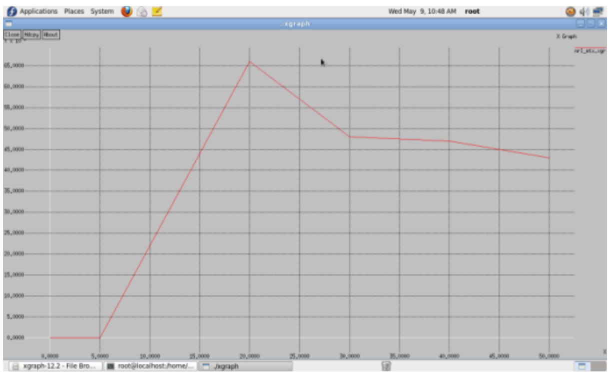

Fig 6: X graph showing NRL for OLSR

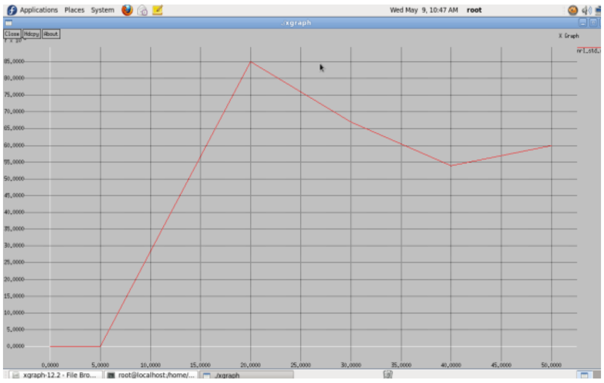

Fig 7: X graph showing NRL for QoS OLSR-ETX

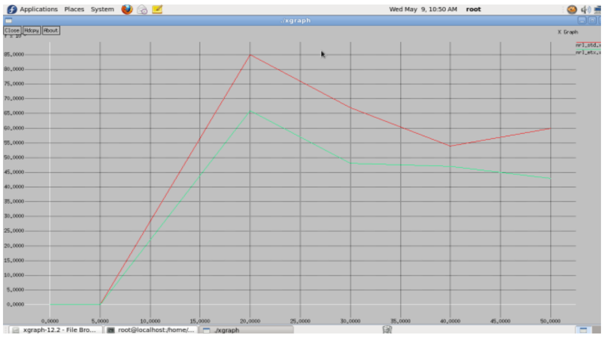

Fig 8: Comparison of OLSR and QoS OLSR-ETX in terms of NRL

Fig 8 shows the comparison between the QoS OLSR-MD and ML. It can be observed that OLSR-MD suffered from high network load as compared to OLSR-ML. As, ad-hoc probes are used to measure the metric values and are sent periodically along with TC and HELLO messages. On the other hand, OLSR ETX and OLSR-ML calculate the probabilities for the metric from the values obtained from the enhanced HELLO messages.

From the results it can be depicted that OLSR-ETX has the lowest NRL value followed by OLSR-ML and finally OLSR-MD. Hence, OLSR-ETX performs well as compared to others. OLSR-MD suffered from the highest routing loads. As, ad-hoc probes are used to measure the metric values and are sent periodically along with TC and HELLO messages. On the other hand, OLSR-ETX and OLSR-ML calculate the probabilities for the metric from the values obtained from the enhanced HELLO messages.

4.3 X graph Evaluation of Average Throughput

Network Throughput refers to the volume of data that can flow through a network. Network Throughput is constrained by factors such as the network protocols used, the capabilities of routers and switches. Throughput or network throughput is the average rate of successful message delivery over a communication channel. This data may be delivered over a physical or logical link, or pass through a certain network node. The throughput is usually measured in bits per second (bit/s or bps).

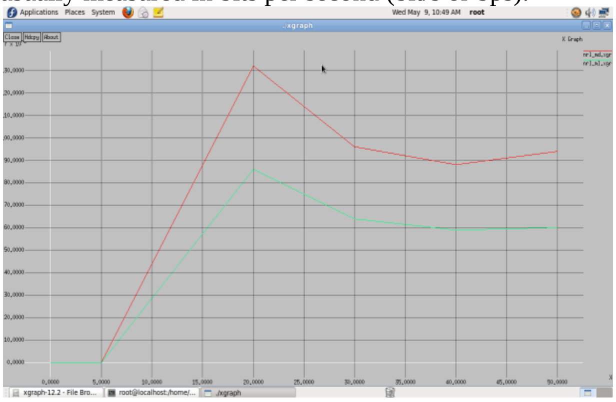

Fig 9: Comparison of QoS OLSR-MD and ML in terms of NRL

Fig 9 shows the average Throughput when the network was simulated for 50 seconds for OLSR and OLSR-ETX. It can be analysed from the above graph that average Throughput for general OLSR protocol comes out to be less as compared to QoS Constraint OLSR-ETX. From the above X graph it can be observed that maximum throughput is achieved by minimizing the number of transmissions per packet over the shared medium, and they have demonstrated a two-fold improvement in throughput compared to the minimum hop-count metric used in basic OLSR.

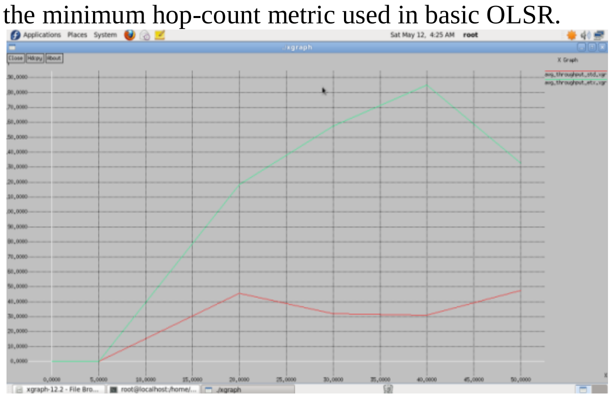

Fig 10: Average Throughput of OLSR and QoS OLSR-ETX

Fig 10 shows the average throughput when the network was simulated for 50 seconds for OLSR-MD and OLSR-ETX. It can be analyses from the above X graph that average Throughput for QoS OLSR-MD protocol comes out to be less as compared to QoS Constraint OLSR-ETX. Because adhoc probes cause routing overhead in a network and decrease the Throughput when data load is high in a static network which is used by OLSR-MD.

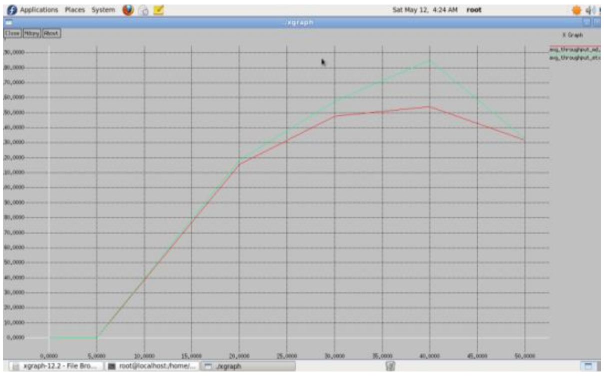

Fig 11: Average Throughput of QoS OLSR-ETX and MD

Fig 11 shows the comparison between average Throughput between QoS OLSR-ETX and MD. It can be analyses from the X graph average Throughput of QoS constraint OLSR-ML is better than ETX.OLSR-ETX uses the same mechanism to measure the link quality as that of OLSR-ML, i.e., modified HELLO messages. But summing up the individual probabilities and preference of the shortest path reduces the delay of ETX as compared to ML. Thus, a slow link preference results more drop rates of OLSR-ETX as compared to OLSR-ML.OLSR-ETX may choose a route in which the PLR is so high that degrades network Throughput, causing it to miss its main target, namely, minimizing retransmissions. It can be analyses that paths with minimum loss rates (or higher probabilities of successful transmissions) also lead to high Throughput, with the added benefit of more stable routes and lower packet loss rates.

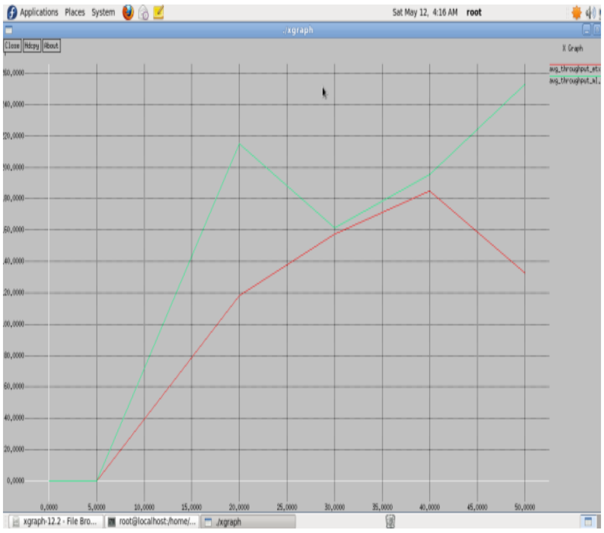

Fig 12: Average Throughput of QoS OLSR-ETX and ML

Fig 12 shows the comparison of average Throughput of all the protocols with and without QoS constraint. It can be analyses from the above graph that OLSR without QoS has the lowest average Throughput and OLSR-ML with QoS constraints gives better average Throughput as compared to other protocols. The Performance comparison of OLSR and its QoS constraint is summarized in Table 3.

Table 3: Comparison Table for OLSR and its QoS Constraints

Protocol	Metric Used To compute shortest path	Throughput	End-to-End delay	Normalized routing load
OLSR	Hop count	Minimum	Maximum	
OLSR-ETX	Transmission count			Minimum
OLSR-ML	Delivery ratio	Maximum		
OLSR-MD	Delay		Minimum	Maximum

V. CONCLUSION

After comparative analysis of results OLSR and its QoS Constraint in terms of average throughput, normalized routing load and End-to-end delay, it is concluded that OLSR with Qos constraint performed well under all circumstances as compared to basic OLSR protocol. OSLR-ETX and OLSR-MD with Qos constraints showed less end-to-end delay overall out of four protocols. Average throughput of OLSR-ETX and OLSR-ML with Qos constraint was recorded far better than original OLSR. Normalized routing load of OLSR-MD was maximum as compared to other protocols and OLSR-ETX has the minimum NRL value.

REFERENCES

[1] Joseph Macker and Scott Corson, "Mobile ad hoc networks (MANET)", *ACM SIGMOBILE Mobile Computing and Communications Review, 3(1), 1999, 11-13.*

[2] J. Mackar and S. Corson, "Mobile Ad hoc Networking (MANET): Routing Protocol Performance Issues and Evaluation Considerations", *IETF, RFC 2501, 4(8), 1999, 54-61.*

[3] Dimitri Butsekas & Robert Gallager, "Data Networks", *2nd edition Prentice Hall, New Jersy, 1997.*

[4] J. Moy, "Open Shortest Path First (OSPF) Version 2," *RFC 2328, 1998.*

[5] T. Clausen, G. Hansen, L. Christensen, and G. Behrmann, "The Optimized Link State Routing Protocol", *Proceeding of 4th International Symposium Wireless Personal Multimedia Comm. Aalborg, Denmark, 2001, 1- 6.*

[6] Rai Tirthraj, Verma A K, "Survey and Analysis of Secure Routing Protocols for MANETs", *Proceeding of National Conference on cutting Edge Computer and electronics Technology, 2009, 501-506.*

[7] E.M Royer, C.K Toh, "A Review of Current Protocols for Ad Hoc Mobile Wireless Networks", *IEEE Personal Communications, 2(6), 2007, 46-55.*

[8] Aleksandr Huhtonen, "Comparing AODV and OLSR Routing Protocols", *HUT T-110.551 Seminar on Internetworking, 2004, 26-27*.

[9] Z. Wang and J. Crowcroft, "Quality of service routing for supporting multimedia applications", *IEEE Journal on Selected Areas in Communications, 1996, 1265–1275.*

[10] Douglas S. J.,De Couto Daniel, Aguayo John , Bicket Robert Morris, "A High Throughput Path Metric for MultiHop Wireless Routing", *Wireless Networks - Special issue: Selected papers from ACM MobiCom, 11(4), 2005 , 419 -434*.

[11] Waldir Aranha Moreira Junior, Fernando Joaquim Pereira, "A multiple metric approach for routing in Wireless Mesh Networks", *IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks & Workshops, 2009, 1-6*.