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PERFORMANCE EVALUATION OF QoS ROUTING FOR MOBILE AD HOC NETWORK USING NS-2

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ABSTRACT

A mobile ad hoc network (MANET) is a collection of mobile nodes, where each node is free to move about arbitrarily. These are self configuring that does not require any existing infrastructure. As in this network the nodes are mobile, so the network topology can be very dynamic. Hence there are special routing protocols to cater to the dynamic nature of MANETs. The protocols are Optimized Link State Routing (OLSR) protocol, Ad Hoc On-Demand Distance Vector (AODV) routing protocol, Dynamic Source Routing (DSR) protocol etc. The OLSR Protocol is one of the well known and efficient MANET protocol. For simulation we have used NS-2 simulator tools for the performance of OLSR routing protocol. The performance parameters like average end-to-end delay, packets sent and received, jitter, has been analyzed. . This paper aims towards efficient Quality of Service (QoS) routing by enhancing the multipoint relay (MPR) selection criteria. In the previous papers they have proposed the OLSR protocol introducing metric such as bandwidth that is more appropriate than the hop distance for MPR selection. In this paper the MPR is selected with minimum delay.

KEYWORDS: Mobile Ad Hoc Networks, Multipoint Relay, Quality of Service, Quality of Service Routing, Routing Protocol

INTRODUCTION

A mobile ad hoc network (MANET) is consists of mobile nodes and these nodes are free to move about arbitrarily [1]. A MANET is a infrastructure-less network of mobile device, which are connected by wireless links. Mobile ad hoc network is shown in figure 1. The main characteristic of MANET the change of network topology and unpredictab in which many mobile nodes moves to and from a wireless network without any fixed access point where routers and hosts move, therefore the topology is dynamic. MANET 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.

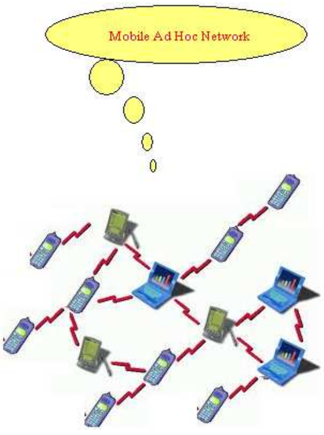


Figure 1: Mobile Ad Hoc Networks-MANET

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.

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.

There are many routing protocols. These are: 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).

The Most routing protocols for mobile Ad hoc networks (MANETs) [2] are OLSR [3], AODV [13], DSR [14]. Thse 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.

The remaining paper is organised as follows: section II gives information about the OLSR protocol and algorithm used. Section III gives some information about related work done by various researchers in the field of QoS routing in ad hoc networks. Section IV includes proposed approach. Section V gives the some information about metrics used. Section VI gives information about simulation and results. Section VII gives conclusion.

OLSR PROTOCOL

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 main key concept used in OLSR protocol is of Multipoint Relays (MPRs). Optimized link state routing is a proactive routing protocol [12]. 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.

Multipoint Relay (MPR)

The MPR is based on the idea 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 broadcasting of packets by reducing duplicate retransmissions in the same region and hence reduce the size of the control message.

It is basically for the reduction of nodes in broadcasting the messages from source to destination. 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.

Using this technique the overhead of congestion and nodes is reduced. To implement MPR selection 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 MPR Selectors information, each node calculates and updates its routes to each known destination. Therefore, the route is a sequence of nodes through the multipoint relays from source to destination. Hence the nodes selected using this technique are responsible for selection of optimal path to send packets easily from source to destination without any congestion and overhead of nodes. Here by reducing the packet size overhead is also reduced.

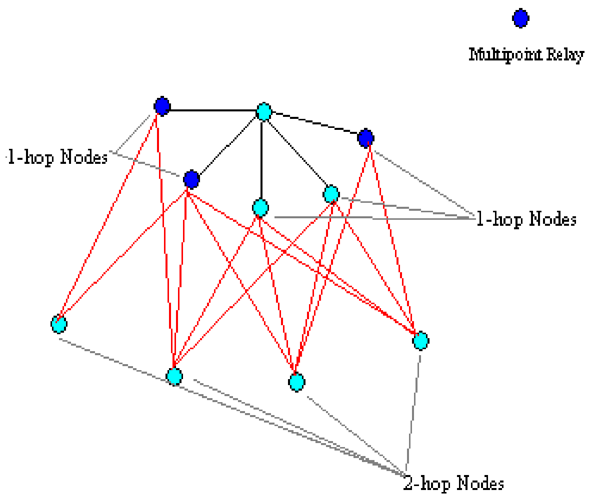


Figure 2: Multipoint Relays

The technique for the selection of multipoint relays in the standard OLSR does not take into account the delay information. It computes a multipoint relay set of minimal cardinality. So, the links with low delay can be omitted. Using the minimum delay path algorithm has no guarantee that it is the optimal path, after the path calculated between two nodes. For example it is shown from Figure 3 and Table 1:

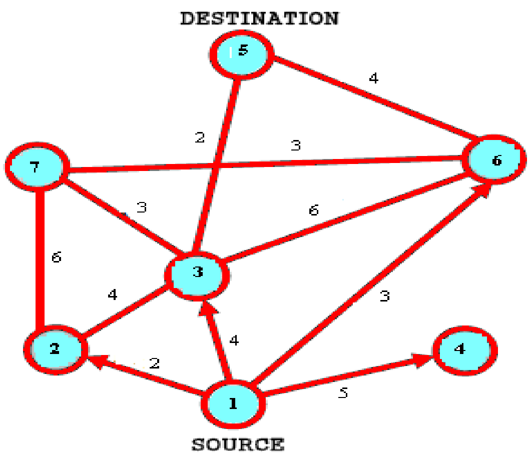


Figure 3: Network Example for MPR Selection

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

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 minimum delay link (a shortest link) to the current node is selected as MPR. The heuristic used in protocol is as follows:

Step 1: Select a source node and start with an empty multipoint relay set.

Step 2: Select the 1-hop nodes of the current node means calculate degree of all nodes in the network.

Step 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.

Step 4: While there still exist some nodes in 2-hop that are not covered by the multipoint relay set.

Step 4: 1. Select that node of 1-hop as a MPR which reaches the maximum number of uncovered nodes in 2-hop.

Step 4: 2. If there is a tie in the above step, select that node with minimum delay as MPR.

Step 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 MPR set will not cover all the 2-hop neighbors. So these nodes will be selected as MPRs in the process, sooner or later. In step 5, an optimization is performed by reducing the number of MPRs, if possible.

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.

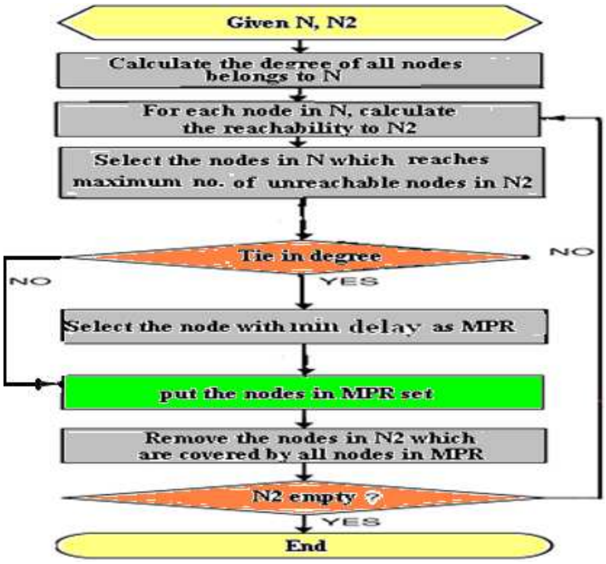
PROPOSED APPROACH

In our research work we will optimize the path and flood the information to all the nodes in the network. The OLSR protocol optimize a pure link state protocol for mobile ad hoc networks and a pure link state routing protocol declare all the links with neighbor nodes and flood the entire network. Instead of all links, it declares only a subset of links with its neighbors who are its multipoint relay selectors.

Therefore, it reduces the size of control packet. To diffuse its messages in the network it minimizes flooding of this control traffic by using only the selected nodes, called multipoint relays. 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.

The following flow chart given in Figure 4 summarizes the essence of adapted version of the heuristic algorithm [15].



N: It is for 1-hop Nodes
N2: It is for 2-hop Nodes

Figure 4: 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.

PERFORMANCE METRIC

We simulate and evaluate a performance of the quality of service according to the given parameters as: jitter, end-to-end delay, and average end-to-end delay, packet sent and received. These parameters are shown as follows:

- *Jitter* is a variation in the delay of received packets.
- *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.(1)
- *Average End to End Delay* is averaged over all surviving data packets from the source to the destinations.
- *Packet Sent and Received* is the total number of packets sent and received during the complete simulation time frame, packet size is 512 bytes.

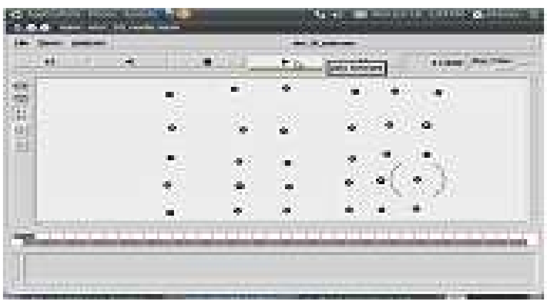


Figure 5: OLSR with 30 Nodes: Sending and Receiving Packets and Route Discovery

SIMULATION AND RESULTS

Simulation parameters for OLSR protocol are given in the table. Following table signifies the simulation parameters taken for simulation environment. Various parameters have been measured by simulating the OLSR routing protocol using NS2 simulator. 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	30

For MANET OLSR routing protocol the simulation are performed with different parameters using NS2 simulator and determined their performance in static network.

Figure 6 depicts the jitter of sent packets with respect to sequence number. Jitter is the variation in the time between packets arriving, caused by network congestion, timing drift, or route changes. In the following graph, X-axis depicts the sequence number; Y-axis depicts the jitter of sent packets. In this the 30 number of nodes are included. The OLSR is Proactive in nature and it uses MPR technique for selective flooding of control messages to provide optimal routes in terms of number of hops. Initially, the jitter is very high to its maximum value and then it decreases and fluctuates between 0 to 0.2 seconds. The jitter is due to network congestion, route changes etc. here in this, the MPR distribute the packets. The OLSR has to keep the enough information topology to have routes to all nodes; this is done using TC messages. They arrive to all nodes and update the routing table. For this need of update in routing table and change in routes fluctuates the jitter.

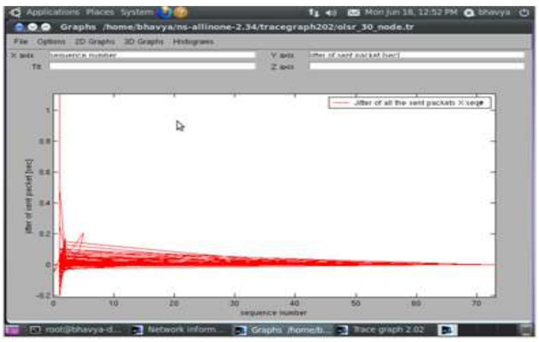


Figure 6: Jitter of Sent Packets vs. Sequence Number

Figure 7 depicts the jitter of received packets with respect to sequence number. Jitter is the variation in the time between packets arriving, caused by network congestion, timing drift, or route changes. In the following graph, X-axis depicts the sequence number; Y-axis depicts the jitter of received packets. In this the 30 number of nodes are included. Initially, the jitter of received packets increases sharply to 0.206 seconds, then it fluctuates 0.204 to 0.205 seconds. The OLSR uses MPR technique for distributing the packets to provide optimal routes. The MPR send and process the packets and can retransmit them but the other neighbor nodes can only send and receive the packets but can’t process them. The control messages keep all the nodes up-to-date with information and updated routing table. That’s why for the need to update routing table it increases the overhead and increases the jitter of received packets. The receiving nodes need to keep information about all nodes up-to-date. Therefore, the jitter fluctuates for keeping the information up-to-date.

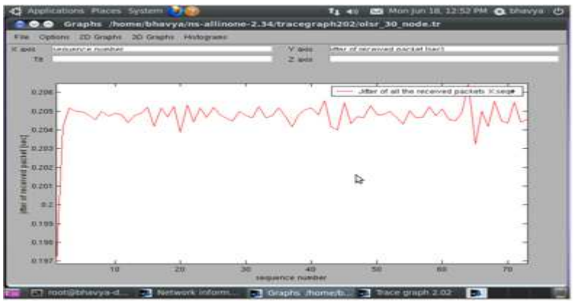


Figure 7: Jitter Received on all Nodes vs. Sequence Number

Figure 8 depicts the Average end-to-end delay is averaged over all surviving data packets from the source to the destinations. In the following graph, X-axis depicts the average end-to-end delay; Y-axis depicts the number of nodes. The simulation is run for a period of 50 seconds duration. In a static network the OLSR algorithm introduces less overhead into the network. For fewer nodes network, there are optimal minimum delay conditions. So in these networks, they find better optimal delay routes than in dense networks. In fixed network case, because of few topology updates, algorithm has low overhead. With fewer numbers of nodes they nodes can send packets very easily without any interference of packets. This is the reason with less overhead network has less delay and that's why network with fewer nodes has minimum delay route than in the dense network. Here the result shows that as the number of nodes increases delay increases. It can seen that during the period of simulation, when there are increase of number of sent packets, there is increase of Average delay correspondingly but after a period of time, it becomes almost linear. e.g. no. of sent packets is 226 in case of 5 nodes during the period of entire simulation which is 50 sec duration and delay is .254 sec. Similarly there is number of sent packets are 365 in case of 10 nodes simulation and delay is .272 sec. It is seen that in case of 30 nodes, simulation has been run for same time period which is 50 sec, no. of sent packets are 1105 which is almost5-times than 5 nodes simulation but delay is not equal to 5-times; it is just like double than 5-node's simulation. Therefore it can concluded that less the number of nodes, more will be delay and more of the number of nodes in wireless network, delay will be less correspondingly as observed.

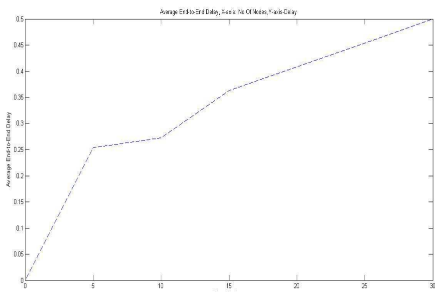


Figure 8: Average End-to-End Delay vs. Number of Nodes

Figure 9 depicts the average end-to-end delay with respect to packet size. Average end-to-end delay is averaged over all surviving data packets from the source to the destinations. In the following graph, X-axis depicts the packet size; Y-axis depicts the average end-to-end delay. In this the 30 number of nodes are included. For small size packets, OLSR has the lowest overhead, therefore network is least congested, resulting in the least delay. The result shows that till packet size 120 bytes there is no congestion in the network, therefore OLSR has no overhead. This results in no delay. After 120 bytes packet size the delay starts gradually, because with increase of packet size the overhead of OLSR start increasing, therefore the network becomes congested. It keeps on increasing to the packet size 500 bytes, then after 500 bytes average end-to-end delay decreases very sharply. Means with the increase in packet size increases the average end-to-end delay in sending packets from source to destination. In MPR the nodes distribute the packets. Here if the packet size is increased then there is a delay in distributing the packets and hence the packets are delayed in sending from source to destination. For small size of packet the routing algorithm may select a route that is less congested, resulting in the lower delay.

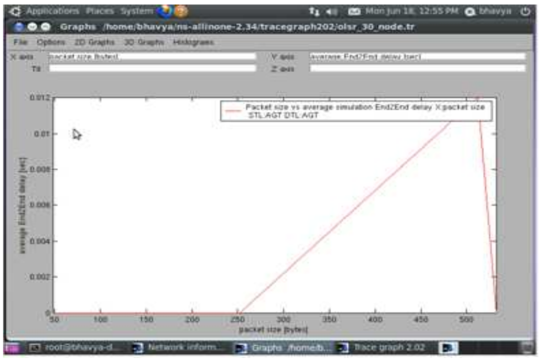


Figure 9: Average End-to-End Delay vs. Packet Size

CONCLUSIONS

In this work we evaluated the three performance parameters i.e. jitter send and received on all nodes, average end-to-end delay with different number of nodes. The OLSR routing protocol was simulated with 30 nodes moving randomly in an area of within the network range 600 sq m. In this paper, the performance of MANET routing protocol OLSR was analyzed. In this paper, the path was determined with delay parameter and its performance is identified with number of nodes.

The result for delay concludes that as the number of nodes increases the delay increases very small and then it becomes almost constant. The jitter sent on all nodes is minimum for 30 numbers of nodes, which is good for this network. The jitter received on all nodes varies with sequence number. It is maximum for large value of sequence number. The result of average end-to-end delay also concludes that as the numbers of nodes increases the delay is constant for large packet size. After packet size 250 bytes the delay starts to increase, and then reaching its maximum value 0.012 seconds it decreases very sharply. Here the optimal minimum delay path is for dense network.

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