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EVALUATION OF QUALITY OF SERVICE (QOS) PARAMETERS OF OLSR PROTOCOL WITH MULTIMEDIA TRAFFIC

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ABSTRACT

Mobile Ad hoc Networks (MANETs) have unique mobility characteristics and are used for many applications similar to wired networks. These networks are capable of providing services to the users at acceptable standards and have become highly essential in our daily life. The performance of MANETs is largely dependent on routing protocols. With high traffic load, the processing of queued packets has significant effect on overall end-to-end performance and congestion avoidance. The data packets that are to be transmitted from a node are queued in a single line and forwarded using First in First out (FIFO) or using a Weighted Fair Queuing (WFQ) model. The Optimized Link State Routing protocol is an optimization of pure link state routing protocol and it is designed mainly for mobile ad hoc networks. It has a table driven approach i.e. it exchanges the information with other nodes of the network. Among routing protocols available to deliver data packets from source to destination, OSLR protocol constantly updates topology information and routes which are available. It is observed that the control traffic overhead decreases with modifications in OLSR routing protocol using traffic shaping based on packet priority. Investigations are carried out for multimedia traffic with FIFO and WFQ for various Quality of Service QoS parameters namely PDR, end to end delay, jitter and no. of TC packets.

Keywords: Mobile Ad hoc Networks (MANETs), First in First out (FIFO), Weighted Fair Queuing (WFQ) model, OSLR protocol, Quality of Service QoS.

1 INTRODUCTION

The dynamic nature of the ad hoc network requires a different set of network strategies than the wired network for efficient end-to-end communication. The error prone nature of the wireless medium and frequent route changes and packet losses pose many challenges to ad hoc network (Deng et al 2002). As the traffic load increases, the problems such as packet delay and decreased throughput leads to degradation of performance. Routing protocols employed in an ad hoc network determines the success of the network. The performance of the network is largely dependent on the routing protocol. Routing protocols are researched based on efficient routing of packets hop by hop (Sobrinho et al 2002 and Badis et al 2005). When the traffic load is high, the processing of queued packets has significant effect on overall end-to-end performance and congestion avoidance. Thus, packet scheduling algorithms are used to determine the sequence in which the packets in the queue are forwarded.

The data packets that are to be transmitted from a node are queued in a single line and forwarded using First in First out (FIFO). But the major disadvantage of FIFO is that, when the head of line is blocked, it prevents other packets from being forwarded. To avoid this block, fair queuing (Bensaou & Fang 2007) is used to share the link capacity fairly for forwarding of multiple packets. A buffer is formed where the data packets are stored temporarily before transmission and fair queuing forwards packets from the buffer. Usually, the buffer contains multiple queues, with each containing packets of one flow. The finish time of the packets is estimated and packets with the earliest finish time are selected to be transmitted first. Weighted Fair Queuing (WFQ) calculates weights for each packet by multiplying the packet size with the inverse of a weight for the associated queue.

For each arriving packet at the node, it is tagged with a start tag $start_{i,n}$ and finish tag $finish_{i,n}$ by the WFQ algorithm (Perkins et al 1994) as given in Equations (1) and (2) respectively:

$$start_{i,n} = \max\left\{v\left(A\left(t_{i,n}\right)\right), finish_{i,n-1}\right\} \tag{1}$$

$$finish_{i,n} = s_{i,n} + P_{i,n} / r_i \tag{2}$$

where *n* is sequence number of the packet of flow *i* arriving at time $A\left(t_{i,n}\right)$ $P_{i,n}$ is the packet size and weight r_i . The virtual time $v\left(A\left(t\right)\right)$ is calculated as given in Equation (3):

$$\frac{dv\left(t\right)}{dt} = \frac{C}{\sum_{i\in B_{FFQ(t)}} r_i} \tag{3}$$

where *C* is the channel capacity in bits/sec and $B_{FFQ(t)}$ is the set of backlogged flows at time t in error-free fluid service. The average data rate is calculated using WFQ as given in Equation (4):

$$data\ rate = \frac{Rr_i}{\left(r_1 + r_2 + ... +_N\right)} \tag{4}$$

where *R* is the link data rate and *N* is the active data flow.

2 METHODOLOGY

2.1 Optimized Link State Routing Protocol (OLSR)

OLSR is an optimization version of link state protocol, where the routes are readily available. Any change in topology of the network results in flooding for updating the topological information to all available nodes. Optimized Link State Routing protocol is an optimization of pure link state routing protocol and it is designed mainly for mobile ad hoc networks. Also it has a table driven approach i.e. it exchanges the information with other nodes of the network. The two key concepts used in this protocol are:

a) Multipoint Relays (MPRs)

b) Optimized link state

In Multipoint Relay the broadcast of message for selected nodes during the flooding process is performed. It is reduces the message overhead when compared to flooding. In the flooding mechanism every node re transmits each message while receiving the first copy of the message. In OLSR, link state Information is generated by nodes chosen as MPRs. An MPR with one hop and 2 hop neighbor is given in Figure 1 below.

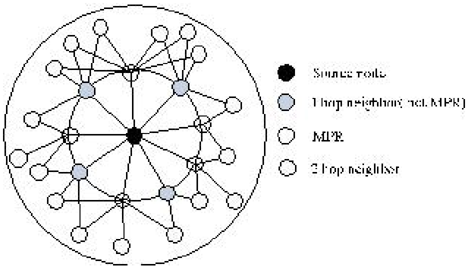


Figure 1 MPR with one hop and 2 hop neighbours

In optimized link state the optimization is accomplished by minimizing the number of control messages flooded in the network. OLSR provides optimal route to the available hops. This protocol is suitable for a large and dense networks (Bhardwaj et al 2012).

The characteristic of the proactive routing protocol is that the protocol has the routing information of all the participated hosts in the network. The flooding is minimized by the use of MPRs, which are only allowed to forward the topological messages. An OLSR protocol performs hop by hop routing. For instance, each node uses its most recent information to route a packet. As a result, when a node is moving, its packet is successfully delivered to it, if its speed is such that its movement could be followed by its neighborhoods. Hence the protocol supports a nodal mobility that can be traced through its control messages, which depends upon these message frequencies (Singh 2013).

For establishing a communication process between nodes running a protocol instance, OLSR makes use of a unique packet, in which more than one message can be encapsulated. OLSR packets can carry three different message types, where each one has a specific application:

- HELLO messages: This performs the task of link sensing, neighbour detection and MPR signalling;

- TC (Topology Control) messages: This advertises the link states and
- MID (Multiple Interface Declaration) messages: This is used to perform the multiple interface declaration on a node.

Formerly if all the information has been acquired through the message exchange, then the OLSR calculates route table for each node (Shastri et al 2010).

The control messages used by the OLSR are the 'hello' message and Topology Control (TC) messages.

2.1.1 HELLO and TC packet format of OLSR

The Figure 2 given below shows the hello packet format of OLSR. The reserved portions in the hello packets are used to perform further modifications. Htime is the time taken before the transmission of the next hello packet. Willingness specifies the node willingness to forward traffic. Link code means that it gives the information about link between sender node and neighbor node. The status of the neighbour node can also be represented. Link message size is the total length of link message. Neighbour interface address is the address of interface of neighbour node (Tokekar 2011).

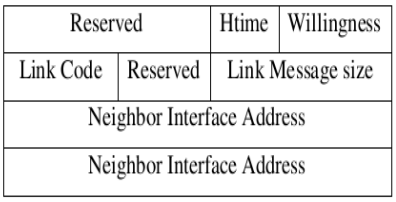

<table>
<tr><td colspan="2">Reserved</td><td>Htime</td><td>Willingness</td></tr>
<tr><td>Link Code</td><td>Reserved</td><td colspan="2">Link Message size</td></tr>
<tr><td colspan="4">Neighbor Interface Address</td></tr>
<tr><td colspan="4">Neighbor Interface Address</td></tr>
</table>

Figure 2 OLSR hello packet format

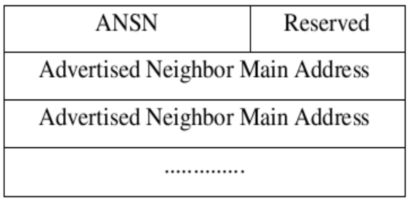

<table>
<tr><td>ANSN</td><td>Reserved</td></tr>
<tr><td colspan="2">Advertised Neighbor Main Address</td></tr>
<tr><td colspan="2">Advertised Neighbor Main Address</td></tr>
<tr><td colspan="2">..............</td></tr>
</table>

Figure 3 OLSR TC packet format

The Packet format for OLSR TC is given in Figure 3 above. Advertised Neighbor Sequence Number (ANSN) represents the increments in sequence number whenever there is a change in the neighbor set. The reserved field is used to represent further modifications in TC packets. Advertised Neighbour Main Address (ANMA) field consists of the main address of the neighbour node.

2.1.2 TC message significance

In the network, each node maintains topological information about the network with the help of TC messages. Nodes selected as MPR broadcasts the TC messages at regular intervals i.e. TC_interval. The TC message is originated from node which declares MPR selectors of that node. If any changes occur in the MPR selector set, then the TC messages can be sent earlier than pre specified interval. To avoid number of retransmissions the TC messages are sent to all nodes in the network by taking advantage of MPR nodes. Hence a node can be reachable directly or through its MPRs. Thus the topological information collected in each node consists of holding time i.e. Top_hold_time, after which the information is not valid (Tokekar 2011).

2.1.3 Neighbour sensing

In OLSR, the related information of neighbour nodes is gathered with “hello” messages which are sent over the network periodically. These “hello” messages are used to detect the changes in neighbour nodes and related information like interface address, type of link symmetric, asymmetric or lost and list of neighbours known to the node. Each node performs updates and maintains information set by describing the neighbour and two-hop neighbour periodically after some time.

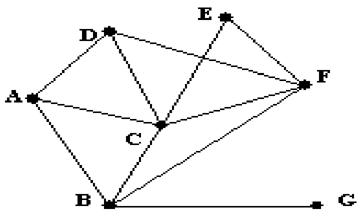
2.1.4 Route discovery of OLSR

For working in a distributed manner, OLSR does not depend on any of the central entity. Each node in the network chooses its MPR which is responsible to forward control traffic by flooding. The neighbour type can be a symmetric one, MPR or not a neighbor. Link type indicates whether the link is symmetric, asymmetric or a lost link. Hence a node is chosen as MPR if link to the neighbor is symmetric one.

A node builds a one hop routing table with the function of hello message information. It discards the duplicate packets with identical sequence number. The node is updated when there is a change in neighbour node or when the route to a destination has expired. OLSR does not require a sequenced delivery of messages because each control message consists of a sequence number and is incremented for each message (Adoni 2012).

2.2 Multi Point Relay (MPR)

To reduce the overheads due to flooding, MPRs are used. The MPRs reduce flooding of broadcasts by reducing the same broadcast to some regions in the network. Figure 4 given below shows the MPR selection in the network.



Node	1 Hop Neighbour	2 Hop Neighbour	MPR
B	A, C, F, G	D, E	C

Figure 4 Examples for MPR Selection

The basic idea of multipoint relay is to minimize the overhead of flooding messages in the network by reducing redundant re transmissions that occur in the same region. In MPR, a node is selected by its one hop neighbour to “re-transmit” all broadcast messages that it receives from other nodes by providing the information that the message is not a duplicate, and that the time-to-live field of the message is greater than one.

In OLSR Protocol, multi point relays use “hello” messages for finding its one hop neighbor and its two hop neighbors through their response. Each node has a multi point relay selection set, which is used to indicate, which node acts as a MPR. Messages are forwarded after the node gets a new broadcast message and message senders interface address in the MPR selector set. MPR selector set is used to update continuously by using “hello” messages, which are periodic. The neighbourhood nodes are dynamic in nature (Vats 2012).

The functions of MPRs are to minimize the overhead of routing messages by limiting the flooding effect of broadcast and provides a shortest path in OLSR (Malik et al 2012). A node sends hello messages to identify itself to its neighbours and the node also receives information about its immediate neighbours and 2-hop neighbours. With the hello message the MPR Selector set is constructed which describes which of the neighbours have chosen this host to act as MPR and from this information the host can calculate its own set of the MPRs. TC messages originate from the MRPs, it announces the node selection as MPR and is relayed through the entire network. The routing table is calculated using the shortest path algorithm (Dijkstra 1959).

Figure 1.5 shows an example of MPR flooding. In Figure 1.5 (a) all the neighbours relay messages which are transmitted by the leftmost node and MPR flooding is shown in Figure 1.5 (b), where only MPR nodes relay the message. This protocol is suitable for large and dense networks. In this manner a node announces that it has reachability to the nodes which have selected it as an MPR to the network. The protocol uses the MPRs to facilitate an efficient flooding of control messages in the network.

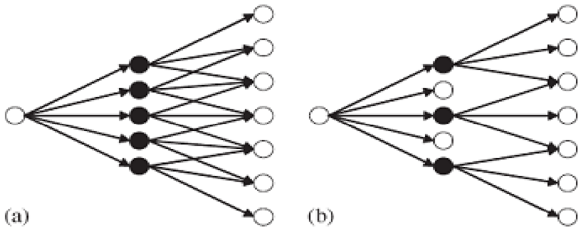


Figure 5 (a) Regular flooding and (b) MPR flooding

A node selects MPRs from among its available one hop neighbours with "symmetric", i.e., bi-directional, linkages. As a result, selection of the route through MPRs automatically avoids the problems associated with the data packet transfer over uni-directional links (Vidhya 2010).

The reactiveness to the topological changes can be adjusted by changing the time interval for broadcasting the hello messages or increasing the neighborhood holding time. This determines whether a link is present between a node and its neighbor. The reliability of the link is not an issue for the control messages, since the messages are sent periodically and the delivery need not be sequential. The soft state approach to signalling is used in OLSR. The routing state times out and is removed unless periodically refreshed by the receipt of routing updates. OLSR depends upon the soft state approach to maintain the consistency of topology information, and the consistency of routing tables amongst network nodes. So, apart from normal periodic messages, the protocol does not generate extra control traffic in response to the link failure and node join/leave events.

In OLSR, the soft state timers have two types of usage: message generation and state maintenance. Hello and TC interval timers are used to send periodic hello and TC messages, while state-maintenance timers keeps the updated state information in OLSR internal tables and removes obsolete state by time-out. By default, the OLSR neighbor state holding time is set to 3 times the value of the default OLSR hello interval; the OLSR TIB holding time is 3 times the default value of the TC interval. TIB and link-tuple timers' expiry interval equals the TIB holding time interval. When new nodes join the network, a node detects its new neighbors with a link-sensing process by sending periodic hello messages. When nodes leave the network, or links between the nodes go down, the corresponding link state in the link set and neighbour state in the neighbour set will be removed after the state holding timers expire. In addition, periodic TC messages help to recover loss of topology information caused by state corruption or nodes restarting. It is clear that the internal state maintenance in each node is related directly to the refresh intervals and so changing these has a greater impact of the protocol as a whole.

Traffic is shaped to represent Pulse Code Modulation (PCM) using G.711 codec. G.711 (ITU 1989) compresses 16-bit linear PCM data down to eight bits of logarithmic data. The *ITU-T Rec. G.711* presents two PCM audio codes called A-law and μ-law. They both transform linear PCM signal into logarithmic PCM. They both operate on single samples. A-law uses 13-bit linear PCM vector and transforms it into 8-bit logarithmic PCM vector while encoding process. μ-law uses 14-bit linear PCM, transforming it into 8-bit. Non-professional sound devices cannot generate either 14-bit sample. In this implementation 16-bit samples are passed to the input of coder. Every sample is converted into 14-bit sample by every sample is converted into 13 or 14-bit sample by cutting off the less significant bits. For a given input x, the A-law encoding (ITU 1989) is given below as Equation (5):

$$F(x) = \operatorname{sgn}(x)\begin{cases} \dfrac{A|x|}{1+In(A)}, & |x| < \dfrac{1}{A} \\ \dfrac{1+In(A|x|)}{1+In(A)}, & \dfrac{1}{A} \le |x| \le 1 \end{cases} \tag{5}$$

where A is the compression parameter.

The μ-law algorithm (ITU 1989) for encoding is given in Equation (6) as:

$$F(x) = \operatorname{sgn}(x)\frac{In(1+\mu|x|)}{In(1+\mu)} \qquad -1 \le x \le 1 \tag{6}$$

where μ=255 (8 bits).

It is proposed to investigate a modified OLSR routing protocol wherein traffic is shaped at the network layer based on the priority of the packet and an increased hello interval and topology control interval to reduce the control packet overhead. The proposed methodology is compared with existing OLSR routing protocol for multimedia traffic and streaming traffic.

2.3 Weighted Fair Queuing (WFQ)

It is based on a class of queue scheduling disciplines. When a packet completes transmission, the sent packet is one with the smallest value of F_i^α (Saravana Selvi et al 2012). The finishing time is calculated using Equations (7) and (8) which are given below.

$$F_i^\alpha = S_i^\alpha + \frac{P_i^\alpha}{\phi_\alpha} \tag{7}$$

$$S_i^\alpha = \max[F_{i-1}^\alpha, R(\tau_i^\alpha)] \tag{8}$$

With Generalized Processor Sharing (GPS), a flow α is assigned a weight $\emptyset_\alpha$ that determines the number of bits transmitted from that queue in each round. Effective packet length is $1/\emptyset_\alpha$ times true packet length. It can be seen that, at any given time, service rate gi for a non-empty flow i is calculated by using Equation (9) given below.

$$g_i = \frac{\phi_i}{\sum_j \phi_j} C \tag{9}$$

where the sum is taken over all active queues and C is outgoing link data rate. Maximum delay experienced by flow i, Di is bounded by equation 10 given below.

$$D_i \le \frac{B_i}{R_i} \tag{10}$$

The flows set is defined by and limited to token bucket specification. Bi and Ri are bucket size and token rate respectively for flow i. Weight assigned to each flow equals token rate. Under WFQ, the first ten packets of flow 1 have processor share finish times smaller than packets on other connections and transmit these packets first.

3 SIMULATION STUDY AND RESULTS

The simulation is carried out using OPNET Simulator Ver. 14.0 includes 20 nodes spread over 2000 meter by 2000 meter with each node's trajectory being at random. The nodes run a multimedia application over UDP. The data rate of every node is 11 Mbps with a transmit power of 0.005 Watts. Simulations are run for 400 sec. The parameters used in the OLSR routing protocol is shown in Table 1 below.

Table 1 OLSR Parameters used in simulation study

Hello interval in seconds	3
TC interval in seconds	7
Neighbour hold time in seconds	9
Topology hold time in seconds	21

Duplicate message hold time in seconds	30
Addressing mode	IPV4

Table 2 shows the network layer packet prioritizing. A weighted queuing approach is adapted with lowest priority for background traffic and very high traffic for streaming traffic where the QoS becomes an essential parameter.

Table 2 Packet Shaping in the Network Layer

Individual queue limit for low priority data	32 Packets
Individual queue limit for high priority data	64 Packets
Weights assigned for streaming packet	50
Weights assigned for multimedia packets	30

Multimedia traffic with First-in-First-Out and Weighted Fair Queuing are described below. The packet delivery ratio (PDR) for multimedia traffic, end to end delay for multimedia traffic, jitter for multimedia traffic, number of packets for multimedia traffic are measured for various hello intervals 1,2,3,4 and 5 seconds at various mobility speeds of the network for 0,5,10,15 and 20 m/s.

a. For Multimedia Traffic with FIFO

Multimedia traffic with first in first out queuing model is given below. The packet delivery ratio for multimedia traffic with FIFO is measured for hello intervals 1,2,3,4 and 5 seconds for mobility speeds 0, 5, 10, 15 and 20 m/sec. The data collected are shown in Table 3. The data in table 3 is transformed to a graph and is shown in figure 6.

Table 3 PDR for multimedia traffic

m/s	hello interval=1 sec	hello interval=2 sec	hello interval=3 sec	hello interval=4 sec	hello interval=5 sec
0	0.8919	0.902	0.9146	0.9321	0.9343
5	0.8749	0.8645	0.8822	0.856	0.8289
10	0.8429	0.8171	0.8082	0.7922	0.7785
15	0.8398	0.8051	0.7922	0.7833	0.7785
20	0.7651	0.7617	0.758	0.746	0.7365

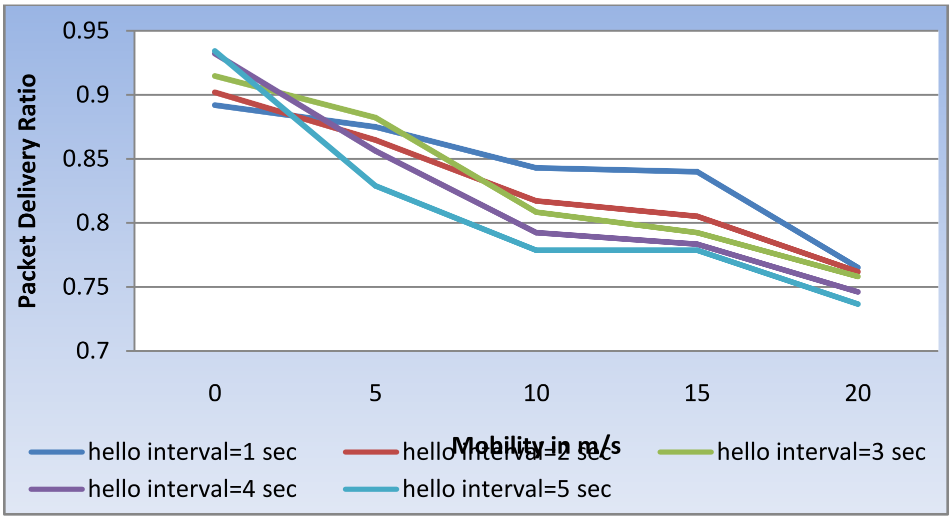


Figure 6 PDR for multimedia traffic

From figure 1.6 it is observed that the PDR achieved is higher for hello intervals of 4 seconds and 5 seconds and decreases with increasing mobility. For hello interval of 1 sec, and no mobility, the average PDR achieved is 1.94 % greater when compared to mobility speed of 5m/sec. It is 16.57% greater when compared to mobility is 20 m/sec. Similarly, for hello interval of 5 sec, and no mobility, average PDR achieved is 12.72% greater when compared to mobility speed of 5m/sec. It is 26.86% greater when compared to mobility speed of 20m/sec.

Table 4 End to end delay for multimedia traffic

m/s	hello interval=1 sec	hello interval=2 sec	Hello interval=3 sec	hello interval=4 sec	hello interval=5 sec
0	10.3265	10.5389	10.5708	11.3825	12.113
5	12.1439	12.5005	13.8553	14.6248	15.2945
10	13.5671	14.2578	16.9224	17.3454	18.0605
15	14.7344	15.7854	16.6136	18.1269	19.5171
20	17.4841	18.613	19.7549	20.0306	21.0246

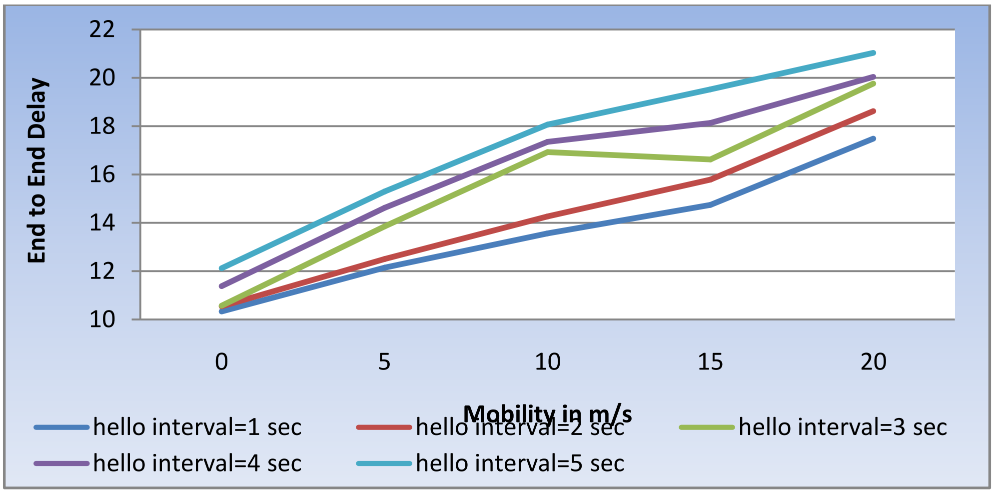


Figure 7 End to end delay for multimedia traffic

The contents of table 4 are graphically represented and is shown in Figure 7. From Figure 7, it is observed that the end to end delay increases as the hello interval and mobility increase. For hello interval of 1 sec, and no mobility, average end to end delay is 14.97% lesser compared to mobility speed of 5m/sec. It is 40.94% lesser when compared to mobility speed of 20 m/sec. Similarly, for hello interval of 5 sec, and no mobility, average end to end delay is 20.8% lesser when compared to mobility speed of 5 m/sec. It is 42.39% lesser when compared to mobility speed of 20 m/sec.

Table 5 Jitter for multimedia traffic

m/s	hello interval=1 sec	hello interval=2 sec	hello interval=3 sec	hello interval=4 sec	hello interval=5 sec
0	1.1161	1.0549	1.1792	1.0781	1.4928
5	1.2814	1.4541	1.5196	1.105	1.0491
10	1.3004	1.2595	1.2684	1.3242	1.0996
15	1.3772	1.0827	1.3776	1.1504	1.5125
20	1.591	1.2587	1.1839	1.3029	1.5311

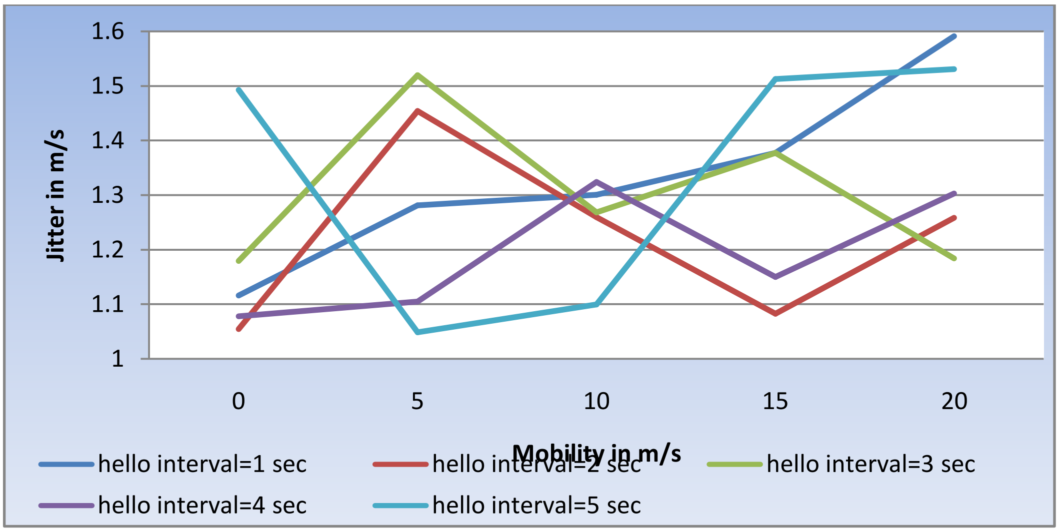


Figure 8 Jitter for multimedia traffic

The contents of Table 5 are graphically represented and is shown in Figure 8. From Figure 8, it is observed that the jitter varies drastically with the hello interval and mobility. For hello interval of 1 sec, and no mobility, the average jitter is 12.9% lesser compared to mobility speed of 5 m/sec. It is 29.85% lesser when compared to mobility speed of 20 m/sec. Similarly, for hello interval of 5 sec, and no mobility, average jitter is 20.8% lesser compared to mobility speed of 5 m/sec. It is 42.39% lesser compared to mobility speed of 20 m/sec.

Table 6 No of TC packets for multimedia traffic

m/s	hello interval=1 sec	hello interval=2 sec	hello interval=3 sec	hello interval=4 sec	hello interval=5 sec
0	360	324	302	294	293
5	468	457	415	409	411
10	487	478	462	457	459
15	504	494	491	487	486
20	563	532	527	522	524

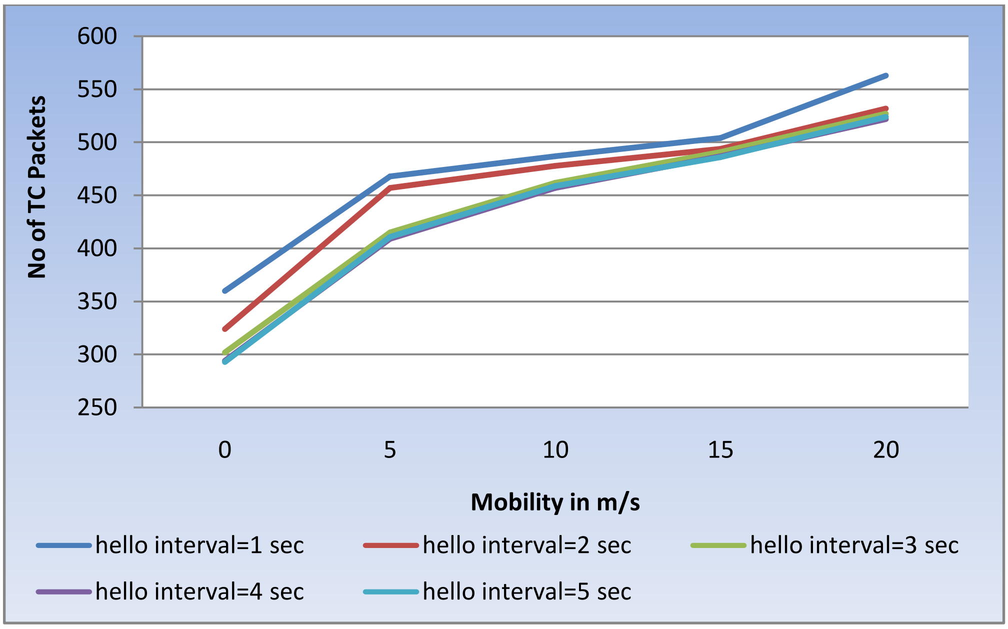


Figure 9 No. of TC packets for multimedia traffic

The contents of Table 6 are graphically represented and are shown in Figure 9. From Figure 9, it is observed that the number of TC packets increases with mobility and decreases as the hello interval increase. For hello interval of 1 sec, and no mobility, the average number of TC packets is 23.08% lesser when compared to mobility speed of 5 m/sec. It is 36.06% lesser when compared to mobility speed of 20 m/sec. Similarly, for hello interval of 5 sec, and no mobility, the average number of TC packets is 28.71% lesser when compared to mobility speed of 5 m/sec. It is 44.08% lesser when compared to mobility speed of 20 m/sec.

b. For Multimedia Traffic with WFQ

Multimedia traffic with WFQ queuing model is given below. The packet delivery ratio for multimedia traffic with WFQ is measured for hello intervals 1,2,3,4 and 5 seconds for mobility speeds 0, 5, 10, 15 and 20 m/sec. The data collected are shown in the Table 7. The data in table 7 is transformed to a graph and is shown in Figure 10.

Table 7 PDR for multimedia traffic

m/s	hello interval= 1 sec	hello interval= 2 sec	hello interval= 3 sec	hello interval = 4 sec	hello interval= 5 sec
0	0.8825	0.8877	0.8941	0.9105	0.9094
5	0.8594	0.8493	0.8594	0.8356	0.8063
10	0.8247	0.8004	0.7864	0.7711	0.7492
15	0.8201	0.784	0.7652	0.7556	0.7463
20	0.7446	0.7379	0.7268	0.7137	0.7056

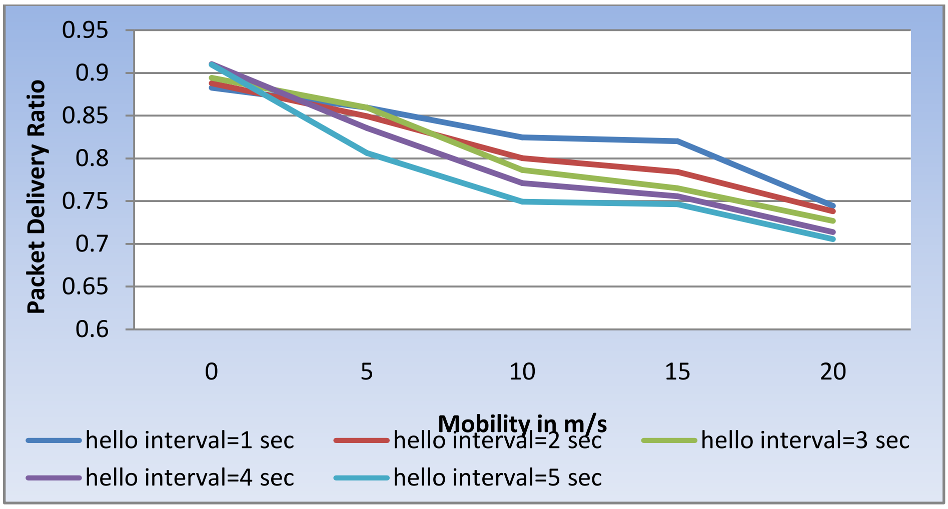


Figure 10 PDR for multimedia traffic

The contents of Table 7 are graphically represented and is shown in Figure 10. From Figure 10, it is observed that the PDR achieved using WFQ is higher for hello interval of 4 sec and decreases with increasing mobility. For hello interval of 1 sec, and no mobility, average PDR achieved is 2.69% greater compared to mobility speed of 5m/sec. It is 18.52% greater compared to mobility speed of 20 m/sec. Similarly, for hello interval of 4 sec, and no mobility, the average PDR achieved is 8.96% greater compared to mobility speed of 5 m/sec. It is 27.57% greater when compared to mobility speed of 20 m/sec. For hello interval of 5 sec, it is also observed that the PDR achieved is 2.74% greater compared to mobility speed of 5 m/sec. It is 4.38 % greater compared to mobility speed of 5m/sec.

Table 8 End to end delay for multimedia traffic

m/s	hello interval= 1 sec	hello interval= 2 sec	hello interval= 3 sec	hello interval= 4 sec	hello interval= 5 sec
0	10.1737	10.3165	10.353	11.2664	11.8296
5	11.8148	12.2705	13.5948	14.268	14.9748
10	13.3677	13.8885	16.5738	17.1338	17.7878
15	14.5222	15.3339	16.2165	17.6393	19.3278
20	17.1694	18.399	19.2847	19.8163	20.5158

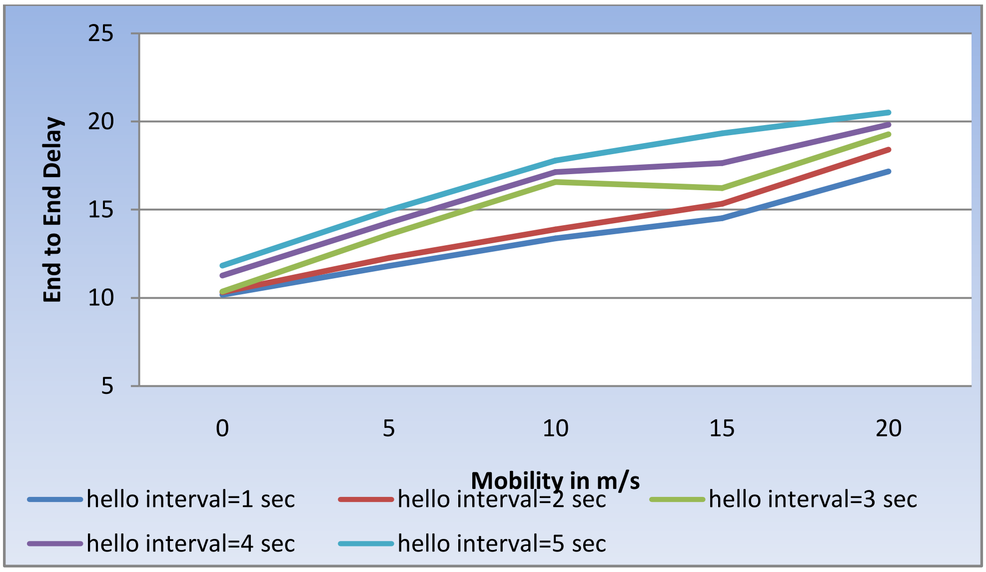


Figure 11 End to end delay for multimedia traffic

The contents of Table 8 are graphically represented and is shown in Figure 11. From Figure 11, it is observed that the end to end delay for multimedia traffic with WFQ increases as the hello interval and mobility of nodes increases. For hello interval of 1 sec, and no mobility, the average end to end delay is 13.89% lesser compared to mobility speed of 5 m/sec. It is 40.75% lesser compared to mobility speed of 20 m/sec. Similarly, for hello interval of 5 sec, and no mobility, the average end to end delay is 21% lesser compared to mobility speed of 5 m/sec. It is 42.34% lesser compared to mobility speed of 20 m/sec.

Table 9 Jitter for multimedia traffic

m/s	hello interval= 1 sec	hello interval= 2 sec	hello interval= 3 sec	hello interval= 4 sec	hello interval= 5 sec
0	1.101	1.0298	1.1569	1.0602	1.4701
5	1.251	1.4129	1.4827	1.0802	1.0332
10	1.2856	1.2236	1.2331	1.3031	1.0768
15	1.3487	1.0564	1.3499	1.1292	1.4819
20	1.56	1.2328	1.1562	1.2832	1.5146

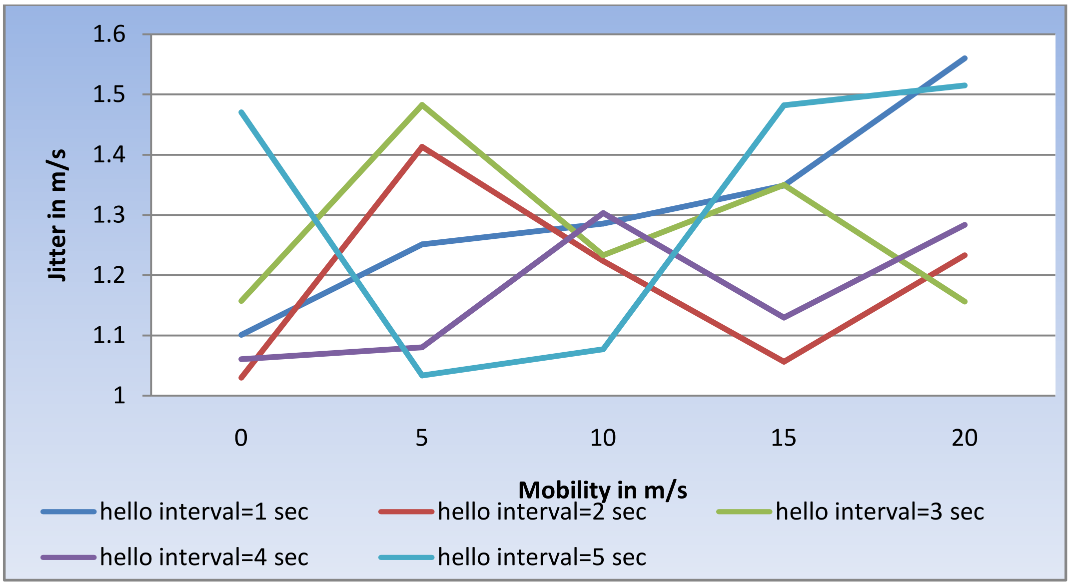


Figure 12 Jitter for multimedia traffic

The contents of Table 9 are graphically represented and is shown in Figure 12. From Figure 12, it is observed that jitter varies randomly with various hello intervals and mobility of nodes. For hello interval of 1 sec, and no mobility, the average jitter is 11.99% lesser compared to mobility speed of 5 m/sec. It is 29.42% lesser compared to mobility speed of 20 m/sec. Similarly, for hello interval of 5 sec, and no mobility, the average jitter is 42.29% lesser compared to mobility speed of 5 m/sec. It is 2.94% lesser compared to mobility speed of 20 m/sec.

Table 10 No. of TC packets for multimedia traffic

m/s	hello interval= 1 sec	hello interval= 2 sec	hello interval= 3 sec	hello interval= 4 sec	hello interval= 5 sec
0	356	318	294	290	289
5	463	451	407	404	401
10	479	472	454	445	451
15	493	485	480	476	474
20	547	522	516	510	513

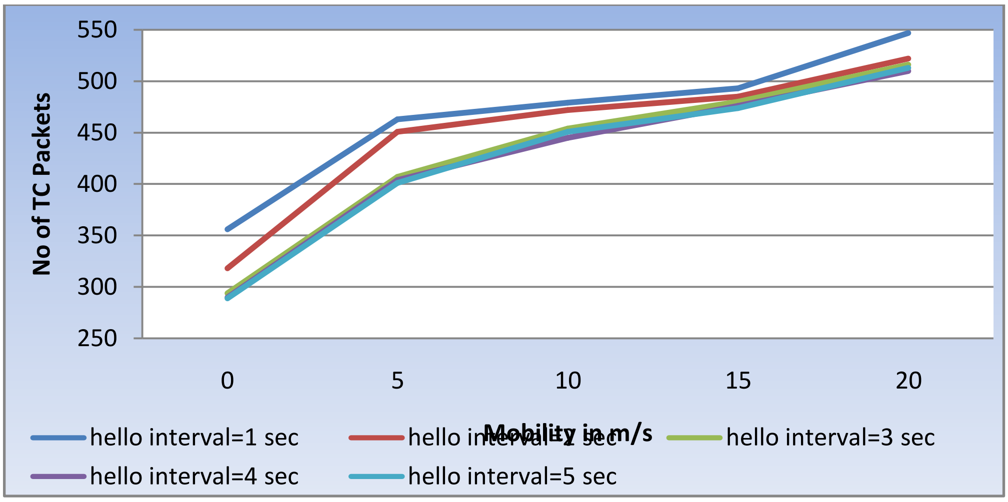


Figure 13 No. of TC packets for multimedia traffic

The contents of Table 10 are graphically represented and is shown in Figure 13. From Figure 13, it is observed that the number of TC packets increases with mobility of nodes and decreases with increase in hello intervals. For hello interval of 1 sec, and no mobility, the average number of TC packets is 23.11% lesser compared to mobility speed of 5 m/sec. It is 34.92% lesser compared to mobility speed of 20 m/sec. Similarly, for hello interval of 5 sec, and no mobility, the average number of TC packets is 27.93% lesser compared to mobility speed of 5 m/sec. It is 43.66% lesser when compared to mobility speed of 20 m/sec.

4 CONCLUSION

a. Among routing protocols available to deliver data packets from source to destination, OSLR protocol constantly updates topology information and routes which are available. It is observed that the control traffic overhead decreases with modifications in OLSR routing protocol using traffic shaping based on packet priority. Investigations were carried out for multimedia traffic with FIFO and WFQ for various QoS parameters namely PDR, end to end delay, jitter and no. of TC packets.

b. For multimedia traffic using FIFO, it is observed that the PDR achieved is higher for hello intervals of 4 seconds and 5 seconds and decreases with increasing mobility. For hello interval of 1 sec, and no mobility, the average PDR achieved is 1.94 % greater when compared to mobility speed of 5 m/sec. It is 16.57% greater when compared to mobility speed of 20 m/sec. Similarly, for hello interval of 5 sec, and no mobility, average PDR achieved is 12.72% greater when compared to mobility speed of 5 m/sec. It is 26.86% greater when compared to mobility speed of 20 m/sec.

c. For multimedia traffic using WFQ it is observed that the PDR achieved using WFQ is higher for hello interval of 4 sec and decreases with increasing mobility. For hello interval of 1 sec, and no mobility, average PDR achieved is 2.69% greater compared to mobility speed of 5 m/sec. It is 18.52% greater compared to mobility speed of 20 m/sec. Similarly, for hello interval of 4 sec, and no mobility, the average PDR achieved is 8.96% greater compared to mobility speed of 5 m/sec. It is 27.57% greater when compared to mobility speed of 20m/sec. For hello interval of 5 sec, it is also observed that the PDR achieved is 2.74% greater compared to mobility speed of 5 m/sec. It is 4.38 % greater compared to mobility speed of 5 m/sec.

d. For multimedia traffic with FIFO, it is observed that the end to end delay increases as the hello interval and mobility increase. For hello interval of 1 sec, and no mobility, average end to end delay is 14.97% lesser compared to mobility speed of 5m/sec. It is 40.94% lesser when compared to mobility speed of 20m/sec. Similarly, for hello interval of 5 sec, and no mobility, average end to end delay is 20.8% lesser when compared to mobility speed of 5m/sec. It is 42.39% lesser when compared to mobility speed of 20m/sec.

e. For multimedia traffic with WFQ, it is observed that the end to end delay increases as the hello interval and mobility of nodes increase. For hello interval of 1 sec, and no mobility, the average end to end delay is 13.89% lesser compared to mobility speed of 5m/sec. It is 40.75% lesser compared to mobility speed of 20m/sec. Similarly, for hello interval of 5 sec, and no mobility, the average end to end delay is 21% lesser compared to mobility speed of 5m/sec. It is 42.34% lesser compared to mobility speed of 20m/sec.

f. For multimedia traffic with FIFO it is observed that the jitter varies drastically with the hello interval and mobility. For hello interval of 1 sec, and no mobility, the average jitter is 12.9% lesser compared to mobility speed of 5m/sec. It is 29.85% lesser when compared to mobility speed of 20 m/sec. Similarly, for hello interval of 5 sec, and no mobility, average jitter is 20.8% lesser compared to mobility speed of 5 m/sec. It is 42.39% lesser compared to mobility speed of 20 m/sec.

g. For multimedia traffic with WFQ it is observed that the jitter varies randomly with various hello intervals and mobility of nodes. For hello interval of 1 sec, and no mobility, the average jitter is 11.99% lesser compared to mobility speed of 5 m/sec. It is 29.42% lesser compared to mobility speed of 20 m/sec. Similarly, for hello interval of 5 sec, and no mobility, the average jitter is 42.29% lesser compared to mobility speed of 5 m/sec. It is 2.94% lesser compared to mobility speed of 20 m/sec.

h. For multimedia traffic with FIFO it is observed that the number of TC packets increases with mobility and decreases as the hello interval increases. For hello interval of 1 sec, and no mobility, the average number of TC packets is 23.08% lesser when compared to mobility speed of 5m/sec. It is 36.06% lesser when compared to mobility speed of 20m/sec. Similarly, for hello interval of 5 sec, and no mobility, the average number of TC packets is 28.71% lesser when compared to mobility speed of 5m/sec. It is 44.08% lesser when compared to mobility speed of 20 m/sec.

i. For multimedia traffic with WFQ it is observed that the number of TC packets increases with mobility of nodes and decreases with increase in hello intervals. For hello interval of 1 sec, and no mobility, the average number of TC packets is 23.11% lesser compared to mobility speed of 5m/sec. It is 34.92% lesser compared to mobility speed of 20 m/sec. Similarly, for hello interval of 5 sec, and no mobility, the average number of TC packets is 27.93% lesser compared to mobility speed of 5 m/sec. It is 43.66% lesser when compared to mobility speed of 20 m/sec.

j. From the results obtained it is observed that the hello interval plays a crucial role in improving the QoS parameters and the same is dependent on the mobility of the nodes. Though the network parameters like PDR, end to end delay, jitter and no. of TC packets are studied for OLSR protocol with multimedia traffic using FIFO and WFQ, other techniques to improve the performance need to be identified and experimented to improve the QoS parameters.

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