

## Performance Measurement and Analysis of OLSR Routing Protocol Based On Node Scenarios Using NS2 Simulator

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### ABSTRACT

To design of a wireless network, measurement of performances and selection of optimum path based on various parameters are the main strategies. In this paper, performance analysis is carried out on "Optimized Link State Routing Protocol" OLSR routing protocol and measurement of performance analysis based on different simulation parameters under various simulation environments is presented. We develop the simulation environment of small network (5, 10, 15, 25, 30 Nodes) using NS2 and observed the complexity of the mobile ad-hoc network. The various performance parameters like average end-to-end delay, packets sent and received, jitter in network, throughput, commutative distribution and frequency distributions 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 of 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.

**Keywords** – MANET, OLSR, NS2, Throughput, Delay, Packet Delivery Ratio

### I. INTRODUCTION

A mobile ad hoc network (MANET) is a self-configuring infrastructure less network of mobile devices connected by wireless. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger Internet. MANETs are a kind of wireless ad hoc networks that usually has a

routeable networking environment on top of a Link Layer ad hoc network [1]

MANET network comprising of wireless mobile nodes also known as mobile nodes (MNs) that pass the messages to each other without centralized control or any kind of established infrastructure. The communication between various MNs directly depends upon the radio range. When MNs are within the range of radio frequencies, they can send the packets to each other while the MNs which are distant of each other rely on their neighbouring MNs to forward the packets. Each MN acts as either a host or router. In MANET environment, MNs are free to join or leave the network at any point of time, resulting in a highly dynamic network environment compared to wired network [2]

Routing protocols used in MANET network are divided into two categories: Proactive and Reactive. Proactive routing protocols are table-driven protocols and they always maintain current up-to-date routing information by sending control messages periodically between the hosts which update their routing tables. The proactive routing protocols use link-state routing algorithms which frequently flood the link information about its neighbours. [3] Reactive or on-demand routing protocols create routes when they are needed by the source host and these routes are maintained while they are needed. Such protocols use distance-vector routing algorithms. [4]

Figure 1 depicts the MANET protocol structure of various routing protocols such as Proactive, Reactive and Hybrid protocols. Optimized Link State Protocol (OLSR) is a proactive 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. To reduce the possible overhead in the network protocol uses Multipoint Relays (MPR).

Proactive	Hybrid	Reactive
<ul style="list-style-type: none"> <li>•DSDV</li> <li>•OLSR</li> <li>•WRP</li> <li>•CSGR</li> </ul>	<ul style="list-style-type: none"> <li>•ZRP</li> </ul>	<ul style="list-style-type: none"> <li>•ABR</li> <li>•TORA</li> <li>•CBRD</li> <li>•DSR</li> <li>•AODV</li> </ul>

Figure 1: MANET protocol structure

• **Pro-Active / Table Driven routing Protocols**

Proactive Manet's protocols are also called as table-driven protocols and will actively determine the layout of the network. Through a regular exchange of network topology packets between the nodes of the network, at every single node an absolute picture of the network is maintained. There is hence minimal delay in determining the route to be taken. This is especially important for time-critical traffic [24].

When the routing information becomes worthless quickly, there are many short-lived routes that are being determined and not used before they turn invalid. Therefore, another drawback resulting from the increased mobility is the amount of traffic overhead generated when evaluating these unnecessary routes. This is especially altered when the network size increases. The portion of the total control traffic that consists of actual practical data is further decreased. Lastly, if the nodes transmit infrequently, most of the routing information is considered redundant. The nodes, however, continue to expend energy by continually updating these unused entries in their routing tables as mentioned, energy conservation is very important in a MANET system design. Therefore, this excessive expenditure of energy is not desired. Thus, proactive MANET protocols work best in networks that have low node mobility or where the nodes transmit data frequently. Examples of Proactive MANET Protocols include:

1. Optimized Link State Routing (OLSR)
2. Fish-eye State Routing (FSR)
3. Destination-Sequenced Distance Vector (DSDV)
4. Cluster-head Gateway Switch Routing Protocol (CSGR)

• **Reactive (On Demand) protocols**

Portable nodes- Notebooks, palmtops or even mobile phones usually compose wireless ad-hoc networks. This portability also brings a significant issue of mobility. This is a key issue in ad-hoc networks. The mobility of the nodes causes

the topology of the network to change constantly. Keeping track of this topology is not an easy task, and too many resources may be consumed in signaling. Reactive routing protocols were intended for these types of environments. These are based on the design that there is no point on trying to have an image of the entire network topology, since it will be constantly changing. Instead, whenever a node needs a route to a given target, it initiates a route discovery process on the fly, for discovering out a pathway [8].

Reactive protocols start to set up routes on-demand. The routing protocol will try to establish such a route, whenever any node wants to initiate communication with another node to which it has no route. This kind of protocols is usually based on flooding the network with Route Request (RREQ) and Route reply (RERP) messages. By the help of Route request message the route is discovered from source to target node; and as the target node gets a RREQ message it send RERP message for the confirmation that the route has been established. This kind of protocol is usually very effective on single-rate networks. It usually minimizes the number of hops of the selected path. However, on multi-rate networks, the number of hops is not as important as the throughput that can be obtained on a given path [15].

The different types of On Demand driven protocols are:

1. Ad hoc On Demand Distance Vector (AODV)
2. Dynamic Source routing protocol (DSR)
3. Temporally ordered routing algorithm (TORA)
4. Associatively based routing (ABR)
5. Signal Stability-Based Adaptive Routing (SSA)
6. Location-Aided Routing Protocol (LAR)

• **Hybrid Routing Protocols**

Since proactive and reactive protocols each work best in oppositely different scenarios, hybrid method uses both. It is used to find a balance between both protocols. Proactive operations are restricted to small domain, whereas, reactive protocols are used for locating nodes outside those domains [8]. Examples of hybrid protocols are:

1. Zone Routing Protocol, (ZRP)
2. Wireless Ad hoc Routing Protocol, (WARP)

**II. OLSR ROUTING PROTOCOL**

An OLSR is a proactive or table driven, link-state routing protocol. Link-state routing algorithms choose best route by determining various characteristics like link load, delay, bandwidth etc. Link-state routes are more reliable, stable and accurate in calculating best route and more

complicated than hop count. To update topological information in each node, periodic message is broadcast over the network. Multipoint relays are used to facilitate efficient flooding of control message in the network. Route calculations are done by multipoint relays to form the route from a given node to any destination in the network. The OLSR protocol is developed to work independently from other protocols. Conceptually, OLSR contains three generic elements: a mechanism for neighbour sensing, a mechanism for efficient flooding of control traffic, and a specification of how to select and diffuse sufficient topological information in the network in order to provide optimal routes [5].

- **Neighbour Sensing**

In OLSR, neighbour nodes related information are gathered with "HELLO" messages which are sent over the network periodically [6]. These "HELLO" messages detect changes in neighbour nodes and related information such as interface address, type of link symmetric, asymmetric or lost and list of neighbours known to the node. Each node updates and maintains an information set, describing the neighbour and two-hop neighbour periodically after some time.

- **Multi Point Relay (MPR)**

The idea of multipoint relays is to minimize the overhead of flooding message in the network by reducing redundant retransmission in the same region. In MPR (Multi Point Relay) a node which is selected by its one hop neighbor to "re-transmit" all the broadcast messages that it receives from other nodes, provided that the message is not a duplicate, and that the time to live field of the message is greater than one [6]. In OLSR protocol, Multi Point Relays use "HELLO" messages to find their one hop neighbor and their two hop neighbors through their response. Each node has a Multi Point Relay selection set, which indicates, which node acts as a MPR. Messages are forwarded after the node gets a new broadcast message and message sender's interface address in the MPR Selector Set. MPR Selector Set is updated continuously using "HELLO" messages which are periodic because neighbor nodes are called of dynamic nature of MANET.

- **Topology Control Information**

Topology Control messages are diffused with the purpose of providing each node in the network with sufficient link-state information to allow route calculation [6]. TC messages are broadcast periodically by a node. Like "HELLO" messages with these TC messages the topological information is diffused over the entire network. A minimum criterion for the node is to send at least the link of its MPR Selector Set [5], [7].

- **PACKET FORMAT OF OLSR**

OLSR uses unified packet format to carry information related to the protocol. This particular packet can be embedded in UDP datagrams for transmission over the network. It contains Packet Length (0-15 bytes) and next 16-31 bytes in packet format Reserved for future use, Message Type, Message Size and Information [8].

Packet Length (0-15)		Reserved for future use (16-31)
Msg Type	Reserved	Message Size
Message		

Figure 2: Packet format of OLSR

### III. SIMULATION PLATFORM CREATION

For the simulation of nodes in mobile adhoc network (MANET), we have created the platform on windows as well as on Ubuntu as linux distribution. As per the research study, we have come to know that considering that the refresh rate of the monitor under Linux system is lower (60) compared with Windows XP (you may improve it to 85). This low rate is harmful for your eyes. Also, many guys cannot install NS2 under Windows XP successfully. We are very happy to compile and install NS2 under Windows XP system [9]. But at the end we can use any kind of environment such as Ubuntu based or windows based for simulation.

The MANET network simulations are implemented using NS-2 simulator [10]. Nodes in the simulation move according to a model that we call Random Waypoint Mobility model [11]. Each node is then assigned a particular trajectory. The simulation period for each scenario is 50 seconds. Packet size of 512 bytes for transmission and receiving of packets has been set for communication between nodes. In each simulation scenario, the nodes are initially located at the center of the simulation region. The MAC layer protocol IEEE 802.11 is used in all simulations with the data rate 11 Mbps. The transmission range is 250m. The application used to generate is CBR traffic and IP is used as Network layer protocol. The performance evaluation, as well as the design and development of routing protocols for MANETs, requires additional parameters which is addressed in RFC developed by Internet Engineering Task Force (IETF)

### IV. PERFORMANCE EVALUATION AND RESULTS

- **Performance Measurement Evaluation and Results**

- Performance Evaluation

Here we present the measurement of various parameters by implementing the simulation environment based on complexity of the nodes. 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 throughput and avg. end to end delay. Throughput is defined as the ratio of the data delivered to the destination of the data sent out by the sources. Average end-to-end delay is the avg. time a packet takes to reach its destination. The table's shows difference between sent packets, received packets, throughput and avg. end to end delay as the number of nodes is increased.

The goal of our experiments is to examine and quantify the effects of various factors and their interactions on the overall performance of ad hoc networks. Each run of the simulator accepts as input a *scenario file* that describes the exact motion of each node. The performance metrics helps to characterize the network that is substantially affected by the routing algorithm to achieve the required Quality of Service (QoS). In this work, the following metrics are considered.

**End-to-End Delay (EED):** It 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 delay (PD). Therefore, EED is evaluated as:

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

**Throughput:** It is the measure of how fast a node can actually sent the data through a network. So throughput is the average rate of successful message delivery over a communication channel.

**Packet Sent and Received:** It is the total number of packets sent and received during the complete simulation timeframe, packet size is 512 bytes.

**Jitter:** jitter is the variation in the time between packets arriving, caused by network congestion, timing drift, or route changes.

**Cumulative Distribution Function:** CDF is short for cumulative distribution function. This function describes a statistical distribution. It has the value, at each possible outcome, of the probability of receiving that outcome or a lower one. A CDF is usually denoted in capital letters.

Consider for example some  $F(x)$ , with  $x$  a real number is the probability of receiving a draw less than or equal to  $x$ . A particular form of  $F(x)$  will describe the normal distribution, or any other one-dimensional distribution.

**Frequency Distribution:** A representation, either in a graphical or tabular format, which displays the number of observations within a given interval. The intervals must be mutually exclusive and exhaustive. Frequency distributions are usually used within a statistical context.

**Control Overhead:** It is ratio of the control information sent to the actual data received at each node.

**Packet Delivery Ratio (PDR):** It is the ratio of the total data bits received to total data bits sent from source to destination.

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 NS-2 simulator; column 1 signify the simulation parameters like packet size, time duration etc; column 2 depicts the corresponding values of them like packet size is 512 bytes, duration of simulation is 50 sec. etc.

- **Simulation Parameters:** Following table depict the various simulation parameters

Simulation Parameters	Values
Network Type	Mobile Ad Hoc
Connection Pattern	Radio-propagation
Packet size	512 bytes
Duration	50s
Connection Type	CBR/UDP
Simulation Area ( sq.m)	600
No. of Nodes	5,10,15,25,30

Table 1: Simulation Parameters

## V. RESULTS AND ANALYSIS

During the course of implementation of this research, an attempt was made to compare the performances of OLSR routing protocol based on various node scenarios and positions under the same simulation environment. For all the simulations, the same movement models were used, the numbers of traffic sources are varied, the maximum speed of the nodes was set to 20m/s and the packet size is fixed to 512 bytes. The area of simulation is 600 sq.m

For the experimental significance, here we only discuss the experimental results of simulation of 5 nodes only. The simulations environment is the same for other nodes of 10,15,25,30 no. of nodes. The diversity of the experiments is more as we increase the number of nodes in a simulation environment.

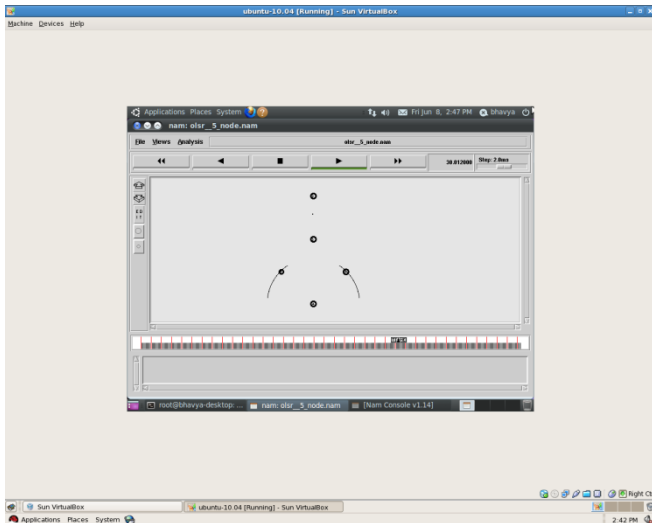


Figure 3: Simulation with 5 nodes

Figure 3 depicts the OLSR simulation environment with 5 nodes as well as Sending and Receiving Packets.

Figure 4 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 50 seconds. We have got the following throughput of the packet sent. Throughput is the average number of packets sent during the complete simulation time window. 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.

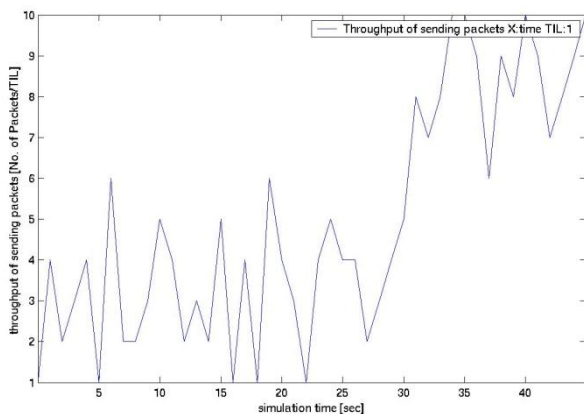


Figure 4: Throughput of sent packets vs Simulation time.

Similarly as throughput of sending packets vs simulation times has been depicted above, figure 5 represent the Throughput of receiving packets during the simulation time. X-axis represents the

total simulation time and Y-axis represents the throughput obtained during that simulation time. As we have run the simulation for a complete duration of 50 seconds.

The 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), and sometimes in data packets per second or data packets per time slot. The system throughput or aggregate throughput is the sum of the data rates that are delivered to all terminals in a network.

The throughput can be analyzed mathematically by means of queuing theory, where the load in packets per time unit is denoted arrival rate  $\lambda$ , and the throughput in packets per time unit is denoted departure rate  $\mu$  [22].

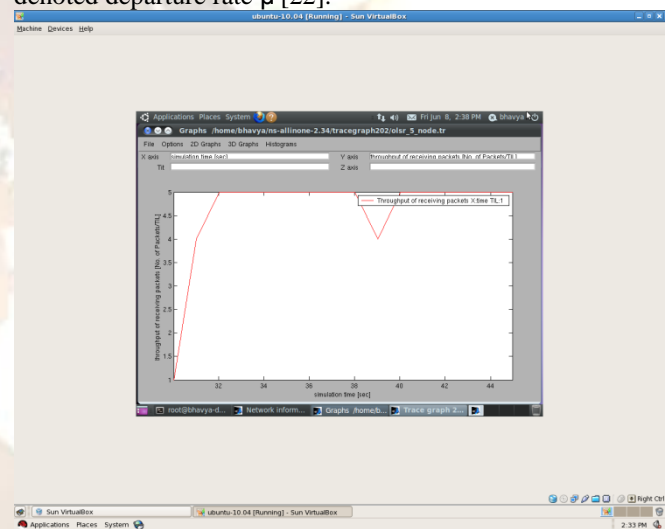


Figure 5: Throughput of Received Packets Vs Simulation Time.

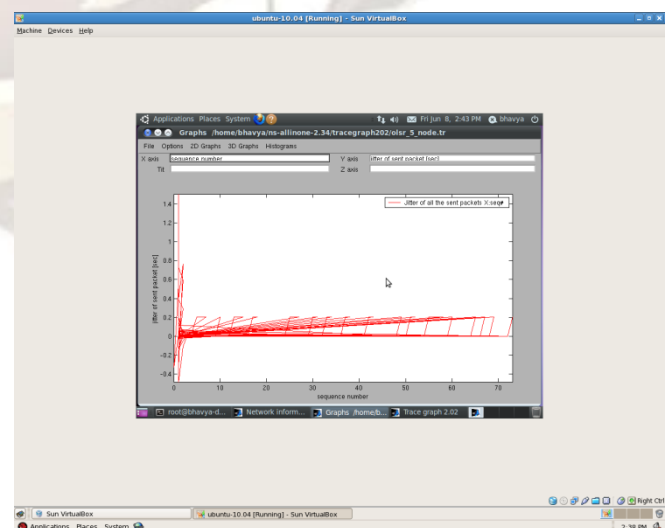


Figure 6: Jitter sent on all nodes

Finally we compare the Average end to end delay vs various simulation nodes based on the packets.

	5	10	15	25	30
<b>Packets Sent</b>	<b>226</b>	<b>365</b>	<b>552</b>	<b>926</b>	<b>1105</b>
<b>Avg End to end delay</b>	<b>.254</b>	<b>.272</b>	<b>.363</b>	<b>.454</b>	<b>.5</b>

Table 2: Comparison of various parameters v/s no of nodes.

Table 2 depicts the comparison of packet sent during the simulation time period with respect to average end to end delay. It is obvious that when we increase the number of nodes in a simulation environment, it will affect the corresponding end to end delay. But we can see, in case of 10 numbers of nodes, there is a little increase in end to end delay time but when we move to 15 numbers of nodes, the cumulative difference is slightly high as compare to the previous one. We can say there is no fixed differences noticed by implementing the various nodes.

## VI. CONCLUSION

In this work we evaluated the four performance measurement of OLSR routing protocol i.e. packets sent and received, jitter, end-to-end delay, throughput, cumulative and frequency distribution of sent and received packets with different number of nodes. 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. 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 above, 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 throughput and avg. end to end delay. 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.

In future, utilizing these performances we can design such a protocol that can be suitably provide data integrity as well as data delivery in highly random mobility network better QoS applications. In our research study, we have considered a packet of data of 512 bytes and minimum packet size is 48 bytes but in multimedia application, we should have packet bigger. So, our future work will consist of studying multimedia traffic on this protocol and queue management, as

well as finding a solution for supporting different data stream.

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