IMPACT OF DIFFERENT TRAFFICS ON OLSR PROTOCOL IN MANET

By

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A Dissertation submitted to the Department of Electrical Engineering, Bayero University Kano, in partial fulfillment of the requirements for the award of the degree of Masters in Electrical Engineering (Communication Engineering Option)

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DECLARATION PAGE

I, MASHHOOD ISMAIL AHMAD, SPS/12/MEE/00006 hereby declare that this work is the product of my research efforts undertaken under the supervision of Dr. Dahiru Sani Shuaibu and has not been presented anywhere for the award of degree or certificate. All sources have been duly acknowledged.

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CERTIFICATION PAGE

This is to certify that the research work for this Dissertation and the subsequent write-up by (Mashhood Ismail Ahmad, SPS/12/MEE/00006), were carried out under my supervision. The report has been prepared and written in accordance with the requirements of the Department of Electrical Engineering for the award of degree of Masters (M.Eng.) in Electrical Engineering, Communication Option.

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This is to certify that this Dissertation report on *Impact of Different Traffics on OLSR Protocol in MANET* has been examined and approved by the undersigned persons on behalf of the Department of Electrical Engineering, Bayero University, Kano, as meeting one of the requirements for the award of Masters Degree (M.Eng.) in Electrical Engineering, Communication Option.

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LIST OF ABBREVIATIONS

BER	Bit Error Rate

DSDV	Destination Sequence Distance Vector
DSR	Dynamic Source Routing
FTP	File Transfer Protocol
GPS	Global Positioning System
IEEE	Institute of Electrical and Electronics Engineers
LAN	Local Area Network
MAC	Medium Access Control
MANET	Mobile Ad hock Network
MATLAB	Matrix Laboratory
OLSR	Optimized Link State Routing Protocol
SANET	Static Ad hoc Network
TCP	Transmission Control Protocol
TORA	Temporally Ordered Routing Algorithm
TTL	Time-To-Live
ZHLS	Zone-Based Hierarchical Link State

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ABSTRACT

Mobile Ad hoc network (MANET) is a multi-hop ad hoc wireless network where nodes can move arbitrarily in the topology via routing protocols. Routing protocols are procedures used in transmitting packets from source to destination. Routing protocols are categorized as Reactive, Proactive and hybrid Routing Protocols. OLSR protocol was used to maintain the routing table through storing information of the neighbours. The challenges encountered in the ad hoc network is the effect of mobility which is caused by signal fading, inter-symbol interference, distortions etc, hence the use of routing protocol to negate the abnormality and the impact of different traffic. This is achieved by simulating and analyzing OLSR protocol using throughput, delay and fairness based on different traffics as performance metrics. The study showed an improved performance in terms of metrics used compared to existing work by (Rawendra Pratap (2012)). it was found that voice traffic has high throughput and moderate delay, and then followed by file transfer protocol (ftp) traffic in both throughput and delay, and then video conferencing traffic and email in that order. In the case of fairness, video conferencing traffic has better fairness followed by ftp with low throughput and then Email traffic. It was also shown that throughput has improved to 18.64% and 7.77% for voice & email traffics respectively. A reduction in delay for voice traffic of 52.6% and improvement of 48.1% for email were also achieved.

CHAPTER ONE

INTRODUCTION

1.0 BACKGROUND

Wireless network is a collection of nodes which are interconnected together through wireless link e.g. radio link. In terms of node accessibility to the network, wireless network can be classified into two types (K. Sharma, N. Mittal and P. Rathi 2014):

1. Cellular Wireless Network

2. Ad Hoc Wireless Network

The Cellular Wireless Networks is infrastructure dependent networks, where the node communicates through a base station. In the other hand, Ad Hoc wireless network utilizes multi hop radio relaying and are capable of operating without fixed infrastructures. Here, the absence of a central coordinator makes routing a complex one as compared to cellular network. In order to standardize the protocols and functionalities of Ad Hoc Wireless Network, Mobile Ad hoc Networks (MANET) was formed. It is a self –configuring network of mobile nodes connected using wireless links forming a random topology.

However, nodes move freely and randomly. The range of the MANETs applications can be static area networks to highly dynamic area networks. The main challenge of designing MANETs is developing a robust routing protocol which can ease communication between mobile nodes. The role of routing protocol is to find a path which data packets can follow from source to destination (K. Sharma, N. Mittal and P. Rathi (2014))

A mobile ad hoc network may consist of a minimum of two nodes, hundred nodes or thousand nodes as well. The entire collection of nodes is interconnected in many different ways. As shown in Figure. 1.0 there is more than one path from one node to another node. To forward a data packet from source to destination, every node in the network must be willing to participate in the process of delivering the data packet. For example, a single file data stream is split into a number of data packets and then these data packets are transmitted through the different paths. At the destination node, all these packets are combined in sequence to generate the original file (Sandeep Kaur and Supreet Kaur (2013))

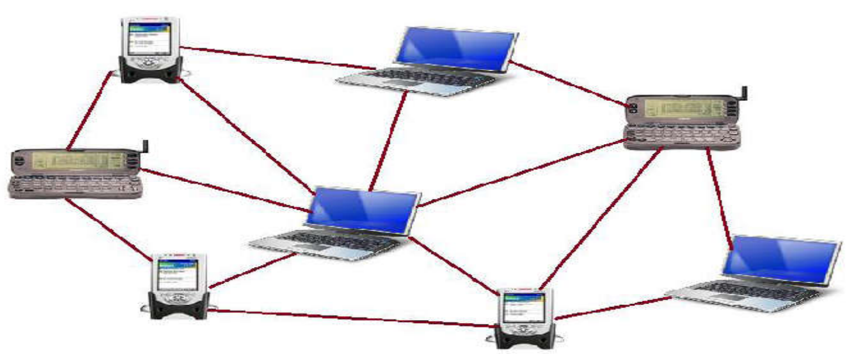


Figure 1.0: Mobile Ad hoc Network

The growing interest in Mobile ad hoc Network techniques has resulted in many routing protocols. The routing protocols used in MANET are dissimilar from routing protocols used in conventional wired networks (R Kumar, M Sharma, N Kaur and G Singh (*2014)*).

1.1 MOTIVATIONS

It is of great concerned on rapid usability of wireless networks in everyday activities of human endeavor and indeed mobile ad hoc network has surpassed when compared with static ad hoc network. It has been reviewed by some researchers the performance of OLSR based on CBR & VBR traffic. Thus, in this work; it was proposed to consider voice, video conferencing, ftp & Email traffics because of their importance in the networking and internet applications. So, it's decided to work on throughput, delay and fairness performance metrics as a guide of getting the behavior of the protocol in order to improve on its service delivery.

1.2 PROBLEM STATEMENT

Mobile ad hock network (MANET) is supporting temporary-oriented network where every node in the network is free to change position. The major challenge faced is the effect of mobility which eventually causes signal fading, inter-symbol interference, distortions etc. Consequently, routing becomes a vital factor and a major challenge in such a network in order to curtail the effect of mobility. The routing protocol that is considered in the research is Optimized Link State Routing (OLSR).

1.3 AIM AND OBJECTIVES

The aim of this research is to find out the impact of different traffics on OLSR protocol in MANET in order to enhance the performance of the protocol.

The following objectives are set in order to achieve the above aim:

- To verify an OLSR protocol in MANET.

- To simulate & analyze the performance of the verified OLSR protocol based on throughput, delay & fairness performance metrics for different traffics.
- To compare the performance of the verified protocol with existing algorithm and traffics in Rawendra Pratap Singh1, Savita Shiwani2 (2012).

1.4 METHODOLOGY

The methods to be adopted in carrying out this research include:

1. Mathematical modeling of node topology in order to discover neighbours in random topology set up of 70 nodes.
2. Preprocessing of the neighbours discovered for every node by transforming it into Matlab format (matrix).
3. The matrices are then processed to find out the shortestpath/route of the network
4. Performance of the network is analyzed based on throughput, delay & fairness.
5. The above performance is further compared with existing work of Rawendra Pratap Singh1, Savita Shiwani2 (2012) through simulation.

1.5 SCOPE OF THE THESIS

The research comprises of 70 nodes in a MANET network. The traffics involved are voice, video Conferencing, FTP and Email traffics on a simulated area of 2000m by 2000m. In neighbour discovery of OLSR protocol, Friss equation (free space propagation) is proposed to model the olsr Protocol. MATLAB modeler is used in modeling the network and indeed carrying out the simulations.

1.6 SIGNIFICANCE OF STUDY

MANET is widely useful in our life, the protocols that guide the packet transmission is of paramount importance. The goal in this study is to evaluate the performance of optimized link-state routing protocol (OLSR) and to find the impact of traffic (voice, video conferencing, ftp & Email) on the said protocol based on the performance parameters (delay, throughput & fairness). There is need to improve the reliability, efficiency and robustness of the protocol because these traffics have different behaviors with respect to performance parameters.

1.7 THESIS STRUCTURE

The report is organized in the following format:

Chapter one is a general introduction, chapter two contains MANET, OLSR & its Route Discovery. Chapter three presents Research Methodology. Chapter four covers Simulation & Result analyses and finally conclusion and recommendation are presented in Chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

In the beginning of this chapter, classification of wireless networks such as infrastructure networks and ad hoc networks or infrastructure-less network were discussed. Then, OLSR protocol features, operations etc are also discussed.

MANET have a dynamic nature, a large number of applications make them ideal to use. Quick deployment and minimal configuration of MANET in emergencies such as natural disaster makes them more suitable. The growth of technology makes increase in Wi-Fi capable laptops, mobile phones, MP3 players and other small portable devices become a genuine reason for MANET popularity.

Extensive research work has been done on the performance evaluation of OLSR protocol using different simulator such as opnet, ns2. MATLAB software is chosen in the study because of the following advantages among others:

- Flexibility
- Affordability
- Readily available

Different methods and simulation environments give different results for MANET routing protocol performance. The aim of this thesis is to provide the impact of different traffic Applications on OLSR protocol in MANET. Voice, video conferencing, ftp & Email traffic applications are considered in conducting the research. The project goal is to simulate the above protocol and provide graphical results based on throughput, delay & fairness performance metrics based on voice, video Conferencing, ftp & Email traffic. The simulations will have a strong link with the theoretical concept and also with the expected performance in practical and real time implementation.

2.1 WIRELESS NETWORK

A Network is a collection of two or more nodes which are logically connected together to perform certain task. The nodes may or may not be physically connected in following topologies among others.

- Ring topology
- Mesh topology
- Token-ring topology
- Random topology etc

Network can either be wired as in wired network or not-wired as in wireless network. Wireless network is a network which connects mobile nodes through wireless link.

2.2. TYPES OF WIRELESS NETWORK

One of the distinct features of wireless networks as compare to wire network is that data is transmitted from one point to another through wireless links i.e. there is no need of wired link between the two nodes for transmission. They just need to be in the transmission range of each other. A wireless network is divided into two categories: Cellular Wireless Networks (Infrastructure) and ad hoc wireless network (infrastructure less).

2.2.1 Cellular Wireless Network

This is infrastructure dependent network because it has a fixed network topology. Wireless nodes connect through the fixed point known as base station or access point. In most cases the access point or base station is connected to the main network through wired link. The base station, or access point, is one of the important elements in such types of networks hence the term infrastructure dependent because of the presence of access point (base station). All of the wireless connections must pass from the base station. Whenever a node is in the range of several base stations then it connect to any one of them on the bases of some criteria (K. Leung and Vivtor O.K. Li, (2006)).

2.2.2 Ad hoc Wireless Network

Ad hoc network is also called infrastructure-less network which is a complex distributed system consisting of wireless links between the nodes and also each node works as a router to forward the data on behalf of other nodes. Nodes are randomly positioned which can easily join or depart the network upon any change of node information. Thus the networks have no permanent infrastructure. In ad hoc networks the nodes can be stationary or mobile. Therefore one can say that ad hoc networks basically have two forms, one is static ad hoc networks (SANET) and the other one is called mobile ad hoc networks (MANET). From the introduction of new technologies such as IEEE 802.11 (IEEE Standard 802.11(2007)) the commercial implementation of ad hoc network becomes possible (A. A. Hanbali, E. Altman, and P. Nain, (2005)).

One of the good features of such networks is the flexibility and can be deployed very easily. Thus it is suitable for the emergency situation. But on the other side it is also very difficult to handle the operation of ad hoc networks. Each node is acting as a router in the network. Topology changes are very frequent and thus there will be need for an efficient routing protocol, whose construction is a complex task. TCP performances are also very poor in mobile ad hoc network.

2.3 ROUTING PROTOCOLS IN MANET

Data link and network layers are among the layers used in wireless network, therefore active research work for MANET was carried out mainly in the fields of Medium Access Control (MAC), routing, resource management, power control, and security. Because of the importance of routing protocols in dynamic multi-hop networks, a lot of MANET routing protocols have been proposed in the last few years. When thinking about any routing protocol MANET contains special properties. The following properties are expected though all of these might not be possible to incorporate in a single solution.

- A routing protocol for MANET should be distributed in a manner in order to increase its reliability.
- The routing protocol should consider its security.
- A hybrid routing protocol should be much more reactive than proactive to avoid overhead.
- A routing protocol must be designed considering unidirectional links because wireless medium may cause a wireless link to be opened in one direction only due to physical factors.
- A routing protocol should be aware of Quality of Service.
- The routing protocol should be power-efficient (V Singh & Yadav (2013)).

MANET is an infrastructure less network because mobile nodes in the network are subject to change and create paths dynamically among themselves to broadcast packets. Each node functions as a router to forward packets if it is not an end node. MANET can be viewed as a random graph because the nodes in the wireless network keep on moving. The nodes can move anywhere and organize themselves into the network. Since MANET has dynamic topology, it possesses several salient features like resource constraints, limited physical security, and no infrastructure (D. Cañas, A. L.Orozco, L. J. García and P.-S. Hong (2013)). The nodes may join or depart the network at any time, and thus wireless links are constantly created and destroyed.

Based on routing information update mechanism the routing protocols can be categorized as (K. Sharma, N. Mittal and P. Rathi (2014)):

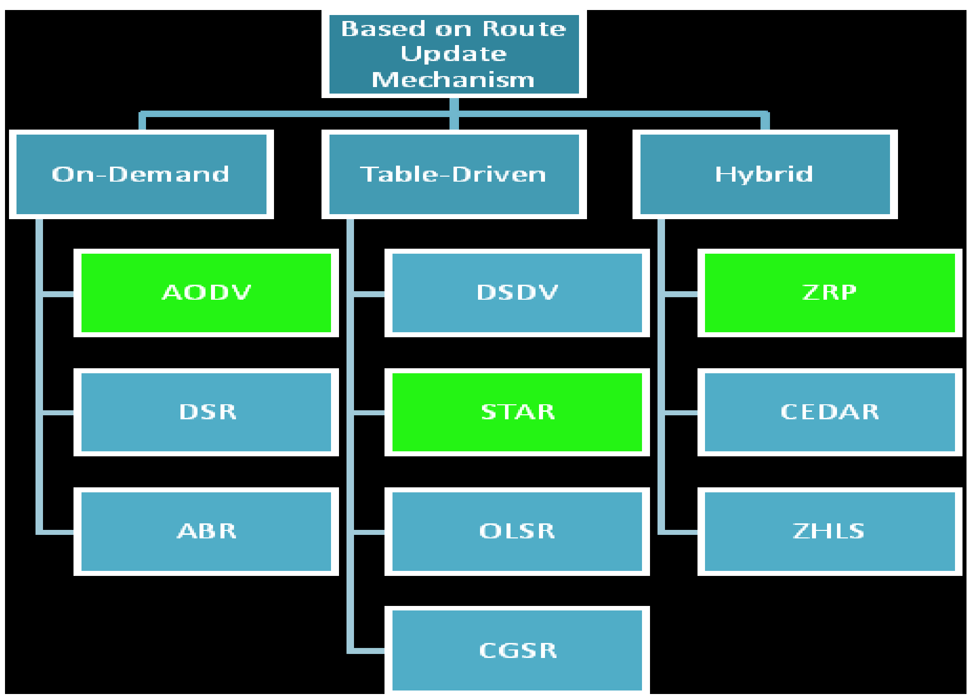


Figure 2.1: Types of Routing Protocols

2.3.1 Proactive Protocol (Table Driven)

These protocols require each node to maintain one or more table to store routing information and they respond to changes in network topology by propagating updates of routes throughout the network in order to maintain a consistent network view (P Malik & A. Rana (2014)). It's also known as table driven because link state/distance vector algorithm is used in its route establishment where a table of information relating to routing in each node is formed. As route is already specified in the table so packet forwarding is faster and as the routes have to be defined first before transferring the packets so overhead is more (Sandeep Kaur and Supreet Kaur (2013)). All routes are maintained at all the times so latency is low.

2.3.2 Reactive Protocol (On-demand/Source Initiated)

In reactive routing protocols a route discovery procedure is started whenever a node demand for a route for packet transmission. This type of routing protocol is also known as on-demand routing protocol or source-initiated routing protocol. The main feature of reactive protocol is that it imposes less overhead due to route messages on the network (P Malik & A Rana (2014)). This route discovery mechanism is based on flooding algorithm which employs technique where a node will broadcast a packet to all its neighbours and intermediate nodes forwards the packets to their neighbours (Sandeep Kaur and Supreet Kaur (2013)). Thus, Overhead is smaller in reactive protocols but latency is higher.

2.3.3 Hybrid Protocol

Hybrid routing protocol combines the advantages of both proactive and reactive routing protocols. These protocols exploit the hierarchical network architecture and allow the nodes with close proximity to work together to form some sort of backbone, thus increasing scalability and reducing route discovery (Sandeep Kaur and Supreet Kaur (2013)). It proactively maintains routes for nearby nodes and acts reactively to far nodes (G Jayakumar, and G. Gopinath (2007)). Nodes within a particular geographical area are said to be within the routing zone of a given node. For routing within this zone, Proactive i.e. table-driven approach is used. For nodes that are located outside this zone, Reactive i.e. on demand approach is used (Sandeep Kaur and Supreet Kaur (2013))

2.3.4 Optimized Link State Routing Protocol *(OLSR)*

OLSR is a proactive routing protocol. Every node of a network maintains information about all routes in route table; when a route is needed, the route table is immediately available (P Mittal, P Singh & S Rani 2013).

OLSR protocol is an optimization for MANET of legacy link-state protocols. The key point of the optimization is the multipoint relay (MPR). Each node identifies (among its neighbors) its MPRs. By flooding a message to its MPRs, a node is guaranteed that the message, when retransmitted by the MPRs, will be received by all its two-hop neighbors. Furthermore, when exchanging link-state routing information, a node lists only the connections to those neighbors that have selected it as MPR, i.e., its Multipoint Relay Selector set. The protocol selects bi-directional links for routing, hence avoiding packet transfer over unidirectional links (G Jayakumar, and G. Gopinath (2007)).

2.4 OLSR OPERATION

OLSR operates in the network layer which is based on link state algorithm that maintain topology information at each node by employing periodic exchange of messages due to the proactive or table-driven nature of the protocol.

Initially, the nodes emits HELLO message to its neigbouring nodes after which the control message is used to choose which neighbor is characterized as either symmetric or asymmetric. Symmetric neighbors are those which communicate in bidirection while asymmetric are unidirectional in their communication mode. Having identified symmetric neighbors from one hop neighbours, the two hop neighbor will further use one hop neighbour to detect symmetric neighbors. Through two hop neighbors, HELLO message are rebroadcast to neighbors of the two hop neighbors to select multipoint relaying nodes (MPR) using willingness portion of the HELLO message.

However, upon selection of MPRs; an MPR selector set is establish which is a set of nodes that is been selected by a particular MPR. After selection of the MPRs, the nodes generate and broadcast the topology control messages to all its neighbors up to where the message is destine to be.

2.4.1 Flooding Technique

Relaying of messages is what makes flooding in MANET possible. OLSR specifies a *default forwarding algorithm* that uses the MPR information to flood packets. But all messages received that carries a type not known by the local node, must be forwarded according to the default forwarding algorithm. The algorithm can be outlined as:

1. If the link on which the message arrived is not considered symmetric, the message is silently discarded. To check the link status the link set is queried.

2. If the TTL carried in the message header is 0, the message is silently discarded.

3. If this message has already been forwarded the message is discarded. To check for already forwarded messages the duplicate set is queried.

4. If the last hop sender of the message, not necessarily the originator, has chosen this node as MPR, then the message is forwarded. If not, the message is discarded. To check this, the MPR selector set is queried.

5. If the message is to be forwarded, the TTL of the message is reduced by one and the hop-count of the message is increased by one before broadcasting the message on all interfaces.

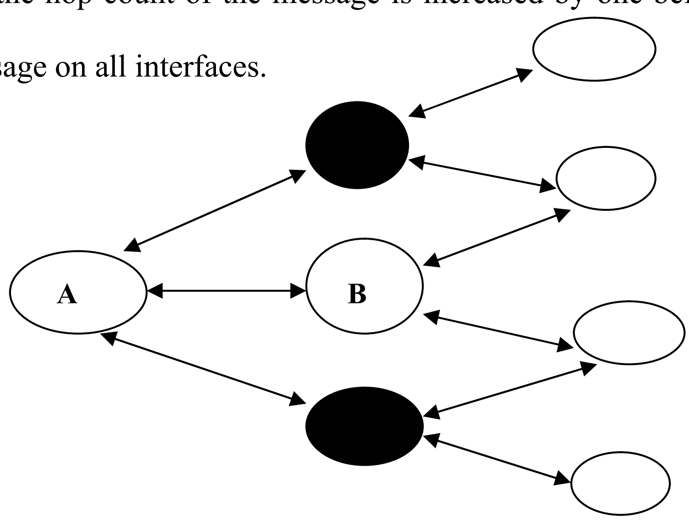


Figure 2.2: Node A has selected the Black nodes as its MPRs (Andreas Tønnesen (*2004)*).

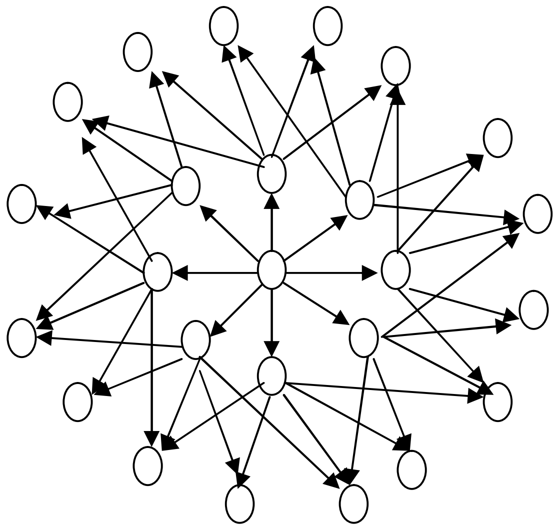


Figure 2.3: Flooding a packet in a wireless Multihop Network. The arrows show the way information is passed, *not* all transmissions (Andreas Tønnesen (*2004)*).

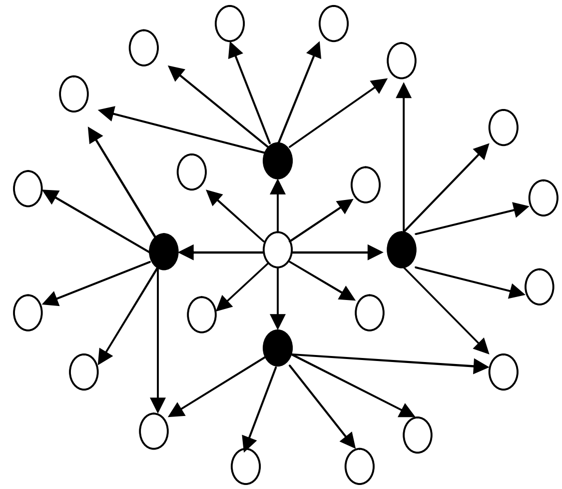


Figure 2.4: Flooding a packet in a wireless Multihop network from the center node using MPRs (black). The arrows show the way information is passed, *not* all transmissions (Andreas Tønnesen (*2004)*).

The fact that all received unknown message types are forwarded using this approach makes flooding of special message-types possible even if these message-types are only known to a subset of the nodes.

Figures 2.3 and 2.4 shows the path information is passed when being spread, first using regular flooding, and then using MPR flooding. The number of retransmissions in an MPR scenario is highly depends on the network topology and the MPR calculation algorithm. Using the same topology as in Figure 2.3, a possible MPR calculation could lead to the black nodes in Figure 2.4 being chosen as MPRs by the center node. As one can see, if the center node is to flood a message throughout the network, 4 retransmission is done using MPR as opposed to 24 using traditional flooding.

2.4.2 Control Messages in OLSR

During transmission, several OLSR messages are defined and frequently changed when they are active in a network and which results in the formation of OLSR control traffic. OLSR uses UDP Port 698 to broadcast OLSR control messages, assigned by the Internet Assigned Number Authority (IANA). Three types of messages that OLSR supported are "Hello", "Topology Control (TC)" and "Multiple Interface Declaration (MID)".

- HELLO message are sent on periodic intervals due to the necessary information for link sensing and (one and two hop) neighborhood observed by a node. Every active node interface in the network generates and sends these messages.
- MPR optimization is used to flood "Topology Control (TC) messages", which is usually done at a periodic interval. Moreover, "Topology Control (TC) messages" are generated immediately when changes are discovered in the MPR selector set. The Topology Control (TC) message has a sequence number which is updated regularly when the advertised neighbor set has changed.
- Each node has multiple interfaces. Multiple interface declaration (MID) message is used to broadcast information about the multiple interfaces to other nodes frequently. MID message contains a list of address used by interfaces. Only additional interface address is added in the originator address since node's address is already included in the originator address (Klein, J. (2005)). Upon receiving MID message, the node updates *Multiple Interface Association Information Base* according to the information in the message.

Every node has to detect the neighbor nodes with which it is directly linked to. Each node broadcasts its “**hello messages”** from time to time, containing the information about its neighbors’ nodes and their link status. The link status can be “symmetric”, “asymmetric”, “multipoint relay” or “lost in nature” (Abayomi Awe (2013)).

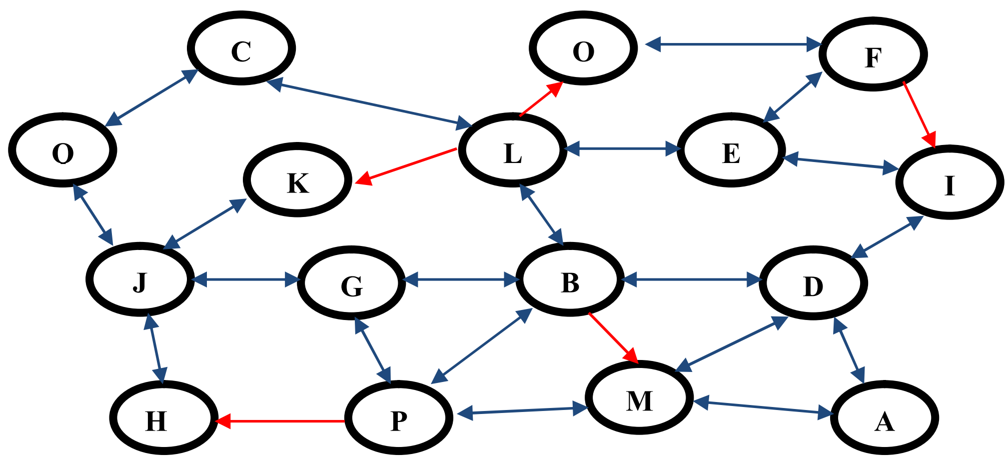


Figure 2.5 Sample of a Small Network with uni and bi directional links (Abayomi Awe 2013))

Uni-directional link

Bi-directional link

- Symmetric (Bi-directional) means that the communication link is possible in both directions.
- Asymmetric (Uni-directional) means that the communication link is possible in one direction.
- Multipoint relay means that the communication link is symmetric and the sender of the hello message has selected this node as a multipoint relay (MPR).
- Lost means that the communication link is lost.

2.4.3 Neighbor Sensing & Detection

Neighbor node (1-hop neighbor): A node Y is a neighbor of node X if node Y can HEAR node X as depicted in the figure 2.6. Similarly node Z is a neighbor to node Y. While in figure 2.7 X is not a neighbor of Y because Y cannot hear X, but node Z is a neighbor to node Y.

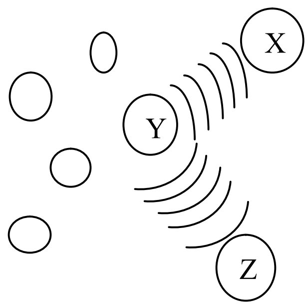


Figure 2.6: Neighbor Sensing (João Rodrigues (2001)).

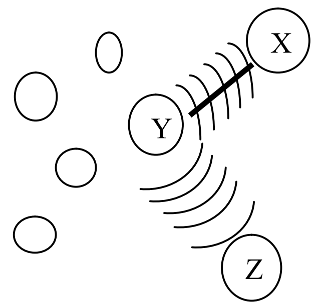


Figure 2.7: Neighbor Sensing (João Rodrigues (2001)).

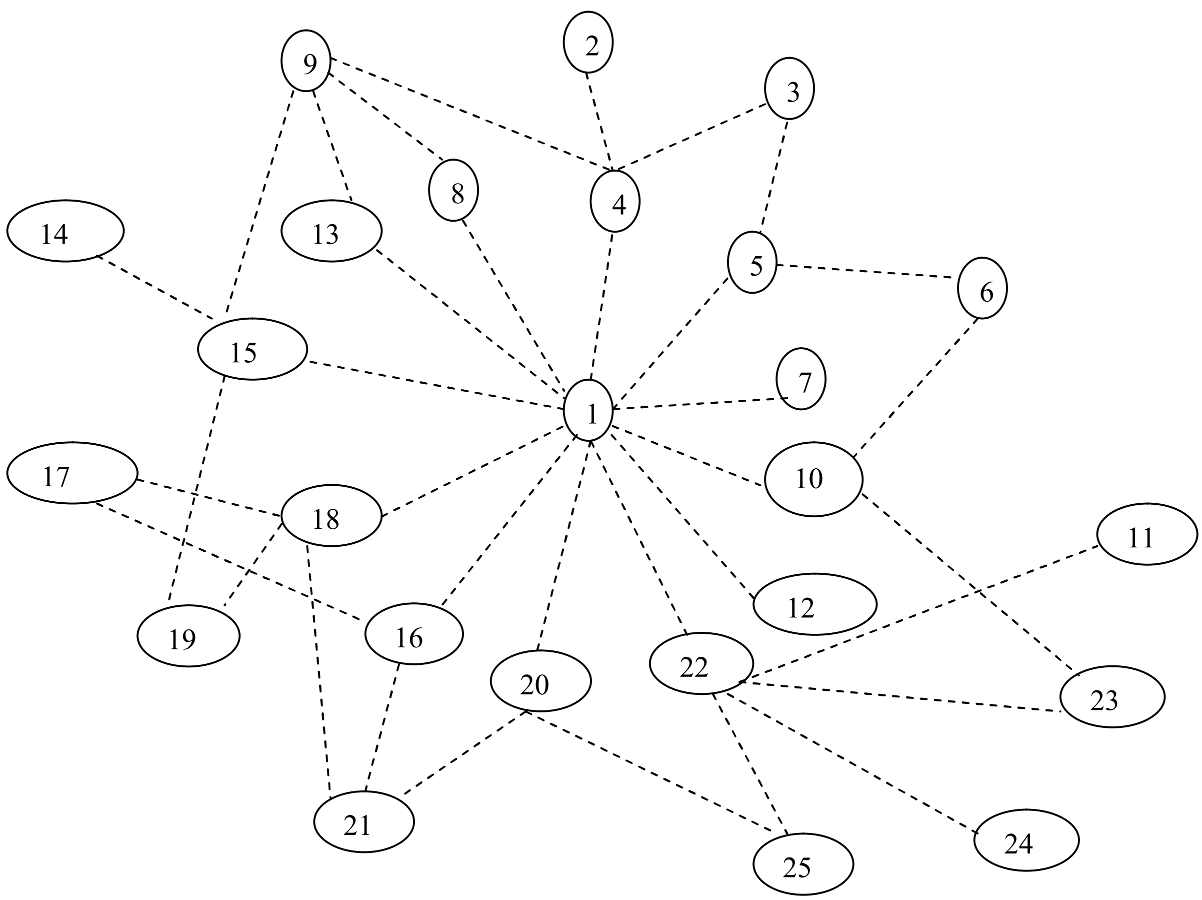


Figure2.8: Network Topology Showing 1-hop & 2-hop nodes

- 2-hop neighbor: 2- hop neighbor is described as a neighbor's neighbor i.e. it's a node that is heard by a neighbor (João Rodrigues (2001)). In the figure 2.6, Z is a 2-hop neighbor of X as it's a neighbor of Y and Y is a neighbor of X. Thus Z is a neighbor of X. In figure 2.8 nodes 2, 3, 6, 11, 23, 24, 25, 21, 19, 17, 14, 9 are 2-hop neighbors of reference node 1.

Neighbor sensing is achieve from link sensing. A symmetrical link always yields symmetrical neighbor and vice versa for asymmetric neighbor. Details will be discussed in link sensing subsection.

- Multipoint relay (MPR): Any node which is selected by node X within 1-hop neighbor to 'retransmit' all the broadcast messages that it receives from X (João Rodrigues (2001)). In figure 2.8 nodes 4, 10, 22, 18 & 15 are MPR nodes because all the 2-hop neighbors can be reached via them.

2.4.4 Link Sensing

Every node generates & broadcasts HELLO MESSAGE which includes its complete neighborhood specifying the address of the originator, 1-hop neighbor, 2-hop neighbor and a status of the link.

Initially, a reference node has no information about its neighbor. It sends empty HELLO message to its neighbor. For each neighbor in the HELLO message a status of a link is added that may be SYM/ASYM. When node i receives a HELLO message by a neighbor j, i will include j in its HELLO message as an ASYM neighbor. If j is able to receive HELLO from i it will do the same. When i receive HELLO from j containing address of i in the neighbors, i will sponsor j as a symmetric neighbor. j will do the same (leonardo maccari (2012)).

Literally speaking, a link is said to be symmetric if a packet can be sent and received through it i.e. bi-directional communication; otherwise is said to be asymmetric. In figure 2.8, a link connecting node 4, 5, 22, 18, 15 are symmetric links because all 2-hop nodes are connected to node 1 via it. Similarly links connecting node 1 to node 7, 10, 12, 20, 16, 13, 8 are asymmetric link due to the fact that communication 2-hop neighbors is uni-directional.

A node is described as symmetric neighbor if its link connecting to reference node is symmetric. In figure 2.8, link 4, 5, 22, 18 and 15 are MPR nodes.

Having chosen MPR nodes, topology control message is generated & broadcast by MPR nodes. Since these nodes are used to reach 2-hop neighbors in the case of figure 2.9. Subsequently 3-hop neighbors are reached via 2-hop MPR neighbors as the case may be. Generally, any N-hop neighbors are communicated via (N-1)-hop MPR neighbors where N is a number of hop count.

TC message include timer (scheduler) for sending periodic TC message through the network (João Rodrigues (2001)). Any 1-hop neighbor which is not selected as MPR node its timer expires. It also contains list of neighbors which have selected the sender node as multipoint relay. E.g. considering node 4 &18 MPR in the figure 2.9. The selector nodes for 4-MPR are 2 & 3 while that of 18-MPR node are 17, 19, 21

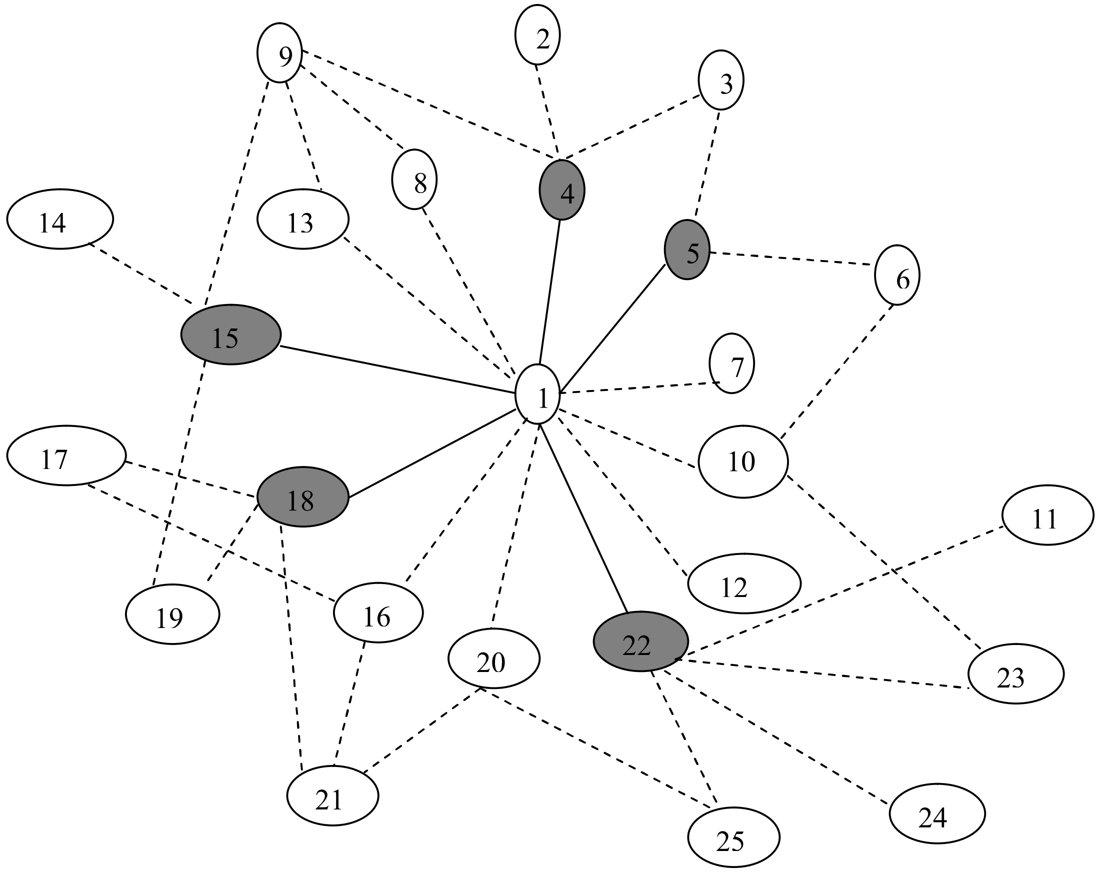
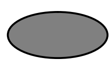


Figure 2.9: Network Topology Showing MPR Node Connections

Key:  MPR node

―――――― Symmetric link

- - - - - - - - - Asymmetric link

Set of 1-hop neighbors= {4, 5, 7, 10, 12, 22, 20, 16, 18, 15, 13, 8}

Set of 2-hop neighbors= {2, 3, 6, 11, 23, 24, 25, 21, 19, 17, 14, 9}

Set of MPR nodes= {4, 5, 22, 18, 15}

Set of MPR selector nodes: 4-MPR= {2, 3, 9}, 5-MPR= {3, 6}, 22-MPR= {11, 23, 24, 25}, 18-MPR= {17, 19, 21}, 15-MPR= {9, 14, 19}

TC message also help to update the topology table in a node. Topology table contains set of neighbors, 2-hop neighbors, MPR nodes etc. whenever there is a change in the topology, TC messages are broadcast by MPR to all nodes for actualization (João Rodrigues (2001)).

Table 2.1: Summary of literatures of Some Selected Works

s/n	Author	Pros	cons
1	Andreas Tønnesen *(2004)*	OLSR protocol features, structures & operations are exhaustibly highlighted	The author made more emphasis on design & extension aspect of OLSR.
2	Abayomi Awe(2013)	OLSR protocol features, structures, operations & behaviors are highlighted	The author made no emphasis on simulation. .
3	João Rodrigues (2001)	MPR node technique & link quality are deliberated	No detailed information on OLSR operation
4	leonardo maccari (2012)	Neighbour discovery is the major priority.	No detailed information on OLSR performance

2.5 REVIEW OF RELATED WORK

Among many researches on OLSR protocol, very few were considered as fully related to the study. Though, number of nodes, performance metrics and traffic types are the basis of the comparison but some parameters are also considered. The followings are some of the related works in order to get yardstick for comparison.

Three routing protocols AODV OLSR TORA were simulated using OPNET 14.5 with 70 nodes and 2000 by 2000 simulation area in findings of (Rawendra Pratap Singh1,Savita Shiwani2 (2012)). FTP, HTTP, E-mail & Voice traffic are considered. The throughput analysis shows that OLSR has highest throughput while the rest have low performance with email traffic. Performance of OLSR is good with FTP traffic compared to the rest. OLSR has less performance i.e. low throughput compared to the two protocols in voice traffic. Similarly in delay analysis, in voice traffic OLSR has moderate delay compared to other protocols. In FTP and Email traffic, OLSR has lowest delay. This translate to OLSR has better efficiency in FTP & Email traffics because the packet transfer is much faster. Fairness parameter was not considered.

Kiranveer Kaur (2014) analyzed DSR AODV and OLSR using opnet simulator in 20, 40 & 100 nodes and HTTP, FTP, video conferencing & Email traffic were considered; but only 100 nodes result was shown. For throughput performance OLSR in FTP, video conferencing & Email traffic is high compared to the two protocols. Similarly OLSR protocol performed better as compared to protocols in case of network delay ie shorter delay.

However in (Gagangeet Singh (*2013))*, the research was conducted on AODV, DSR, TORA, OLSR & GRP protocol with 30, 60 & 90 nodes and video conferencing & Email traffic using OPNET 14.5 modeler. The results show that with 30 nodes scenario GRP exhibits least delay followed by OLSR and then others followed for Email traffic and OLSR has moderate delay in Video conferencing. In 60 nodes scenario, GRP has least delay followed by OLSR in both Email & video conferencing traffic. Lastly in 90 nodes scenario, GRP has least delay followed by OLSR for Email traffic and vice versa for video conferencing traffic. In throughput performance for 30 node scenario, OLSR posses highest in Email traffic while is its lowest in video conferencing traffics. In 60 nodes, OLSR has highest in email traffic but in video conferencing traffic its second to the highest. In 90 nodes scenario, it's similar to 60 nodes scenario.

In (Hande Bakiler (2014)) the thesis was conducted on DSR, AODV, OLSR and GRP protocols based on 30 nodes using OPNET modeler comprising all the traffic applications. The results for voice traffic show that the delay is unbalanced for normal OLSR network (5.134s) and attacked network. The throughput performance for normal OLSR network: for email traffic (153.9 bytes/sec), video conferencing traffic (7,718 bytes/sec)

The summary of the review of related works is shown in the table below

Table 2.2: summary of review of related work

s/no	Author	Pros	Cons
1	Rawendra Pratap (2012)	Heavy traffics are considered & node density is adequate	Fixed packet size is considered.
2	Kiranveer Kaur (2014*)*	Traffics considered are adequate.	Variable network area & number of nodes.
3	Gagangeet Singh (*2013)*	Performance metrics are adequate.	In adequate traffics & variable node density are considered
4	Hande Bakiler (2014)	Simulations were conducted on OLSR	The author emphasize more on

		networks without security attacks	security attacks in MANET

2.6 PERFORMANCE PARAMETERS

There are different kinds of parameters for the performance evaluation of the routing protocols. These have different behaviors of the overall network performance. Three parameters are evaluated for the comparison of the impact of the different traffic on OLSR. These parameters are delay, fairness and throughput for traffic evaluation. These parameters are important lin the consideration of evaluation of the routing protocols in a communication network in general. These traffics need to be checked against certain parameters for their performance for the effectiveness in transmitting packet across shortestpath of the OLSR protocol. If the traffic gives much end to end delay so probably traffic is not efficient as compare to the traffic which gives low end to end delay. Similarly in the case with the throughput as it represents the successful deliveries of packets in time. If traffic shows high throughput so it is the efficient and best traffic than the traffic which have low throughput. These parameters have great influence in the selection of an efficient routing protocol in any communication network.

2.6.1 Throughput

This is an average rate at which the data packet is delivered successfully from one node to another over a communication network (Rawendra Pratap Singh1, Savita Shiwani2 (2012)).

2.6.2 Delay

It is the ratio of time difference between every packet sent and received to the total time difference over the total number of packets received (Gagangeet Singh Aujla1, Sandeep Singh Kang2 (*2013*)).

2.6.3 Fairness

Fairness is attributed to resource sharing or allocation in wireless network. It's a measure of how resources can be equitably distribute based on necessity/demand (Huaizhou SHI, R. Venkatesha Prasad, Ertan Onur, I.G.M.M. Niemegeers).

2.7 CONCLUSION

In this chapter, wireless network and MANET were discussed. OLSR operations, features, behaviors were reviewed and presented. Neighbour discovery and link sensing of the nodes were presented. Multipoint relaying (MPR) nodes concept was also presented and finally a table showing previous works, their pros and cons was also presented.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 INTRODUCTION

This chapter provides detailed description of the material and methodology adopted for the study. A network of 70 nodes was modeled and simulated for OLSR protocol description; shortestpath algorithm was also simulated using Matlab codes. Finally, the result obtained was compared to analyze the impact of different traffics on OLSR protocol.

3.1 OBJECTIVE 1- MODELING OF OLSR PROTOCOL

This is where the protocol (OLSR) is verified. It includes network topology set up, discovery of neighbour nodes, MPR selection and finding a shortestpath for transmitting packets in the network.

3.1.1 Network Topology

Random mobility is chosen in order to align the research to reality because practical wireless nodes are spread randomly. 70 nodes are chosen on the simulation area of 2000m by 2000m. The above parameters when simulated will yield a result of network topology as shown in figure 4.1.

3.1.2 Neighbour Discovery

Neighbour discovery in OLSR is vital as it's used in getting multipoint relaying nodes (MPR) which is very vital in OLSR operation. Every node must know its neighbors with all information that is related to that node. In knowing neighbors several measures could be considered like distance between nodes, transmitted power and link quality etc. due to the nature of the default algorithm in OLSR considered-Djiktra's algorithm. Distance between nodes is chosen in discovering neighbors of a node. The amount of distance acceptable for the above is determined from the general friis equation for signal propagation. Distance d is chosen to be 250m in order to achieve acceptable power Pr that can allow the signal to be detected.

Depending on application, SNR of at least 10 or 20 dB, or more, may be required (Richard J. Mohr-President, R.J. Mohr Associates, Inc. (2010)).

Upon selecting neighbours to every n number of nodes, the neighbours will be converted to 0s & 1s in a matrix form for every node. The above matrices are used to draw the actual network topology showing all the links, nodes and distances between nodes.

Mathematical Model for objective 1

Pr=Pt*Gt*Gr*(λ/ (4*Pi*d)₦2)…………………….(1)

λ=C/f…………………………………………..… (2)

Where: C=3*e8 m/s, f=2.4 GHz, Pt=1W, Gt=Gr=1, λ=0.125m, Pr=160μW

In discovering neighbours a simple quadratic equation is used in calculating the distance between nodes.

d=sqrt ((x(i)-x(j)₦2+(y(i)-y(j))₦2)………………………………(3)

Where: x(i) is x-coodinate of reference node

x(j) is x-coodinate of expected node

y(i) is y-coodinate of reference neighbour node

y(j) is y-coodinate of expected neighbour node

Algorithm & Flowchart for objective 1

1 Generate n no. of nodes randomly in specified simulation area of x & y.

2 Calculate the distance between nodes (i is reference node & j any other node) as d.

3 If d is less than or equals to 250m, then j is a neighbor to I,

4 Else go back to step 3

5 Repeat step 4 until all n-1 nodes(less i node) are tested

6 All the js calculated are represented in matrix for all the value of is

7 Then all matrices of js are converted to 0s & 1s. ie 0s signifies non neighbour nodes and 1s represent neighbours

8 Network graph is drawn showing all links, nodes & distances between them

9 Shortestpath is calculated using Djiktra's algorithm

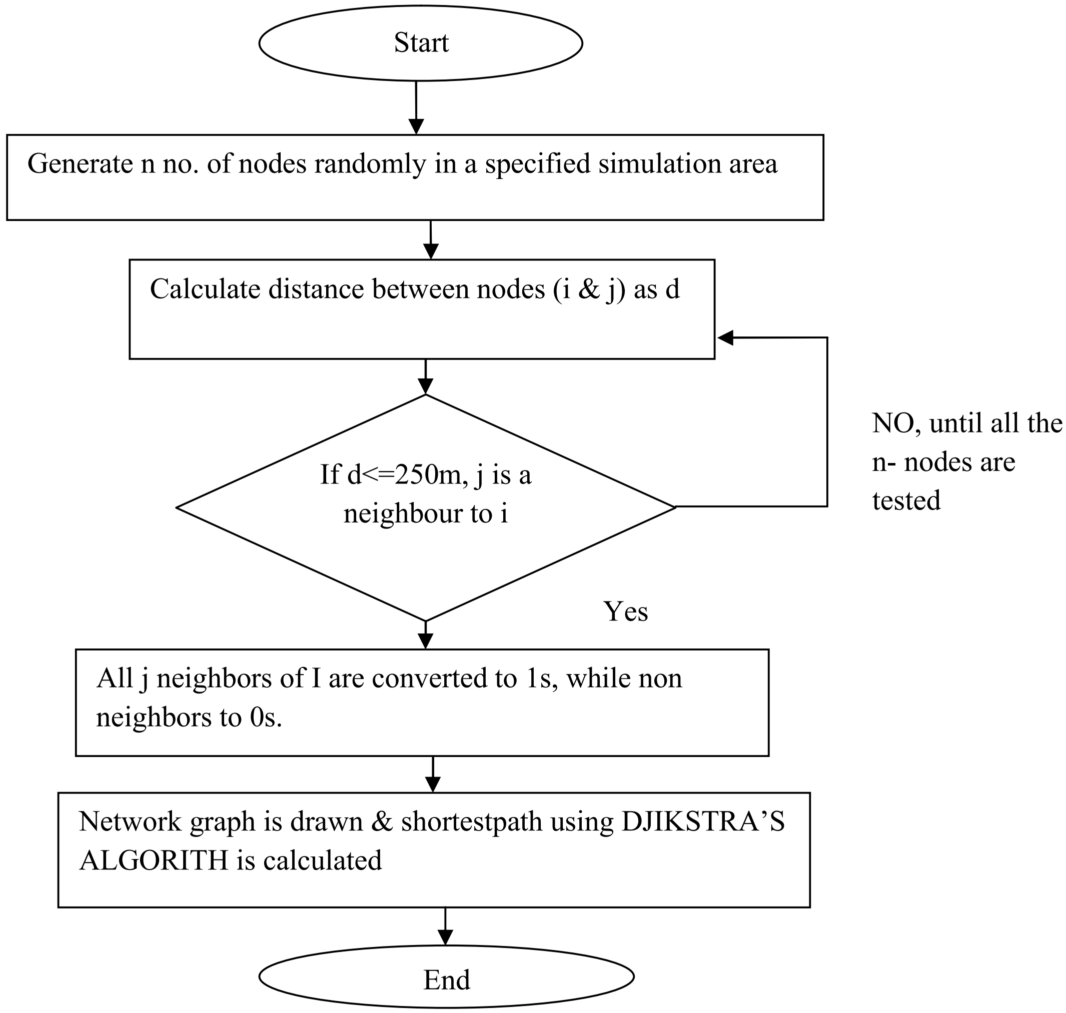


Figure 3.1: Network Topology & Neighbor Discovery Flowchart

3.2 OBJECTIVE 2- PERFORMANCE ANALYSIS MODEL

This sub chapter explains how packets are modeled and simulated. It also presents performance of different traffics on the OLSR model based on simulation.

3.2.1 Buffer Establishment

Four buffers are created based on 4 traffics: voice, video conferencing, ftp & email. The buffers are set with 5 rows and 4 columns. The rows depict the span of the buffer i.e. its length, the column entails the packet size, latency, packet id etc. e.g. if a buffer is buffe (2, 2, 1, 5), it represent a buffer of voice traffic in node no. 5 with latency in a second row. Buffer establishment is created in a buffer subprogram. Then, the actual parameters of the buffers are encoded in source subprogram. All the scheduling subprogram for all the traffics (voice, video conferencing, ftp & Email) is co-opted in the main program. Details of those subprograms are in the algorithm sub chapter.

Algorithms & Flowcharts for objective 2

Buffer settings

1 Initialize by establishing the buffer size.

2 Represent each buffer parameter with packet size, current time, & id for four traffics.

Parameter settings

1 set id manipulation for the traffic

2 four traffic decision selection is considered as type (1-4)

3 if type =1, set the traffic to voice and assign its parameters (packet size etc)

4 else if type=2, set the traffic to video conferencing and assign its parameters (packet size etc)

5 else if type=3, set the traffic to ftp and assign its parameters (packet size etc).

6 else set the traffic to email and assign its parameters (packet size etc).

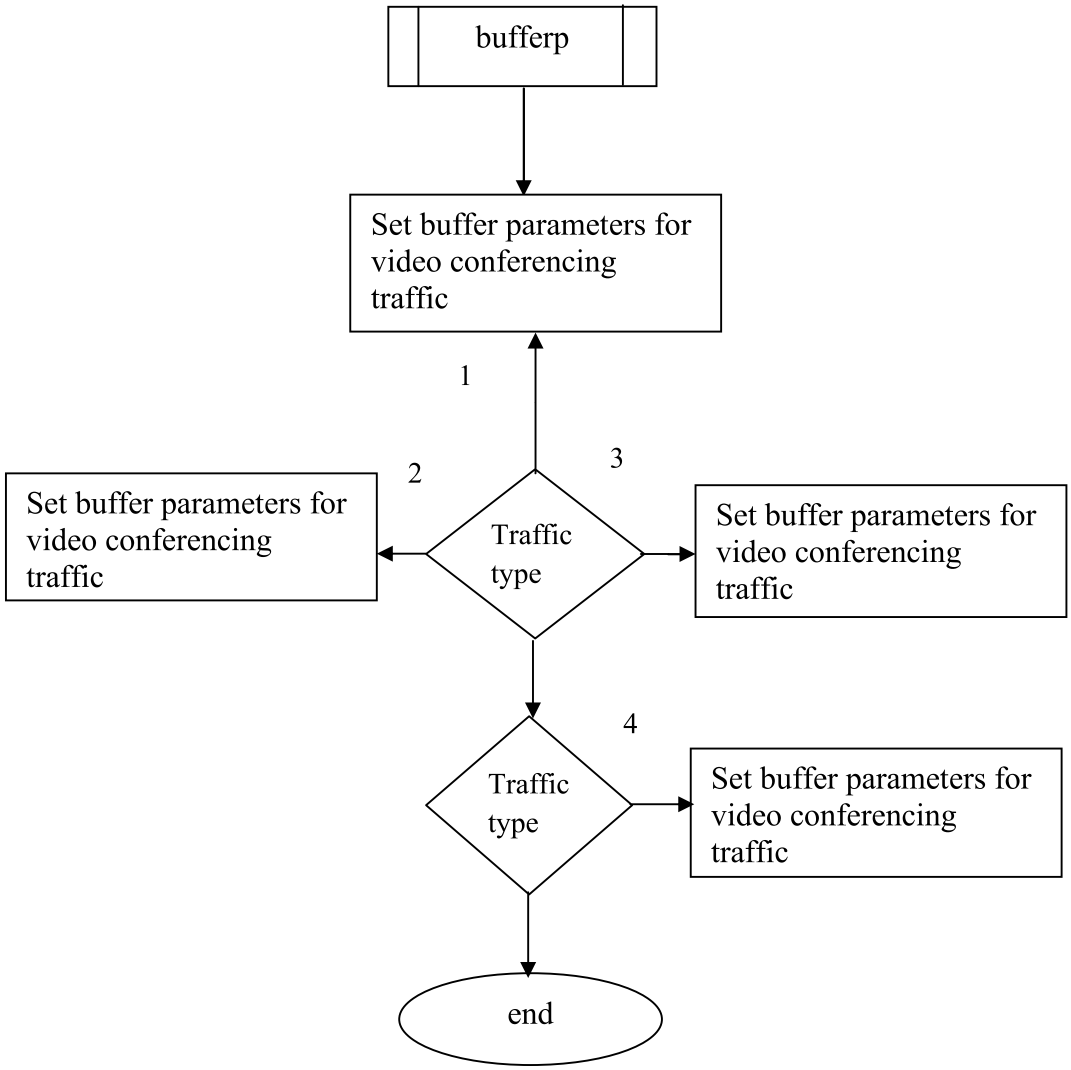


Figure 3.2: Buffer Flowchart

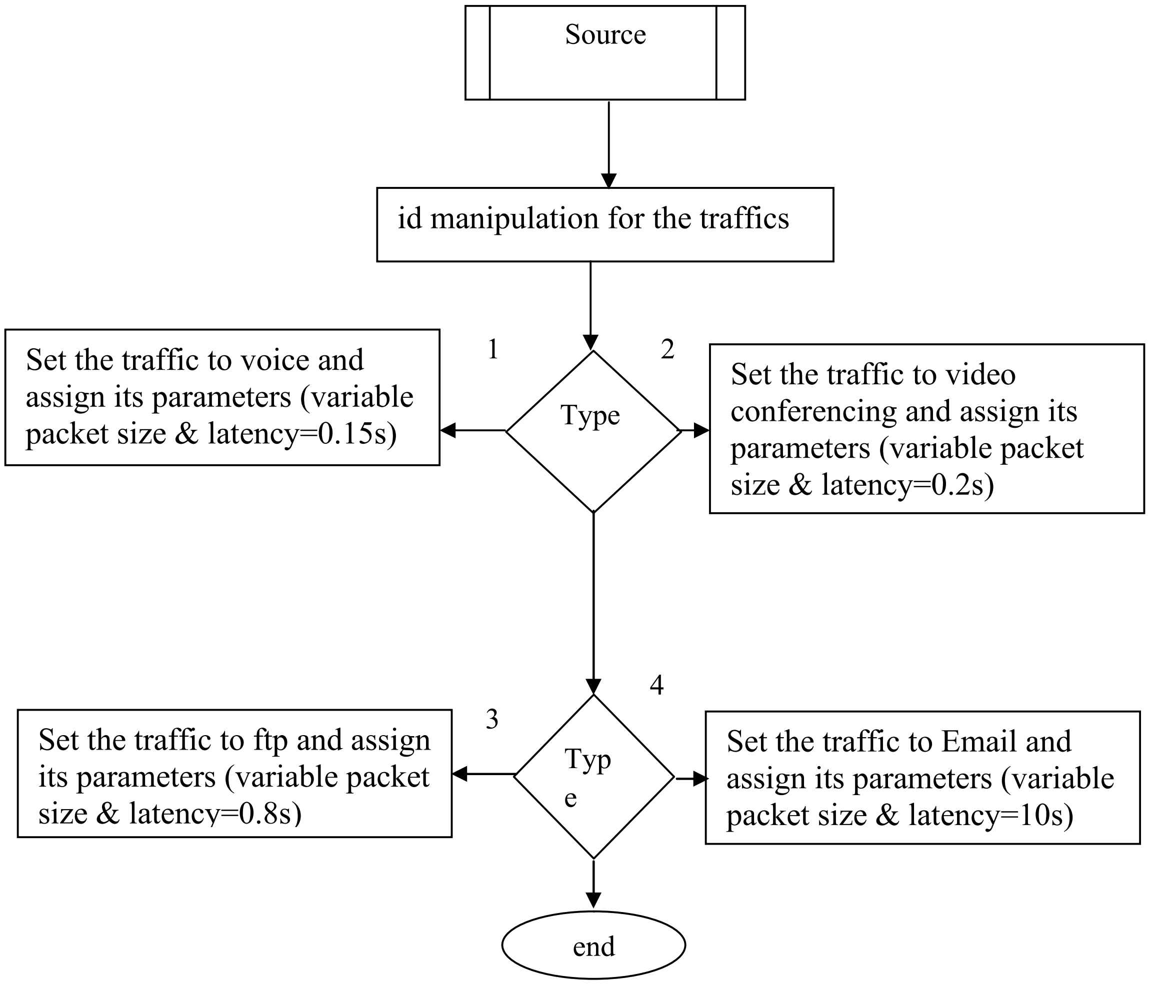


Figure 3.3: Source Flowchart

3.2.2 Packet Transmission

In this research, effort is made in selecting best scheduling algorithm that will suite the protocol packet transmission. Round robin scheduling shown in figure 3.4 best suited in the thesis because the scheduler works in rounds by serving the first packet in each priority queue in sequence according to their precedence till all queues are served and then it restarts over to the second packet in each queue .

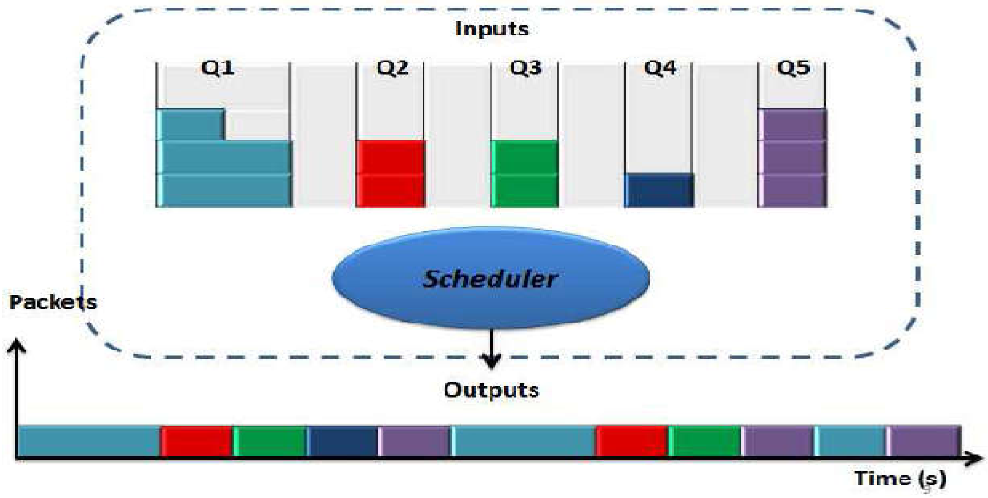


Figure 3.4: Round Robin Scheduler

Algorithms & flowcharts of objective 2 cont…

- **Voice traffic settings**

1 find packet which has the minimum time

2 get current time

3 get the difference btw current time and the starting prog time

4 assume latency this can be change

5 delay time is more than the latency

6 details of scheduled package: delay, packet arrive & their time_arrival

- **Video conferencing traffic settings**

1 find packet which has the minimum time

2 get current time

3 get the difference btw current time and the starting prog time

4 assume latency this can be change

5 delay time is more than the latency

6 details of scheduled package: delay, packet arrive & their time_arrival

- **ftp traffic settings**

1 find packet which has the minimum time

2 get current time

3 get the difference btw current time and the starting prog time

4 assume latency this can be change

5 delay time is more than the latency

6 details of scheduled package: delay, packet arrive & their time_arrival

- **Email traffic settings**

1 find packet which has the minimum time

2 get current time

3 get the difference btw current time and the starting prog time

4 assume latency this can be change

5 delay time is more than the latency

6 details of scheduled package: delay, packet arrive & their time of arrival

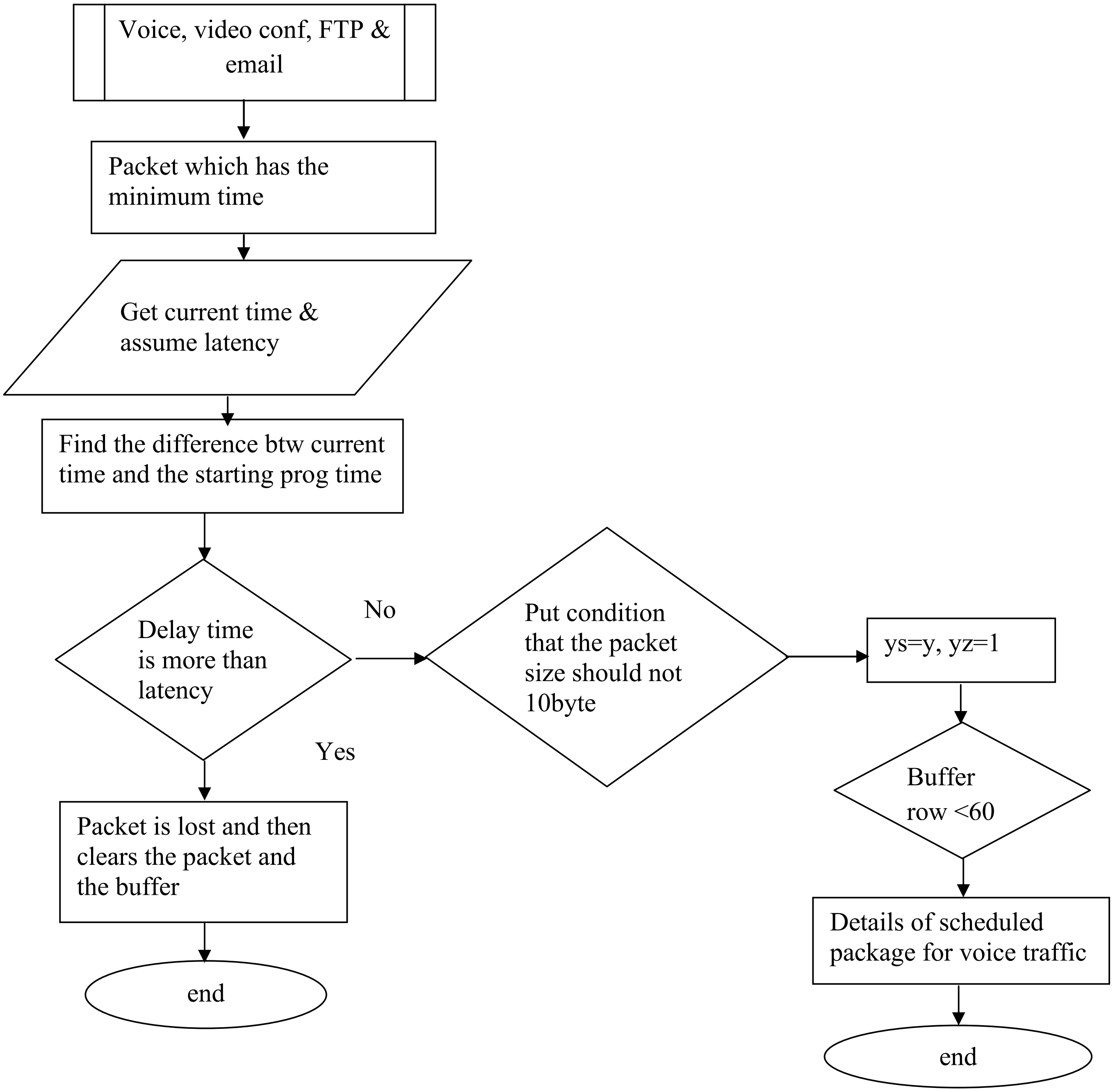


Figure 3.5: Flow chart of Packet Scheduling for Voice, Video conferencing, Ftp or Email traffic

3.3 OBJECTIVE 3-RESULTS COMPARISON

This is where results in section 3.1.2 is compared with existing work of (Rawendra Pratap (2012)).

In theory about three comparison methods exist: using analytical method, comparison with different scenarios within a research and lastly comparison with an existing work. Rawendra Pratap (2012) is chosen because it has same number of nodes, same simulation area and contains three traffics that were used in this research. Since the related work is done on different software with MATLAB (OPNET). It was decided to pick plotting points and plot it on the same modeler (MATLAB).

3.4 CONCLUSION

The processes and methodology adopted for this study was presented in this chapter. OLSR protocol was modeled and simulated through network topology, neighbour discovery and MPR selection models using Matlab software. Performance of the OLSR protocol was simulated based on voice, video conferencing, Email and ftp traffics. A performance comparison with the existing work was also presented based on throughput, and delay parameters.

CHAPTER FOUR

SIMULATION RESULTS, ANALYSIS &COMPARISON

4.0 INTRODUCTION

This chapter contains simulated results and analysis of the simulated results. The analysis is done on performance of voice, video conferencing, ftp & Email traffics on OLSR based on throughput, delay and fairness performance parameters. The chapter is further explains comparison of simulated results with existing work.

4.1 ROUTE DISCOVERY & SHORTESTPATH FINDING

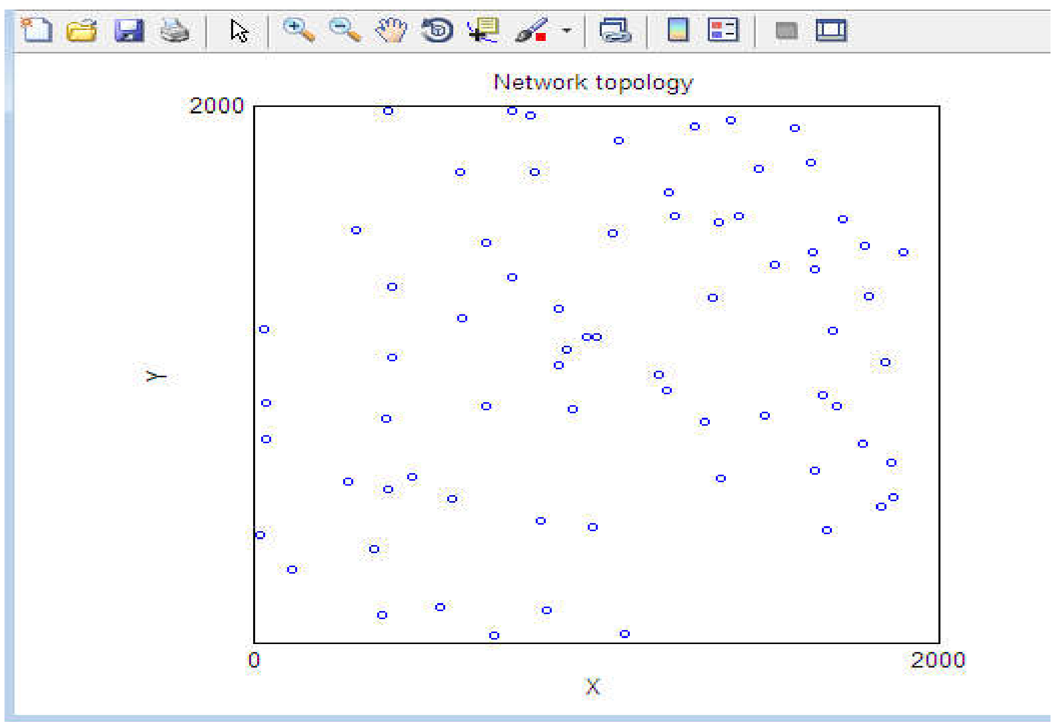


Figure 4.1: Result of Network Topology of 70 nodes

Figure 4.1 above shows 70 nodes randomly positioned in mesh topology. This provides communication between any of the nodes. Figure 4.1 is a network model used to discover neighbours of every node and to find out Multipoint relaying (MPR) nodes.

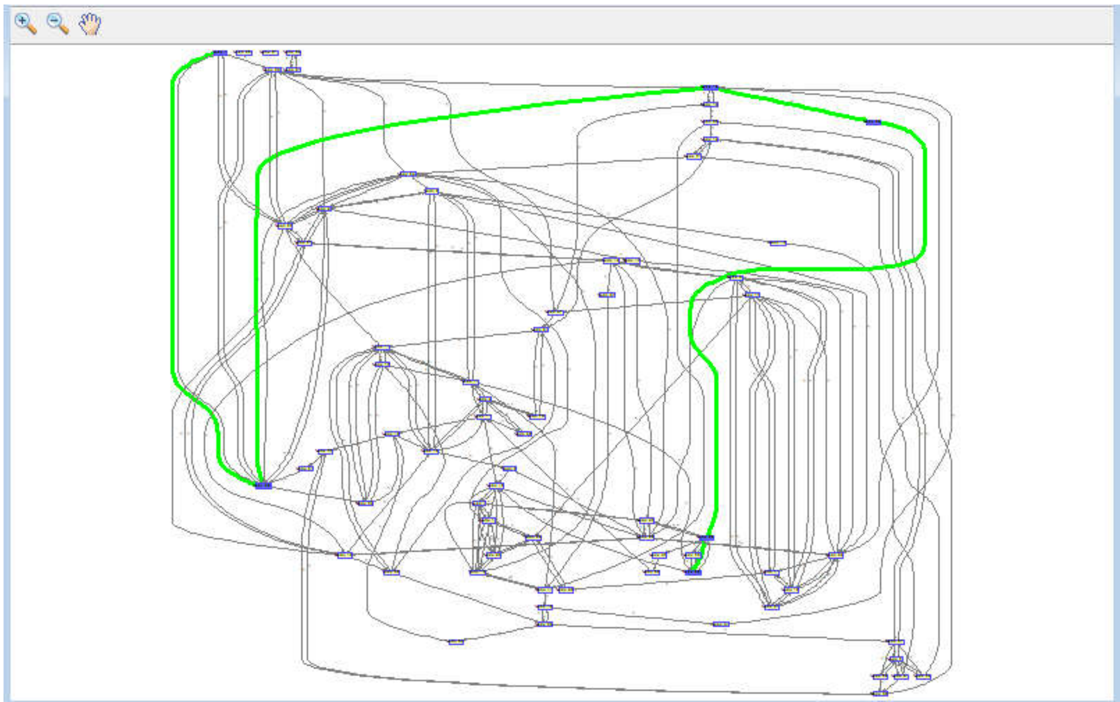


Figure 4.2: Result of shortestpath for 70 nodes with 1 & 60 nodes as source & destination respectively

Figure 4.2 shows a shortestpath of the network topology and it's a mesh network which is very complex. In the figure 4.2, node 1 can communicate to node 60 through many routes. But with Shortestpath calculation, route containing node 1 58 19 53 66 60 is considered to be the shortest and hence a packet is transmitted via it.

4.2 SIMULATED RESULTS

In the research packet sizes are considered to be varied, hence the variation in the starting points in the graphs.

4.2.1 Delay Performance

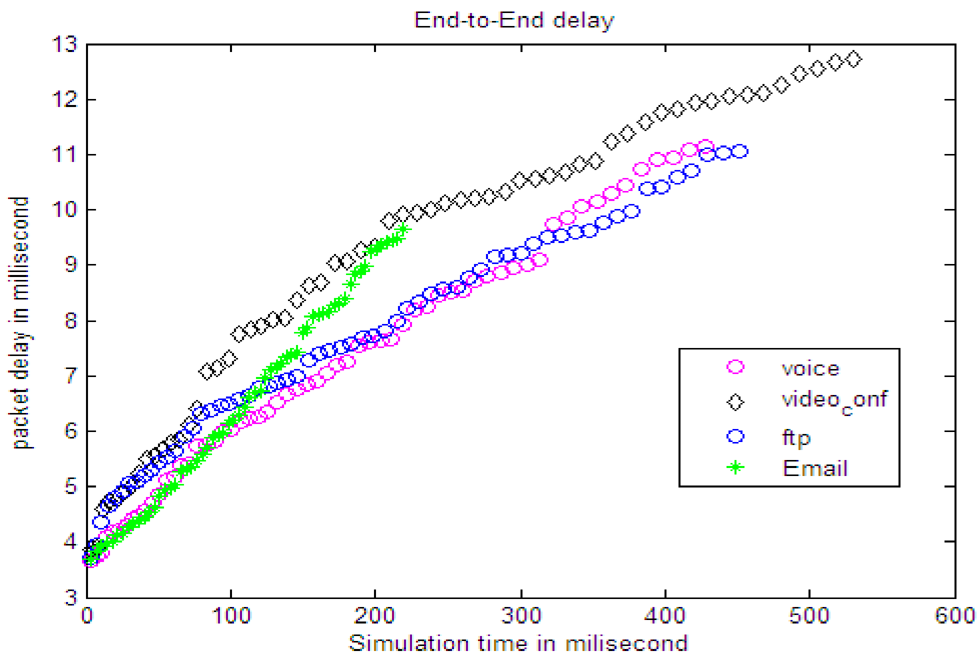


Figure 4.3: Delay Performance for four traffics

Table 4.1: Summary of Delay Performance of the four Traffics

traffic	VOICE	VIDEO CONFERENCING	FTP	EMAIL
Delay (ms)	Min=3 .666 Max=11.14	Min=3.854 Max=12.73	Min=3.729 Max=11.05	Min=3.698 Max=9.641

Figure 4.3 shows network delay in respect to four traffics. In voice traffic, packet delay of 11.14ms is recorded which is somewhere in average among the four because

the limit of voice packet latency is 0.15ms and voice traffic is considered as real time traffic with constant bit rate. The least delay occurred in the email traffic (9.641ms), because email traffic is among the best effort traffics which has constrain on packet delay. Some packets are lost in the email traffic due to longer arrival time. Video conferencing traffic shows highest delay and it covered virtually all the packets i.e. minimum lost packet to around 12.73ms because its real time in nature with variable bit rate. Similarly ftp traffic shows same behavior as its non real time in nature which has less constrain to packet delay. Its highest value is around 11.05ms.

In summary, Email traffic arrives at the destination node on time because email traffic is among the best real time traffic which is faster but lots of lost packets occur, followed by ftp traffic. Voice traffic is moderate. Video conferencing constitutes high delay because it is real time in nature and link impairments do affect it seriously.

4.2.2 Throughput Performance

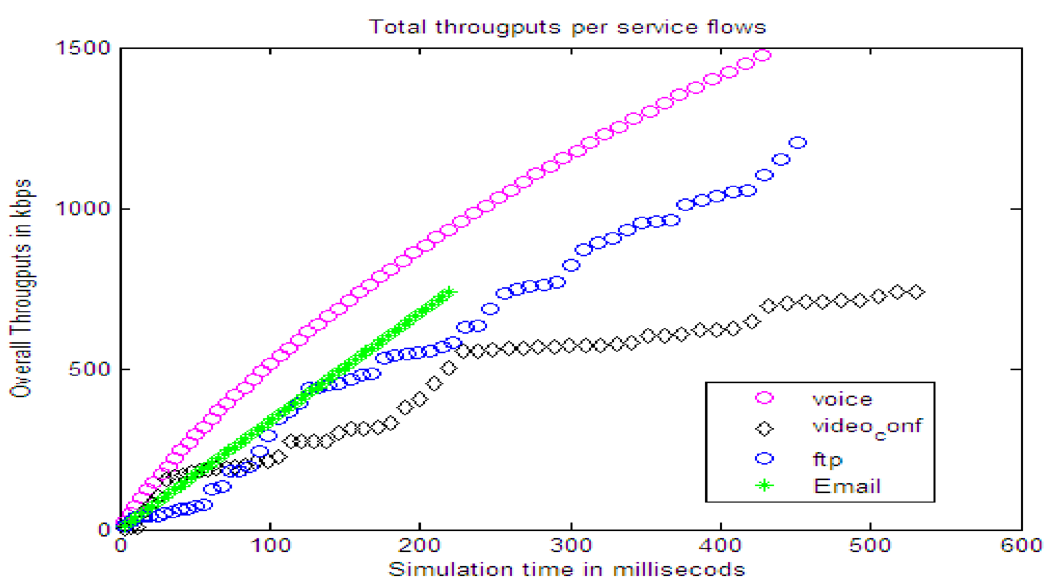


Figure 4.4: Throughput Performance for four Traffics

Table 4.2: Summary of Throughput Performance of the four Traffics

traffic	VOICE	VIDEO CONFEENCING	FTP	EMAIL
throughput(kbps)	Min=24.57 Max=1475	Min=3.072 Max=741.1	Min=12.29 Max=1202	Min=12.29 Max=737.3

From figure 4.4, it illustrates that voice traffic constitutes a highest throughput of 1475kbps. This is due to the fact that voice traffic is considered to be real time traffic with constant bit rate. FTP traffic is followed in throughput with 1202kbps because as non real time traffic, a high bandwidth is required. Video conferencing is the third in throughput efficiency with 741.1kbps because real time traffic require good link quality which is difficult to realize. The least in throughput is email traffic due to many lost packets in the transmission.

4.2.3 Fairness Performance

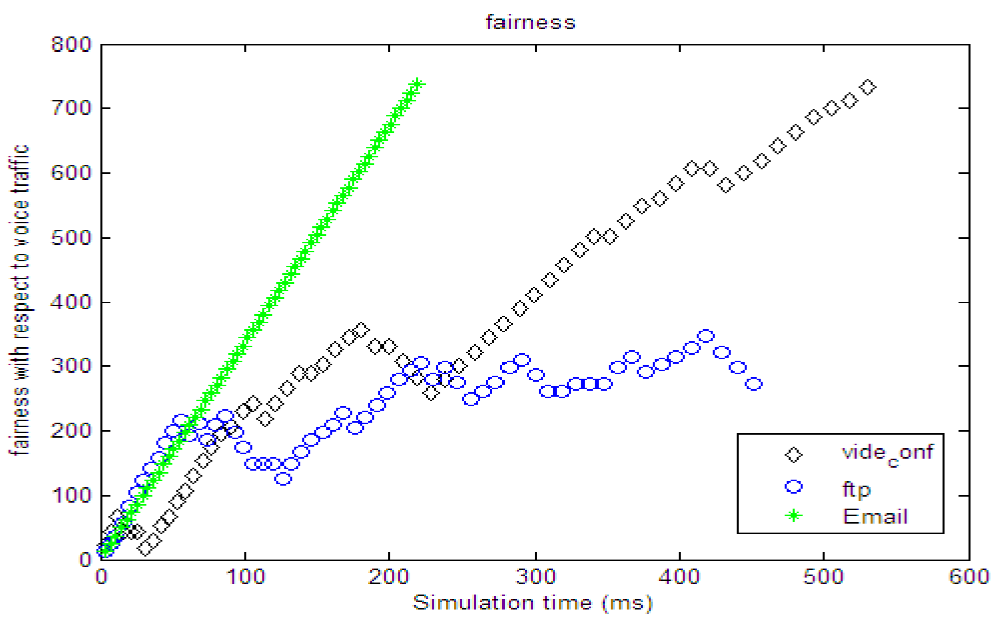


Figure 4.5: Fairness Performance for the Traffics

Table 4.3: Summary of Fairness Performance of the Traffics

traffic	VOICE	VIDEO CONFERENCING	FTP	EMAIL
Fairness to voice in respect (kbps)	Nill	Min=17.66 Max=733.4	Min=12.29 Max=346.4	Min=12.29 Max=737.3

Figure 4.5 shows fairness performance with respect to voice traffic. Ftp traffic has better fairness because the throughput is evenly distributed, followed by video conferencing with low throughput but the fairness is better. Email traffic is the worst in fairness despite the fact it's better than video conferencing in throughput. Therefore it shows the level of equal access in transmission across the simulation time in respect to throughput with respect to voice traffic.

4.3 RESULTS COMPARISON

(Rawendra Pratap (2012)) was chosen for comparison where throughput and delay of email & voice were taken as a sample. Due to difference in modeler, plotting points were picked in (Rawendra Pratap (2012)) work to simulate on MATLAB software.

4.3.1 Throughput Comparison with Email & Voice Traffics as a Sample

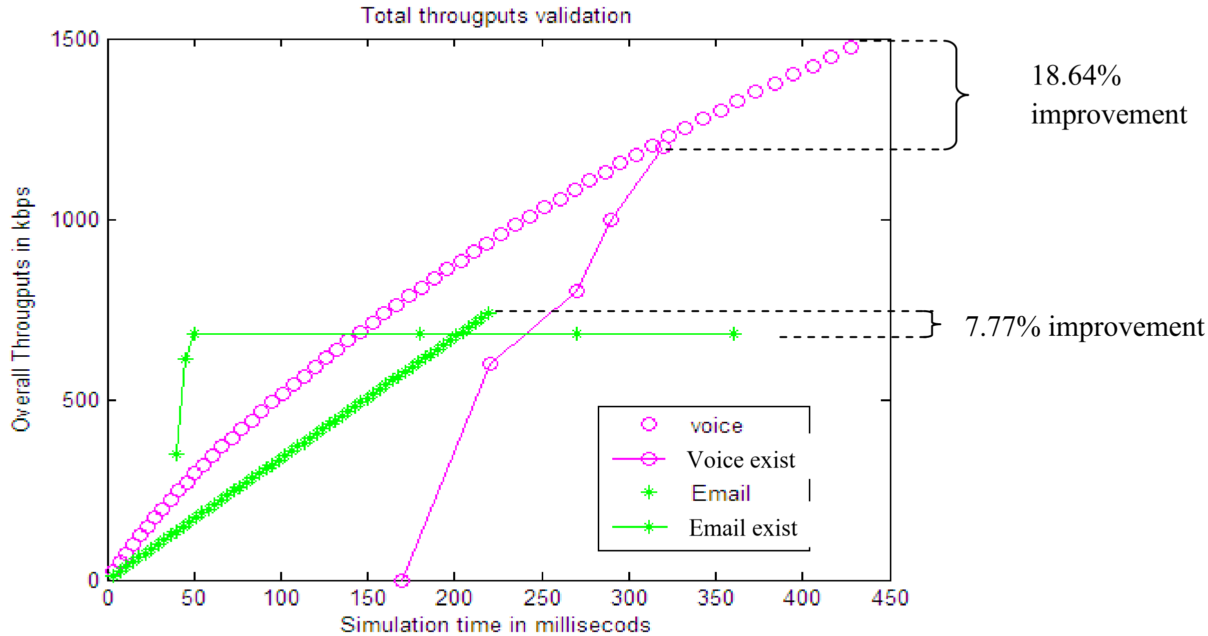


Figure 4.6: Throughput Comparison

Table 4.4: Summary of Throughput Comparison

traffic	VOICE	VOICE_EXISTING	EMAIL	EMAIL-EXISTING
throughput(kbps)	Min=24.58 Max=1475	Min=0 Max=1200	Min=12.29 Max=737.3	Min=350 Max=680

In both scenarios in figure 4.6, it shows an improvement over the work of (Rawendra Pratap (2012)). Voice traffic recorded 18.64% improvement while email traffic recorded 7.77% improvement.

4.3.2 Delay comparison with Voice & Email Traffics as a Sample

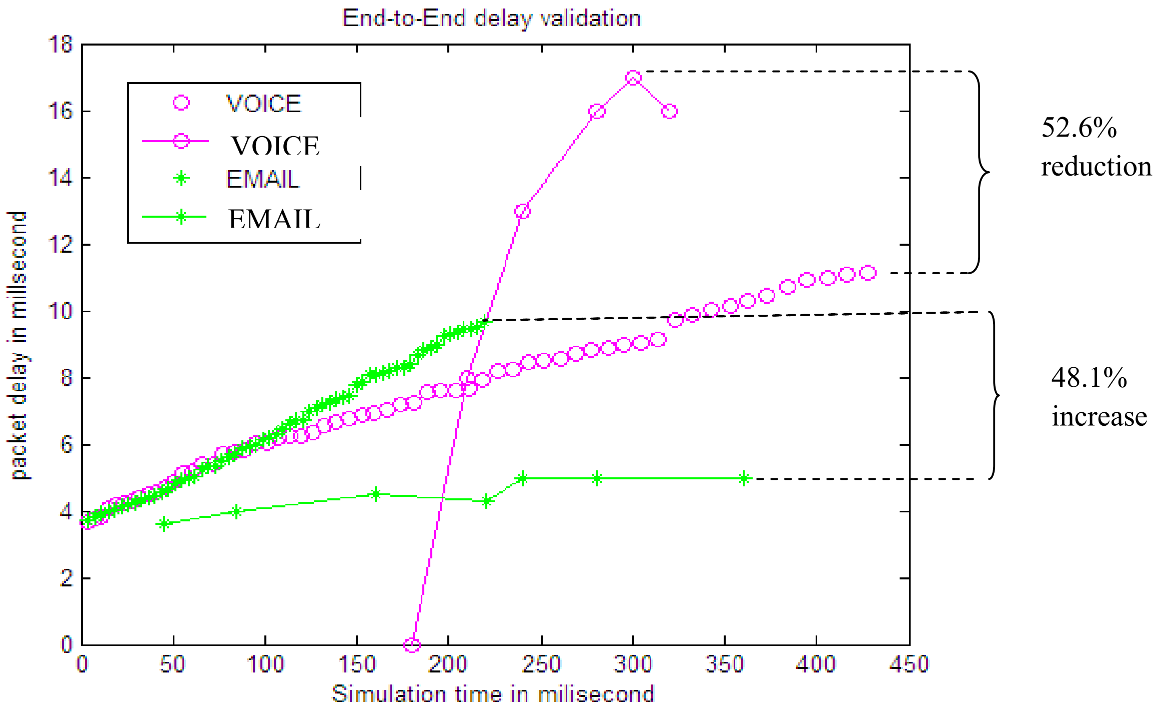


Figure 4.7: delay comparison

Table 4.5: summary of delay comparison

traffic	VOICE	VOICE_EXISTING	EMAIL	EMAIL-EXISTING
delay(ms)	Min=3.666 Max=11.14	Min=0 Max=17	Min=3.698 Max=9.641	Min=3.6 Max=5

Figure 4.7 above shows the delay comparison. It shows a reduction in delay in voice traffic of 52.6% which performs better than that of (Rawendra Pratap (2012)) while an increase in delay for email traffic of 48.1% is achieved which perform less as compared to related work.

4.4 CONCLUSION

In this study, performance of the OLSR protocol based on different parameters has been implemented using various models from the simulation carried out in chapter three. The results obtained were analyzed and presented. It was showed that email and video conferencing traffics recorded lowest and highest delay respectively. Voice traffic is the best while email traffic is the worst in terms of throughput performance. Comparative analysis with existing work showed an improvement in throughput performance of 18.64% and 7.77% for voice and email traffics respectively while a decrease in delay of 52.6% and increase in delay of 48.1% for voice and email traffics were recorded respectively.

CHAPTER FIVE

CONCLUSION

5.1 CONCLUSION

In this study, Optimized link-state routing (OLSR) was studied, modeled and simulated. The performance of the protocol based on voice, ftp, video conferencing and email traffics under throughput, delay and fairness parameters were analyzed and presented. The results obtained from the analysis were compared with Rawendra Pratap Singh1, Savita Shiwani2 (2012).

As mentioned in the previous chapters, Email and video conferencing traffics recorded lowest and highest delay respectively. Voice traffic is the best and email traffic is the worst in throughput analysis. Comparative analysis of the results with existing work showed that there is a throughput improvement of 18.64% and 7.77% for voice and email traffics respectively. A decrease of 52.6% and increase of 48.1% in delay for voice traffic and email traffic respectively are also achieved. The above observations were valid due to the selection of variable packet sizes in the course of the research.

5.2 CONTRIBUTIONS

The following contributions have been made to fill the knowledge gap on the impact of different traffic on OLSR in MANET based on the objectives of the research.

1. The OLSR protocol model was verified on MATLAB software where all nodes are spread randomly; node's neighbours and indeed their MPR nodes are selected. Thus, Variable Packets are generated and transmitted

randomly across the shortestpath found. Therefore, first objective was achieved

2 Objective 2 is achieved through simulating the above model (OLSR) based on four traffics (voice, video conferencing, ftp & Email). This is indeed a contribution because at the end of the simulation a graphical behavior of the said traffic on OLSR is presented and analyzed.

3 Objective 3 is also achieved where it showed a decrease of 52.6% for voice traffic and an increase of 48.1% for email traffic respectively in delay performance. In the case of throughput, there is performance improvement of 18.64% for voice traffic and 7.77% for email traffic.

5.3 RECOMMENDATIONS

Performance analysis of the Optimized link-state routing (OLSR) protocol is conducted on MATLAB modeler, another possibility of doing the same work can be done through another tool like NS-3 etc, different node density, topology, packet size, bandwidth or even on variable simulation area etc in a view to get wider knowledge of behavior of these traffics (voice, video conferencing, ftp & Email) on OLSR.

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