Improving Performance of Optimized Link State Routing for MANET with Quality of Service Metrics

By: Leworkalush Dagnachew

A Thesis Submitted to the

Department of Computer Science and Engineering

School of Electrical Engineering and Computing

Presented in partial fulfillment of the requirement for the Degree of

Masters of Science in Computer Science and Engineering

Office of Graduate Studies

Adama Science and Technology University

February 2019

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Declaration

I hereby declare that, this MSc thesis is my original work and has not been presented as a partial degree requirement for a degree in any other university, and that all sources of materials used for the thesis have been fully acknowledged.

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Approval of Board of Examiners

We, the undersigned, members of the Board of Examiners of the final open defense by ***Leworkalush Dagnachew*** have read and evaluated her thesis entitled "***Improving Performance of Optimized Link State Routing for MANET with Quality of Service metrics***" examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial.

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Chairperson	Signature	Date
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External Examiner	Signature	Date

Acknowledgment

First and foremost, I would like to express my deepest gratitude to GOD for his grace, strength, wisdom, protection and good health throughout my life. My sincere gratitude to my advisor Dr. Ketema Adere for his friendly approach, readiness, and willingness to advise on the research, his critical comments, commitment to guide, and support greatly improved this thesis.

Adama Science and Technology University is kindly acknowledged awarding me a full scholarship to follow a degree of master's in Computer Science and Engineering. I have respect and thanks to all the ASTU community to their special treatment during my study time from BSC up to now and I want to thank PG coordinator Dr. Mesfin Abebe and Dr. Bahiru for there valuable comments and supportive moral advice.

My special appreciations extend to all my recent friends for their time, for there support, guidance, patience and hopeful advice throughout the preparation of this thesis.

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Acronyms

AODV	Ad hoc Distance Vector
DSDV	Destination Sequenced Distance Vector
DSR	Dynamic Source Routing
DYMO	Dynamic MANET On demand
FSR	Fisheye State Routing
ID	Identification Number
IEEE	Institute of Electrical Electronics Engineering
IETF	Internet engineering Task Force
IP	Internet Protocol
MANETs	Mobile Ad hoc Networks
MPR	Multi Point Relay
OLSR	Optimized Link State Routing
OMNET++	Objective Modular Network Test-bed in C++
QoS	Quality of Service
RFC	Request for Comments
TC	Topology Control Message
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
VoIP	Voice over Internet Protocol
ZRP	Zone Routing Protocols

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Abstract

A Mobile Ad hoc Network (MANET) are nodes that are mobile, infrastructure-less and multi-hop collected and communicated nodes. Nowadays, MANETs are becoming popular and in the area time sensitive applications are increasing as well. Such applications need Quality of Service (QoS) evolving with respect to bandwidth, delay, etc. As a result, it becomes important for MANETs to have consider QoS metrics to select nodes that are can flood packets to next hop.So, it becomes critical for MANETs have an environment with desirable topology and QoS metrics based MPR selection for MANET. Then, we recommend improving the performance of the network based on. Generally, dealing with the QoS issue in MANETs are challenging because of the network topology changes quickly and the reachable link information for routing is naturally indefinite.

Generally, this thesis is a proposed QoS based routing algorithm by improving MPR selection methods in the OLSR protocol considering the quality of service-needed applications like multimedia and time-sensitive applications. As such, we use the Modified-clustering algorithm for topology management and QoS based MPR selection for OLSR. Give chance for the multiple Quality of Service metrics in order to select the MPR node has been improving the performance of MANET nodes. finally, the performances of the proposed algorithm have been evaluated as such the algorithm achieved high throughput and packet delivery ratio in which delay has been minimized when compared with standard OLSR. The simulation results show that the proposed algorithm achieved from 60% to 62 % packet delivery ratio and from 590.4 Byte/Sec to 654 Byte/Sec throughputs while the average end-to-end delay is minimized from 40ms to 33ms and during the simulation period, a node that is selected as MPR stays for 728.6 seconds, approved from 570.9 seconds.

KeyWords: MANET, OLSR, MPR, QoS. Cluster

CHAPTER ONE

1 Introduction

1.1 Background

Computing is a concept of improving the previous technology,application,architecture and software.Dynamic and wireless devices can be used anywhere and anytime without any fixed infrastructure.However,exchanging data and making communication in mobile nodes is a challenge [1].

MANET nodes communicate through multi-hop and single-hop paths in peer-to-peer and any conversation between these nodes is executed both directly via intermediate appearing as routers.Thus,the nodes operate as both hosts and routers.Owing to the restricted range of transmission ,countless nodes may additionally be wished to route a packet to its destination.Since the nodes are not static, the design of routing paths is altered by using the addition and deletion of nodes. The concept of MANET is used in many utility environments besides requiring any infrastructure support [1].

MANETs are a group of wireless infrastructure-less nodes that dynamically form a network and each node in MANET moves arbitrarily making the multi-hop community topology to trade randomly at unpredictable time stations. In MANET there is a concept of path selection ,which will play a important role in an ad hoc network to connect nodes that cannot connect with each other directly and does not stop to be a subject of research work to increase the performance of wireless networking solutions [1].

There are many routing protocols like OLSR,AODV,DSR AND DSDVetc. But, we are interested in Optimized Link State Routing (OLSR) [1, 2], which is a form of link state and proactive protocol and have topology control (TC) and hello messages. TC messages are for dissiminate link-state information and hello messages are to find neighbor information in the whole mobile Adhoc network. Shortest hop forwarding paths are used to compute destination of next hop by this topology for each node.

In OLSR [3, 4, 5, 6] each node selects its MPR to reduce the overhead with minimum hop ccount. In this protocol routes are always changed or prcessed with lower latency and suitable in dense networks. It is basically concern on Multi-point relay node selection.So there is one selection to approve QoS concept that is selection of MPR BASED ON quality of service metrics.

In QoS, the term quality means - Quality includes data loss, encouraged about the end-to-end delay,and proper use of network resources and Service also is ability end-to-end conversation between purposes and protocol [6].

1.2 The Motivation of the Study

The use of MANETs will extend their presence in future communication environments. Future functions of MANETs are estimated to be based totally on all-Internet Protocol (IP) architecture and they will be successful in carrying out real-time multimedia purposes such as voice and video. Such applications need QoS requirements on networks for delivering real-time audio and video packets. The first case that motivates us for this problem is the fact that now mobile computing is the biggest issue. There are a lot of mobile devices are used for different purposes and applications like online gaming, voice/video conferencing, VoIP, and other mobility concepts. In these situations, it is mandatory to exchange of messages between mobile nodes and create connections. MANET is a mobile adhoc communication that is used to communicate peoples and devices without infrastructure with considering mobility.

1.3 Statement of the Problem

In the routing data,messages for link state are spread periodically to make homogeneity allover the network. At the occurrence of the difference in the topology of the network, this change will be flooded (broadcast) to only a few nodes these selected nodes reflood it based on MPR (Multi-Point Relay nodes). Nodes, which do not get the update information will just read the change and will not rebroadcast this update to the other nodes. Flooding of packets and its drawback is reduced and control message will be minimized in number. In this proactive table-driven protocol of MANET, there is one necessity that makes in OLSR that is the selection of MPR nodes. In this case, there is a big influence on the overall quality we enhance the existing protocols to satisfy better for QoS requiring applications such as voice/video conferencing, VoIP, and other time-sensitive applications [7].

So, selecting the best and correct MPR node is very hard.Many research deal wirh with idea but none of them did not solve the problem. Some of them try to consider QoS metrics like bandwidth and delay selectively but considering multiple quality of service metrics to select MPR node to floodpackets to the next hop is an important issue. In addition to this managing the flat and dense topology of the network must be considered.

1.4 Research questions

To this end, this study tries to answer the following questions

- How the selection of MPR decrease the performance of optimized link state routing as well as MANETs?
- How we manage the difficult topology of OLSR to improve the performance?
- How we apply the Modified clustering algorithm in the selected protocol?
- How we select the appropriate MPR node in OLSR protocol based on selective QoS metrics?

1.5 Objectives

1.5.1. General objective

The main aim of this research work is to enhance the performance of the OLSR protocol based on QoS MPR selection and manage the topology of OLSR with modified clustering for MANETs.

1.5.2. Specific objective

To achieve the above main aim we must fulfill the following:

- To study the problem of MPR on the performance of the OLSR protocol.
- To design an algorithm based on selective QoS metrics that chooses best MPR
- To use clustering to manage the topology for OLSR

- To simulate the designed solution
- Analyze and compare the proposed one with an existing using performance evaluation parameters (packet delivery ratio, end-to-end delay, and throughput).

1.6 Methodologies

1.6.1. **Overview**

In this section, we will get a brief understanding of our development method, define the design of the proposed system method, describing proposed system testing method, and compare and contrast available development tools to choose appropriate tools for the our proposed system were described.To understand the current MANET and the performance of protocols in MANET especially for OLSR (optimized link state routing) document review is used and to understand.

1.6.2. **Design MPR Selection Algorithm and Manage the Topology with Cluster.**

The new algorithm selects the optimized MPR based on QoS metrics bandwidth and delay and improve OLSR flooding of the packet and use modified to manage the hard topology of OLSR

1.6.3. **Simulate the Proposed Solution**

To simulate the proposed solution, different tools, hardware, and software tools are used in table 1.1.

Table 1.1: Tools to simulate the proposed solution

Software	Operating System	Ubuntu 16.04
		Microsoft Windows 10
		Microsoft Windows 8.1
	Simulation tool	OMNET++ 4.4
	Programing language	C++ and NED language
	Architecture and diagram draw tool	word office 2016
Hardware	RAM	Installed memory (RAM) 4.00GB
	System Type	X64 based processor.

1.6.4. **Performance Evaluations**

The proposed OLSR based on new MPR and cluster topology was compared with existing OLSR by taking a different parameter (end-to-end delay, throughput, PDR) to evaluate performance.

1.6.5. **Research Overall Procedure**

The research design has been designed for analyzing the input based on the designed system and finally give the output. As in figure 1.1, Generally, to attain the above objectives and to answer the research questions, the following procedures and techniques were followed.

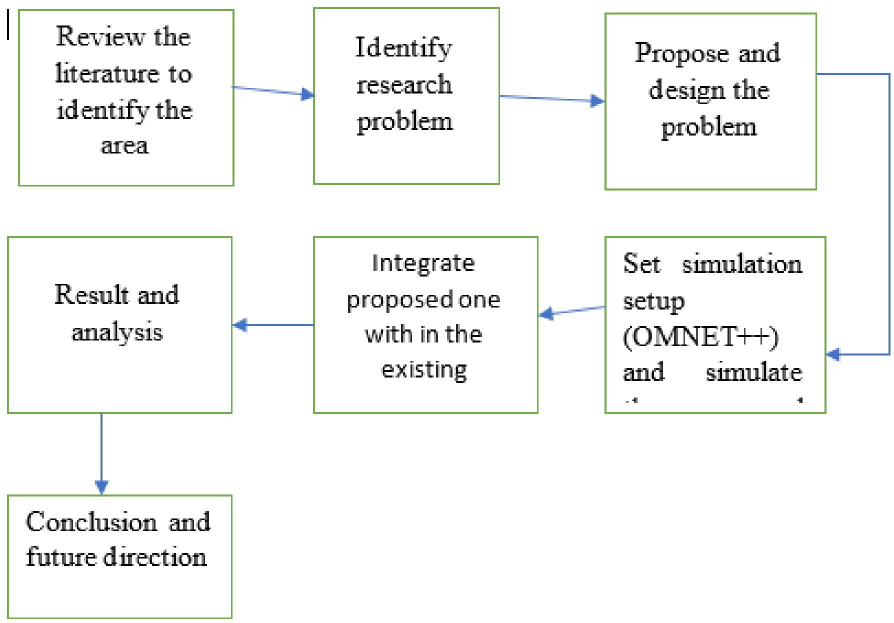

Figure 1.1: Process of this Research

1.7 Scope and Limitation

1.7.1. Scope of the Study

This study only focuses on improving performance of MANET protocol that is OLSR by simulating the QoS metrics based MPR and managing topology in OLSR with the cluster.

1.7.2. Limitation of the Study

Ad-hoc have a lot of research area, our study delimited in MANET, we did not include other kinds of ad-hoc networks. The performance of OLSR was affected by different cases, such as node behavior but this study limited to only node topology and how we select MPR (Multi Relay Point) node based on QoS (bandwidth and delay). The limitation is we did not concern about the security issues.

1.8 Research Beneficiary

Recently,mobile devices are become popular with with huge number of adhoc mobile networks and applications. So,this research is useful in improving performance mobile ad-Hoc network (applications like education area, intertainments, military sector and conferences etc.The main significance of the research is to enhance performance of MANETs routing protocols for delivering QoS services in more necessary applications.

1.9 Thesis Organization

Generally,our thesis is organized into five chapters.In the first chapter, we are talking about the introduction or clue about the area, the problem and the current situation in chapter one.The remaining Chapters are organized as follows Chapter 2 presents a literature about MANETs and QoS routing in MANETs and introduces related works, which are conducted for routing a data on a MANET. Chapter 3 presents the detail of the proposed model and algorithms. Chapter 4 provides simulation study(about the simulation tool OMNET++ bathe INET framework), results and evaluation(with Delay, Packet Delivery Ratio (PDR) and Throughput) of the proposed solution. Lastly, the we conclude and give future directions are listed in Chapter 5.

CHAPTER TWO

2 Literature Review

2.1 Overview and Definition of MANET

In this part, we are trying to discuss, an overview of MANET. A Mobile Ad-Hoc Network (MANET) [2, 3, 7] , is one types of a dynamic wireless network which is built by a group of mobile nodes. These nodes are connected with each other for exchange network information. Addationally , MANET network topology changes may be occurred in randomly and frequentely.This wireless communication network provides transfer information from source mobile node to the distnation node by using forwared packet transmition method.

Mobile Adhoc Network is fundamental Feature of an ubiquitous computing because users are no a ware of computation being done [8, 9]. Due to their ability to be intelligent, devices are self-organizing, packet forwarding, connecting to the Internet and they can be embedded pervasively to the physical world. In MANETs, many research areas have potential study value and thus attract much attention. Currently , there are numbers of potential research issues are available about MANET like routing, location service ,TCP , medium acces control ,quality of service(QoS) , power management , security, and so on.However ,finding efficient solutions to these issues can be increasing the survivability of MANET. Now a days , Internet Engineering Task Force(IETF) is proposing number of research directions inorder to improve current MANET service [10, 1].

2.2 Characteristics of MANET

Following are the main characteristics of Mobile Ad Hoc network [1, 4, 10] [[6] [8],as we observe MANETs are dynamic network topology, low bandwidth, limited battery power, distributed operation, autonomous terminal, unreliable communications ,weak physical protection, low scalability(because of limited memory and processing power on mobile devices),ad hoc, multi hop routing and self-created, administered, configured.

2.3 Application areas for MANET

Mobile Ad Hoc network can be used anytime,anywhere with out any infrastructure [11] [12].

2.3.1. Military Battlefield

Currently , military organizations are used digital battlefield demands which requires reliable communication in many forms [13]. Figure 2.1, in addition, soldiers could carry telecom devices that could talk to a wireless base station or directly to other telecom devices if they are within the radio range. However, these forms of communication are considered primitive [12].

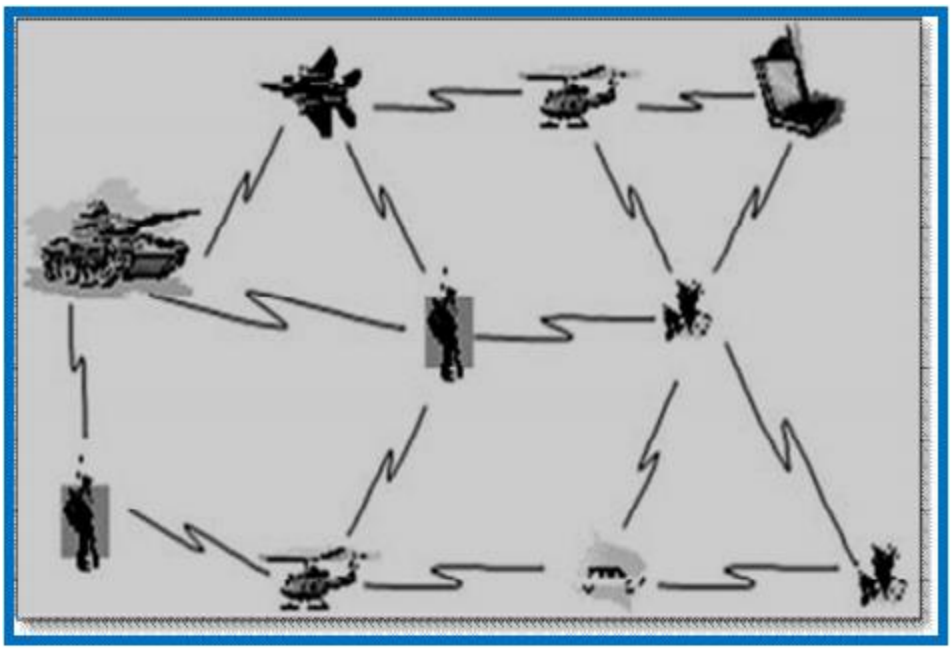

Figure 2.1: MANETs Military Battlefield *[13]*

2.3.2. Sensor Networks

A Sensor network is a collection of huge number of small sensors. Sensors are used to detect any number of properties of an area such as pollutions, temperature, pollutions, pressure, and toxins, etc. They are the amount of humidity for agriculture, prediction of earthquakes [1].

2.3.3. Automotive Applications

Vehicles should be communicate to each other, to the road, and to traffic lights, forming ad-hoc communication of various sizes. The communication will be responsible for the drivers with information about congestions, road conditions, helping to optimize traffic flow, and accident-ahead warnings.

Figure 2.2: VANETs [14, 11]

As shown in Figure 2.2, (VANETs (Vehicular Ad Hoc Networks) [14] [11] are used for communication among means of transportation and between vehicles and roadside equipment, to provide vehicular traffic management.

2.3.4. **Personal Area Network (PAN)**

Personal Area Networks [13] [14] [11] are formed between various mobile (and immobile) devices mainly in an ad-hoc manner, e.g. for creating a home network. Networks involve communications between smart appliances, laptops, Personal computers, entertainment systems and phones in home and in other areas.

2.3.5. **Conferencing**

Highly need Ad-hoc networks at the time of peoples are participating in that and form a network without any pre-existing network these areas.

2.4 Routing process and Routing Protocol in MANET

Mobile Ad hoc network has not fixed infrastructure. This leades to routing problem [3, 15, 5]. Routing is the process of selecting appropriate path in the network when to send data packets from the source to the destination device. This has standard protocol that controls how nodes decide appropriate ways to route data pakets towards its destination node.The quality of the path is measured in different metrics such as numbers of hops, bandwidth, traffic load, transmission range and so on. In ad hoc networks, the new node may declare its impressive and should be listen for describe broadcast by its next nodes. The routing process always using forward approach based on the routing tables that are keep record of the routes to different network destinations. In MANETs , the connection is creating dynamic way inorder to eliminate routing problem;such as path breaks, topology changes, resource management ,and etc.to overcome these probelems different reserchers were proposed solution [1, 3, 7, 6]. The MANET protocol is classified into three groups based on the way of finding new routes which are shown in below figure2.3: [12, 16].

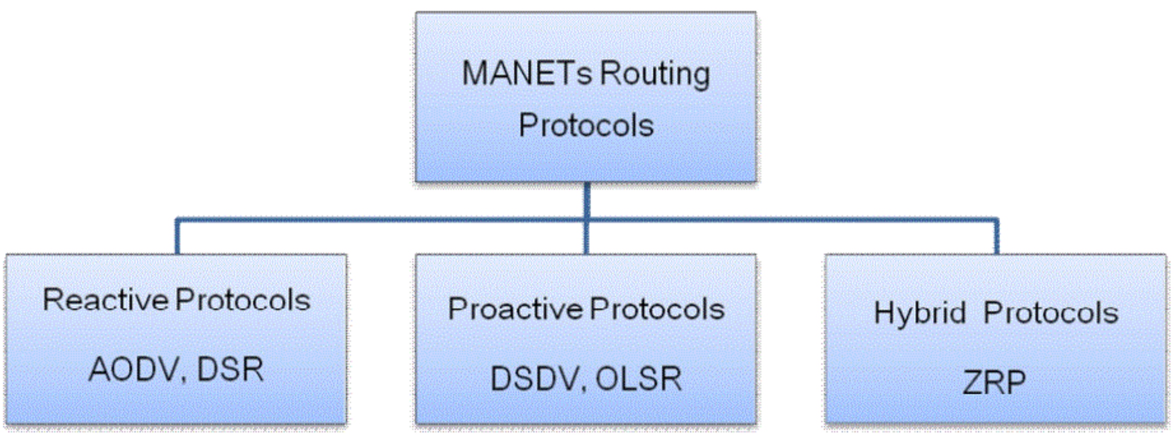

Figure 2.3: Types of MANETs routing protocols *[12, 16]*

2.4.1. **Proactive Routing Protocols**

All proactive routing protocol are required to maintain correct information in its routings [7]. This tries to achieve continuously evaluate all of the routs in the network .Therefore, the router table should be distributing destination node information periodically throughout the network.In this routing protocol, once the routing table set up then data transmitions will be fast and easy as compare with traditional wired network method. However, proactive routing protocol has big overhead to maintain routing table information in a mobile ad hoc network. Consequently, this protocol has the following major disadvantages,consume many network resource;slow reaction on rebuilding network and failures of individual nodes.So, proactive routing protocol is more suitable for small numbers of nodes available in the network. Generally,it has different types of proactive routing protocol proposed to minimize the above limitation which are described in below.Therefore, proactive routing protocols are more appropriate for a smaller number of nodes in networks, which will need minimum delays of QoS required applications. These routing protocols are not suitable for larger networks, as they need to maintain node entries for each node in the routing table of every node. This causes overhead and leads to the consumption of more resources like bandwidth, processing power, etc.

2.4.1.1 Optimized Link State Routing (OLSR)

The Optimize Link State Routing Protocol(RFC 3626) is built for mobile ad hoc networks [1, 3, 17, 18]. This is the most popular types of proactive routing protocol because nodes are maintain the routing information in the routing table.Hence, the route information is available quickly when it is required.The source node will notice by the topology control messages during this time the bandwidth change happen.So, a new route will be calculate again. Basically, the OLSR routing protocol differs from othe routing protocol is it uses Multipoint Relay(MPR) to minimize the numbers of hosts to prodcast the data throughout the network [17, 15]. Currently, OLSRv2 types of OLSR version which are developed with in LETF [1, 18, 2] It has flexible and modular design to use shared components like packet format and Neighborhood Discovery Protocol(NHDP).The OLSRv2 routing protocol is standardized and applicable for MANET which are handling multiple address and interface enabled nodes. OLSR proactive routing protocol is focused on four points that are described in below.

Sensing neighbours: each node periodically broadcasts a HELLO message, containing the information about its neighbors and their link status. Each nodes must detect the neighbor figure 2.4**.** Flooding a Packet with MPRs nodes with which it has a direct and bidirectional link. Node discoveries its own address in a HELLO message, it considers the link to the sender node as bi-directional.

Multipoint Relay Selection:

In the network, every node should select its own set of MPRs. A one hop neighbor nodes that can forward data to the two hope MPRs.This is important to minimize the flooding of the broadcast message to all two hope neighbor nodes.

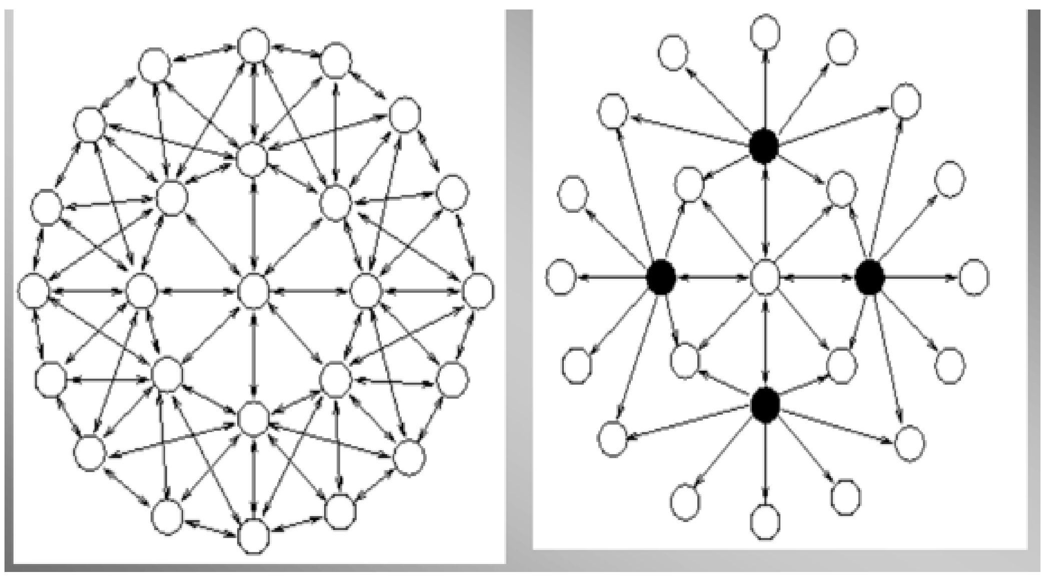

Figure 2.4: Non MPR flooding of packet and MPR based flooding respectively *[19]*

In the above first diagram show that [1, 10] each node transmits the incoming packets to all other neighbor nodes. This leads to high numbers of unnecessary retransmitions between nodes . Consequently , packets are collide to each other through message overhead between nodes then loss of packets. Whereas , in diagram two show that, [1, 10], only black nodes are selected as MPR inorder to forward the packet to the neighbor nodes.This reduce the flooding of transmmition packets and the overhead of the network.

Declaration of MPR Information

By using Transmission Control(TC) messages are sent at specific interval by each node in the network which to declare its MPR selector set. Hence,the message consists of a list of neighbors that have selected thesender node.

Calculation routing table

each node keep the routing table infroration in the network. The routing table have distination address, hope address estimated distance compare with destination [4, 6, 17, 20].The routing table information is defined based on both neighbor and topology table information .Hence, If any of these table information changed then the routing table also recalculate and update the routing information.According to previous research [2, 7, 6, 17],OLSR has lower latency, provide optimal routes,better for high network mobility and good inn scalability.

Data flow and Organization in OLSR

In below figure 2.5 shows the structure of OLSR for moving an input data and relation to message processing , message generation and rauting calculation elements in the routing process [1, 10].

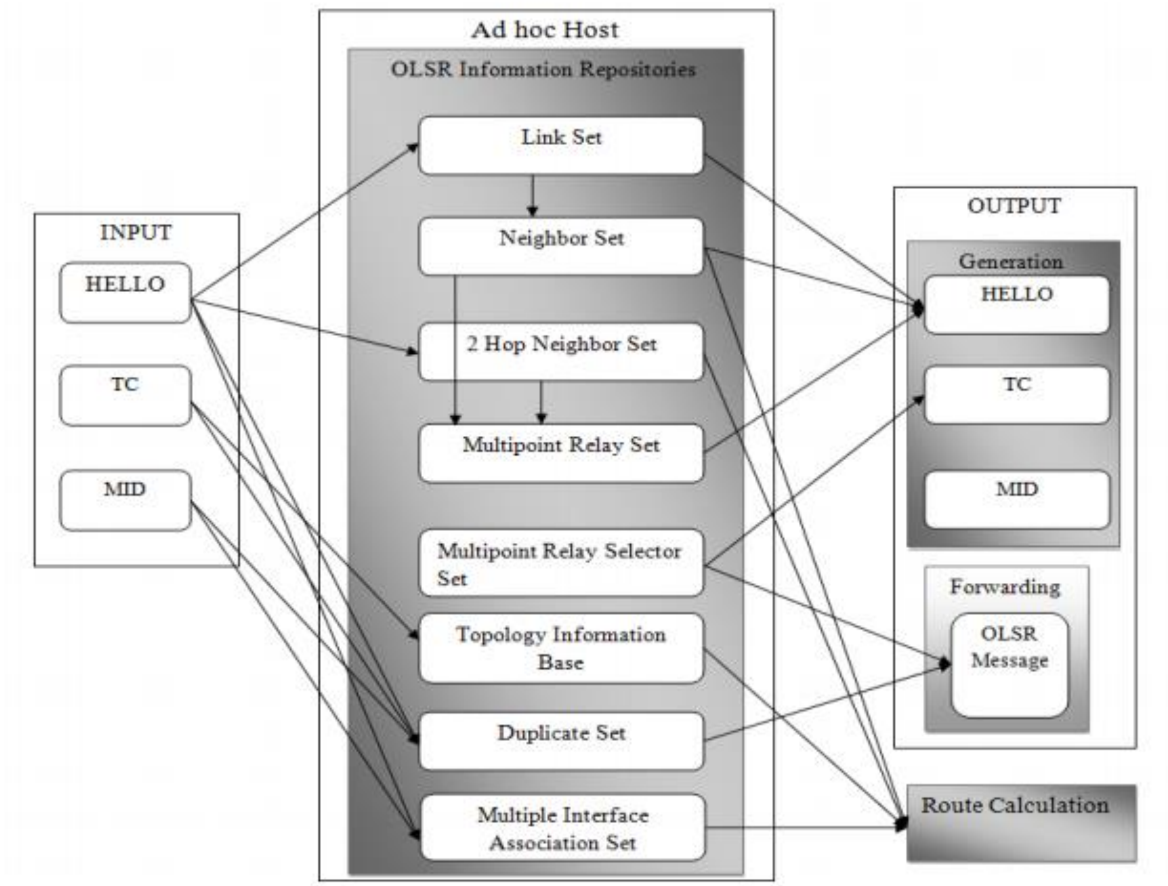

Figure 2.5: Flooding of data in OLSR *[10]*

OLSR has three types of messages such as HELLO,Topology Control(TC) and Multiple Interface Declaration (MID).HELLO message is sent periodically into all neighbor nodes. In the network with TC message, each node is continuously flood by using the multipoint mechanism. This message is consists of the node's MPR selector set. A MID message is used to announce that node is running OLSR on more than one interface. The MID message is flow in all the network by the MPRs.Generally , the MPR selector set is updated based on the information received from HELLO messages. All received messages will be also registered in the duplicate set when it is not registered.

Information Repositories in OLSR

OLSR maintains the state by keeping different characteristics of database information. These information repositories are updated the recent information on processing received messages.

Basically, OLSR information repositories consisting of different types of data like link set, neighbor set, 2-hop neighbor set, multipoint relay set , multipoint relay selector set , topology information base, duplicate set and multiple interface association set.

Packet forwarding in OLSR

During OLSR repositories information build and maintain, it requires different types of OLSR messages are defined. These messages are exchanged by their nodes which are using in the network. As we are seen in the above data flow in OLSR figure 2.5 [1, 10], , it has different types message information like packets, packet format, packet header and sequence number to maintain information independently and to define the length of each interface of the OLSR nodes. The packet body has one or more messages that are come before the message header. The message header also consist of various types message information such as message type, message size, validity time , originator address, destination time , hop count and message sequence number. To eliminate establishing routing loops and resend of already data each packet and message consist a sequence number.

Works on the Selection of MPR Nodes

To optimization, the MPR protocol is introduced different types of mechanism like selecting flooding approach. The approaches are put forward to become better in various features of broadcasting qualities in MANET. These performance qualities include the numbers of forwarding nodes; efficient power usage; collision avoidance; and Quality of Services (QoS). These selections schemes can be divided into various types of groups based on require criteria's. In this research, we are classified MPR selection schemes into two major groups based on their objectives and the ways of MPR selection features. Such as pure MPR schemes and QoS based MPR schemes which are defined in below.

Orginal MPR approach

This approach is extended from the original MPR selection mechanism to minimize transmission collisions and power usage in the MANET. These problems are always eliminated by reduce transmit information size at a time and to avoid overlapping coverage between MPRs.

MPR based on QoS approachs in the orginal scheme

In the previous scheme, MPRs are chosen links without depend on quality of services (QoS). Therefore, information is propagated between nodes and its MPR selectors rather than to ensure good quality links between nodes in the network. However, in this scheme, the qualities of services issues are considered in the network. Hence, in this scheme there are two schemes are proposed to guarantee of QoS [21]. The first approach is called QMPR-1, which has similar initial steps with original MPR except it changes procedure to supply quality of services priorities like maximum bandwidth with minimum delay is selected [3, 4, 5].

MPR selection problems(challenges)

The MPR technique is provided optimizing the routing package in the network. However, this is difficult to select appropriate MPR in the MANETs because it nodes are highly mobile, paths are not constant, and they are updated continuously. Additionally, each node is communicating through wireless transmission media and it has limited transition range. Consequently, the nodes are dynamic then MPR selection criteria also may not stable. This leads to QoS problem but when select any node to transmit information, they must be consider QoS constraints [22, 23].

2.4.1.2 (DSDV)Destination Sequenced Distance Vector routing protocol

It is an improvement of Bellman-Ford routing algorithm [24, 25]. It uses additional parameter sequence number to improve the route table for each node.Station lists store number of hop count and available link and used to control the loop problem of distance vector of proactive protocol .DSDV performance is high with minimum mobility and small number of nodes [26, 17, 24, 25]. The bandwidth and the routing table size become high as the number of nodes become high in the network. In few papers [24, 25], Destination Sequenced Distance Vector routing protocol is greatly good in terms of routing overhead.

2.4.2. **Reactive Routing Protocols**

Reactive Routing Protocols must become silent at the time of no route traffic in minimum bandwidth and with low power network areas and they are ondemand protocols they didn't make route [24, 27, 18].

2.4.2.1 Ad-hoc On-demand Distance Vector Routing

At the time of sender want to send packet to destination ,Ondemand route request and route replay is used to find paths in AODV [28]. In this routing protocol, to get their updated destination route, all node preserves the routing table of next hop. When a sender wants to establish a communication, it initiates to flood packets to the destination if it has a current route to the destination in its routing table. Otherwise, it initiates a path discovery process by broadcasting a route request message. As a reactive routing protocol [24, 28, 23], AODV uses a periodic broadcast of Hello Message to track neighboring nodes. This periodic propagation causes network overhead in AODV.

2.4.2.2 DSR(Dynamic Source Routing)

This is an on-demand source routing protocol. In DSR [27, 18, 29, 23], the route paths are discovered after the source sends a packet to a destination node in the ad-hoc network. DSR needs no periodic updates of any type at any level in the network. It uses source routing through which the node that wants to send packet knows the whole hop by hop route to the reciver node. These routes are stored in a route cache. Data packet store the source route in the packet header. DSR involves two mechanisms, route discovery and route maintenance [18, 23].

In MANETs, DSR can be chosen to provide soft QoS guarantees in different areas of MANET applications when better QoS parameters like reliability, packet delivery, overhead, etc. The protocol provides a reliable route for packet transmission with a minimum network overhead. Due to source, routing DSR has major scalability problem [27, 30, 23], Nodes use routing information to reply to route queries. This results in uncontrolled replies and repetitive updates in host caches. In addition, early queries cannot stop the propagation of all query messages, which are flooded all over the network. Therefore, at the time of network expansion, the increment of message packets and control packets is happend. This condition could decrease the protocol performance after a time.

2.4.3. **Hybrid Routing Protocols**

These types of protocols mix or use the benefits of proactive and reactive routing protocols [25]. Some proactively arranged routes and then give the demand from additionally activated nodes via reactive flooding initially design the path.

The main drawback of hybrid (mixed) routing protocols is that splits the topology into zones and seeks to use different routing protocols between and within the zones based on the prons and cons of the protocols [25] .

In Ad-Hoc networks, if network congestion is most likely to occur, IERP identified and maintains a route record of nodes that exist in the routing zone. This will reduce unnecessary broadcast of route requests to identify the nearest neighbor. ZRP bounds the overhead proactive within the size of the zone [25].

2.5 Comparison of the properties of MANETs Routing Protocols

Table 2.1: characteristics and features of routing protocols

Characteristics	MANETs routing protocol					
	Proactive		Reactive		Hybrid	
	OLSR	DSDV	AODV	DSR	DYMO	ZRP

Organization of the network	Flat	Flat	Flat	Flat	Flat	Flat
Route availability	Always available	Always available	Computed as per need	Computed as per need	Computed as per need	Depends on the location of the destination
Route information	Keep stored in table	Keep stored in table	Doesn’t store	Doesn’t store	Doesn’t store	Depends on requirement
Route freshness	Up-to-date	Up-to-date	Not Up-to-date	Not Up-to-date	Not Up-to-date	Up-to-date inside each zone
Data forwarding type	Hop to hop	Hop to hop	Hop to hop	Hop to hop	Hop to hop	Hop to hop
Update transmitted to	MPR node	Neighbors	Neighbors	Neighbors	Neighbors	Neighbors
Supports asymmetric	Yes	No	Yes	No	Yes	No
Route discovery	Periodic	Periodic	On-demand	On-demand	On-demand	Periodic
Need of hello message	Yes	Yes	Yes	No	Yes	Yes

Multi-hop wireless support	Yes	Yes	Yes	Yes	Yes	Yes
Multiple routes	No	No	No	Yes	No	No
Redundant route	No	No	No	No	No	No
Node overhead	Medium	High	Medium	High	Medium	Medium

Table 2.1, Provides the characteristic features of some of the well-known routing protocols and described which protocols are best in large networks to maintain routing information. The protocols we discussed in this Chapter have their own characteristic features and performance parameter combinations where they outperform their competitors. Still, MANETs have posed a great challenge for researchers due to changing topology in the routing processes, and none of the protocols is fully efficient for satisfying QoS demanding applications.

Surveys [26, 7, 17] on different routing protocols have been conducted to recommend a better routing protocol for QoS routing in MANETs. Assuring the capability to manage dynamic connectivity of nodes and delivery are the most significant issues, which are reflected in the surveys of routing protocols.

2.6 QoS and QoS routing in MANETS

MANETs attain popularity their need to assist real time and multimedia applications is growing as well [7, 31] [6, 10]. Such applications have stringent fantastic of service necessities such as bandwidth, delay, and extend variance (jitter).The sketch and development of routing algorithms with QoS experiencing increased research interest.Several approaches, which advise more than a few routing algorithms with QoS issues for MANETs, have been in the research. Due to the dynamic nature of MANETs, designing communications and networking protocols for these networks is a challenging process. While this may be sufficient for a sure class of MANET applications, it is not enough for the help of greater demand functions such as multimedia audio and video. Such applications require communication to give guarantees on the Quality of Service. *Figure 2.6*, shows clearly the effects of routing on QoS support routing protocols with that of non-QoS supports. That is, the first, which does not show clear video as it, uses non-QoS support routing protocols while the later uses QoS satisfying protocols.

a) Video data with QoS support routing
b) Video data without QoS support routing

Figure 2.6: Video data with and without QoS support routing

Quality of service is the qualitatively or quantitatively clarify agreement of performance between the service provider and user applications based on the related requirements. That is, the network is expected guarantee to a collection of determinate service attributes to users based on end-to-end performance parameters such as delay, bandwidth, jitter, error rate. Intrinsic to the idea of QoS is an agreement or a assurance with the help of the community to give a set of measurable pre-specified service attributes to the clients. The concept can be described using numbers and qualitative metrics presented in Table 2.2, which shows a given network satisfies QoS requirements or not [26].

Table 2.2: Different Metrics of quality of service

Quantitative metrics	***Qualitative metrics***
End to end delay	Loop freedom

Overhead	Route stability
Packet Delivery	Reactive /proactive
Mobility	Reliability

2.6.1. **QoS Support for Mobile Ad hoc Networks**

The Internet has only recommended best-effort service best effort in the sense that it will do its best to transport the user packets to their intended destination, although without any guarantee. Although substantial work has been done for the quality of service on the Internet, none of the existing proposals can be applied to MANETs due to limitations and constraints intrinsic to MANETs. The QoS requirements in MANET are quite different from that of the classical approach and existing QoS works predominantly designed for the traditional networks are unfit for MANETs.

Consider Figure 2.7: where the numbers next to the links represent their respective bandwidths, say in Mb/sec. To minimize delay and for better use of minimizing the number of intermediate hops and network resources is one of the principal objectives in determining suitable routes. However, suppose that the packet flow from A to E requires a bandwidth guarantee of three Mb/sec. The most important element among them is QoS routing, i.e., the process of choosing the routes to be used by the flow of packets of a logical connection in attaining the pre-established QoS guarantee. QoS routing will then select the route [A→B→C→E] over the route [A→D→E] because the latter is unable to meet the bandwidth need although it has fewer hops. The only other alternative, [A→B→D→E], will also be rejected for failing to meet the bandwidth need.

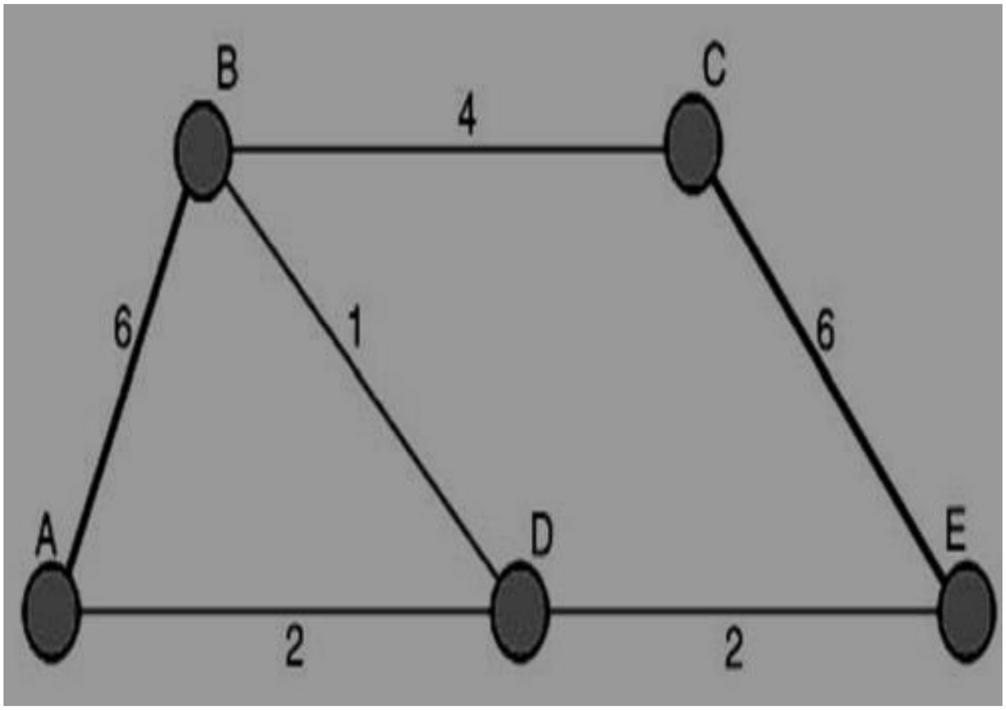

Figure 2.7: QoS Route

2.6.2. **QoS Service Models**

The best-effort service model does not provide any guarantees regarding packet loss or delay, available bandwidth, jitter, etc. This technique is environment friendly for purposes that do not longer require bounds on packet delay or different QoS metrics. However, real-time applications, such as video-on-demand (VoD), video conferencing and Internet telephony, are sensitive to packet loss and delay and might have minimal bandwidth requirements [31].

2.6.2.1 QoS routing using Reactive Routing Protocol

Over the final few years, many on demand routing protocols for MANETs have been proposed. Here we have reviewed the most well-known types of reactive routing protocols that will provide us a better QoS routing in MANET applications.

QoS routing using AODV Routing Protocol

Some important works, which are conducted for QoS routing using AODV, are discussed as follows:

In [24] the authors made a comparative study and performance evaluation of the reactive quality of service routing protocols that are best suited for MANETs. The study has been done by considering parameters like average jitter, overhead, throughput and the total number of packets sent and received. The results were analyzed using a simulation method and the QUALNET simulator was used for the analysis. Finally, they summarize that compared to most reactive protocols AODV is better for QoS routing. However, this protocol is not suitable for multimedia applications in which the average delay is taken as a critical issue.

In [26] the authors proposed an approach and summarized some existing schemes for QoS aware routing protocols for MANETs by considering two important metrics: data rate and delay. NS2 was used to evaluate, presente and to do simulations with both AODV and QAODV routing protocols. Different data rates and moving speeds are tested in order to see the performance of two simulated protocols. The outcomes show that the QAODV performans is better than the AODV in terms of end-to-end delay when traffic on the network is high. They also get that when the network begins to be saturated, the getting route and maintenance process become more important [28].

In [22] the authors analyzed the performance of different reactive routing protocols based on the fuzzy inference system. In this paper, the fuzzy inference system offers to accept multiple input constraints like energy, number of collisions, end-to-end delay and number of hopes for finding an optimal routing path. Finally, the simulation outcome illustrations that the proposed system increase the performance of the AODV protocol on real-time applications.

QoS routing using DSR Routing Protocol

Some of the works that are conducted on DSR are summarized as follows. In [27] [29] a new QoS-DSR strategy for reactive route discovery was proposed. The method is based on two QoS parameters, low bandwidth requirement and the maximum permited end to end delay. DSR routing protocol was used as a groundwork for implementing the proposed route getting mechanism. Using NS2 network simulation the proposed approach was evaluated on 50 nodes and the outcomes shows that in all comparisons of DSR and QoS-DSR, the proposed approach (QoS DSR) exhibits reduced end-to-end delay while maintaining high packet delivery ratio.

In [18] the authors proposed Ant Based Dynamic Source Routing (ADSR) algorithm to provide QoS support routings, such as acceptable delay, jitter, and energy in the case of multimedia and real-time applications. The proposed protocol selects a minimum delay path with the maximum residual energy at nodes. The performance of DSR and ADSR are analyzed using the NS2 simulator and the outcomes shows that the proposed algorithm is better than the existing ones in terms of delay, energy, jitter, and throughput. Even if ADSR performs well in route discovery with dynamic changes in the network topology and produces much better throughput with very low variance in the delay, it results in slightly higher routing overhead than DSR.

In [30] the authors proposed a QoS model for DSR protocol via adding extension related to the bandwidth metric to its structure to support certain aspects of QoS capabilities. The change that had been made in this paper was bandwidth availability along the path from the source to the destination that can satisfy the requirement. In order to check the proposed model, a simulation is carried out the use ofNS2 and specific eventualities were examined to see the performance of the modified protocol compared with the original DSR protocol .The outcomes show that improve quality of service to protocols is neccessary to increase the performance of traffic on the network especially in real-time traffic [32].

2.6.2.2 QoS Routing using Hybrid Routing Protocols

As we described in the literature, hybrid routing protocols are appropriate in the area when the advantage feature of both reactive and proactive protocols is required. The researches which is conducted using hybrid routing protocols are discussed as the following.

QoS routing using Zone Routing protocol (ZRP)

In [25] the authors analyzed the performance of ZRP on various node densities in terms of end-to-end delay, average jitter, and packet loss. As the density of the node increases, the number of neighbors nearby the node and the range of zones in the area increase. Hence, the overall delay required by the packet path to a destination will increase. Similarly, the chance of wrong path selection and packet loss also increase. Moreover, when the times required for sharing information between zones vary, the packets reach the destination at a different time delay. Finally, they concluded that ZRP is suitable for large networks by providing the benefit of both proactive and reactive routing protocols. However, this result is dependent on the type of application in which we use ZRP. If we use it for real-time applications like video transmission, in high node density, the performance of ZRP routing will decrease.

2.6.2.3 QoS Routing Using Proactive Routing Protocols

In the above sections we are discussed in QoS in the reactive and hybrid routing protocol. In the following section, we will summarize the works, which are conducted on the most well known proactive routing protocols for providing QoS routing service. In the last decade, several researchers proposed the OLSR routing protocol for applications that require QoS. Here we summarize that are relevant and related to our study.

In [33], in order to reduce the control overhead and routing table size, the authors propose a clustering approach on OLSR protocol. The approach does not depend on a specific clustering algorithm, but it assumes that a clustering mechanism is being executed in the ad hoc network.

The protocol applies ordinary OLSR interior every cluster, and TC messages are forwarded only inside the cluster. In this approach, two new messages cluster hello, and cluster TC messages are defined to define the behavior of an OLSR node by a cluster. This may generate additional overhead of the network. In [34, 35, 33], other than applying clustering

2.7 Evaluation of Routing Protocols in MANETs

As we see in the following table 2.3,we can conclude the quality of service routing in MANET within proactive,reactive and haybride type of routing protocols [7] [17, 24].

Table 2.3: Comparison of QoS Routing Protocols

QoS Parameter	Proactive		Reactive		Hybrid
	OLSR	DSDV	AODV	DSR	ZRP
End to end delay	Lower	Lower	Higher	Higher	Low for local destinations

					and high for Inter-zone
Bandwidth requirement	Medium	High	Low	Low	Medium
Throughput	Very good	Good	Good	Good	Poor
Mobility	Good	Good	Very good	Good	Good
Packet delivery ratio	Very good	Good	Good	Good	Very good
Loop free	Yes	Yes	Yes	Yes	Yes
Reliability	Good	Poor	Good	Very good	Good
Overall complexity	Low	High	Medium	Medium	Medium
Communication overhead	Medium	High	Low	Low	Medium
Scalability	Partial	No	No	No	Partial

Any protocol has its own prons and cons based on the concept or scenario applied.Delay is the main concern on quality of service needed applications like multimedia ,telephony, audio/video and time based applications.So proactive protocols are good to minimize delay because they already select or decide the rute before the source wants to send.but reactive routing proitocols are not advisable or appropriate in delay sensitive applications because the route is not initially defined because they are ondemand.In addition to this reactive routing protocols has high traffic because of there way of flooding packet and less suitable for time sensitive applications.So, we must use proactive protocols

So we are focused on proactive protocol specifically OLSR.

2.8 Recent issues in MANETS

Recently,there are many challenges in MANET, but some of them are network scalability,routing overhead,quality of service,asymmetric links,dynamic changing topology,battry issues and topology etc.

Service quality

In MANET it is difficult to diliver good quality service.For the reason that we canot support most requirements of QoS because of its inherent nature.

Scalability of network

Now adays, most networks are static ,wireless and small networks but MANETs need large networks for tactical and sensor networks and this needs scalability.

Overhead of network

Location of nodes are varied in MANET inside the network and in the routing table some static paths are created.These paths lead unnecessary flood of packets and gives high overhead.

Limitation of physical layer

Because of high electro magnetic interference or weather inclement,links quality can not predicted and unreliable communication and error is occurred in wireless media.

Asymmetric links

Networks tha are not wireless have symmetric and alyways fixed links.but in wireless Adhoc networks this not not happened. They have dynamic and both symmetric and assymetric links because of mobility. So we can not know the quality in asymmetric links.

Dynamic changing Topology

Nodes can move at any time and the topology also changed and all other issues are changed and it becomes difficult to manage the network.

Limited physical security

Generaly, mobile adhoc wireless networks are more disposed to security threats physicaly.

2.9 Related Work

This section reviews the different kinds of literature that are recent and more related to the objective of the study. As we know wireless communications are becoming more popular and must be robust and friendly operations with collaborative routing performance in to hosts.so the MANETs QoS support popularity help the subject to be wonderful interest in wireless area.In the following table 2.4 section, we see recent and more related past papers to our work.

Table 2.4: Related work

No.	Title	Authors	Main concept	Limitation /drawback
1	Minimax Algorithm for MPR Selection in Improving the Performance of OLSR Protocol on MANET (2018)	K. E. Purnima, E. Setijadi, M. H. Purnomo	Use **min-max for MPR** selection and Aims to **reduce TC messages** on each node, so as not to cause the occurrence of Packet redundancy. [36]	They did not worry about all QoS. Using only the min max algorithm also cannot solve the problem of QoS issues. They use only **Delay** to select MPR.
2	A Cluster-Based QoS-OLSR Protocol for Urban Vehicular Ad Hoc Networks (2018)	Maha Kadadha, Hadi Otrok, Hassan	Extends the street-centric QoS-OLSR protocol for urban VANETs Improve network connectivity [37].	It only concern on urban and VANET application. It **only uses some of QoS metrics and the current street** for selecting MPR and cluster head.

3	Multipoint Relay Selection ways by Reducing Topology Control Traffic for OLSR Protocol in MANETs	A. Boushaba, A. Benabbou, R. Benabbou, A. Zahi, M.Oumsis,	Proposed the concept of OLSR-New Degree-MPR. Reduce TC route costs, increase PDR	Only focus on maximal speed simulations, not the number of nodes. Even did not worry about the quality of metrics.
4	Survey of Clustering Schemes in Mobile Ad hoc Networks [38]	Abdallah Bentale, Abdelhak Boubetra, Saad Harous	**review existing clustering** approache.Evaluate there performance and cost	It is a survey. All papers that are survived has a strong side and its weakness. But they conclude Id based clustering is the most useful and simplest way for proactive MANETs.
5	Quality of service routing in Adhoc networks using OLSR	Ying Ge, Thomas Louise Lamont	Improving the performance of OLSR in a static network	Did not consider constraints other than bandwidth and did not consider overlapping of MPRs [3]
6	QoS routing using OLSR protocol	Oudidi Kamal, Abdelhamid Hayami,	Improving the performance of the routing protocol through maximizing the network throughput	MPR selection and routing table calculation did not clearly define [4]
7	NFA: Necessity first Algorithm: the new	Zheng Li, Nenghai	Reduce overhead and minimizing	Only focused on overhead and the parameter only

	Algorithm to select MPRs in OLSR	Yu, and Zili Deng	the number of MPR nodes [39]	necessity of selecting (not QOS) and used for higher density network. Did not extend to QoS Metrics like bandwidth, delay.

As we see in table 2.4 from all reviews multi point relay node selection based on QoS metrics and the toplogy of networks also not considered or they see individually.They did not consider all issues and there not adequate enough solution. To manage topology and to select the best quality MPR node a new approach is needed.

2.10 Summary of the literature

Generally,all works that was done past are concern on variety concepts or objectives on MANET routing.Any of them can not answer issues like flooding error,total delivery of packets,stability of mobile nodes,overhead of networks with good QoS based route.so it is must to have or design a multiple QoS metrics based techinique.For quality of service needed applications we use OLSR protocol based on multiple QoS metrics.We concern on on the following concepts which was not concern on the previous litratures.

- ❖ First we use clustering algorithm to manage the flat topology of OLSR by making group of nodes with no the hierarchical communication.
- ❖ We use bandwidth and delay to select the appropriate MPR node for flooding packets with minimum overhead , reduce overlapping of nodes ,mimimize the delay and increase the stability of MPR node.To select this node we use bandwidth and delay in addition to connectivity of nodes

CHAPTER THREE

3 Design of the Proposed Solution

3.1 Overview

In this section we will discuss algorithms that we implement in our thesis therefore we have used mechanisms for improving the services of MANET routing applications. In this thesis, we propose to design a cluster-based topology and deploy an OLSR protocol for optimal rote computation. Our algorithm focuses on to select the node which have maximum bandwidth or to select MPR from routing table computation. Therefor from this topology the algorithm will select nodes which have optimal packet forwarding form the routing table using MPR computation techniques. We have used OLSR routing protocol for our thesis because OLSR is a routing protocol for best effort traffic, with emphasis on how to reduce the overhead. So, in its MPR selection,the node selects the neighbor that covers the most unreached 2-hop neighbors as MPR selection.How ever in QOS routing, by such MPR selection mechanism, the good quality links may not be selected in the network.

3.2 The design of the proposed proactive routing protocols

Right now, portray and present the general engineering of our proposed framework in a MANET hub. Right now, portray and present our proposed QoS mindful directing model, calculations for MPR choice, steering table calculations, and ideal steering way calculation for sending a specific parcel to the beneficiary.

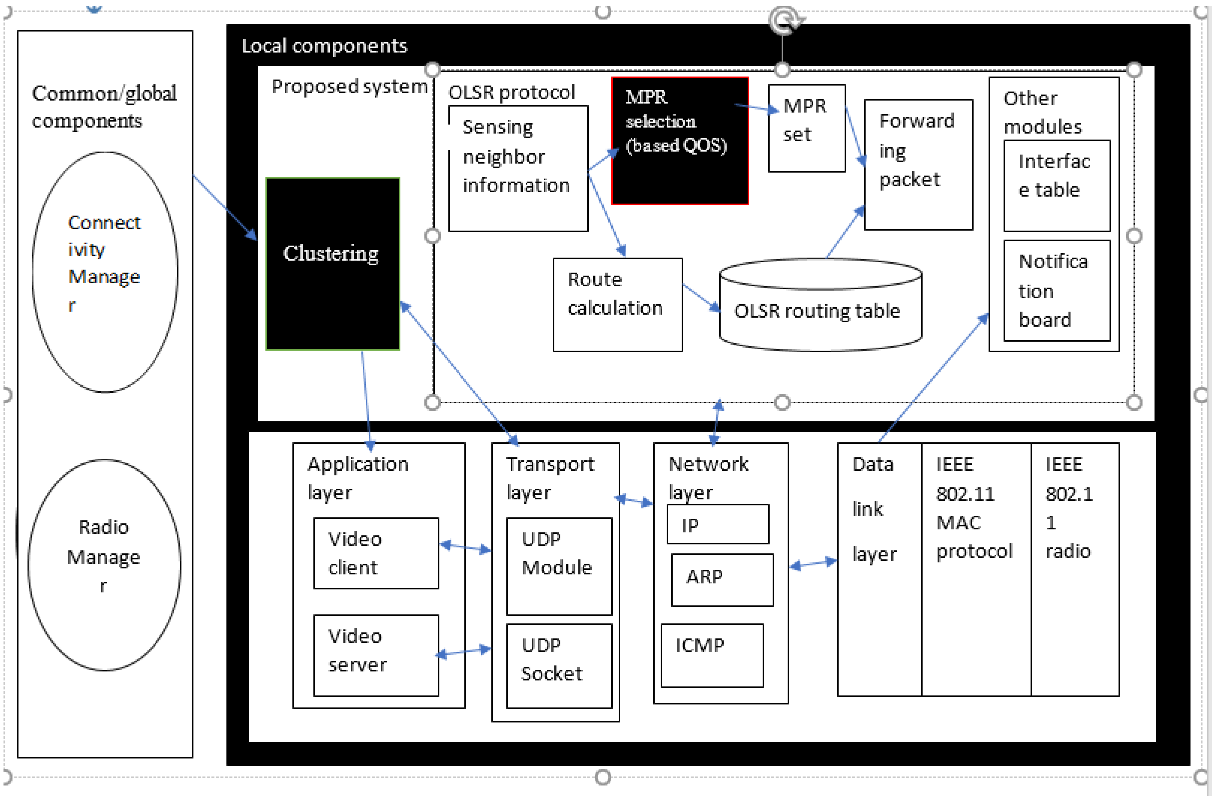

Figure 3.1: Proposed Architecture in MANET Layer

In the above Figure, 3.1 shows impromptu hubs having not at all like modules on each layer of the system. The segments are requested in a way for administrative the progression of information inside the system. On the off chance that one bundle should be directed from hub 1 to hub n, it should go through every one of the layers of the system segments. In the layers, there is a help of tending to, mistake checking, steering, and so forth., for the effective declaration between source hub 1 and goal hub n. the general MANET convention engineering that will be executed in our proposed framework. Every specially appointed host contains various modules that will be utilized for directing a specific parcel from the source to the goal have. At first, every hub performs bunching activity to be one of the group states, and steering data of each hub is maintained by the bunch data.

To have grouping data in such sort of system encourages us to improve steering at the system layer by diminishing the size of the directing data to lessen transmission overhead by refreshing the status of the nature after the occurrence of topological change ,to spare correspondence transfer speed in versatile adhoc arranges by limiting the communicate and multicast area and to add up to topology information as the hub a bunch is littler when related to the hubs of the whole system [38, 39, 40] [41].

At the point when the goal hub runs the application that should have been sent to the hub. To begin with, it keeps up the steering data dependent on the bunching calculation in which it is assembled. Our proposition relies upon the system layer that we propose to improve the QoS for OLSR steering calculation of the convention. By that as it may, MANET applications consider QoS measurements are actualized dependent on the OLSR convention for ideal steering, which transfers on the information.

From Figure 3.1, we have two components. Common /global components and local components.

Common /Global

This is the general system. The most and first is the availability supervisor which decides, for each hub in the system, the hubs in its transmission go, the second is radio channel director is utilized to choose the on or off status of the channel whether it is on or off.

Local Components

Information from every application are bundled, shipped, tended to, lastly moved to the appropriate collector. Along these lines, simultaneously, when the application layer readies the bundles that will be steered to the goal, the vehicle layer acknowledges it and makes division, mistake recuperation, and retransmission of the harmed parcel. At that point tending to and steering a parcel to the tending to and directing an information to the beneficiary hub will be performed.

Modified Clustering

Hubs are partitioned into bunches, and the adjusted grouping calculation is performed when a hub joins the system. In our proposed work, we are keen on structuring a grouping calculation for the bunching of MANET hubs. The group is performed dependent on availability and ID of hubs inside the transmission go, and each hub can be in one of the three states, which are common, bunch head, or door. Id put together grouping calculation registers based with respect to hub id and network. The hub will have its own states like bunch head or entryway. The topology hub will have its own bunch at each group gathering. There will be one bunch head hub, which controls inside and outside the group zone.

From this theory, the principle objective to make hubs into the bunch is to diminish hubs, which are chosen as portal hubs that know more than one group head, and they permit passing correspondence to each neighbor bunch head. Utilizing this calculation, we can lessen the system perspective on every hub. Additionally, the neighborhood development of hubs is taken care of just inside the bunch zone without influencing different pieces of the system thus the postponement and parcel misfortune is exceptionally decreased. In any case, at first, every hub needs the joining activity by setting a clock and communicates a Hello message. This, as a standard MANET topology, may have organize overhead. The methodologies think about various imperatives in an alternate MANET application. Here, we decided to choose and alter one of the bunching calculations according to the accompanying study [38, 40, 41, 33] .

It is proposed by lin's and received for this case with alteration; it is a neighboring based bunching plan. Each portable hub turns into an individual from one of the group states relies upon their hub ID.According to an overview done [38], Id based bunching plan has negligible correspondence in bunch development upkeep. Obviously, just considering hub ID for group development has a downside if there should arise an occurrence of portability, transmission go, and different issues.

To keep up a bunch topology, as our goal of giving a proficient course to an application, which requires QoS bolster like interactive media information, a lower postpone group definition is chosen. From the plans, the Modified bunch conspire, which is a neighbor-based grouping, fulfills our criteria, and it is chosen, and we have made some alteration to completely fulfill our necessity. In the current Modified bunch detailing, is proposed by each portable hub keeps its own ID, hubs intermittently communicate their ID to their irect neighbors. At that point, each versatile hub contrasts possess ID and the IDs of its neighbors. head in the event that it has the most minimal ID among its neighbors' IDs, it chooses to turn into a bunch head. Be that as it may, right now, disadvantages like a profoundly portable hub with the least ID among its neighbors can be chosen as a bunch head, causing awkward re grouping undesired group head changes in the system. Right now, fundamental concern is keeping up an ideal directing way of every goal hub. For instance, if a source hub needs to send a parcel out of the group zone yet has no dynamic course, which can be utilized, it floods course demands to its bunch head, and afterward the group head gets a solicitation and communicates to all neighbor group heads. At that point each group checks whether the goal hub is an individual from its bunch zone; if not, the solicitation will be disposed of. Something else, the bunch head that has the location of the goal hub will send an answer to the source hub bunch head. In this way, in view of the answer address and ideal directing way, the bundle will be sent.

Modified clustering algorithm

Input: *Node n*
Process*:*

- ✓ *Node n1 broadcast hello message to all neighborhood*
- ✓ *IF (Node n1 connectivity > neighborhood nodes && willingness! = will never)*
- ✓ *Declare itself as cluster head*
- ✓ *ELSEIF (node n1 node connectivity == node n)*
- ✓ *Compare node ID*
- ✓ *IF (Node n1 ID < node n ID)*
- ✓ *Declare itself as cluster head*
- ✓ *ELSE*
- ✓ *Declare itself as an ordinary node*
- ✓ *ELSEIF (Node n1 is neighbor of two or more cluster heads)*
- ✓ *Declares itself as a gateway node*
- ✓ *ENDIF*

Output: Cluster heads, Gateway, and Ordinary nodes of MANET

At line 1 of the calculation, a hub begins a flooding procedure in process in which a gathering mentioning is sent to one-jump neighbors. By then, every center point in the system keeps up its hub ID with respect to its neighbor hub availability. In light of conditions as determined in calculation fig 12, line 2 up to 7, a hub is chosen as a bunch head on the off chance that it has the most noteworthy network in the neighbor. If there should arise an occurrence of equivalent network, a hub has group head need on the off chance that it has a lower ID. Albeit every hub just decides one group, bunches may cover. This implies a hub can have a place with all groups whose bunch head is at the most h-jumps good ways from the hub. Hubs that have a place with over one bunch become passage hubs.

As the hub is versatile, its transmission range may shift every now and then. Thus, hubs past its transmission range can move starting with one group zone then onto the next.

3.3 Optimized Link State Routing Protocol

As we talked about in the Literature Review Section, OLSR is one of the most realized proactive steering conventions where hubs keep up the course data in a directing table, so a course is accessible quickly when it is required. Figure 3.2 shows the proposed model for QoS steering utilizing OLSR. It contains administrations, for example, detecting neighbors' data, QoS MPR choice, and directing way count, lastly, the gathered data about the course is put away in the steering table of the convention.

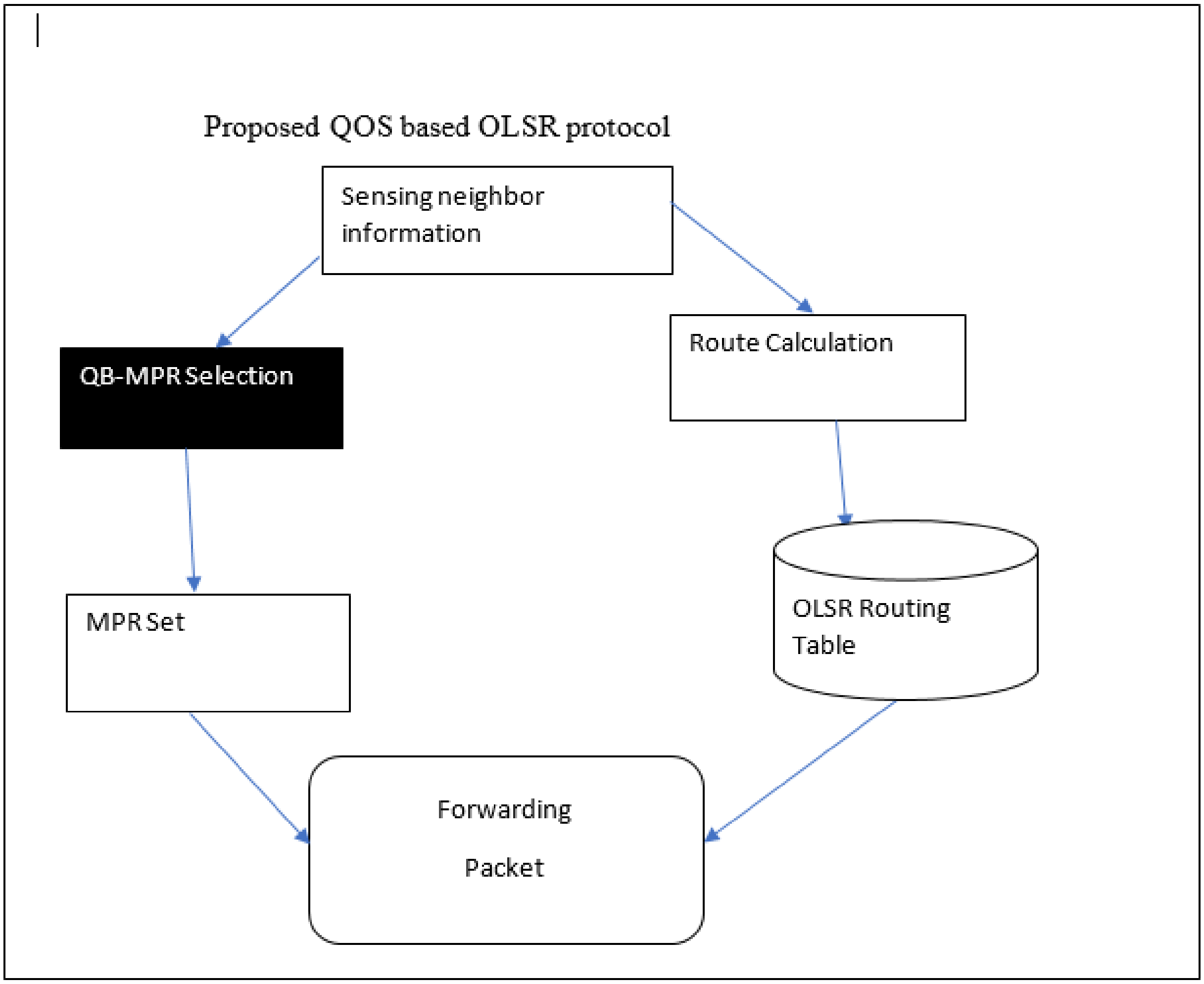

Figure 3.2: Proposed QoS based OLSR Model

3.4 Sensing Neighbors' Information

Every hub occasionally communicates a HELLO message and faculties its present neighbors inside its transmission extend. For a specific hub, whatever other hub that is inside its radio transmission extend is known as a neighbor. All hubs comprise of a neighbor set, which holds subtleties of its neighbor hubs. Since all hubs may be moving, the neighbors for a specific portable hub are continually evolving. The neighbor set is dynamic and should be refreshed much of the time.

3.5 QoS MPR Selection

In OLSR [1, 3] [8], every hub of the system freely chooses its own arrangement of MPRs. Multi-point hand-off set is determined in a way to contain a subset of one-bounce neighbors, which covers all the two-jump neighbors, i.e., the association of the neighbor sets of all MPRs containing the whole two-bounce neighbor set. In our work, choices of MPRs are constrained to the bunch zone. This will assist us with minimizing the event of covering between hubs. MPR set is re-decided when an adjustment in one jump or two-bounce neighbor sets with the bi-directional connection is identified or an adjustment in their QoS condition is distinguished. In order to fabricate the rundown of the 2 jump hubs from a given hub, it needs to follow the track of bi-directional association hubs found in the Hello messages got by this hub. At that point the got two-jump neighbor data is put away in the neighbor table.

3.6 MPR Selection QoS Metrics

a) Node connectivity

Each hub need to know the neighbor hubs with which it has either a direct or bi-directional connection, for this, each hub occasionally flood its Hello messages, their connection status andh aving the posting of neighbors known to the hub. The Hello messages that are gotten by every one of the one-jump neighbors are not sent. Consequently, in light of this message, every hub knows its number of neighbor hubs, which are straightforwardly associated with it.

b) Delay

It is the time taken between two hubs for which a sender hub n1 communicates something specific hi to a reciver hub n2 and effectively conveyed. Creation time of this message is included the welcome message in each hub. At the point when a neighbor hub gets this message, it processes

In EQ. (3.1), we have shown our formula for calculating a delay of nodes.

$$Delay = \sum_{0}^{N} \left(\frac{Recieved\ time - Sent\ time}{Number\ of\ packet\ Recieved} \right) \qquad (3.1)$$

c) Link state: shows the status of the connection at a given time T. Here T is alluded to as the estimation period (specifically, the time required for evaluating accessible data transmission)

$$\text{State (t)} = \frac{(\text{Total available bandwidth} - \text{Transmitted data size})}{\text{Total available bandwidth}} \qquad (3.2)$$

Si (t) = 0 methods or under 0, the connection is occupied, Greater than zero, the connection is inert or there is unused data transfer capacity. The accessible connection data transfer capacity between two hubs is equivalent to the limit of their inactive time duplicated by the greatest transmission capacity. In this manner, in light of the above qualities, QoS measurements are determined as in EQ.(3.3)

3.7 Algorithm for MPR Selection

Input: Node n, N1 (n), N2 (n)

Process:

- ✓ *Start with an empty multipoint relay set MPR(n)*
- ✓ *Find and calculate the number of N1(n) of the current node*
- ✓ *IF (N1 (n) status ==symmetric && willingness! = will never)*
- ✓ *Add these N1 (n) nodes to the multipoint relay set MPRn.*
- ✓ *Select N1 (n) as MPR, which provides the only path to reach some nodes in N2 (n).*
- ✓ *Remove the nodes from N2 (n), which are covered by a node in MPRn.*
- ✓ ***While** (N2 (n) not empty) **Do** //all nodes in N2 (n) that are not covered by the MPR(n)*
- ✓ *IF (N1 (n) is not in MPR(n))*
- ✓ *Calculate the number of nodes, that are reachable through it among the nodes in N2 (n) and which are not yet covered by MPR(n)*
- ✓ *Calculate the QoS metrics value //as shown in (EQ.3.3)*
- ✓ *The select node of N1 (n) as an MPR, which reaches the maximum number of uncovered nodes in N_2 (n) and meets the QoS requirements*
- ✓ *EndIf*
- ✓ *Else*

- ✓ *IF (multiple choices of N_1 (n)) // one hop neighbors of nodes having identical number of node connectivity*
- ✓ *Select node of N_1 (n) as an MPR, which have a maximum QoS metrics*
- ✓ *ENDIF*
- ✓ *Remove the nodes from N_2 (n) which are covered by a node in MPRn*

Output: MPR set of n

The above Algorithm shows the proposed calculation in the choice of MPRs of a MANET with n hubs, 1 bounce neighbor set N1 (n), and 2 jump neighbors set N2 (n). Every hub n keeps up the arrangement of its MPR selectors. This set covers the hubs that have been chosen by n as a MPR. Hub n of MPRs is just responsible for sending communicated messages got from one of its N1 (n).

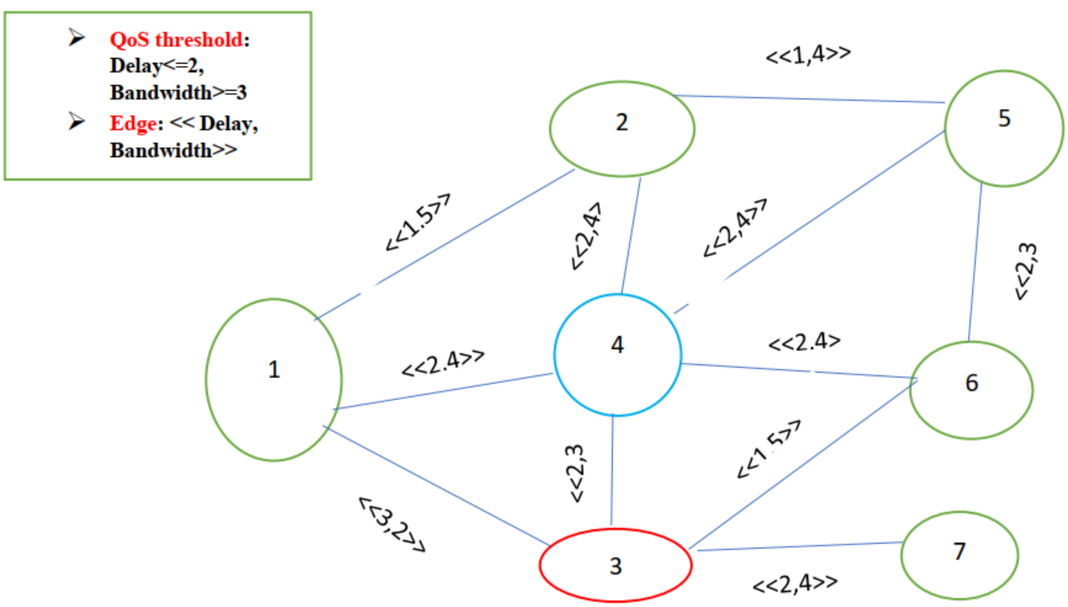

Figure 3.3: MANET Nodes

Table 3.1: MPR Node Selection

Node	1 hope neighbors	2 hope neighbors	MPR

3	1 4 6 7	2 5	4

In the above table hub, 3 has picked the MPR hub among its neighbor hubs (1, 4, 6, 7). In the first place, it floods a welcome message to there neighbors, and afterward each neighbor who is accepting the bundle will communicate it to its proportionate neighbor hubs. The procedure proceeds, and finally,node 3 will get a few bundles from its 1-bounce neighbours(1, 4, 6, 7), which reach in all the two-jump neighbors (2, 5), i.e., the association of the neighbor sets of all MPRs containing the whole two-bounce neighbor set. When hub 3 knows the status of its one and two-jump neighbors, in view of requirements an examination is finished. From the neighbors just hub 4 has a neighbor of the hub (2, 5), so this hub is the main hub that has the most extreme hub network among every single other hub and reachable to the 2-jump neighbors of hub 3. In the above table

3.8 Summary

To highway a bundle, which is either information or interactive media content, the hub should cover all layers of the model. For transmitting media applications, the source and the collector hubs will have the option to utilize UDP, and applications are executed over UDP modules. UDP modules and attachments are answerable for associating, getting, and sending video bundles to the layers. Correspondingly, the OLSR module is straightforwardly associated with the system layer. At the point when a parcel comes to at the IP layer, the layer quickly sends the bundle to the convention. When the bundle comes to at the OLSR module, a way that will fulfill a superior QoS measurements between the correspondence endpoints of a MANET hub will be processed and exemplified in the parcel header, and the hubs which are accountable for depending on the throwing bundle to the beneficiary are likewise determined.

CHAPTER FOUR

4 Evaluations, Results, and Discussions

In this chapter discussed our proposed solution simulation result and discussed it.

4.1 Overview

Direction-finding hypermedia data in a condensed flat MANET network is much thought-provoking because nodes are chaotic and formless, and there is a high overflowing rate of multicasting and broadcasting messages. Hence, to solve these challenges, we have designed methods for enlightening and providing suitable QoS routing practice for MANET applications. Applying clustering structures in such kinds of networks facilitates the routine of a routing protocol by dropping the routing difficulty and minimizing of broadcast and multicast range. As per our planned routing protocol, OLSR provides an approach that realizes the best route that links up two or more nodes in a network. The strategies take into interpretation variables in the network, such as the random topology, the number of links, the bandwidth, etc.

4.2 Development and Simulation Tools

As we have pragmatic from the reviews [42, 43, 44], NS2, NS3, and OMNET++ is the best adoptions which deliver well performance and simulation situation for MANETs. However, seeing criteria like the ability to run large networks, obtainability of changes of modules, correcting and tracing support, supportive, influential GUI, elasticity, and active topology creation, we have selected OMNET++ with INET agenda for applying and both Linux and Windows support assessing our proposed work and it.

OMNET++ [45, 46], offers a module founded ranked, modular and extensible building. Mechanisms are programmed in C++, which consists of the simulation kernel and utility classes for statistics collection and topology discovery. Elements relationships and message links are stored as Network Description (NED) files and can be shown explicitly. Together with the recreation kernel library, the imitation setting contains a Graphical Network Editor (GNED), graphical (Tkenv), and command-line interfaces for simulation.

4.2.1. **OMNET++**

OMNeT++ (Objective Modular Network Tested in C++) [46], is a free simulator used to simulate both wireless and wired networks. The language used to write the code in C++. It used for simulation, educational purposes, and the global scientific community. It supports eclipse based and graphical run time environment and host of different tools. It can simulate a different system composed of interrelated devices. OMNET++ support component and modular architecture. For this reason, it supports the graphical user interface. Easily embedded into other applications.

4.2.2. **Network simulator version 3(Ns3)**

The NS3 is also used for educational purposes and research. NS3 is approved under the GNU GPLv2 license and is available for research and development, but it is new and library; other issues are updated quickly [43].

4.2.3. **Network Simulator Version 2 (NS-2)**

There are a lot of simulation tools are existing for network research; among them is, NS-2, which is widely used and highly recognized as a network simulator tool. However, the codes do not easily interact with the user [44].

4.2.4. **Comparison of Simulation Tools**

	NS-2	NS-3	OMNeT++
Integrability	Limited	Good	Excellent
Reusability	Good	Excellent	Excellent
Testability	Limited	Good	Good
Flexibility	Limited	Excellent	Excellent
Complexity	High	Moderate	Low

***Figure 4.1: comparison of network simulators** [47]*

Finally, OMNET++ is the best choice, which provides better performance and a simulation environment for MANETs. However, considering criteria like the ability to run large networks, availability of varieties of modules, debugging and tracing support, supporting powerful GUI, flexibility, and dynamic topology creation, we have selected OMNET++ with INET framework for implementing and evaluating our proposed work.

4.3 Prototype Simulation

MANET networks are difficult to manage quickly. Because the topology changes rapidly, and it is impossible to maintain the routing table. Sending TC message to all interfaces also generates a very high overhead; therefore, applying clustering schemes in proactive MANET will minimize this overhead. Maintaining clustering information with lower communication delay and overhead and minimize the possibility of re-clustering MANET nodes. In this topology, we use 30 hosts using OMNET++ nodes to have transmission ranges for each other while nodes are in transmission range. They can transmit packets to each other. Otherwise, as the distance increases between hosts, the intermediate hosts are in charge of establishing communication between nodes. Nodes are highly mobile; they move randomly in different directions and they have limited resources like memory, CPU, bandwidth, battery, etc.

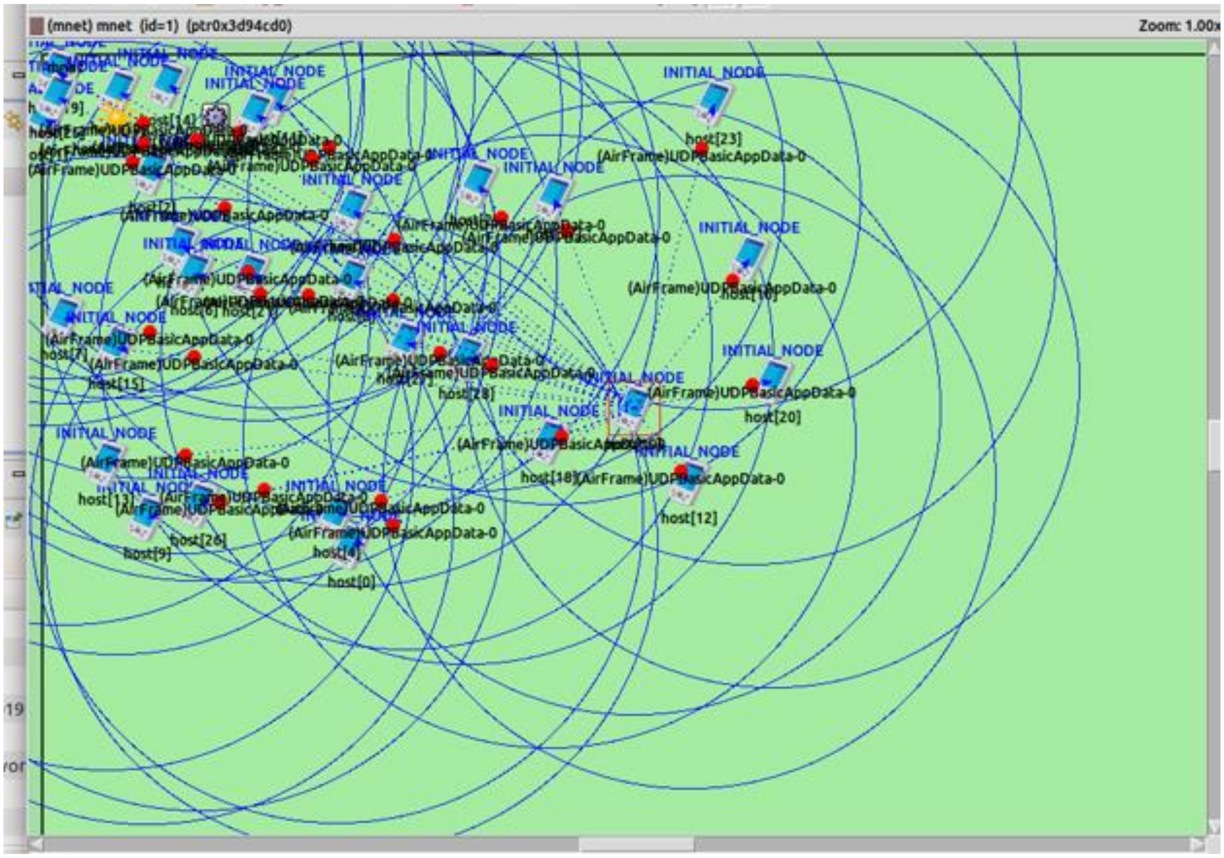

Figure 4.2: MANET Setup

In the above simulation topology, there are modules like video server, video client, and Modified clustering. At the middle layer, transporting and routing maintenance like IP and MANET routing protocols are found. On the bottom layer, there are channel modules, which contain interfaces of the network of the MANET node. Other modules, which are found in MANET hosts, are interface table, routing table, notification board, and mobility. Through the mobility module, each node in the network is becoming movable. Signal strengths, radio interference, and channel occupancy depend on the distances between nodes. The mobility module influences the results of the simulation like packet delivery ratio, end-to-end delay, and throughput.

The paradigm of topology map implements topology discovery mechanisms like link sensing, neighbor detection, and topology sensing using the information generated by the Modified clustering algorithm. In the first part, every node populates its local link information base (link set) and establishes communication with its symmetric neighbors, i.e., nodes with bidirectional communication. Throughout the neighbor detection phase, every node populates its neighborhood information base (i.e., set of 1-hop and 2-hop neighbor). The link sensing and neighbor detection phases are based on the periodic exchange of Hello messages. Hello messages are solely transmitted to 1-hop neighbors. Every Hello message, the nodes tell to their 1-hop neighbors. This information is used to construct and maintain the neighbor routing table for every node, in addition to select its MPR set. In the neighbor table, each node records the information about the 1- hop neighbor link status (i.e., unidirectional, bidirectional or MPR).

Table 4.1: Sample Set of MPRs and MPR Selector

MPR	***Selector Set***
Host [3]	Host [19], Host [11], Host [6]
Host [13]	Host [2], Host [24], Host [14], Host [11], Host [8], Host [7], Host [22]
Host [15]	Host [2], Host [13], Host [24], Host [18], Host [14], Host [8], Host [7], Host [5], Host [22]

Exchange of TC messages is used for sensing topology within a specified range. These messages allow each node to construct its topology table and to declare its MPR selector set. A TC message contains the MPR selector set of its originator. A node that has an empty MPR selector set does not send or retransmit any TC messages. An MPR forwards a message only if it comes from a node in its MPR selector set (i.e., a source-dependent mechanism).

4.4 MPR Selection Algorithms

4.4.1. Description of MPR Selection Algorithms

To improve the service of OLSR, different schemes for the selection of MPR nodes are designed in the last decade. The initial phase of all MPR selection procedures is almost the same. However, when many one 1-hop neighbors are getting the same number of uncovered 2-hop neighbors, different schemes used different criteria to give a priority for a node, which can be selected as MPR. Therefore, the ability to consider multiple appropriate constraints in the selection of MPR nodes has an impact on providing QoS routing.

4.4.2. Proposed QoS MPR Selection

We use an algorithm for selecting the optimal MPR set. An optimal MPR set for a node is defined as a subset of the 1-hop neighbors, which covers the 2-hop neighbors of that node, and it has the minimum number of nodes among all other sets that cover the two-hop neighbors of the node. In this algorithm, first, it checks 1-hop node connectivity, if multiple ties to the same 2-hop neighbor nodes, select the one having the maximum number of 2-hop neighbors and that meet an optimal QoS metrics as MPR. If more than one node in 1-hop neighbor can cover the same maximum number of nodes in a 2-hop neighbor, a 1-hop neighbor having better QoS metrics in terms of delay, quality, and bandwidth is selected as MPR. Therefore, a node, which is selected, as MPR will, satisfies all possible constraints.

4.5 Simulation of MPR Selection

The performances of the two MPR selection algorithms are evaluated in a typical MANET simulation environment of 600 by 400 meters with a varied number of nodes. We run these simulations for 1000 seconds. The efficiency of the algorithms evaluated in terms of numbers of MPR forms, stability, and overhead the metrics are defined:

a) **Stability:** as we know, MANET nodes are mobile; they may not have a stable dedicated place since the nodes, which are selected as MPR, may have a varied location, and they may change their state.
b) **Number of MPR:** moderate number of MPRs in the network. The increment in number of MPRs in the network, the overhead becomes higher.
c) **Overhead:** The average number of control packets transmitted at each MPR node during the simulation. Each hop is counted as one separate transmission.

Table 4.2: MPR Selection Performance Result

Algorithm	***Overhead (# Packets)***	***Stability (in sec.)***	**#MPR**
Original MPR	60.12	570.9	9
Proposed QoS MPR Selection	50.73	728.6	7

All the existing QoS MPR selection approaches were implemented and evaluated on a flat MANET topology. QoS MPR is considered node connectivity of neighbor nodes, limits the nodes view (a small number of 1-hop neighbor can reach all 2-hop neighbors), and selects the minimum number of MPRs and overhead of a network. However, QoS MPR-1 does not always find an optimal path, as its MPR selection algorithm may omit the optimal bandwidth link of a node.

As we see from Table 4.2, our proposed algorithm has a better result in terms of packet overhead, stability, and number of MPRs. This is because, in this algorithm, we considered multiple constraints like delay, bandwidth, and connectivity of nodes, and satisfying of optimal required QoS metrics in the selection process. A node having a maximum bandwidth only is not selected as MPR; instead, it checks other constraints as well. Therefore, the proposed selection algorithm outperforms the minimum possibility of re-selecting MPR nodes, and the nodes become more stable. In the simulation period, on average, the node, which is selected as MPR, stays for 728.6 seconds.

4.6 Simulation Experiments and Results

To test the performance of our proposed QoS routing on a MANET, we have performed a simulation experiment and evaluation using different metrics. To achieve this, we followed the following procedure: first, we defined the simulation setup where it encompasses defining the arrangement of MANET nodes in the network.

4.7 Simulation setup parameters

We use OMNET ++ with the INET framework, for our simulation environment the study has been conducted on a required number of nodes that are changing dynamically. Nodes in the simulation move according to the Mass Mobility model. The simulation period takes 1800 seconds and the simulated mobility network area is 600 m x 400 m rectangle. The MAC layer protocol IEEE 802.11 is used in all simulations with a bit rate of 2Mbps. The different parameters as shown in table 4.3 below [33, 46, 45].

Table 4.3: Simulation setup parameters

Parameter	***Value***
Number of MANET nodes	25, 50 and 60
Scenario size	600 X400
Application type	Video streaming
Mobility	Random Mobility model
Simulation time	1800 sec
Channel type	IEEE 802.11
Bit rate	2 Mbps
Transmission range	100 M
Channel and network interface	Wireless

4.8 Evaluation Metrics and Results

In order to route multimedia data with QoS support, we have evaluated the performance of QoS routing schemes. The performance methods from the data or results are calculated in terms of packet delivery ratio, average end-to-end delay, and throughput. According to the survey [7, 6, 24, 45, 48], the metrics are discussed as follows:

a) **Average End-to-End Delay (AEED):** is calculated by subtracting "sent time that time at which the first packet was flooded by source" from "time at which the packet arrived in receiver." This summarize all possible delays caused by buffering throughout route searching latency and processing at intermediate nodes.
b) **Packet Delivery Ratio (PDR):** This evaluation metric will give us an idea of how well the scheme is performing in terms of packet delivery at different network density. Generally, Packet Delivery Ratio (PDR): It is the ratio of actual packet delivered to total packets sent.

$$(PDR)\ (\%) = \frac{\sum \text{Number of packet received}}{\sum Number\ of\ packet\ sent} * 100 \qquad (4.1)$$

c) **Throughput (THP):** It is the total number of delivered data packets divided by the total duration of simulation time. In this case, the throughput of each of the routing schemes in terms of the number of messages delivered per one second is evaluated.

Throughput (THP)=$\frac{\sum \text{Number of delivered data}}{\sum Number\ of\ simulation\ time}$

Table 4.4: **Performance Evaluation Result**

	Selection approach	***Network Size (#node)***	***Total Packet Sent (#packet)***	***Total Packet delivered (#packet)***	PDR %	AEED (ms)	THP (byt/s)
Standard OLSR	MPR-1	25	634	306	48	30.8	420.5
		30	674	312	46	37	587.9
		50	705	422	60	40	590.4
OLSR with Modified Clustering	Proposed QoS MPR selection	25	732	513	70	11.6	565.23
		30	765	519	68	16	640.24
		50	831	612	62	33	654.14

After performing exhaustive simulations with varied network sizes for the defined parameters, vector and scalar data are recorded and stored in a spreadsheet file.

A TC message contains the MPR selector set of its originator. A node that has an empty MPR selector set does not send or retransmit any topology control messages.Topology sensing is accomplished via the change of Tc messages within a distinictive range. The messages permit any node to construct its topology table and to declare its MPR selector set. Lastly, routing tables are built using information from the one hop and two hop neighbors and the topology table.Routing tables consist of the next node and number of hops to reach every other node in the network. As we are using the hop-by-hop routing method, the source node stores in its routing table only the next hop to reach node n.

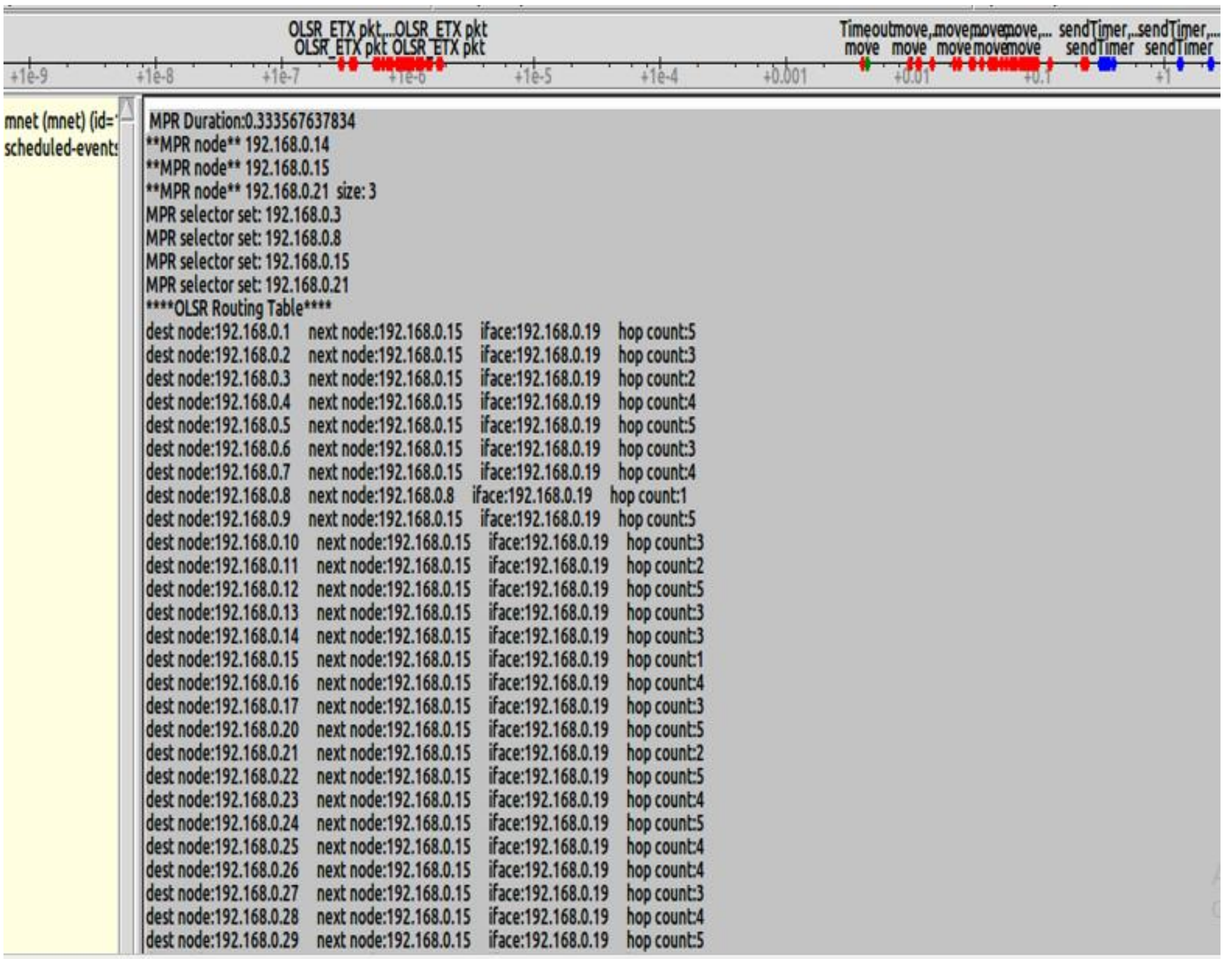

Figure 4.3: Result Recorded from Simulation

The above routing table shows a statistical graph that analyses and displays end-to-end results when the packet is received by the destination during the simulation of a scenario. The statistical graph can be exported to spreadsheets in CSV format.

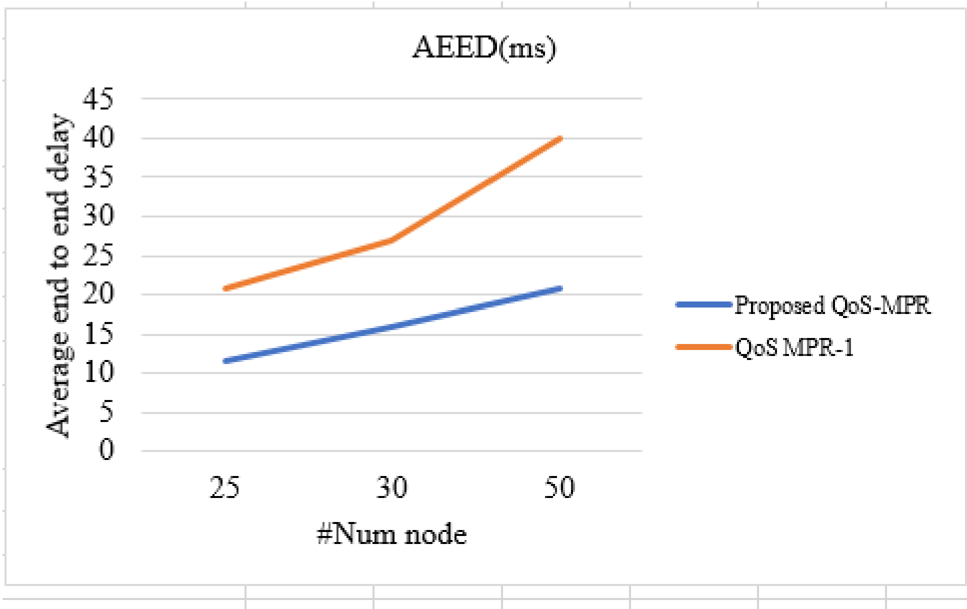

Figure 4.4: End to end Delay in different QoS Routing Schemes

The above figure shows the behavior of the QoS in a variety of network sizes. Our proposed QoS uses the Modified clustering algorithm to manage the topology. In all network sizes, we have a lower average end-to-end delay in our simulation. This shows that based on clustering information, the network is more manageable, a smaller number of intermediate nodes, easy to maintain the optimal route, and each node maintains stable routing information and has less congested routes. We use 50 nodes for the above result shown in fig 4.3, which have high topology updates, and it sends update messages, which tend to make the network busy, resulting in high congestion and packet delay.

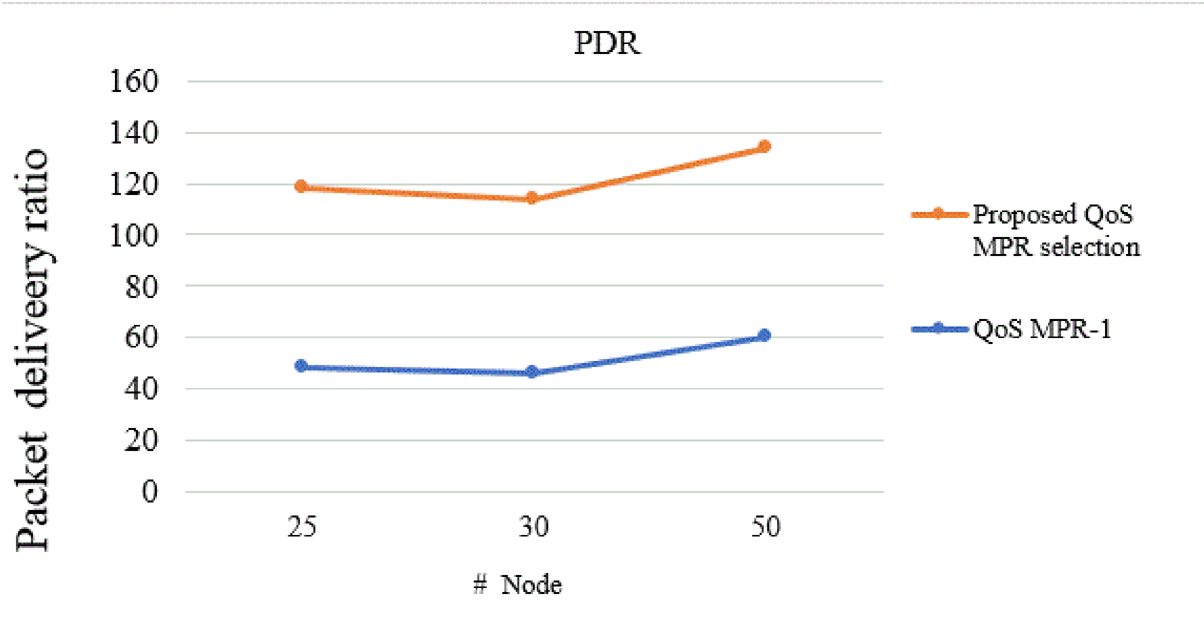

Figure 4.5: PDR Result in a different QoS Routing Schemes

The above figure shows, in a dense, our proposed QoS MPR selection has the highest packet delivered ratio because the routes are optimal and have the minimal number of unreachable lists of next-hop nodes for a particular destination node. We assume that the quality of links, the established links between the nodes have a lower probability to break. However, there is a list of optimal routes in the node routing tables, which results in a higher ratio for correct packet delivery. Because of the proactive nature of the routing schemes, MANET nodes usually need to maintain accurate information in their routing table. They attempt to continuously evaluate all of the routes within a network. This means to get appropriate routing information, periodically a number of control messages are broadcasted in the network. When we increase the network density, there is a possibility of retransmission of control messages becoming more crowded, and results in lower delivery of routing packets.

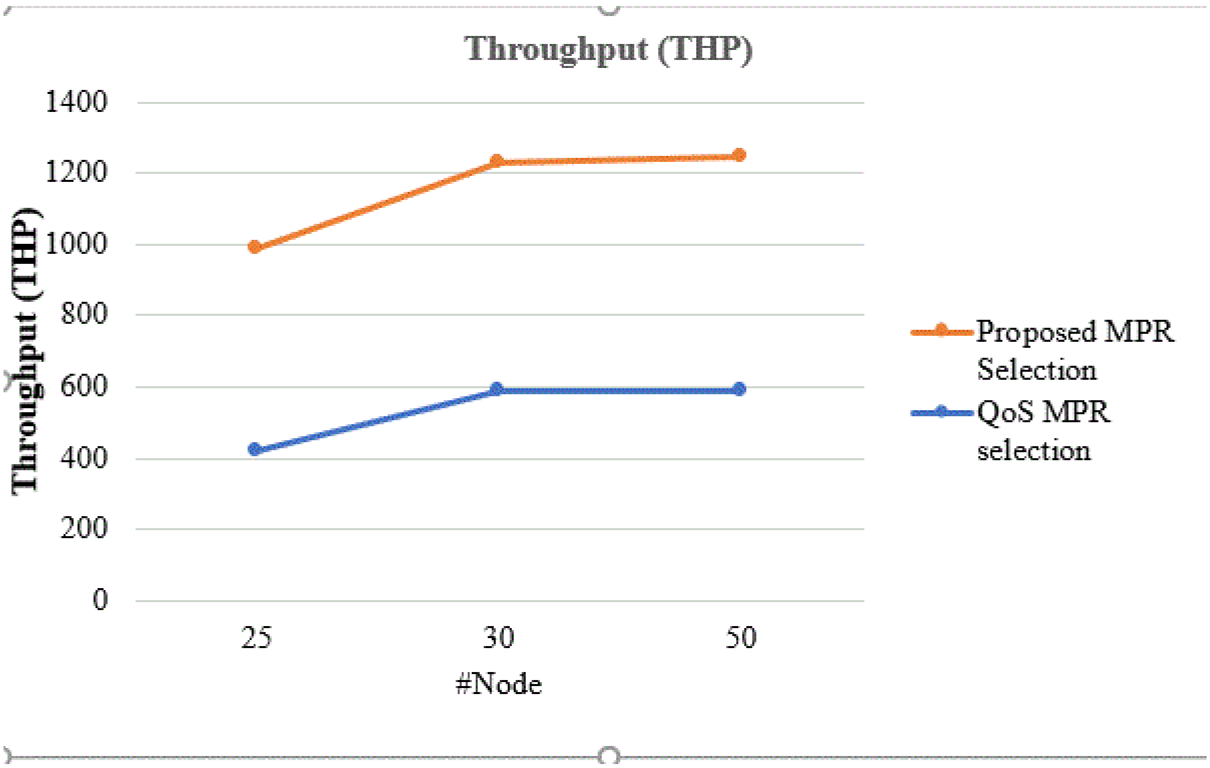

Figure 4.6: Throughput Result in QoS Routing Schemes

As we have seen in the above figure, we observed that the more efficient a network results in the higher throughput, a lower packet loss rate, and the better the delivery ratio. Because from our simulation the source node gets the most correct routing information about the network the topology, and it delivered accurately with a lower link breakage and congestion of the network. A higher value of average throughput requires a low end-to-end delay, lesser packet loss and higher packet delivery fraction. This is because applying a clustering scheme on the network helps to manage the network, and maintaining routing information better.

4.9 Summary

As our objective of providing a better QoS routing in MANETs, QoS based approaches were designed to adaptively provide better management for dynamic changes of network topology. To compare it with the existing works, we summaries a simulation on a MANET environment using OMNET++ and performed an evaluation with different parameters. In all simulation parameters, the performance of the network decreases with the increase of the number of nodes.

This is due to the increase in the number of intermediate mobile nodes resulting in high probability of path breakage and loss of data packet and increases updating of topology information.

The simulation experiment result shows that our proposed QoS routing provides better performance for QoS required applications with high throughput and packet delivery ratio, and minimizing delay,because of in our proposed QoS routing approach, we were considered multiple constraints for MPR selection and nodes were grouped each other based on the clustering algorithm. As we see the results, all QoS evaluation metrics have good performance, which makes the proposed QoS routing a candidate and primary choice scheme for deploying, especially in a time-sensitive application like video streaming, online conferencing, VoIP, etc.

CHAPTER FIVE

5 Conclusion and Future Work

5.1 Conclusion

Generally, this thesis is a proposed QoS based routing algorithm by improving MPR selection methods in the OLSR protocol considering the quality of service-needed applications like multimedia and time-sensitive applications. As such, we use the Modified-clustering algorithm for topology management and QoS based MPR selection for OLSR. Give chance for the multiple Quality of Service metrics in order to select the MPR node has been improving the performance of MANET nodes. finally, the performances of the proposed algorithm have been evaluated as such the algorithm achieved high throughput and packet delivery ratio in which delay has been minimized when compared with standard OLSR. The simulation results show that the proposed algorithm achieved from 60% to 62 % packet delivery ratio and from 590.4 Byte/Sec to 654 Byte/Sec throughputs while the average end-to-end delay is minimized from 40ms to 33ms and during the simulation period, a node that is selected as MPR stays for 728.6 seconds, approved from 570.9 seconds.

5.2 Future Work

The current work concerns on the manage the flat topology of OLSR and selection of MPR based on QoS metrics bandwidth and delay to get a better performance for time sensitive MANET applications like multimedia data. The result shows that performance of MANET is improved based on the evaluation output(Delay, Throughput, and PDR).

Here are some of the recommendations as a future work of the thesis. For the future, we can do a lot in this area; we can add intelligent rules to make good decisions in routing. MANET nodes have a problem in mobility, topology changes, and resource deficiency, memory, etc. So by considering these issues a new algorithm can be designed for the future.

For example, security issues are not seen in our work, it was out of our work.So, next researchers can include security in there work.

In addition to , this work was evaluated on the simulation, for the future, another researcher can see in the real environment which may get other research problem which is not seen in this study. This work was implemented for real data and like video and audio, and it needs further study and measurement of performance for text data.

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APPENDIX-A: Topology NED file

```
import inet.networklayer.autorouting.ipv4.IPv4NetworkConfigurator;

import inet.nodes.inet.AdhocHost;

import inet.world.radio.ChannelControl;

network mnet

{

   parameters:

      int numHosts;

      @display("bgb=1000,700,#A5ECA2,grey10");

   submodules:

      host[numHosts]: AdhocHost {

         parameters:

            @display("p=250,58;is=n;i=device/pocketpc");

      }

      channelControl: ChannelControl {

         parameters:

            @display("p=60,50");

      }

      configurator: IPv4NetworkConfigurator {

         config = xml("<config><interface hosts='*' address='192.168.0.x'
netmask='255.255.255.0'/></config>");

         @display("p=140,50");

      }

}
```

Appendex - B: Ad hoc host Simulation Parameters

```
[General]
network = mnet
sim-time-limit = 1000s
num-rngs = 3
**.numRadios = 1
**.numUdpApps = 1
**.messageLength = 1B
**.sendInterval = 10ms
**.multicastInterface = "wlan0"
**.mobility.rng-0 = 1
**.wlan[*].mac.rng-0 = 2
#debug-on-errors = true

tkenv-plugin-path = ../../../etc/plugins

**.constraintAreaMinX = 0m
**.constraintAreaMinY = 0m
**.constraintAreaMinZ = 0m
**.constraintAreaMaxX = 600m
**.constraintAreaMaxY = 400m
**.constraintAreaMaxZ = 0m
**.debug = true
**.coreDebug = false
```

```
**.host*.**.channelNumber = 0

# channel physical parameters
*.channelControl.carrierFrequency = 2.4GHz
*.channelControl.pMax = 2.0mW
*.channelControl.sat = -110dBm
*.channelControl.alpha = 2
*.channelControl.numChannels = 1

# mobility
**.host*.mobilityType = "MassMobility"
**.host*.mobility.initFromDisplayString = false
**.host*.mobility.changeInterval = truncnormal(2s, 0.5s)
**.host*.mobility.changeAngleBy = normal(0deg, 30deg)
**.host*.mobility.speed = truncnormal(20mps, 8mps)
**.host*.mobility.updateInterval = 100ms

# ping app (host[0] pinged by others)
#*.host[0].numPingApps = 0
#*.host[*].numPingApps = 2
#*.host[*].pingApp[*].destAddr = "host[0]"
#**.pingApp[0].startTime = uniform(1s,5s)
#**.pingApp[1].startTime = 5s+uniform(1s,5s)
#**.pingApp[*].printPing = true
```

```
# nic settings
**.wlan[*].bitrate = 2Mbps

**.wlan[*].mgmt.frameCapacity = 10

**.wlan[*].mac.address = "auto"
**.wlan[*].mac.maxQueueSize = 14
**.wlan[*].mac.rtsThresholdBytes = 3000B
**.wlan[*].mac.retryLimit = 7
**.wlan[*].mac.cwMinData = 7
**.wlan[*].mac.cwMinBroadcast = 31

**.wlan[*].radio.transmitterPower = 2mW
**.wlan[*].radio.thermalNoise = -110dBm
**.wlan[*].radio.sensitivity = -85dBm
**.wlan[*].radio.pathLossAlpha = 2
**.wlan[*].radio.snirThreshold = 4dB


[Config Ping1]
description = "host1 pinging host0"
*.numHosts = 30

[Config Ping2] # __interactive__
description = "n hosts"
```

leave numHosts undefined here

manet routing

[Config OLSR]

**.routingProtocol="OLSR"

[Config Batman]

**.routingProtocol="Batman"

APPENDIX- C: modified clustering implementation

```
if(pki->getG() == 1)
{
    del_ch(list_of_CH,pki->getNodeid());
    EV << "Received ch giveup removing old ch";
}
if(strcmp(pki->getSta(),"CLUSTER_HEAD")==0&&pki->getNodeid()!=
getParentModule()->getIndex())
{
    if(getParentModule()->getIndex()>pki->getNodeid()&&
strcmp(exsta.c_str(),"CLUSTER_HEAD") == 0 && pki->getG() != 1)//more cluster head const
will be applied
```

```
{
 socket.setOutputGate(gate("udpOut"));
 setSocketOptions();
 char msgName[32];
 sprintf(msgName, "UDPBasicAppData-%d", numSent);
 IPvXAddress destAddr = chooseDestAddr();
 clusteringmsg *payload = new clusteringmsg(msgName);
 payload->setG(1);
 payload->setNodeid(getParentModule()->getIndex());
 emit(sentPkSignal, payload);
 socket.sendTo(payload, destAddr, destPort);
 numSent++;
 intsta = "reg";
  EV << "send ch give up";
 //delete pki;
}
else
{
   CH newch;
```

```
newch.last_recived_time = simTime();

newch.node_id = pki->getNodeid();

newch.nodeip = pki->getNodeip();

check_ch(list_of_CH);

add_ch(list_of_CH,newch);

if(list_of_CH.size() >= 2 && strcmp(exsta.c_str(),"CLUSTER_HEAD")>0 && strcmp(exsta.c_str(),"GW_NODE")>0)

{

    intsta = intstate.at(1);

}

EV << "CH added: With chid  "<< list_of_CH.at(list_of_CH.size()-1).node_id;

}  }
```