Performance Evaluation of QoS Routing in Computer Network

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Abstract:
We discuss and evaluate "Optimized Link State Routing Protocol" OLSR routing measurement performance analysis based on different simulation parameters. We have used NS-2 simulator tools for the performance of OLSR routing protocol simulation, we develop the simulation environment of small network (5, 10,15,25,30 Nodes) and observed the complexity of the mobile ad hoc network. The various performance parameters like average end-to-end delay, packets sent and received, throughput, consumed bandwidth has been analyzed. The paper describes all the simulator parameters taken and then compares the effect of complexity of simulation environment in performance of OLSR routing protocol. Our goal is to carry out a systematic comparative measurement study Optimized Link State Routing (OLSR) protocol in consideration of QoS parameters based on different simulation parameters. We have changed the different simulation environment and measured the various parameters such as throughput, end-to-end delay, packet delivery rate etc. Using NS-2 simulator tools for the performance of OLSR routing protocol simulation, we created in small network (5, 10 nodes), medium size network (15, 25, 30 nodes) and measured statistically the complexity of the mobile ad-hoc network.

Keywords: Ad hoc networks, Mobile ad hoc networks, Multipoint Relay, Optimized Link State Routing Protocol, Quality of service, Quality of Service Routing, Routing protocol.

1. Introduction

An *ad hoc network* is a (possibly mobile) collection of communications devices (nodes) that wish to communicate, but have no fixed infrastructure available, and have no pre-determined organization of available links. An ad hoc network is a local area network or some other small network especially one with wireless or temporary plug in connections, in which some of the network devices are the part of the network only for the duration of a communication session. Each node acts as a router as well as a communication end-point. *Ad hoc* is Latin and means "for this purpose". A mobile ad hoc network (MANET) is a collection of mobile nodes where each node is free to move about arbitrarily [1]. A MANET is a self-configuring infrastructure-less network of mobile device connected by wireless links. MANET is shown in fig (1). It has the characteristics that the network topology changes very rapidly and unpredictably in which many mobile nodes moves to and from a wireless network without any fixed access point where routers and hosts move, that's why the topology is dynamic. MANET can have multiple hops over wireless links. It has to support multi hop paths for mobile nodes to communicate with each other. If mobile nodes are within the communication range of each other, then source node can send message to the destination node otherwise it can send through intermediate node.There are two types of MANETs. One is Vehicular Ad Hoc Network (VANET) and another is Intelligent Vehicular Ad Hoc Network (In VANET).

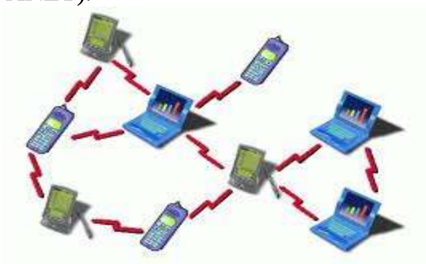

Fig 1 Mobile ad hoc networks (MANET)

The MANETs are mostly used in military tanks, automatic battlefields, search, fire fighters, by police and replacement of a fixed infrastructure in case of earthquake, floods, fire etc, quicker access to patient data about record, status, diagnosis from the hospital database, remote sensors for weather, taxi cab network, sports stadiums, mobile offices, electronic payments from anywhere, voting systems, vehicular computing, conference rooms, meetings, peer to peer file sharing systems.Quality of service is the ability to provide different priority to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow. For example, a required bit rate, delay, jitter, packet dropping probability and bit error rate may be guaranteed. Routing is the process of selecting paths in a network along which to send network traffic.

QoS routing is part of the network layer and searches for a path with enough resources but does not reserve resources. The goal of Quality of Service (QoS) routing protocols is to obtain feasible paths that satisfy end-system performance requirements. Most QoS routing algorithms are mainly extension of existing classis best effort routing algorithms.
The routing protocols of Mobile ad hoc network are characteristically subdivided into three main categories. These are proactive routing protocols, reactive routing protocols and hybrid routing protocols. These are shown in figure (2). In which each has further more protocols.When there is a change in network topology the proactive routing protocol maintains the whole routing information about each node in the network by spreading route updation at fixed time intervals throughout the whole network. The routing information is usually maintained in tables, so these protocols are also called table-driven protocols. It includes the routing protocols i.e. Destination Sequenced Distance Vector (DSDV), Optimized Link State Routing (OLSR), Wireless Routing Protocol (WRP) and Cluster head Gateway Switch Routing (CGSR). Reactive routing protocols establish the route to a destination only when there is a demand for it, so these protocols are also called on demand protocols. It includes the reactive routing protocols i.e. Ad hoc On Demand distance Vector protocol (AODV), Dynamic Source Routing (DSR), Admission Control enabled On-demand Routing (ACOR) and Associativity Based Routing (ABR).

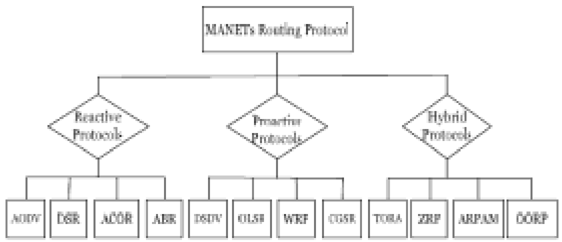

Fig 2 MANETs routing protocols

It uses the route discovery mechanisms to find the path to the destinations, when a source wants to send to a destination.Hybrid routing protocols is the combination of both proactive and reactive routing protocols. It includes the routing protocols i.e. Temporary Ordered Routing Algorithm (TORA), Zone Routing Protocol (ZRP), Hazy Sighted Link State (HSLS) and Order one Routing Protocol (OOPR).The Most routing protocols for mobile Ad hoc networks (MANETs) [2] are OLSR [3], AODV [13], DSR [14], which are designed without explicitly considering the QoS of the routes they find. QoS routing requires not only to find a route from a source to a destination, but a route that satisfies the end-to-end QoS requirement, which are often given in terms of bandwidth, delay or loss probability. Quality of service is more difficult to achieve in ad hoc networks than in their wired counterparts, because the nodes in ad hoc network are not static and therefore the network topology changes unpredictably. The remaining paper is organised as follows: section 2 gives information about the OLSR protocol and algorithm used. Section 3 gives some information about related work done by various researchers in the field of QoS routing in ad hoc networks. Section 4 includes proposed approach. Section 5 gives the some information about metrics used. Section 6 gives information about simulation and results. Section 7 gives conclusion.

2. Optimized Link State Routing (OLSR) Protocol

A. Overview

The IETF MANET Working Group introduces the Optimized Link State Routing (OLSR) protocol for mobile Ad-Hoc networks. The protocol is an optimization of the pure link state algorithm. The key concept used in the protocol is that of Multipoint Relays (MPRs). Optimized link state routing is a proactive routing protocol [12]. In which each node periodically broadcasts its routing table. The large amount of overhead is reduced by limiting the number of mobile nodes that can forward network wide traffic and for this purpose it uses multi point relays (MPRs) which is responsible for forwarding routing messages and optimization for controlled flooding and operations.

B. Multipoint Relay (MPR)

The idea of MPR is that the large amount of overhead is reduced by limiting the number of mobile nodes that can forward network wide traffic and for this purpose it uses multi point relays (MPRs) which is responsible for forwarding routing messages and optimization for controlled flooding and operations. Mobile nodes which are selected as MPRs minimize the flooding of broadcast packets in the network by reducing duplicate retransmissions in the same region and hence reduce the size of the control message. Each node in the network selects a set of nodes in its neighbor nodes is called the multipoint relays of that node periodically announces the information about who has selected it as an MPR. The neighbors of any node which retransmit the broadcast packet received from node for this purpose, each node maintains a set of its neighbors which are called the *MPR Selectors* of the node. Every broadcast message coming from these *MPR Selectors* of a node is assumed to be retransmitted by that node. OLSR protocol relies on the selection of MPRs, and calculates its routes to all known destinations through these nodes, i.e. MPR nodes are selected as intermediate nodes in the path. To implement this scheme, each node in the network periodically broadcast the information about its one-hop neighbors which have selected it as a multipoint relay. Upon receipt of this *MPR Selectors* information, each node calculates and updates its routes to each known destination. Therefore, the route is a sequence of hops through the multipoint relays from source to destination.

Fig 3 Multipoint relays

In our research work bandwidth is the parameter which is used for performance evaluation of quality of service in computer networks.The heuristic for the selection of multipoint relays in the standard OLSR does not take into account the bandwidth information. It computes a multipoint relay set of minimal cardinality. So, the links with high bandwidth can be omitted. After, the path calculated between two nodes using the maximum path algorithm has no guarantee that it is the optimal path. For example it is shown from Figure 4 and Table 1:

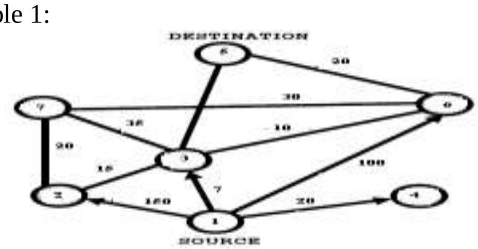

Fig 4 Network example for MPR selection

Table 1 MPR selected in the standard OLSR

Initiator Node	1 hop neighbors	2 hop neighbors	MPR Node
1	2, 3, 4, 6	5, 7	6

In this the MPR is selected with maximum bandwidth. Here node 3 and node 6 has same degree, so the node 6 of maximum bandwidth 100 is chosen the MPR. The decision of how each node selects its MPRs is essential to determinate the optimal bandwidth route in the network. In the MPR selection, the links with high bandwidth should not be omitted.

C. MPR ALGORITHM

In this protocol, MPR selection is almost the same as that of the standard OLSR. However, when there is more than 1- hop neighbor covering the same number of uncovered 2-hop neighbors, the one with maximum bandwidth link (a widest link) to the current node is selected as MPR. The heuristic used in protocol is as follows:

1. Select a source node and start with an empty multipoint relay set.
2. Select the 1-hop nodes of the current node means calculate degree of all nodes in the network.
3. Select those 1-hop neighbor nodes as multipoint relays (MPRs), which provide the only path to 2-hop nodes and add these 1-hop neighbor nodes to the multipoint relay set.
4. While there still exist some nodes in 2-hop that are not covered by the multipoint relay set.
   Select that node of 1-hop as a MPR which reaches the maximum number of uncovered nodes in 2-hop.
   If there is a tie in the above step, select that node with higher bandwidth as MPR.
5 To optimize, remove each node in MPR set, one at a time, and check if MPR set still covers all nodes in 2-hop.
   The third step permits to select some 1-hop neighbor nodes as MPRs which must be in the MPR set, otherwise the MPsetwill not cover all the 2-hop neighbors. So these nodes will be selected as MPRs in the process, sooner or later. In step , an optimization is performed by reducing the number of MPRs, if possible. The heuristics were based on considering only the bandwidth as a QoS routing parameter [4].A maximizable routing metric theory has been used to find a metric that selects, during the routing process, routes that are more stable, that offer a maximum throughput and that live for a long time [5].

3. Related Work

In this section we discuss some previous work done in this field by some researchers as follows.
In [5], Kamal Oudidi et al. have proposed a new routing approach that combines the residual bandwidth, energy and mobility of the network nodes. A maximizable routing metric theory has been used to find a metric that selects, during the routing process, routes that are more stable, that offer a maximum throughput and that live for a long time. Here proposed composite metrics selects a more stable MPR.In [4], N. Enneya et al. have proposed new version of the original OLSR protocol based on a new mobility parameter to enhance and adapt it in the presence of the mobility. For this they used three crieterions for MPRs selection. The first one is for selection, just the mobility of nodes at one-hop, the another two are based on both mobility of nodes at one-hop and two-hops.In [6], S. Javed et al. present the performance analysis of the OLSR protocol in an actual MANET that has been established using multiple wireless routers. One of the key contributions of this paper is establishing the communication efficiency of the OLSR protocol in an actual multi-hop wireless test-bed.In [7, 9], the research group at INRIA proposed a QoS routing scheme over OLSR. Their technique used delay and bandwidth metric for routing table computation. Such metrics are included on each routing table entry corresponding to each destination.In [10], T. Kannan et al. has presented that an ad hoc network is a collection of mobile nodes connected by a wireless link, where each node acts as a router. In order to facilitate the communication within the network, a routing protocol is needed. Due to bandwidth constraint and dynamic topology of the mobile ad hoc networks supporting quality of service (QoS) is challenging task. The aim of this work is to present QoS enabled routing protocol in ad hoc networks and compare it with normal routing protocol. The optimized link state routing (OLSR) protocol is an optimization of the classical link state protocol, which is used for implement the QoS. Such protocol is adopted for the reason that it reduces the size of control messages and minimizes the overhead from the flooding of control traffic. The performance of both routing and QoS routing protocols are evaluated using network simulator Ns-2.QoS enabled routing protocol shows a significant improvement in protocol performance metrics applied in our measurements, such as packet delivery ratio, packet loss and delay.In [8], *QOLSR* and the work presented in [7] propose a solution of providing a path such that the available bandwidth at each node on the path is higher than or equal to the requested bandwidth. Furthermore, *QOLSR* considers delay as a second criterion for path selection.In [11], Q. Ma et al. have presented a systematic evaluation of four routing algorithms that offer different tradeoffs between limiting the path hop count and balancing the network load. Their evaluation considers not only the call blocking rate but also the fairness to requests for different bandwidths, robustness to inaccurate routing information, and sensitivity to the routing information update frequency. It evaluates not only the performance of these algorithms for the sessions with bandwidth guarantees, but also their impact on the lower priority best-effort sessions. They observe that the routing information update interval can be set reasonably large to reduce routing overhead without sacrificing the overall performance, although an increased number of sessions can be misrouted.In [16], Kuldeep Vats et al. have proposed the simulation and performance of OLSR protocol using OPNET simulator tools with different number of nodes. Here the MPR count HELLO message, sent, routing, traffic sent and received, total TC message sent and forward, total hello message and TC traffic sent are analysis.

4. Proposed Approach

In our research work we will be evaluating the performance of QoS routing in computer networks. We will optimize the path and flood the information to all the nodes in the network. In a pure link state routing protocol, all the links with neighbor nodes are declared and are flooded in the entire network. The OLSR protocol is an optimization of a pure link state protocol for mobile ad hoc networks. First, it reduces the size of control packet: instead of all links, it declares only a subset of links with its neighbors who are its multipoint relay selectors. Secondly, it minimizes flooding of this control traffic by using only the selected nodes, called multipoint relays, to diffuse its messages in the network. Only the multipoint relays of a node retransmit its broadcast messages. This technique significantly reduces the number of retransmissions in a flooding or broadcast procedure and then the routing table is determined of all nodes and the MPRs are used to find an optimal path in which MPRs are intermediate nodes.
So we will use a general research methodology for finding multipoint relay set of all nodes and broadcast its MPR information in the periodic update packets, we use the heuristic algorithm proposed for OLSR to compute the MPR with slight adaptation. The algorithm is based on the following flow chart. The following definitions are given first.

- N: represents the subset of neighbors of the current node.
- N2: represents the set of two-hop neighbors of the current node.
  The following flow chart given in Fig.5 summarizes the essence of adapted version of the heuristic algorithm [15].

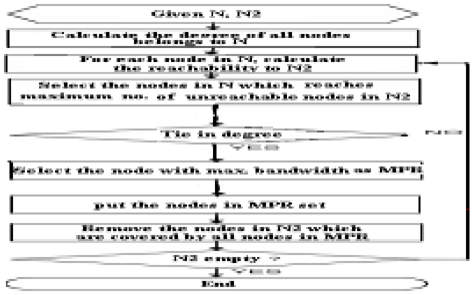

Fig 5 A flowchart for the MPR operation

Select all the 1 hop neighbors that could provide only rechability to some 2 hop neighbors as MPRs. Then, if there are still some 2 hop neighbors are not covered by MPRs, select the 1 hop neighbors who could cover the most uncovered 2 hop neighbors as MPRs. Repeat this step until all the 2 hop neighbors are covered by MPRs.

5. Performance Metric

We evaluate performance of the quality of service according to the given parameters as: throughput sent and received, end-to-end delay: frequency distribution, end-to-end delay: cumulative distribution, jitter sent and received on all nodes, average end-to-end delay, packet sent and received. These parameters are shown as follows:

A. Throughput is the total number of packets received by the destination.

B. End to End Delay is the time taken for an entire message to completely arrive at the destination from the source. Evaluation of end-to-end delay mostly depends on the following components i.e. propagation time (PT), transmission time (TT), queuing time (QT) and processing dealy (PD). Therefore,
EED is evaluated as:

$$EED=PT+TT+QT+PD. \quad (1)$$

C. Average End to End Delay is averaged over all surviving data packets from the source to the destinations.

D. Packet Sent and Received is the total number of packets sent and received during the complete simulation time frame, packet size is 512 bytes.

Fig 6 OLSR with 5 nodes: sending and receiving packets and route discovery

6. Simulation and Results

Simulation parameters for OLSR protocol: Following table signifies the simulation parameters taken for simulation environment. Various parameters have been measured by simulating the OLSR routing protocol using NS2 simulator. Here column 1 signify the simulation parameters like packet size, time duration etc and column 2 depicts the corresponding values of them like packet size is 512 bytes, duration of simulation is 50 sec. etc.

Table 2 Simulation parameters for OLSR protocol

Simulation parameters	**Value**
Network Type	Mobile
Connection Pattern	Radio-Propagation
Packet Size	512 bytes
Duration	50s
Connection Type	CBR/UDP
Simulation Area(sq.m)	600
Number of Nodes	5,10,15,25,30

In OLSR routing protocol simulation experiment results using different parameters of NS2 simulator with the help of graphs we choose the global statistics for analysis result of OLSR routing protocol.Figure 7 depicts the throughput of sending packets with respect to total simulation time. As we have mentioned that total simulation time we have set in our simulation environment is 50 sec, we have run the simulation script which implements the OLSR routing protocol for a period of 5 seconds. We have got the following throughput of the packet sent. In the following graph, X-axis depicts the simulation time in seconds which we have chosen in our case is 50 seconds; Y-axis depicts the throughput of sending packets. We can see that more the simulation time, more will be the throughput of the sending packets.

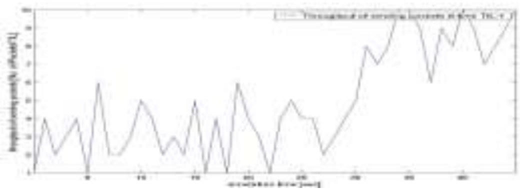

Fig 7 Throughput of sent packets vs. simulation time

Similarly as throughput of sending packets vs. simulation times has been depicted above, figure 8 represent the throughput of receiving packets during the simulation time. In the following graph, X-axis represents the total simulation time and Y-axis represents the throughput obtained during that simulation times.

Fig 8 Throughput of received packets vs. simulation time

Figure 9 represents the bandwidth vs. number of nodes in simulation environment using Ns2. We had run the complete simulation for a period of 50 seconds duration. We have used the MATLAB software for the generation of graphical representation of consumed bandwidth by number of moving nodes in simulation. In this as the number of nodes increases the consumed bandwidth increases.

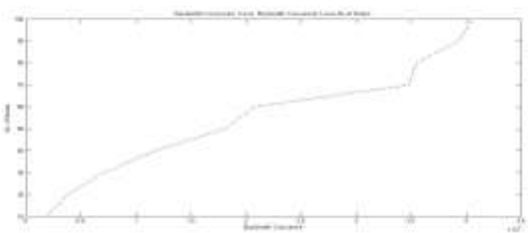

Fig 9 Bandwidth consumed vs. number of nodes

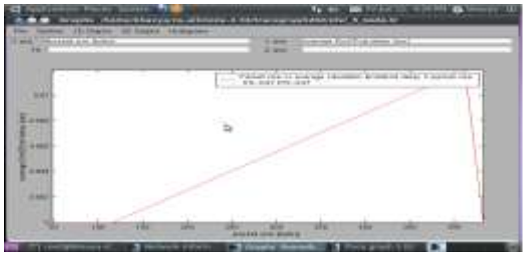

Fig 10 Average end-to-end delay

As we increase the number of nodes for performing the simulation of OLSR protocol, number of sent packets and delivered packets changes, which in turn changes the average end-to-end delay. Average end-to-end delay is the average time a packet takes to reach its destination. The table shows the difference between sent packets, received packets and average end-to-end delay as the number of nodes is increased.

Table 3 Comparison of various parameters vs. no. of nodes

No. of Nodes	**5**	**10**	**15**	**25**	**30**
Packets Sent	**226**	**365**	**552**	**926**	**1105**
Avg End-to-end delay	**0.254**	**0.272**	**0.363**	**0.454.**	**0.5**

7. Conclusion

In this work we evaluated the four performance measures i.e. packets sent and received, throughput, average end-to-end delay, with different number of nodes and consumed bandwidth. A Mobile Ad-hoc Network OLSR routing protocol was simulated with 5,10,15,25 and 30 nodes moving randomly in an area of within the network range 600 sq m. In this paper, MANET routing protocol in the OLSR were performance analyzed. The performance of OLSR protocol through a network different size carried out a comparative analysis of the performance and found it had better performance in all aspects in a network. From results reported in above section we concluded that as we increase the number of nodes for performing the simulation of OLSR protocol, number of sent and delivered packet changes, which in turn changes the average end to end delay and bandwidth. The OLSR protocol is the better solution for high mobility condition. The OLSR protocol is more efficient in networks with high density and highly sporadic traffic. But the best situation is when there are a large number of hosts. OLSR requires that it continuously has some bandwidth in order to receive the topology update messages.

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