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Performance Evaluation of Dynamic Source Routing and Optimized Link State Routing in Mobile Ad-hoc Networks

تقييم أداء توجيه المصدر الديناميكي و توجيه حالة الربط المحسّنة للشبكات اللاسلكية المخصّصة

A thesis submitted in partial fulfillment of the requirements the degree of

M.Sc. in Electronics Engineering (Computer and Networks)

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Dedication

This thesis is dedicated to my beloved family, friends and co-workers who have always been a constant source of support and encouragement.

To my friend Tagwa who have always supported me unconditionally.

ACKNOWLEDGEMENTS

I express my gratitude towards The Almighty God for His blessings upon me. I owe my profound gratitude to my thesis supervisor Dr.Fath Elrahman Ismael Khalifa for his valuable guidance, supervision and persistent encouragement due to the approach adopted by him in handling my thesis. It is extremely hard to find words that express my gratitude to my parents, my sibling and my friends for their invaluable help over this year. I wish them all good luck in their future plans. They gave me courage and strength whenever I needed and supported me in every possible way throughout these years.

Lubna Hassan

المستخلص

الشبكات اللاسلكية المتنقلة العشوائية هي نوع من الشبكات اللاسلكية المتخصصة و هي عبارة عن شبكة ذات إدارة ذاتية للعقد المتنقلة ذات الربط اللاسلكي. حيث تتمتع العقد المتنقلة فيها بحريّة الحركة العشوائية. هنالك بعض التحديات التي تواجه مصمّمي البروتوكولات و مطوّري الشبكات تتمثل في عمليات التوجيه، الخدمة، و التغيير المستمر في هيكل الشبكة. بإمكان العقد المتنقلة إستلام و توجيه البيانات مثل الموجّه. تمثّل عملية التوجيه تحديا حرجاً في هذه الشبكات، لذا كان تركيز هذه الأطروحة على تحليل أداء بروتوكولات التوجيه. ركزت الأطروحة على بروتوكولين معروفين و هما بروتوكول توجيه المصدر المتحرك و بروتوكول حالة الربط المحسن. تم إستخدام أداة محاكاة الشبكة المعروف بأداة هندسة الشبكة الأمثل. تم تحليل أداء البروتوكولات بناء على ثلاثة مقاييس هي زمن التأخير،التحميل على الشبكة، و الإنتاجية، كل النتائج المتحصلة بمقياس متوسط الزمن بناءً على فترة زمنية 10 دقائق. تم شرح البروتوكولات و مقاييس الأداء بشكل أعمق. تم إيجاد و تحليل مقارنة بين هذه البروتوكولات و تقديم خلاصة بنهاية الأطروحة عن أي بروتوكول يناسب الشبكات المتنقلة العشوائية أكثر. أظهر بروتوكول الرابط المحسّن في زمن التأخير مع بروتوكول تبادل الملفات نتائج أفضل من بروتوكول المصدر المتحرك بنسبة 60.9%، 93.1%، و 84.8% في كل من 10، 20،و 50 عقدة على التوالي. التحميل على الشبكة سجّل أسوأ قيمة في حالة بروتوكول المصدر المتحرك تحت 50 عقدة كانت 48851.7بت/الثانية، بينما بروتوكول الرابط المحسّن كان أفضل ب 13.6% في 10 عقد، 54.6% في 20 عقدة،و 4.6% في 50 عقدة. إنتاجية الشبكة أعطت أفضل قيم مع بروتوكول المصدر المتحرك ب 1% في 10 عقد ،و 30.8% في 20 عقدة، لكن في حالة 50 عقدة كان بروتوكول الرابط المحسّن هو الأمثل ب 46.8%.

ABSTRACT

Mobile Ad Hoc Networks (MANETs) are a type of wireless ad hoc network, which is a self-arranging network of mobile nodes connected by wireless links. The mobile nodes are free to move randomly. There are some challenges that protocols designers and networks developers faced. These challenges include routing, service and frequently topology changes. Mobile nodes can receive and forward packets as a router. Routing is a critical issue in MANET; hence, the focus of this thesis along with the performance analysis of routing protocols. Focused was on two well-known protocols; DSR and OLSR. Our simulation tool used was OPNET modeler. The performance of these routing protocols analyzed using three metrics: delay, network load and throughput all results are time averages based on a 10 minutes time span. Routing protocols are explained in a deep way with metrics. The comparison analysis carried out through these protocols and in the last, the conclusion presented that which routing protocol is more compatible for mobile ad hoc networks. Simulation results showed that OLSR has better end-to-end delay under FTP traffic than DSR for all scenarios by 60.9%, 93.1% and 84.8 % in 10, 20 and 50 nodes respectively. Network load record a worst value under DSR protocol with 50 nodes that was 48851.7 bit/sec but OLSR was the better by 13.6% in 10 nodes, 54.6% in 20 and 4.6% in 50 nodes. Network throughput gave better values with DSR by 1 % in 10 nodes and 30.8 % in 20 nodes but in 50 nodes, OLSR was optimal by 46.8%.

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LIST OF ABBREVIATIONS

AODV	Ad hoc On-demand Distance Vector
DES	Destination Sequence Number
DSN	Discrete Event Statistics
DSR	Dynamic Source Routing
FTP	File Transfer Protocol
IETF	Internet Engineering Task Force
MANET	Mobile Ad hoc Network
MPR	Multi Point Relay
OLSR	Optimized Link State Routing
OPNET	Optimized Network Engineering Tool
PD	Processing Delay
PD	Propagation Delay
PDR	Packet Dropping Rate
PMP	Proactive MANET Protocol
QD	Queuing Delay
RFC	Request for Comments
RMP	Reactive MANET Protocol
SANET	Static Ad hoc Networks
TC	Topology Control
TD	Transmission Delay
TZRP	Two Zone routing protocol
WG	Working Group
WiMAX	Worldwide Interoperability for Microwave Access
ZRP	Zone routing protocol

CHAPTER ONE

INTRODUCTION

Chapter One

Introduction

1.1 preface

Mobile ad hoc networks (MANETs) are composed of different nodes being operate in infrastructure less environment work in a highly dynamic and random topology Nodes are distributed and mobile with the capability of self-organizing themselves. MANET nodes have resource constraints such as power, processing, and bandwidth. Comparing with the traditional network, MANET aim is to think of network where each node is mobile one day without the limitation of nodes. Existing protocol also requires significant changes to cope with the challenges and aims of MANET. The main reason to deploy this kind of network is the flexibility and easiness of deployment. MANET is a suitable network for emergency and surveillance use. However, with all these qualities ad hoc network operation is very difficult to handle. Each node is responsible for its operation to maintain its routing table and forwarding packets to its neighbors as routers. MANET has a different topology change while deployed that is why it needs an efficient and reliable routing protocol. The construct of an efficient and reliable routing protocol is a tough and tedious task. Routing needed whenever a packet forwarded from source to destination through some intermediate nodes as in most cases the nodes are not directly connected with each other. Some sort of path finding mechanism is required by protocol, that is, the routing protocol. In case of MANET, routing is a serious research issue as the nodes are mobile in nature. These paths are not always connected; hence, some path maintenance is also an issue. Numerous protocols have been proposed considering the nature and diversity of application, mostly the routing protocol for MANET falls into three categories, that is, proactive, reactive, and hybrid protocols. Some of the most popular protocols examined in previous studies are Dynamic Source Routing (DSR), Ad-hoc On-demand Distance Vector (AODV) and Temporally-Ordered Routing Algorithm (TORA), which belong to the reactive or on-demand category and Optimized Link State Routing (OLSR), Destination-Sequenced Distance-Vector (DSDV) and Wireless Routing Protocol (WRP), which belong to the proactive or table-driven category [1].

1.2 Problem Statement

Transmission over MANETs facing many challenges mainly due to characteristics of MANETs : dynamic topology ,transmission errors ,node failure ,link quality variations and link failures Therefore ,different types of mobile ad hoc network routing protocols with different performance characteristics and efficiencies have been developed. Studying the performance characteristics against their performance metrics and identifying their weaknesses and strengths is crucial in order to find out the suitable routing protocol to make an efficient routing for a particular network operation scenario and make further optimizations.

1.3 Proposed Solution

This thesis will model some of MANET scenarios using OPNET modeller with different parameters. The performance evaluation of these protocols such as DSR and OLSR will be carried out with respect to parameters such as delay, network load and throughput. These scenarios will be simulated based on the above mentioned parameters and evaluate from the results which of protocols is best suitable for MANET.

1.4 Aims and Objectives

The aim of this thesis is to evaluate of DSR and OLSR protocols in MANETs. The performance evaluation of these protocols will be carried out to parameters such as delay, network load and throughput. These scenarios will be simulated based on the above mentioned parameters and evaluate from the results which of protocols is best suitable for MANET.

The objectives of this thesis are:

- To implement different network scenarios using OPNET 14.5 modular for different routing protocols.
- To analyze and compare the performance of FTP traffic in DSR and OLSR routing protocol generally implemented in a mobile ad hoc environment with different performance metrics.
- To understand their internal mechanism of working and suggest in high stressful situations which one is preferred among them.
- to analyse results and suggest witch one is preferred in MANETs.

1.5 Methodology

The thesis is heavily based on the implementation and experiment in a simulation environment. The theme of this project is to evaluate the performance of Dynamic Source Routing protocol (DSR) and Optimized Link State Routing Protocol (OLSR) in OPNET Modeler 14.5 [2]. Thesis goal is to give an extra source of comparison statistics in the MANET research field. This simulation have wireless routing protocols carrying FTP traffic. These simulations performed have a strong link with the theoretical concepts and with the expected performance in practical and real time implementations. In order to evaluate the performance of proposed protocols in this thesis it conducts simulations in OPNET modeller with different parameters, the evaluation process is based on the rate of FTP traffic and also by increasing the number of nodes in different scenarios to assess the performance of each protocol, the performance is analysed by means of delay, throughput and network load. , this thesis modelled some of MANET scenarios using OPNET modeller with different parameters. The performance evaluation of these protocols such as DSR and OLSR have carried out with respect to parameters such as delay, network load and throughput. These scenarios have been simulated based on the above mentioned parameters and evaluate from the results which of protocols is more suitable for MANETs.

1.6 Thesis Outlines

This thesis includes five chapters, Chapter One provides introduction, the problem statement and objectives while Chapter Two covers background study of Ad-hoc routing protocols and highlights some of its threats and literature review. In Chapter Three the methodology section, where the framework of the simulator, routing metric and simulation environment are defined while Chapter Four presents the implementation and performance evaluation results. And Chapter Five includes the conclusion and future work.

CHAPTER TWO

BACKGROUND AND RELATED WORKS

Chapter Two

Background and Related Works

This chapter describes the key concepts of ad hoc routing protocols. It describes the classifications in general, select three and give details about them that it have been chosen to simulate and analyse DSR and OLSR are considered. And it provides an overview of the latest trends of research going in the field of MANET.

2.1 Background

Since mobile ad-hoc networks are networks composed of independent mobile nodes mainly characterized by the absence of any fixed infrastructure or centralized coordination, which makes the nodes in the network act as a potential router with a dynamically and rapidly changing topology. The classical routing algorithms fail to perform properly, as their technology designs are not robust enough to accommodate such a changing environment [3]. Consequently, different researches have been conducted and various protocols that would be able to accommodate for such networks have been developed. In this chapter an overview of the existing MANET routing protocols, working functionalities of selected routing protocols and previous related works are presented.

As mentioned before an ad hoc network is a wireless network, which do not have a centralized and fixed infrastructure. MANET is referred to as a wireless ad hoc network in which nodes are free to move arbitrarily and mobile nodes can transmit and receive the traffic. Also mobile nodes can act like routers by forwarding the neighbor’s traffic to the destination node as the routers are multi hop devices. MANET does not need base stations of wired infrastructure. The mobile nodes in wireless network range can communicate with each other because it is a self organized network. The mobile nodes form a network automatically without a fixed infrastructure and central management . The mobile nodes have transmitters and receivers with smart antennas, which enable the mobile nodes to communicate with each others. The topology of the network changes every time by getting in and out of the mobile nodes in the network. In the beginning MANET was designed for military use but now the MANET is used in many areas. Such as in disaster hit areas, data collection in some region, in rescue missions, virtual classes and conferences . This concept with ad hoc network makes the full name of mobile ad hoc network (MANET). By growing the network, combined with the node mobility the challenges of self configuration of the network become more evident[5].

Security in MANET is a very critical and important issue and many techniques were defined for the security of MANET. Intrusion detection technique is investigated in .Mobile nodes in the network waste much energy by joining in and out with connection to wireless network. This connection and reconnection create energy limitation in the wireless network. The main purpose of developing the ad hoc routing protocols is to cope with the dynamic nature of MANET. The routing protocols efficiency can be determined by the battery power consumption. Energy is consumed during participation of a node in a network and also in routing of traffic. The routing protocol which adapts to the connection tearing and mending is also considered vital. Such routing protocols are AODV, DSR and OLSR, TORA, Wireless Routing Protocol (WRP), Zone Routing Protocol, and Two-Zone Routing Protocol (TZRP)[5] .

2.2 An Example of MANET Application

The versatility and self configuration of MANET makes them a best choice for a wide range of applications. MANET can be used in natural disaster areas, pre planed strategic event like surveillance, data collecting in some regions, conferences and virtual classes. In simple words MANET is used in such areas where the fixed infrastructure is not available before. Like earthquake hit areas where the fixed infrastructure has been destroyed, in flooded areas, fire or explosion hit areas, train or air plane crash . A very common use of MANET is during business conferences. The only and key attribute that make MANET ideal is their self configuration and low cost of deployment.

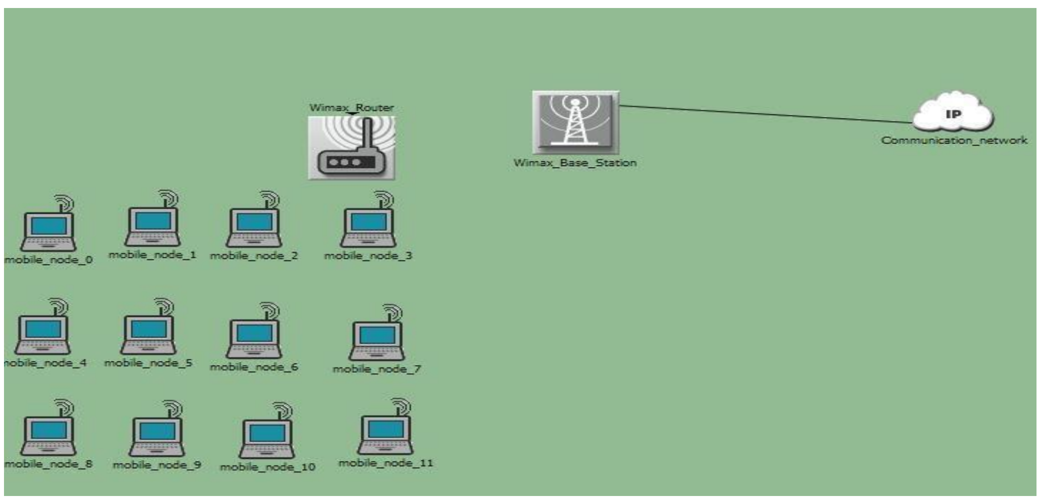


Figure 2.1: MANET example

Here we will present one practical example. In a disaster hit area, a WiMAX radio link may be established. Then a MANET access network can be established to give coverage to those areas that is difficult to cover. The nodes far away from the base station rely on midway nodes for communication. Thus provide a best communication network in such hostile situation. Above in figure 2.1, a deployed MANET over Wimax backbone is shown. In this figure the mobile nodes and the WiMAX WLAN Router form a MANET. These nodes are connected to the WiMAX WLAN router and the router is further connected to the Wimax network. The router is working like a boundary between the MANET and the Wimax network. The WiMAX WLAN router is capable of translation between the MANET protocols and the Wimax network protocols, and also the backbone protocols the Wimax is connected with. The Figure 2.1 is shown above.

There have been made several performance evaluation studies that examine the performance and operation of these protocols, comparing them in terms of various metrics. Routing in the ad-hoc network becomes a more challenging task. Therefore it becomes recent research area in MANETs, Basically ad-hoc is a multi-hop wireless networks have been proposed for nomadic computing applications, with the advance of wireless communication low cost and powerful transceiver are widely used in the mobile application. The key requirements in all the above applications are reliable data transfer and congestion control, features that are generally supported by Transmission Control Protocol (TCP). Unfortunately, TCP performs on wireless in a much less predictable way than on wired protocols in this thesis work it will be evaluated the behavior of above mentioned DSR and OLSR routing protocols when implemented in the network. a look will be taken for that how these protocols affect the network performance, and how they behave in these networks.

2.3 Ad Hoc Routing Protocols

Routing is the process of choosing a communication path between two nodes. The term "routing" is used for various types of networks like the Internet, electronic data networks and in telephony technology. The routing process is controlled by routing protocols. A network protocol is an object that has been characterized with types and format of messages that are exchanged with other peers and the actions that will take place after receiving a message. The routing protocols in mobile ad hoc networks are responsible for searching and finding a route or communication path from one node to all other nodes and for sharing data packets in the network. In ad hoc network, routing is done with use of routing tables. These tables are stored in the cache of nodes. Some routing mechanisms are unicast, multicast and broadcast. In unicast mode, the source node sends the packets directly to one destination. In multicast mode, the source node sends packets to a number of destinations in the network. In broadcast mode, the source node sends packets to all nodes in the network. Ad hoc routing protocols have some standards which control choosing routes that will be used to transmit data packets from source to destination. When a new node wants to enter the network, it will try to discover the topology by using an announcement about its presence and listening to broadcasts from other nodes of the network. The discovery of route is realized in different ways depending upon the type of routing protocol algorithm. There are many routing protocols working in the ad hoc network. These protocols are classified according to routing strategy into three categories; reactive, proactive and hybrid [4]

2.3.1 Reactive Routing Protocols (On Demand)

These protocols are called on demand as a result of not maintaining information of routing table on nodes when there is no communication. When a node wants to send a data packet to another node, firstly, this node will search for a route to the destination in an on-demand way and then transmit the data packet on the discovered route to destination. The process of discovering a route commonly occurs by use of flooding packets of routing request through the network. These types of protocols do not cause a high routing packet traffic on the network. The main disadvantage of these protocols is that they have latency on searching to find a route. There are many routing protocols working in ad hoc networks that belong to this category such as ad hoc on demand distance vector (AODV), dynamic source routing (DSR), admission control enabled on demand routing (ACOR), associatively based routing (ABR) protocols.

2.3.2 Proactive Routing Protocols (Table driven)

Routing protocols of this category are called table driven because they update information of routing table even if the path is not needed or there is no data transmission. Routing table on nodes is periodically updated when changes on the network topology occur [5]. Proactive protocol on each node needs to maintain the entries of its routing table about all nodes in the network. Therefore, this type of protocols is not suitable for large-size networks. Periodically, the control messages are transmitted, even when there is no flow of data to be sent. Collecting information by routing packets between nodes makes consumption of more network bandwidth. On the other hand, the advantage of these protocols is that the node can get up-to-date routing information easily to start transmitting data flow. The protocols that belong to this category are Optimized Link State Routing (OLSR), Destination Sequenced Distance Vector (DSDV), Ad hoc Wireless Distribution Service (AWDS) and Cluster head Gateway Switch Routing (CGSR).

2.3.3 Hybrid Routing Protocols

Based on combination of both table and demand driven routing protocols, some hybrid routing protocols are proposed to combine the advantage of both proactive and reactive protocols. The most typical hybrid one is zone routing protocol (ZRP).

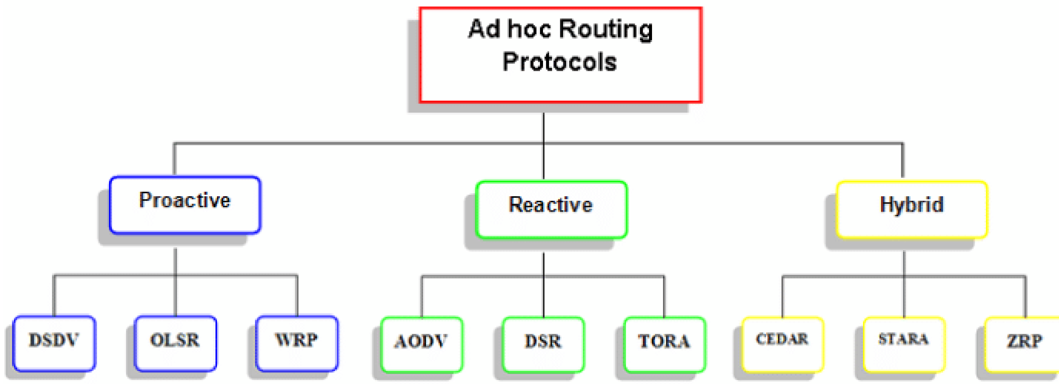


Figure 2.2 AD-HOC routing protocol

2.4 DSR (Dynamic Source Routing)

Dynamic Source Routing Protocol is a reactive routing protocol and is called on demand routing protocol. It is a source routing protocol that is why it is a simple and an efficient protocol. It can be used in multi hop wireless ad hoc networks [6]. The DSR network is totally self-organizing and self-configuring. The protocols is just compose of two mechanisms i.e. route discovery and route maintenance. The DSR regularly updates its route cache for the sake of new available easy routes. If some new available routes were found the node will directs the packet to that route. The packet has to know about the route direction. So the information about the route was set in the packet to reach its destination from its sender. This information was kept in the packet to avoid periodic findings it has the capability to find out its route by this way. DSR has two basic mechanisms for its operation i.e. route discovery and route maintenance. In route discovery, it has two messages i.e. route request (RREQ) and route reply (RREP). When a node wishes to send a message to a specific destination, it broadcast the RREQ packet in the network. The neighbour nodes in the broadcast range receive this RREQ message and add their own address and again rebroadcast it in the network. This RREQ message if reached to the destination, so that is the route to the specific destination. In the case if the message did not reached to the destination then the node which received the RREQ packet will look that previously a route used for the specific destination or not. Each node maintains its route cache which is kept in the memory for the discovered route. The node will check its route cache for the desired destination before rebroadcasting the RREQ message. By maintaining the route cache at every node in the network, it reduces the memory overhead which is generated by the route discovery procedure. If a route is found in that node route cache then it will not rebroadcast the RREQ in the whole network. So it will forward the RREQ message to the destination node. The first message reached to the destination has full information about the route. That node will send a RREP packet to the sender having complete route information. This route is considered the shortest path taken by the RREQ packet. The source node now has complete information about the route in its route cache and can starts routing of packets. Figure 2.3 shows the route discovery procedure. Here is four nodes i.e. A, B, C and D such as node A is the source and node D is destination. When node A wish to send a data packet to the node D, It will first check its route cache that whether it has direct route to node D or not. If node A does not have a direct route to node D, then it will broadcast a RREQ message in the network. The neighbour node B will get the RREQ message. First node

B will check its route cache that whether it have a direct route to the destination node D or not, If it finds a route to the destination node D. So it will send a RREP message to the source node A. In the reply of that message the source node A will start sending the data packets (DP) on the discovered route. If it didn't discover the route from node B to node D so it forwards the message RREQ to the next node C and store the route AB in the cache. The process is going on until the RREQ message reached to destination node D. The destination node D caches the routes AB, BC and CD in its memory and sends a RREP message to the source node A.

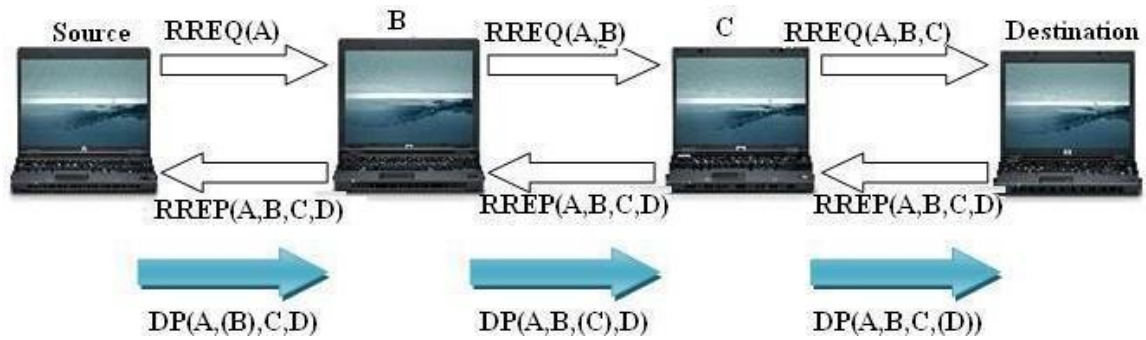


Figure 2.3: Route discovery procedure in MANET using DSR

The next mechanism is the route maintenance. The route maintenance uses two kind of messages i.e. route error (RERR) and acknowledgement (ACK). The messages successfully received by the destination nodes send an acknowledgement ACK to the sender. Such as the packets transmitted successfully to the next neighbours nodes gets acknowledgement. If there is some problem in the communication network a route error message denoted by RERR is transmitted to the sender, that there is some problem in the transmission. In other words the source didn't get the ACK packet due to some problem. So the source gets the RERR packet in order to re initiate a new route discovery. By receiving the RERR message the nodes remove the route entries. In figure 2.4 four nodes are shown i.e. A, B, C and D. The node A sends a message to destination node D. The message goes on up to the node C, while receiving the ACK message up to node B. When the node C forward the RREQ message to the node D and it does not receive the ACK message from node D. The node C recognizes that there is some problem in the transmission. So the node C sends a RRER message to the source node A. Which in return search for a new route to the destination node D.

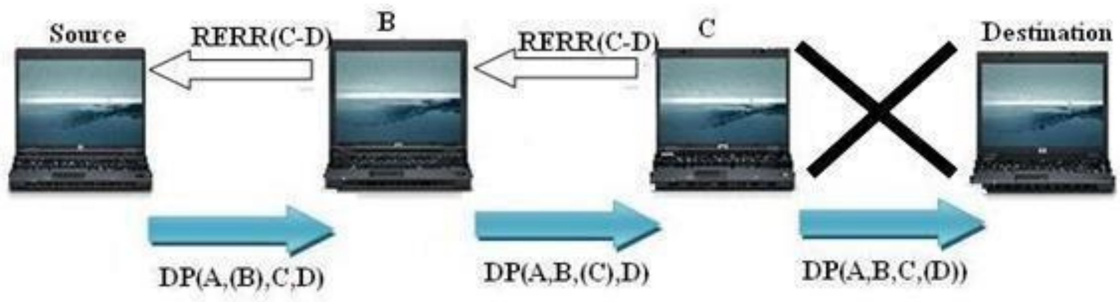


Figure 2.4: Route Maintenance Procedure in MANET using DSR

2.5 OLSR (Optimized Link State Routing)

It is a proactive routing protocol and is also called as table driven protocol because it permanently stores and updates its routing table. OLSR keeps track of routing table in order to provide a route if needed. OLSR can be implemented in any ad hoc network. Due to its nature OLSR is called as proactive routing protocol. Multipoint relay (MPR) nodes are shown in the given figure 2.5. All the nodes in the network do not broadcast the route packets. Just Multipoint Relay (MPR) nodes broadcast route packets. These MPR nodes can be selected in the neighbour of source node. Each node in the network keeps a list of MPR nodes. This MPR selector is obtained from HELLO packets sending between in neighbor nodes. These routes are built before any source node intends to send a message to a specified destination. Each and every node in the network keeps a routing table. This is the reason the routing overhead for OLSR is minimum than other reactive routing protocols and it provide a shortest route to the destination in the network. There is no need to build the new routes, as the existing in use route does not increase enough routing overhead. It reduces the route discovery delay. Nodes in the network send HELLO messages to their neighbors. These messages are sent at a predetermined interval in OLSR to determine the link status. Here it can be understand this by Figure 2.4. If node A and node B are neighbors, node A sends HELLO message to B node. If B node receives this message, It can say the link is asymmetric. If now B node sends the same HELLO message to A node. This is the same as first case, called asymmetric link. Now if the two way communication is possible then it can call it symmetric link, as shown in below Figure 2.6 The HELLO messages contain all the neighbor information. This enables the mobile node to have a table in which it has information about all its multiple hop neighbors.

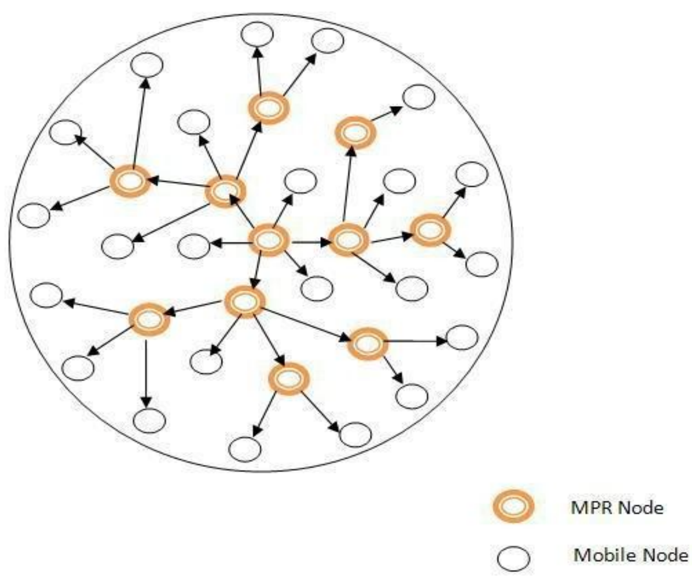


Figure 2.5: MPR node sends the TC message

A node chooses minimal number of MPR nodes, when symmetric connections are made. It broadcast topology control (TC) messages with information about link status at predetermined TC interval [7]. TC messages also calculate the routing tables. In TC messages MPR node information are also included.

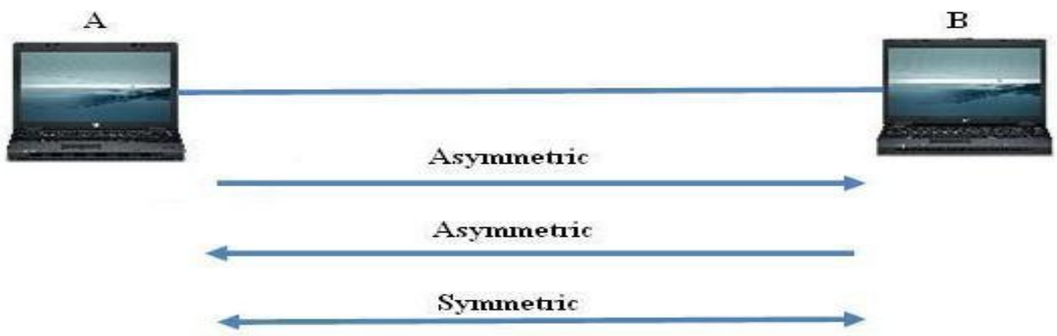


Figure 2.6: HELLO messages in MANET using OLSR

2.6 Related Works

Extensive research work has been done in the field of MANET routing protocols. Different routing protocols were simulated in different kind of simulators. Here it will be discussing different research papers about MANET routing protocols performance.

Evjola Spaho, et.al [8] investigate the performance of OLSR and AODV protocols in a Vehicular Ad-hoc Networks (VANET) crossroad scenario using Cellular Automation based Vehicular NETwork (CAVNET) and NS3. For performance evaluation they used three metrics: the average Packet Delivery Ratio (PDR), throughput and delay. Their result showed that for high transmission rate, the PDR of AODV is smaller than OLSR; OLSR has better throughput compared with AODV; the delay for both protocols is higher than one second and for small transmission rates, the PDR of both protocols is maximal and the throughput is theoretical, delay for both protocols is small.

Ashish Bagwari, et. al[9] analyzes the performance of reactive routing protocol via increasing number of nodes and observing its effect on Quality of Service

(QoS) of Mobile Ad-hoc Network. The reactive protocols that they considering is AODV for this scenario with Multiple Cluster Head Gateway (MCHG). They used following parameters: delay, throughput, traffic sent, traffic received, data dropped and network load using simulation tool OPNET Modeler (Ver. 14.0). They conclude that AODV gives better QoS based on good throughput and acceptable End-End Delay, less data drops. One of notable features of this AODV strategy is that, it reduces our network load which can be responsible for congestion at the time of communication. Therefore, it can be used to extend the network coverage. Priti Garg, et. al[10] compared on-demand and hybrid protocol; temporally routing algorithm (TORA) and Dynamic Source Routing (DSR) and had evaluated their performance with respect to quantitative metrics; average delay, packet delivery ratio and routing load using NS-2 simulator. Their results showed that performance of TORA protocol at mobility variation of nodes has better throughput, packet delivery ratio and routing load than DSR protocol. But average delay of DSR is less compared to TORA. Monika Rajput, et al[11] presents some results on the performance of DP-AODV, on the basis of comparisons with the standard protocols Ad-Hoc On Demand Multipath Distance Vector (AOMDV), Ad-Hoc On –Demand Distance Vector (AODV) and Dynamic Source Routing (DSR) and simulation results show that DP-AODV gives better performance than AODV and DSR in all simulations, but AOMDV gives better than others. DP- AODV uses two mechanisms, power control mechanism and hello message mechanism, to dynamically adjust the transmission power, based on node density. The reduction of transmission power effectively decreases interference between nodes, maintaining the connectivity and enhancing the network throughput. Author in [12] presented their work about DSR, under consider the following metrics end-to-end delay, and routing load. Their findings was that DSR performance will be very good when nodes movement will be low and network traffic also will be low. [13]Stated the negative aspects of MANET routing protocols. They stated that hyper is a unicast along multipath routing technique, and is a protocol which is topology base and apply where network load or density is very rich. [14]Studied the AODV and DSR protocol with the help of qualnet 5.0, is a simulator. Their consideration aim was to examine these protocols by considering the wormhole attack also compare their recital without considering it. Their findings was that by considering wormhole protocols recital goes down. [15] Studied the OLSR AODV in MANET using the ns3 that is a simulator. Their findings was that PDR of AODV is very small than the OLSR but OLSR has much better throughput than AODV. However the delay was high than standards delay that was set in simulation as 1.

CHAPTER THREE

MODELING APPROACH

Chapter Three

Modeling Approach

3.1 overview

In this chapter, it will be a present different metrics considered in the performance evaluation of proactive and reactive routing protocols. Firstly, it will be a briefly discuss the performance parameters considered in the comparison.

3.2Performance Parameters

Performance is a key factor in a computer system. All the software and hardware design go through the performance tests repeatedly before implementation. Integration of computer system in almost every occupation demands a reliable computer network system. It is therefore considers necessary for all computer professionals, researchers and system engineers to acquire basic knowledge of performance evaluating technique. Performance can be evaluate via measurement, modeling and simulation [16]. The simulation technique is suitable for testing models especially in research areas and educational centers. Potential advantages of the simulation are, it saves time, cost and provides detail results and a good understanding of event's occurrence.

There are different kinds of parameters for the performance evaluation of the routing protocols. These have different behaviors of the overall network performance. three parameters have been evaluated for the comparison of our study on the overall network performance. These parameters are delay, network load, and throughput for protocols evaluation. These parameters are important in the consideration of evaluation of the routing protocols in a communication network. These protocols need a checked against certain parameters for their performance. To check protocol effectiveness in finding a route towards destination, we will look to the source that how much control messages it sends. It gives the routing protocol internal algorithm's efficiency. If the routing protocol gives much end-to-end delay, so probably this routing protocol is not efficient as compare to the protocol, which gives low end-to-end delay. Similarly, a routing protocol offering low network load is called efficient routing protocol [17]. The same is the case with the throughput as it represents the successful deliveries of packets in time. If a protocol shows high throughput so it is the efficient and best protocol than the routing protocol, which have low throughput. These parameters have great influence in the selection of an efficient routing protocol in any communication network.

3.2.1 Delay (end to end)

Packet end-to-end delay is the time of generation of a packet by the source up to the destination reception. Therefore, it is the time that a packet takes to go across the network. This time expressed in sec. Hence, all the delays in the network called packet end-to-end delay, like buffer queues and transmission time. Sometimes this delay can be call as latency; it has the same meaning as delay. Some applications are sensitive to packet delay such as voice is a delay sensitive application. Therefore, the voice requires a low average delay in the network. The FTP is tolerant to a certain level of delays. There are different kinds of activities because of which network delay is increased. Packet end-to-end delay is a measure of how sound a routing protocol adapts to the various constraints in the network to give reliability in the routing protocol.

We have several kinds of delays which are processing delay (PD), queuing delay (QD), transmission delay (TD) and propagation delay (PD). The queuing delay (QD) is not considered as network delay, it has no concern with it. Mathematically it can be shown as equation (I).

$$d_{end-end} = N[d_{trans} + d_{prop} + d_{proc}] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.1)$$

Where N is the number of nodes

$d_{end-end}$ = End to end delay

d_{trans} = Transmission delay

d_{prop} = Propagating delay

d_{proc} = Processing delay

Suppose if there are n number of nodes, then the total delay can be calculated by taking the average of all the packets, source destination pairs and network configuration.

3.2.2 Network Load

Network load represents the total load in bit/second submitted to wireless LAN layers by all higher layers in all WLAN nodes of the network. When there is more traffic coming on the network, and it is difficult for the network to handle all this traffic so it is call the network load. The efficient network can easily cope with large traffic coming in, and to make a best network, many techniques have been introduced. High network load affects the MANET routing packets and slow down the delivery of packets for reaching to the channel [18], and it results in increasing the collisions of these control packets. Thus, routing packets may be slow to stabilize.

3.2.3 Throughput

Throughput defined as; the ratio of the total data reaches a receiver from the sender. The time it takes by the receiver to receive the last message is called as throughput. Throughput expressed as bytes or bits per sec (byte/sec or bit/sec). Some factors affect the throughput as; if there are many topology changes in the network, unreliable communication between nodes, limited bandwidth available and limited energy [19]. A high throughput is absolute choice in every network. Throughput can be represented mathematically as in equation (3.2);

$$\text{throughput} = \frac{\text{Number of delivered packet} * \text{Packet size} * 8}{\text{total duration of simulation}} \quad (3.2)$$

3.4 Building Model

Run the OPNET modeller 14.5 to make a network model. The first step is to create a blank scenario by start-up wizard and the project editor workspace will be open. The network designing will be in this workspace. The network design is done through two methods, one is automatically and the other is manually. The first method is automatically generating different topologies using rapid configuration. The sec method is by dragging different kind of objects from the object palette to the project editor workspace. A user can also import some predefined scenarios from the hard drive. However, wireless network cannot be designed by importing scenarios [21]. When the network have designed then the nodes need to be configured. This configuration can also be performed manually or by using pre-defined parameters in the workspace.

3.4 Results and Statistics In OPNET

In OPNET there are two kinds of statistics, one is Object statistics and the other is Global statistics. Object statistics can be defined as the statistics that can be collected from the individual nodes. On the other hand, Global statistics can be collected from the entire network. When someone choose the desired statistics then run the simulation to record the statistics; These collected results are viewed and analyzed. To view the results right click in the project editor workspace and choose view results or click on DES results then view results. Then a browser pops up as shown in this figure 3.1

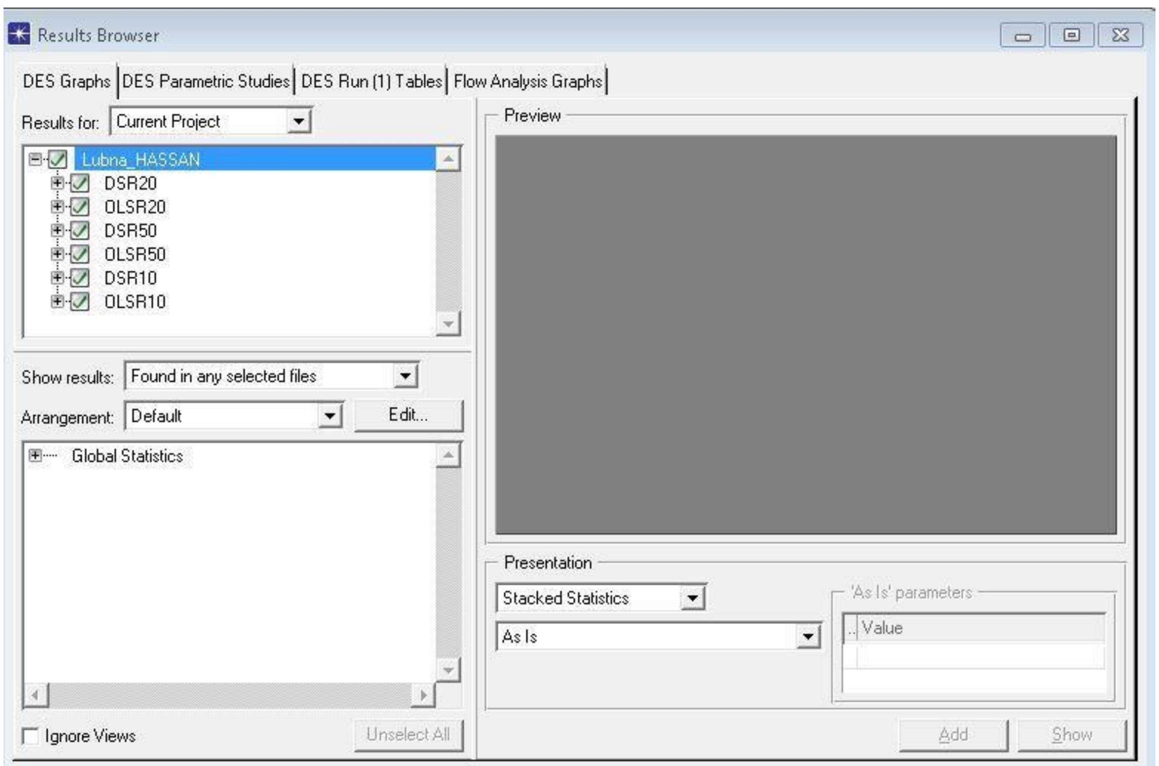


Figure 3.1: OPNET results browse

3.5 Simulation Environment

This thesis simulation have carried out in the OPNET Modeller 14.5.

First step new project has chosen from file tap and then an initial topology with empty scenario, network scale chosen as a campus network with 1000x1000 meter , next step was about to choose a technologies used in building a network, MANET technology chosen ,then it finished with a work space with an object palette tree, figure 3.2 below show a blank work space with the options chosen from a previous steps

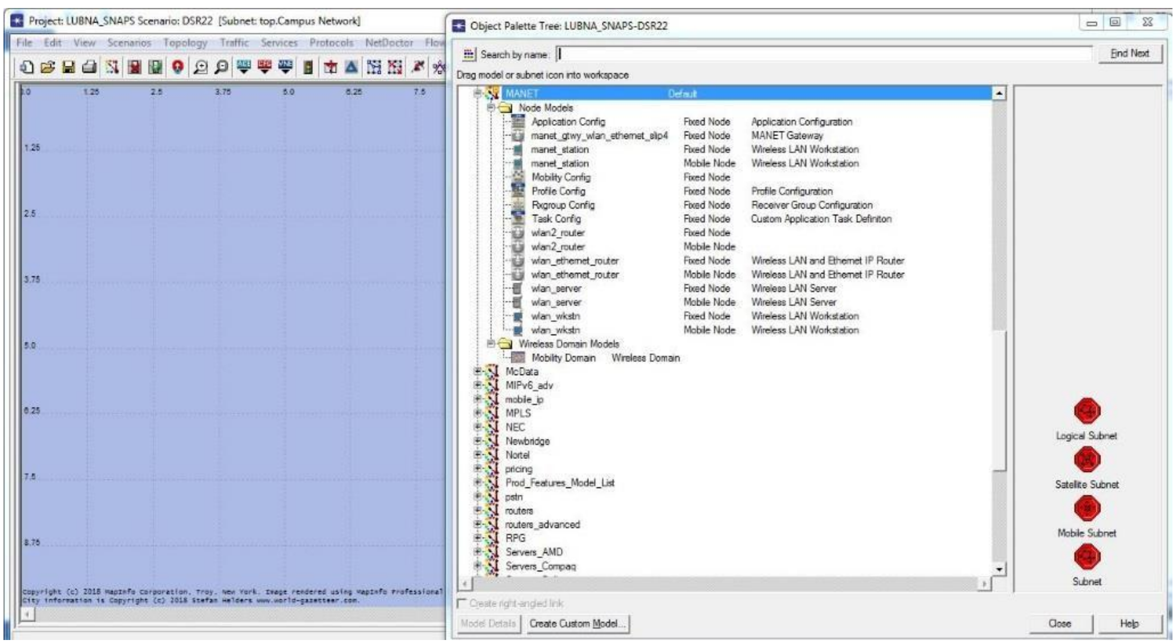


Figure 3.2 blank work space to start network building with MANET technology

WLAN mobile work stations have dragged into work space ,WLAN fixed server dragged into blank work space, from protocol tap IP addressing auto assigned to all nodes, application configuration and profile configuration have been dragged into work space, . The FTP traffic was taken to analyze the performance of routing protocols. profile with FTP application were configured by right click on application node, from attributes application number of rows changed to one row ,application name given and from description FTP high load chosen and remain as their default values as, figure 3.3 below shown the attributes changed.

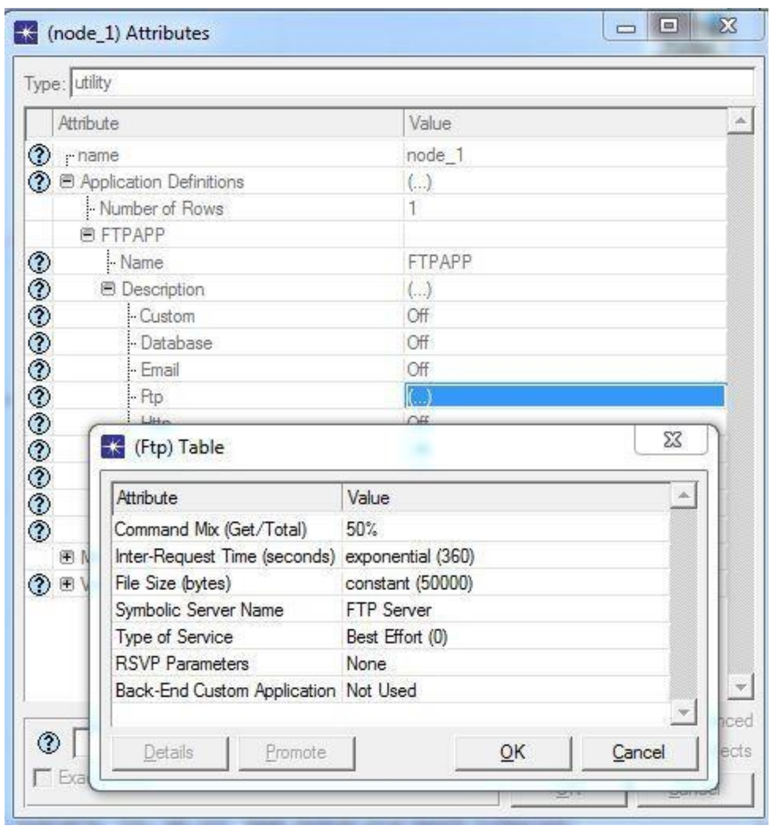


Figure 3.3 application attributes of FTP high load traffic

From profile node right click attributes from profile configuration ,number of rows changed to one ,profile name set to prober name and application number of rows set to one then the created application appeared in application name field, figure 3.4 below shown the profile application attributes.

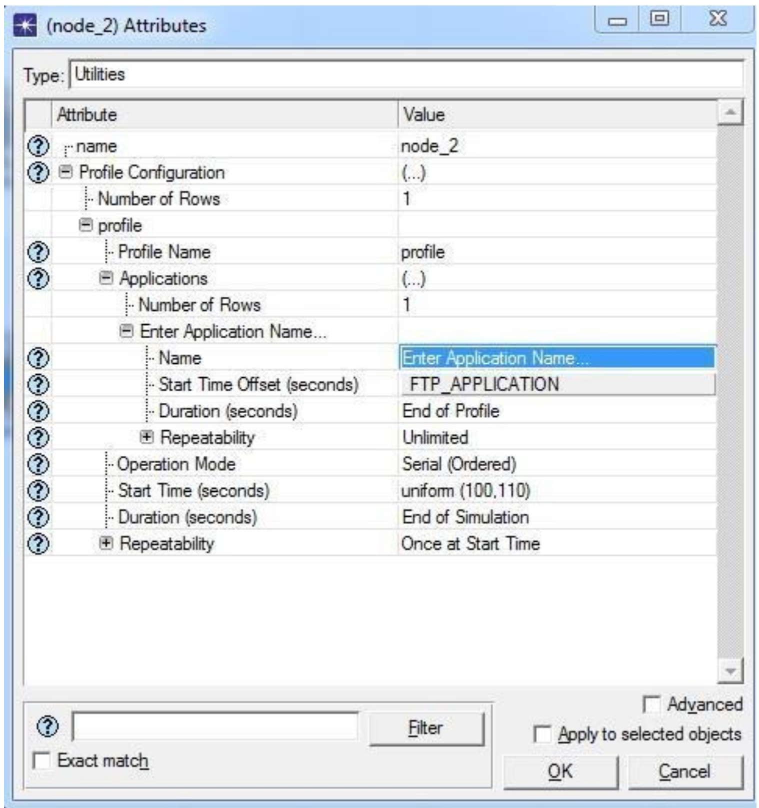


Figure 3.4 Profile Application created attributes for network

All nodes with server have been selected to set AD-HOC routing protocol, DSR has selected for first scenario, as shown in figure 3.5 below application supported services and application profile supported which created in the previous steps have been choose.

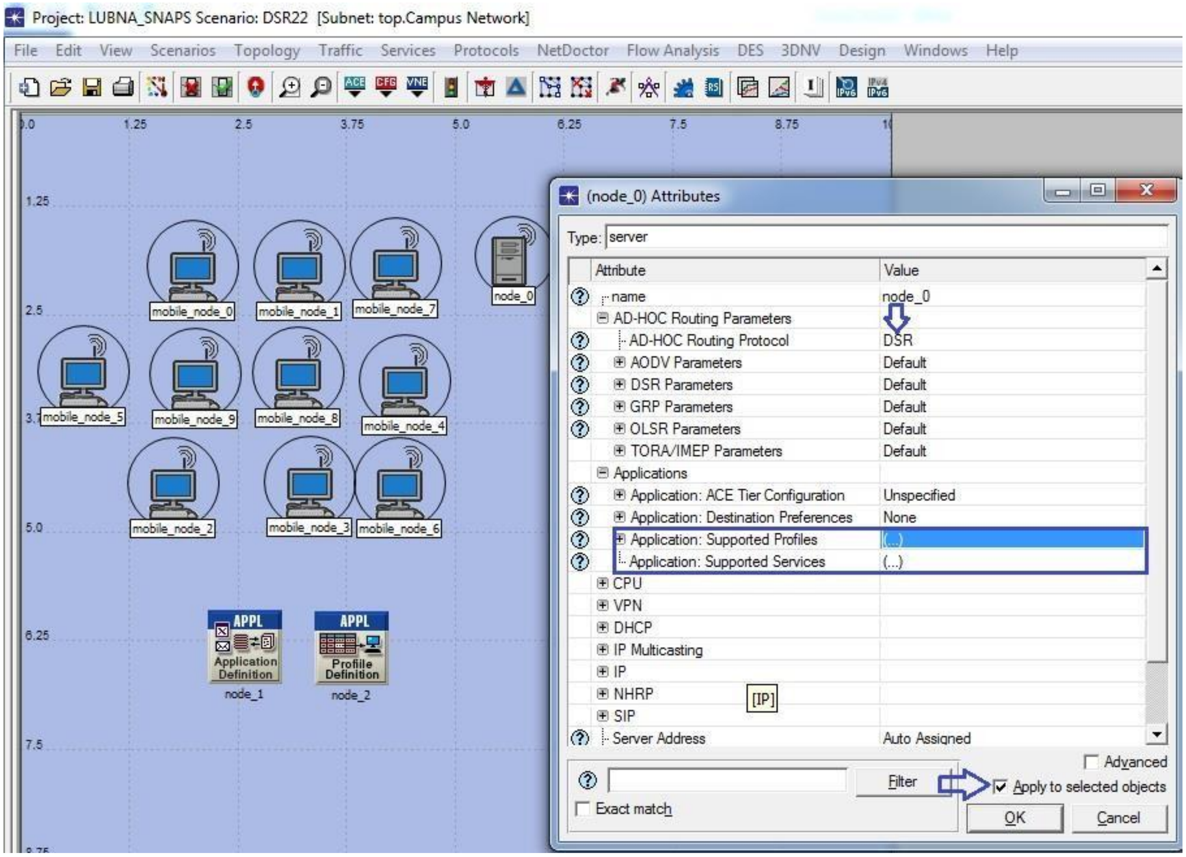
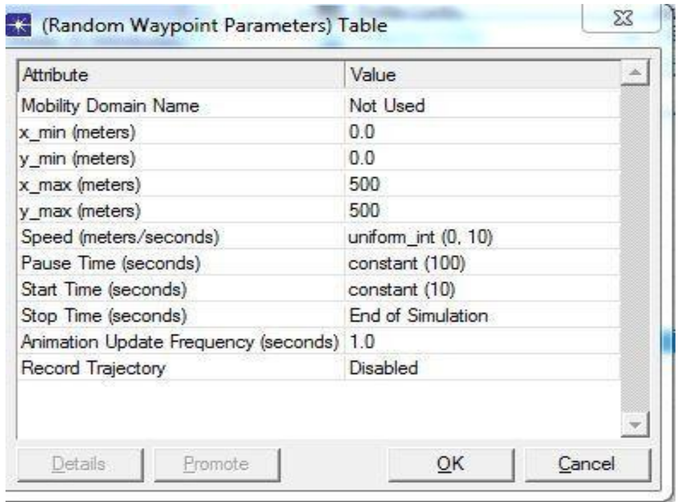


Figure 3.5 Ad-hoc routing protocol, application supported service and application profile supported attributes

Random waypoint mobility model was used in these simulations. The mobility model with default parameter used, figure 3.6 shown the mobility parameters, A mobile node begins the simulation after waiting for a 100 second pause time . After this time it selects a random destination in the area and a random speed distributed uniformly between zero m/s and Vmax=10. After reaching its destination point, the mobile node waits again pause-time seconds before choosing a new waypoint and speed.


(Random Waypoint Parameters) Table

Attribute	Value
Mobility Domain Name	Not Used
x_min (meters)	0.0
y_min (meters)	0.0
x_max (meters)	500
y_max (meters)	500
Speed (meters/seconds)	uniform_int (0, 10)
Pause Time (seconds)	constant (100)
Start Time (seconds)	constant (10)
Stop Time (seconds)	End of Simulation
Animation Update Frequency (seconds)	1.0
Record Trajectory	Disabled

Details Promote OK Cancel

Figure 3.6 Random way point parameters attributes used for network mobile nodes mobility

Below in figure 3.7 it is showing the simulation environment of a scenario having 10 mobile nodes for DSR routing protocol. The key parameters provided here were delay, network load and throughput. Many scenarios run, In every scenario there are different numbers of mobile nodes. In first scenario, there were 10 mobile nodes. In second one, there were 20 and 50 mobile nodes in third scenario.

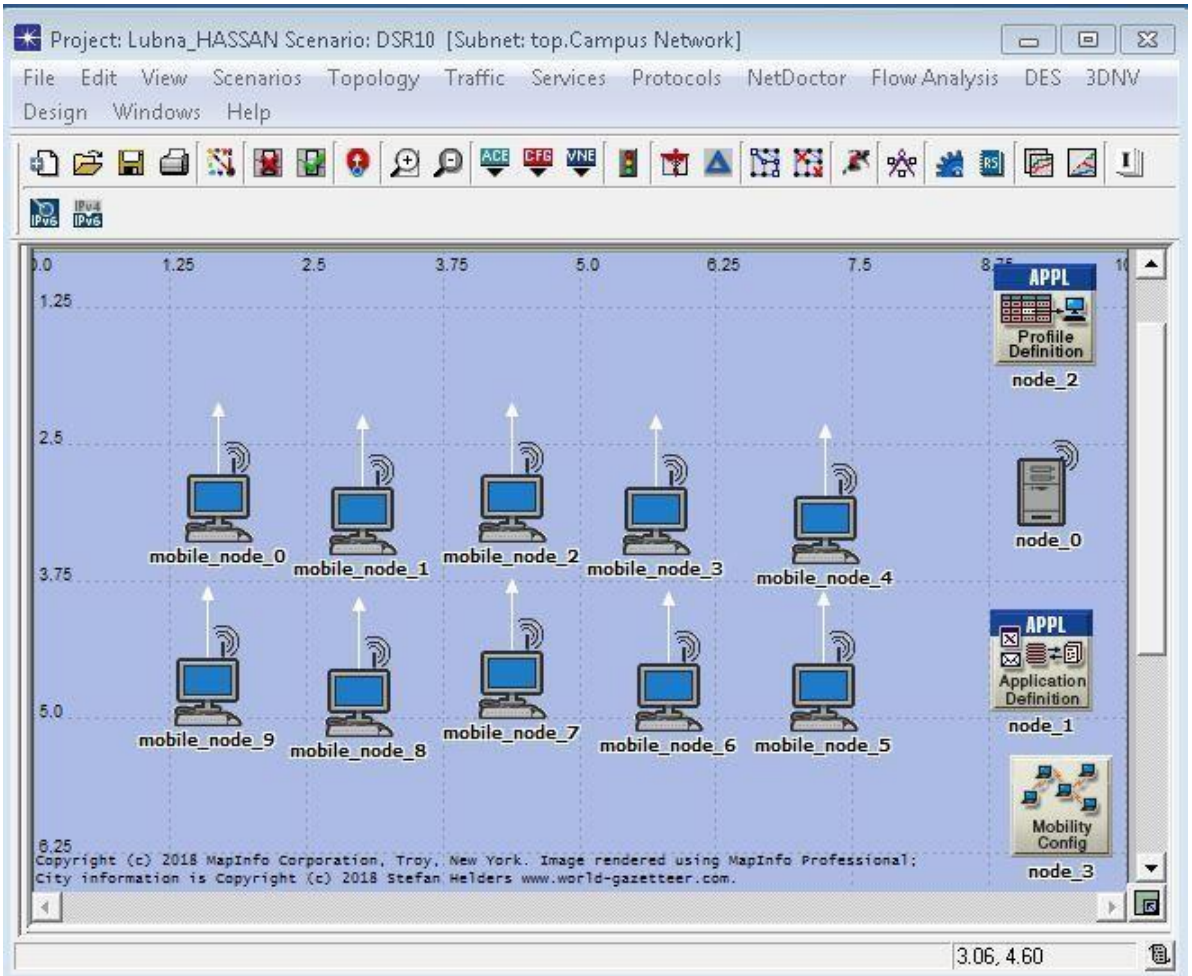


Figure 3.7: Simulating 10 mobile nodes scenario with FTP traffic application and random mobility

Each scenario was run for 10 minutes (simulation time). All the simulations show the required results. Under each simulation the behavior of DSR and OLSR will be checked. Multiple graphs got from simulations like a graph for delay, network load, and throughput. Main goal of the simulation was to model the behavior of the routing protocols. DES (global discrete event statistics) collected on each protocol and Wireless LAN. Average statistics were examined of the delay, network load and throughput for the MANET.

3.6 Simulation of Second Scenario

The second scenario consists of 20 mobile nodes. All other attributes remain the same except the number of nodes were increased to double. By clicking the scenario tab and then new scenario, give an appropriate name. In this scenario the same protocols are tested against the same parameters. The second scenario is shown in the below figure 3.8.
duplication of the same scenario with the other OLSR protocol has done also to test another protocol behavior.

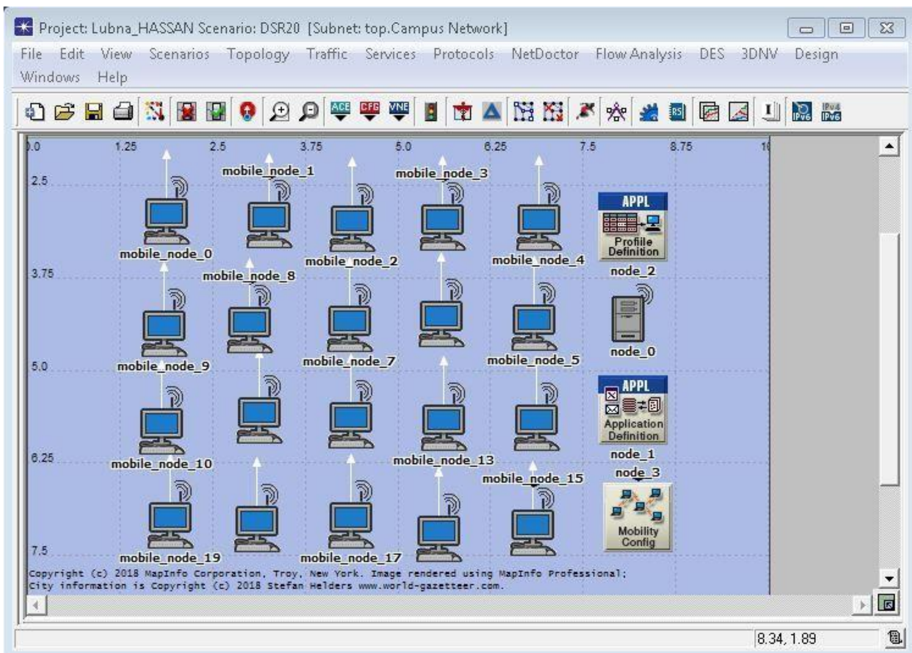


Figure 3.8: Simulating 20 mobile nodes scenario with FTP traffic application and random mobility

3.7 Simulation of third Scenario

In third scenario, the numbers of mobile nodes are 50. The same procedures were followed. By clicking the scenario tab then new scenario and giving an appropriate name. All the steps remain the same just the number of nodes are increased. The reason of increasing the mobile nodes is that we can have a profound look on the performance of routing protocols. The third scenario is shown in the below figure 3.9 the same scenario with the other protocol has also simulated.

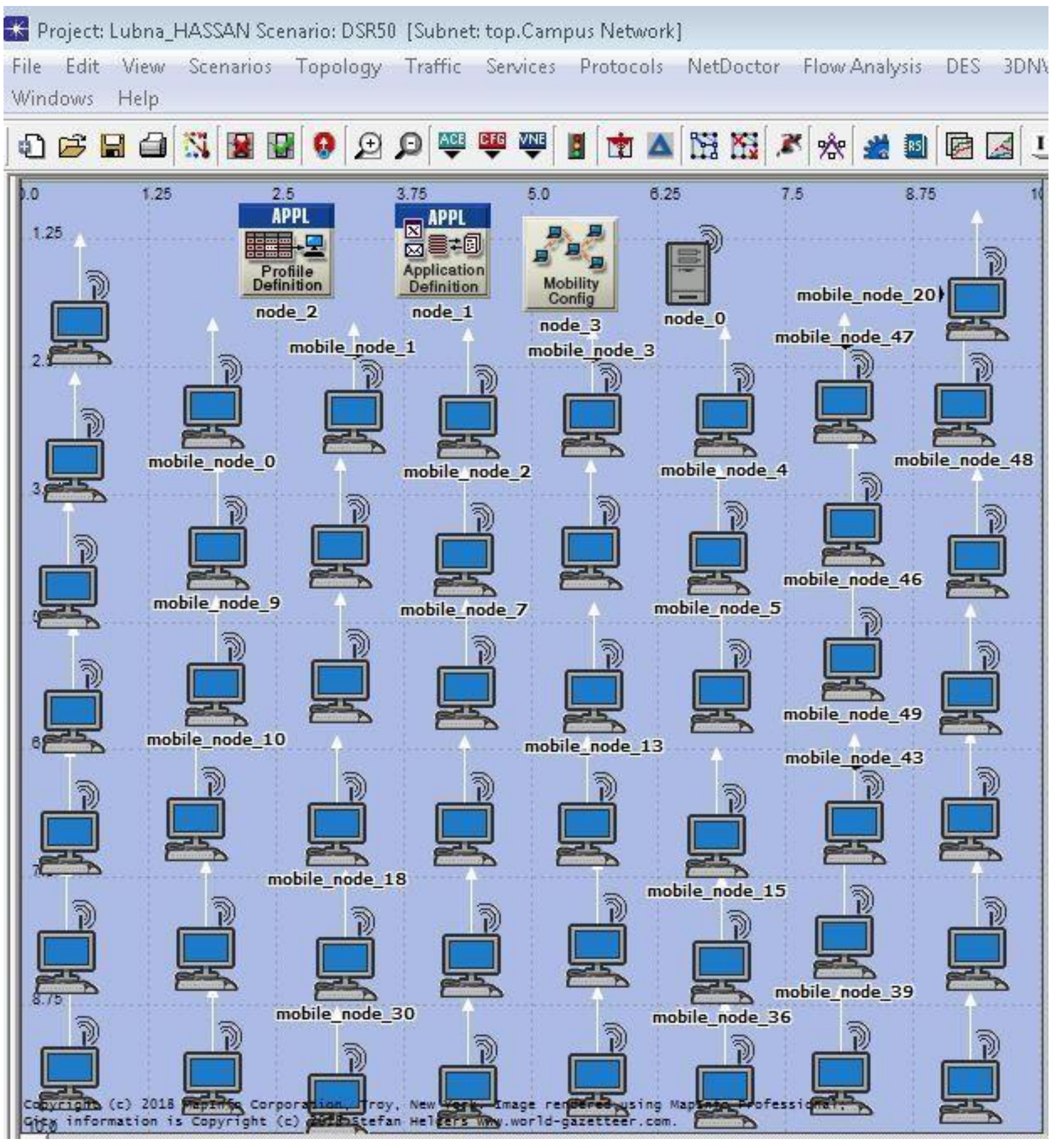


Figure 3.9: simulating 50 mobile nodes scenario with FTP traffic application and random mobility

CHAPTER FOUR

RESULTS AND DISCUSSION

Chapter Four

Results and Discussion

4.1 Introduction

Here the results of simulations will analysed and discuss. Beginning will be with the analysis of DSR and OLSR. These protocols will be checked by three parameters as mentioned delay, network load, and throughput. The results obtained in the form of graphs, all the graphs were displayed as time average. Three scenarios will analyse and discuss are 10 nodes, 20 nodes and the last one is 50 nodes.

4.2Analyzing Simulation

The three scenarios were made in the OPNET Modeller 14.5 The simulation run for Ten minutes and the graphs were saved for analysis and calculation. These graphs were found very helpful in the statistical analysis of these routing protocols performance. The required graphs were saved the images for the statistical analysis. These figures will be discuss in the next coming section. Here the DES execution manager window for the simulation is shown in below figure 4.1.

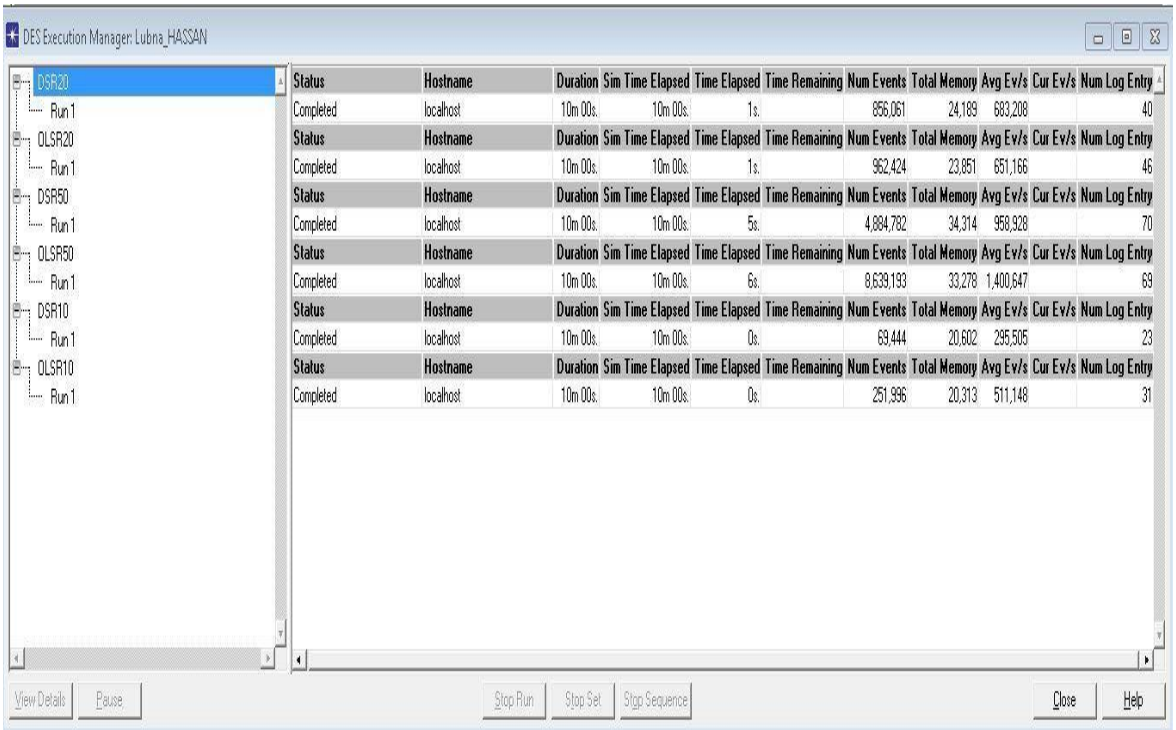


Figure 4.1: DES Execution window shown project scenarios their status, simulation duration and other results

4.2.1 DSR Performance

The below image gives the DSR required results and it is shown in the below figure 4.2. number of mobile nodes was 10. Dynamic Source Routing protocol was checked for three parameters as delay, network load and throughput. The peak value of network delay is 0.0031 second, then A sudden drop in the graph value occurred until remain constant from the fifth second to the end of simulation time at 0.0010 second.

In the same given figure 4.2, the middle graph shows the network load. The peak value of network load is 5800 bit/sec. Network load is gradually grow from zero bit/sec. from the beginning of simulation time, then sudden growing happened at 1.5 minutes to 3900 bit/second then growing and drops gradually happened till the end of simulation.

The third graph in the same given figure 4.2 is for throughput. The peak value of throughput is 5800 bit/sec. Throughput value take the same behavior and value of network load.

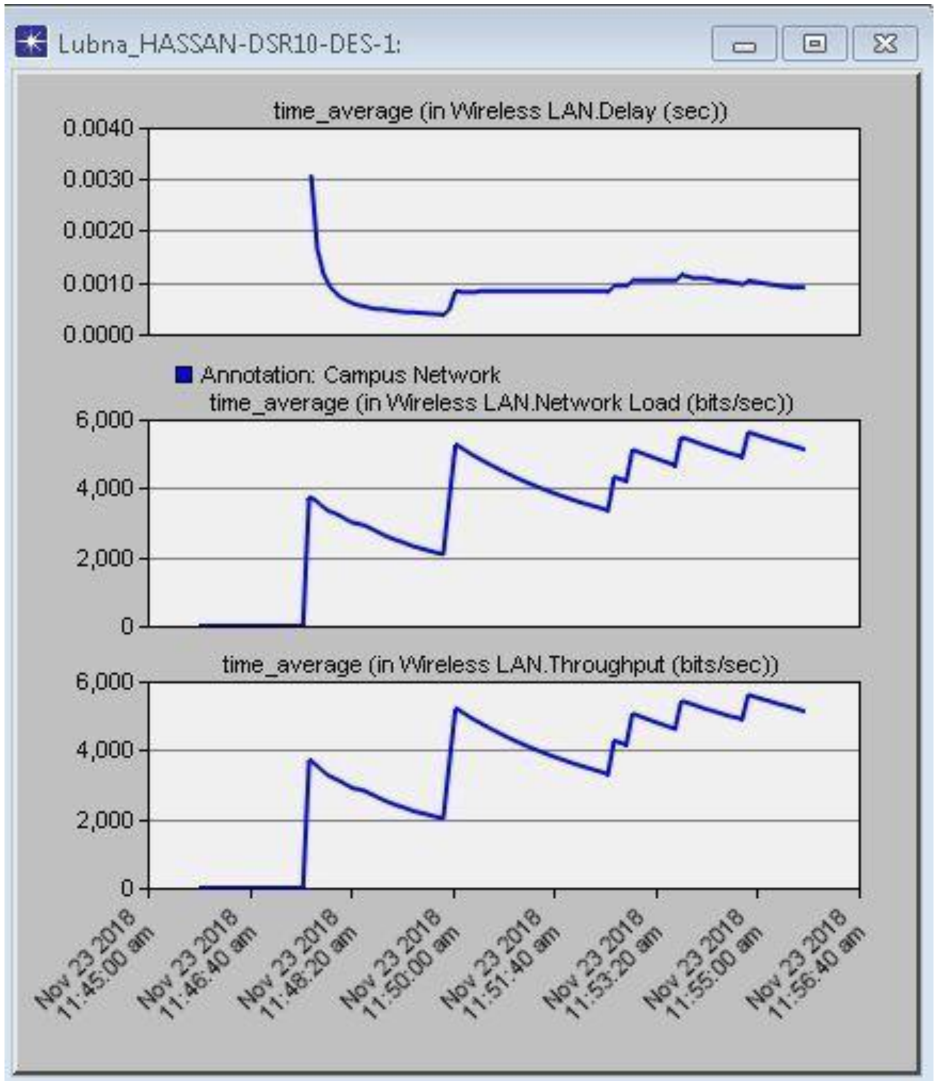


Figure 4.2: 10 Mobile nodes scenario results of delay in upper chart, network load in middle and throughput chart in lower, nodes were under DSR

4.2.2 OLSR performance

The below given image shows Optimized Link State Routing protocol(OLSR) for the following three parameters Delay, Network Load and Throughput. The numbers of mobile nodes were still kept as 10 mobile nodes. In the given figure 4.3, the first upper graph shows the network delay. It is taking a zigzag line growing in the delay value recorded then sudden peak delay 0.00062 second. happened after 2 minutes of the simulation time .After some time the delay graph drops gradually to under 0.0004 second . The network load have shown in the middle graph in the given figure 4.3. The first value of network load has recorded as 2100 bit/second, the network load peak value recorded as 5800 bit/second, and then gradually drop until the eighth minutes of simulation time then a sudden growing happen then it keeps constant value. The last graph in the given figure 4.3 is for the throughput of OLSR 10 nodes. The peak value of the throughput in OLSR is 5700 bit/sec. at the eighth minutes then the value is keep almost constant.

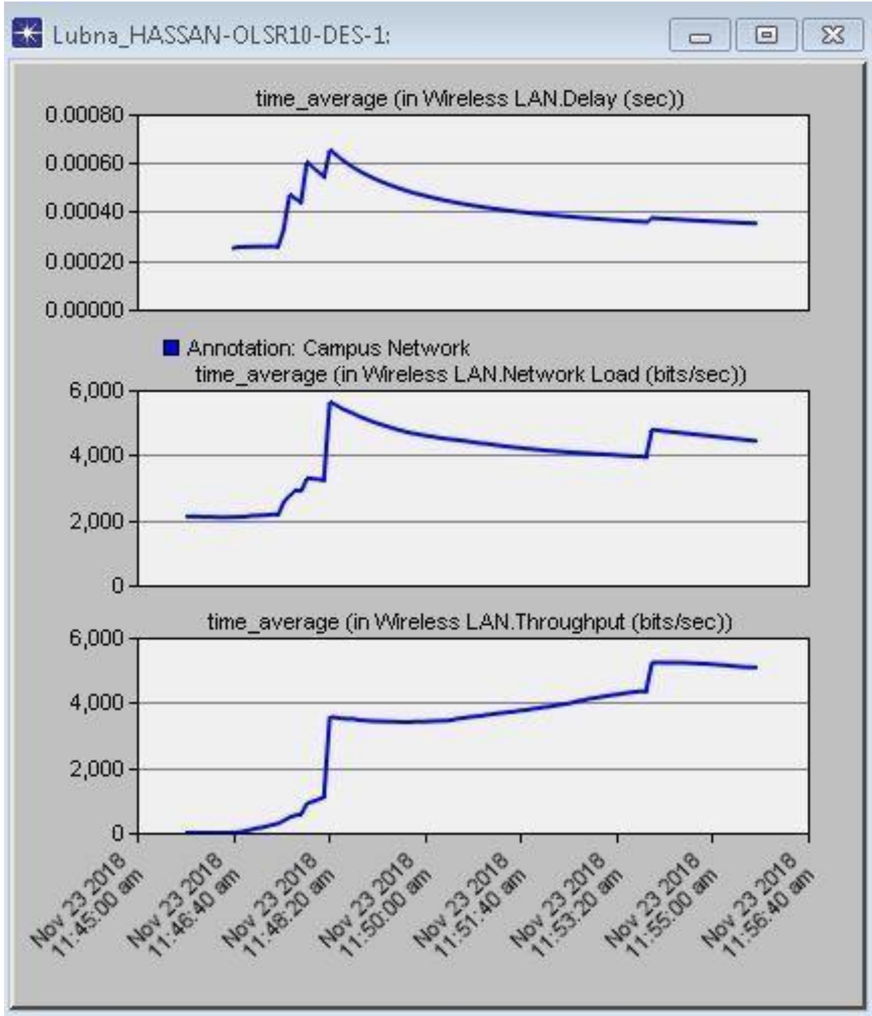


Figure 4.3: 10 Mobile nodes scenario results of delay in upper chart, network load in middle and throughput chart in lower, nodes were under OLSR

4.2.3 Analyses of Increased Nodes

In the other scenarios, the numbers of mobile nodes were increased from 10 to 20 and 50 mobile nodes. DSR and OLSR have been checked against three parameters as mentioned delay, network load and throughput. The reason of increasing mobile nodes was to check the behavior of these routing protocols in the large Ad hoc mobile network. The routing protocols simulated in the same environment of OPNET Modeler 14.5.

4.2.3.1 DSR Performance

The performance of DSR has been checked by increasing the number of mobile nodes while the WLAN fixed server will be one. The numbers of mobile nodes are 20. The DSR checked against three parameters such as delay, network load and throughput. The given figure 4.4 shows the graph for the DSR delay, network load and throughput. The first upper part of the graph shows the DSR delay. From the figure, the difference in DSR delay can be seen clearly. In the above figure 4.3 when the numbers of mobile nodes were 10 the DSR delay were low as 0.0031 sec, and here the DSR delay is increased as 0.0065 sec, the difference in DSR delay is clear. This increase in delay is because of the increasing in number of nodes. In the same figure 4.4 the middle graph shows the DSR network load. The DSR network load is also increased in the increased 20 number of mobile nodes. The peak value of DSR network delay in 10 mobile nodes were 5800 bit/sec which is shown in the above figure 4.3, and the peak value of DSR network load when the number of mobile nodes is 20 is 39000 bit/sec. The difference in the peak DSR network load of both scenarios can noticed clearly. The network load in 20 mobile nodes is high than 10 mobile nodes.

The DSR throughput can be seen also from the same figure 4.4. The peak DSR value of throughput when the numbers of mobile nodes were 20 is 34000 bit/sec.

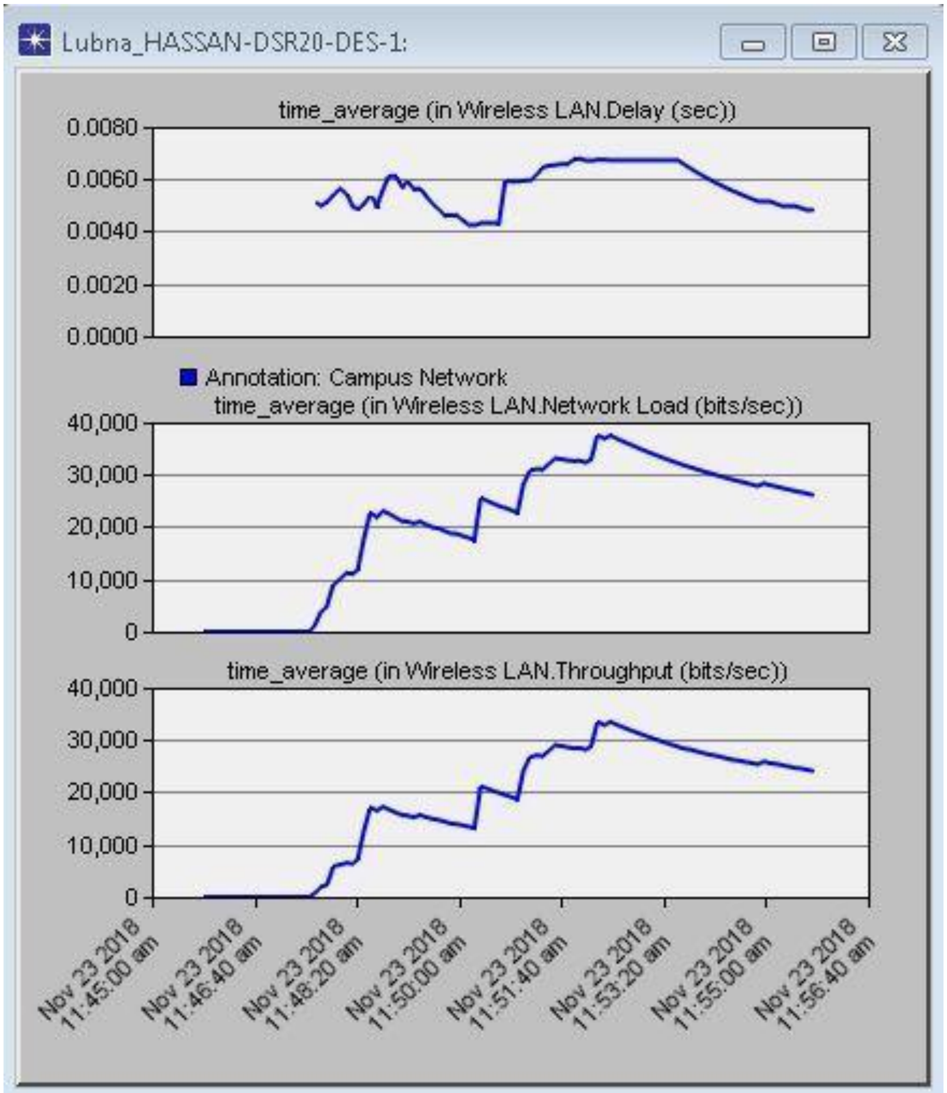


Figure 4.4: 20 Mobile nodes scenario results of delay in upper chart, network load in middle and throughput chart in lower ,nodes were under DSR

In the given figure 4.5 the DSR protocol will be checked against three parameters such as delay, network load and throughput. The changes in the graph can be seen clearly The DSR shows its peak delay value is 0.0035 sec. The network load is 62000 bit/sec. The DSR throughput can be seen from the given figure 4.5 which is 60000 bit/sec. High network load affects the MANET routing control packets and slow down the delivery by competing for access to the channel [22], and it results in increasing the collisions of control packets, and routing packets may be slow to stabilize.

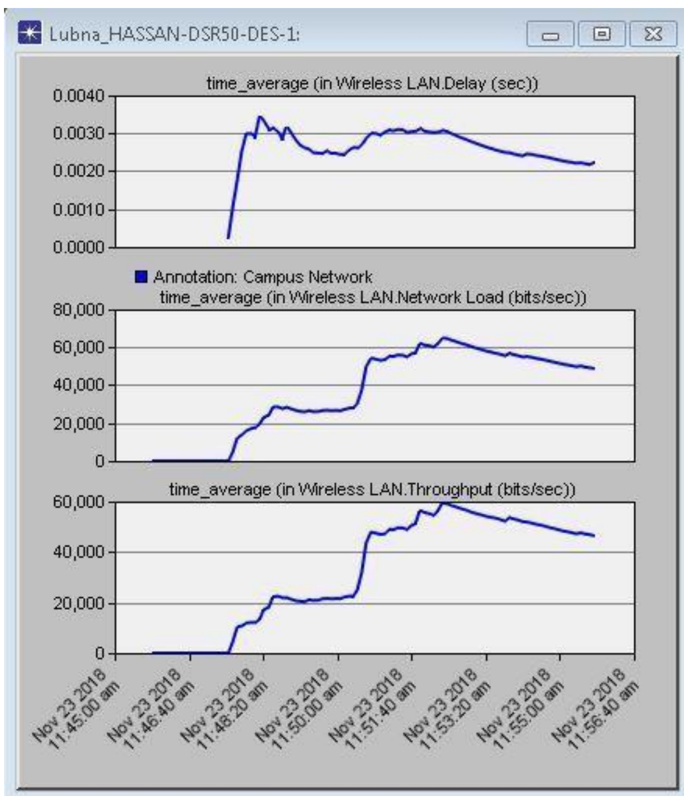


Figure 4.5: 50 Mobile nodes scenario results of delay in upper chart, network load in middle and throughput chart in lower ,nodes were under DSR

4.2.3.2 OLSR Performance

The OLSR routing protocol can be checked when the numbers of mobile nodes were 20 mobile node and the WLAN fixed server. The graph is given in the below figure 4.6. The upper part of the figure shows delay. The middle one shows network load and the third part shows the OLSR throughput. The OLSR delay has very minor changes when the numbers of nodes were 10 and the numbers of nodes were 20. In the 10 mobile nodes, the OLSR peak delay value was 0.00062 second and in 20 mobile nodes OLSR peak delay value was 0.00040 second. The middle part of the given figure 4.6 shows the OLSR network load. The peak value of OLSR network load when the numbers of mobile nodes are 20 is 15000 bit/second By comparing this value with the OLSR network load when the numbers of mobile nodes were 10 is 5800 bit/second, This change is because of the increasing numbers of mobile nodes as the data has to pass from more mobile nodes to their destination. Therefore, because of increased number of mobile nodes the network load is increased. The last graph in the given figure 4.6 is for OLSR throughput. The peak value of OLSR throughput is 17000 bit/sec when the numbers of mobile nodes were 20.

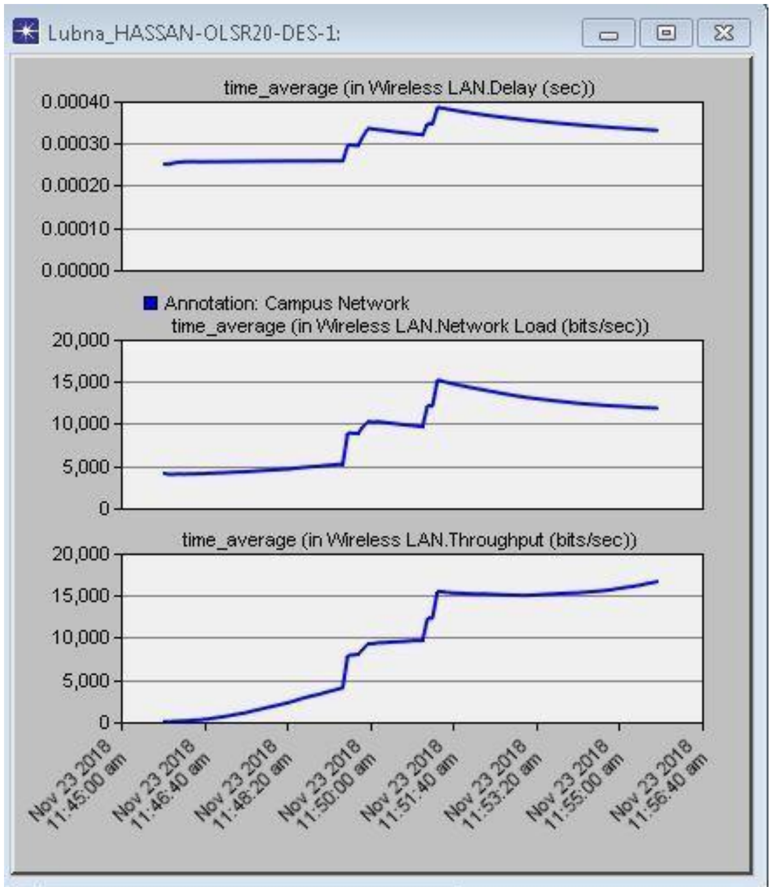


Figure 4.6: 20 Mobile nodes scenario results of delay in upper chart, network load in middle and throughput chart in lower ,nodes were under OLSR

In the given figure 4.7 OLSR protocol simulation results with 50 mobile nodes. The upper part of the figure shows the OLSR delay. The second middle part shows the OLSR network load and the third and last part shows the OLSR throughput. The OLSR delay peak value is 0.00036 second. The OLSR delay values when the mobile nodes were 10 and 20 were 0.00062 second and 0.00040 second respectively. The difference is clear from the given values. These values were taken from the graph, which is given in the figure 4.7. The OLSR network load peak value is 43000 bit/second The OLSR throughput peak value is more than 80000 bit/second.

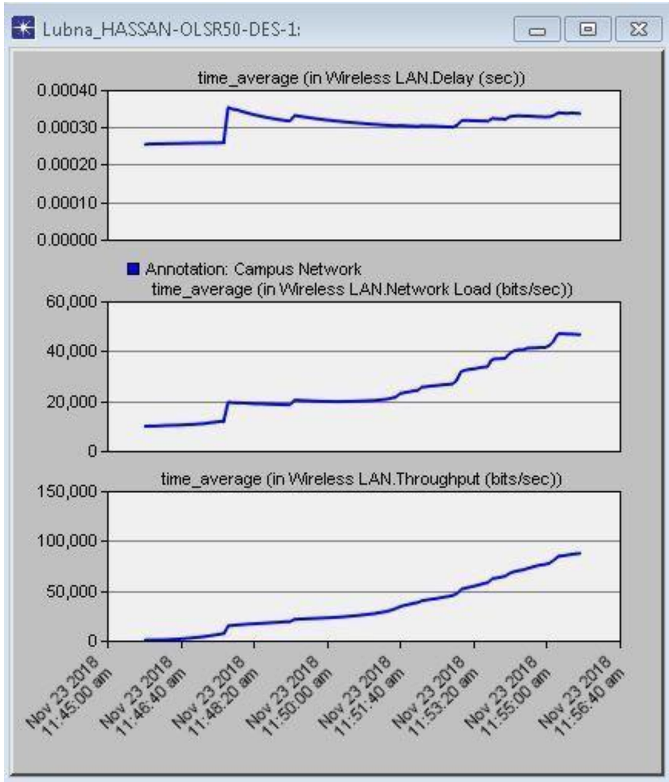


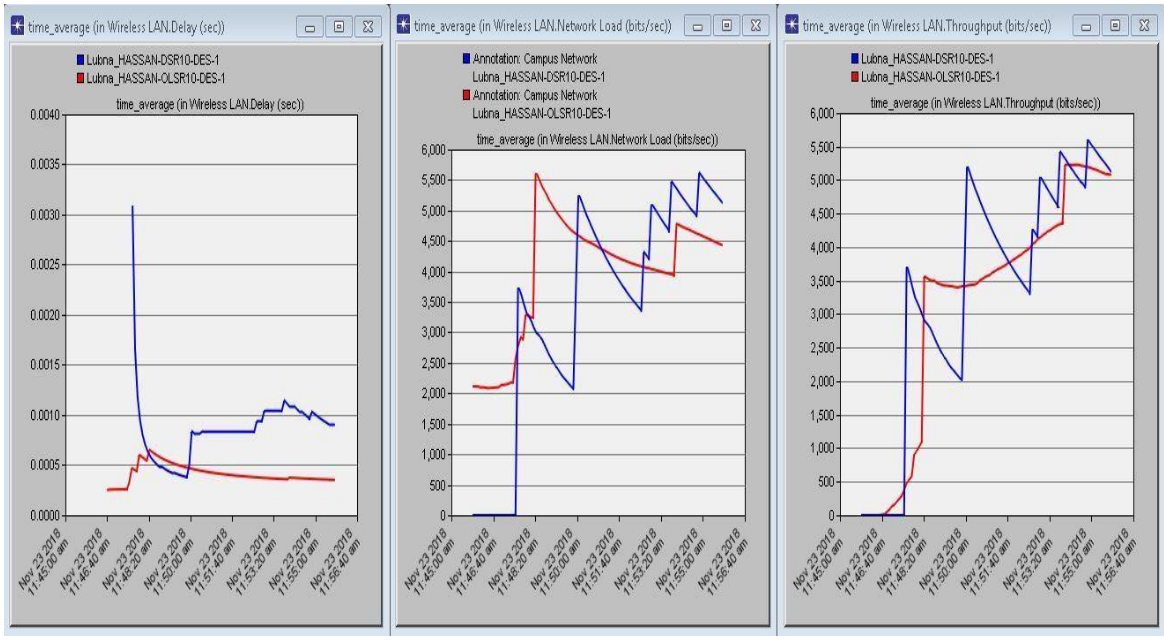
Figure 4.7: 50 Mobile nodes scenario results of delay in upper chart, network load in middle and throughput chart in lower, nodes were under OLSR

4.3 Comparative Analysis

In this section of thesis a comparative analysis have made to the protocols for every mentioned scenario against the three metrics witch are delay, network load and throughput .The given figures below show the comparative analysis of the routing protocols.

4.3.1 DSR and OLSR in three scenarios

The below figures 4.8, 4.9 and 14.10 showing delay, network load and throughput in 10, 20 and 50 mobile nodes scenarios with DSR, and OLSR respectively. The color scheme is showing the protocols behavior in different graphs along with a table 4.1 that gives the average values. From these average



values, it has concluded the behavior of all these routing protocols.

Figure 4.8: Comparison charts of 10 mobile nodes scenario results of delay, network load and throughput, nodes were under DSR in blue line and OLSR in red.

As given in figure 4.8 and table 4.1, OLSR performs better in delay by 60.9% than DSR and by 13.6% in network load parameters. Although The OLSR delay is the lowest but DSR has the high throughput by 1.01% better than OLSR.

Figure 4.9 below show 20 nodes scenario results and again OLSR performs well in delay and network load metrics by 93.1% and 54.6% respectively, DSR showed better network throughput by 30.8% than OLSR.

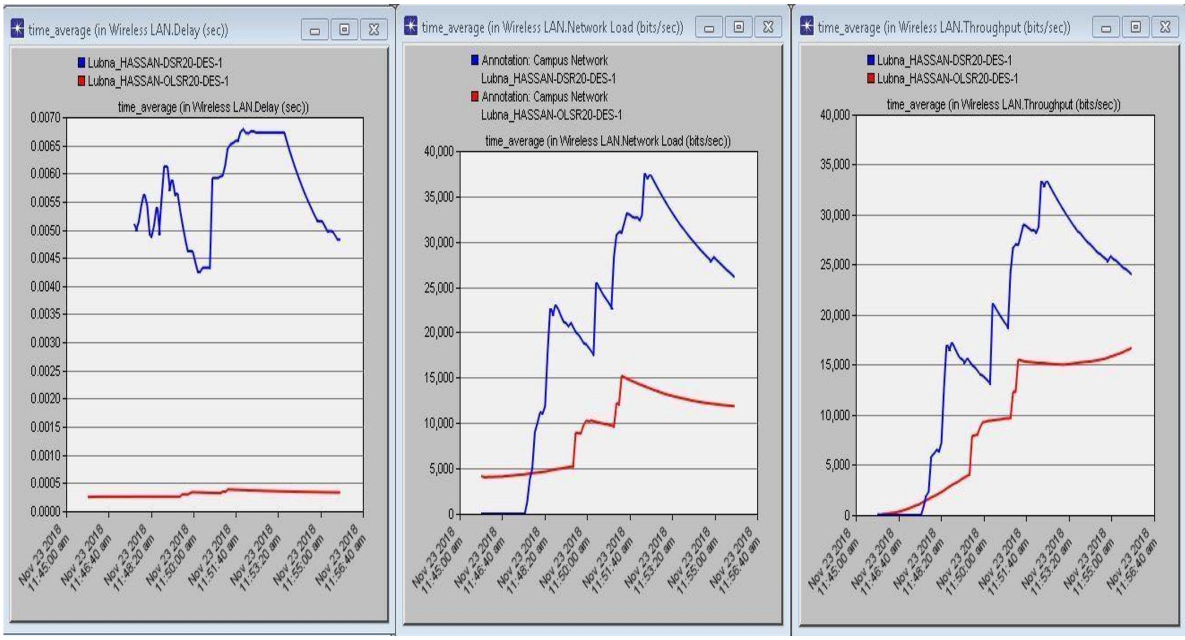


Figure 4.9: Comparison charts of 20 mobile nodes scenario results of delay, network load and throughput, nodes were under DSR in blue line and OLSR in red

Figure 4.10 below show the last scenario of 50 nodes results, OLSR gives best results in all metrics by 84.8% in delay, 4.6% in network load and 46.8% in network throughput.

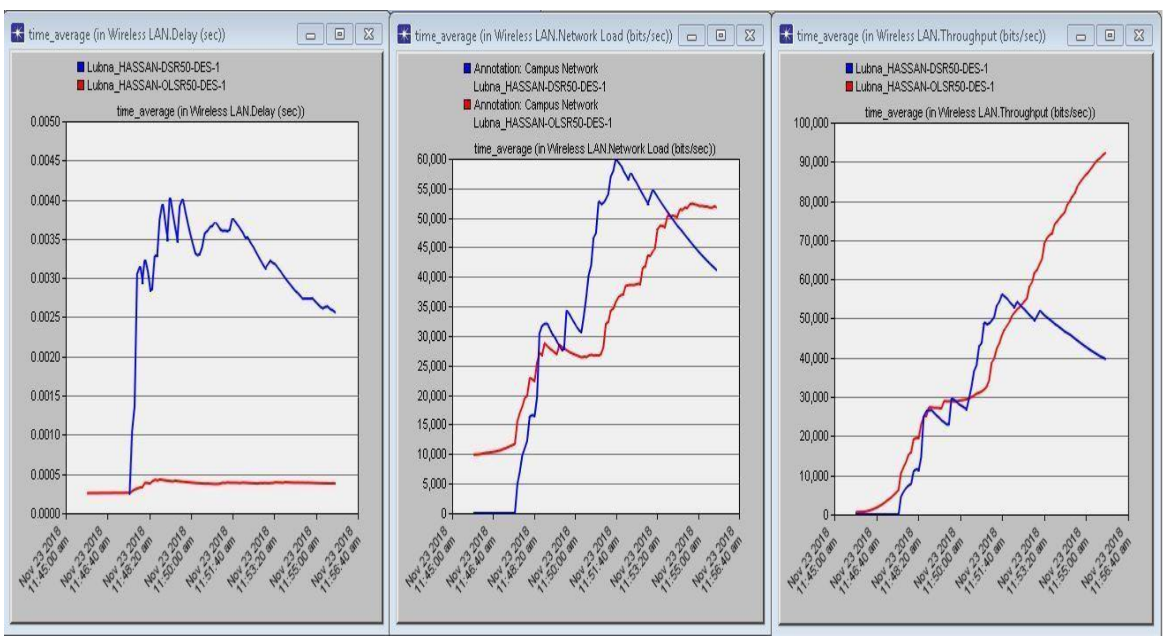


Figure 4.10: Comparison charts of 50 mobile nodes scenario results of delay, network load and throughput, nodes were under DSR in blue line and OLSR in red.

table 4.1 below show an average values of all three performance metrics in each scenario of 10, 20, and 50 mobile nodes under DSR and OLSR routing protocols ,each metrics average value taken from simulation results.

4. 1: Average values of delay, network load and throughput for DSR and OLSR

No. of nodes	parameters	DSR	OLSR
	Delay (second)	0.000902697	0.000352554
10	Network load (bit/sec)	5132.75	4433.65
	Throughput (bit/sec)	5132.85	5080.75
	Delay (second)	0.00482348	0.000331208
20	Network load (bit/sec)	26139.9	11865.2
	Throughput (bit/sec)	24097.5	16665
	Delay (second)	0.0022245	0.000336356
50	Network load (bit/sec)	48851.7	46588.3
	Throughput (bit/sec)	46485.3	87410.7

CHAPTER FIVE

CONCLUSION AND FUTURE WORK

Chapter Five

Conclusion and Future Work

5.1 Conclusion

In the present scenario the performance of MANET routing protocols is examined with respect to the following parameters namely end-to-end delay, network load and throughput. DSR is under category of reactive protocols whereas OLSR come under proactive protocols. Every individual protocol has got its own advantages and disadvantages and performed well at their peer level, but for the purpose of efficiency, they are compared using OPNET tool.

The various conclusions drawn from various experiments, observations, and analysis done in the thesis are as follows: end-to-end delay under FTP traffic had better values with OLSR protocol for all three scenarios which was 10, 20 and 50 mobile nodes in this thesis than DSR. OLSR also performs well in Network load for all three scenarios done by 0.000352554 second, which is 13.6% better than DSR in 10 nodes network 54.6% in 20 nodes and 4.6% in 50 nodes. OLSR also performs better in network load for all three scenarios with best value in 10 nodes with 4433.65 bit/second . throughput has best value in OLSR with 50 nodes by 87410.7 bit/second although DSR was better in 10 and 20 nodes by 1% in 10 nodes and 30.8% in 20 nodes.

5.2 Future Work

The future work suggested is the development of modified version of the selected routing protocols, which should consider different aspects of routing protocols such as rate of higher route establishment with less route breakage and the weakness of the protocols mentioned, should be improvised.

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