Chapter One

Introduction

1.1 Introduction:

With the new type of real time applications in the IP networks, bandwidth became an important issue in the Internet community and service providers. Many real time applications such as video streaming and VOIP and Video conference caused huge congestion on IP networks. Among all these services, VoIP has considered as one of the cheapest communication.

These applications and services not only need bandwidth, but also need a good quality of service, such as delay, Jitter and packet loss. New application put new challenges to service provider [1].

During the past several years, numerous mechanisms have surfaced for providing QoS for communication networks.

The main function of any QoS mechanism is to avoid massive congestion for the packets with guaranty QoS. It must be know that QoS mechanisms do not generate new capacity, but only support prioritization of traffic and allocation of capacity under congested conditions, or minimize the packet rates to minimize congestion [2].

Some of dynamic routing protocols like OSPF (open shortest path first) always forward the packets to the shortest path. But sometime shortest path routing cause imbalanced traffic distribution. This can lead to congestion in some place in the network even if the load is not very heavy. This can disturb the flows so it needs Quality of Service to balanced traffic when the shortest path has less resource.

One of the most popular solution installed to manage the flows of packet inside the network is Traffic Engineering (TE), it’s take information offered by the available resources and avoiding imbalance network utilization by choosing the metric according to available bandwidth, so TE is important in the service provider network to avoid the metric of shortest paths in forward traffic heavy load.

When applying TE in ISPs network, it makes big optimize resource utilization and enhance the performance of network.

To better result IETF introduces MPLS with TE to enhanced link state IGP.

MPLS abbreviate off Multi-Protocol Label Switching, and it is acceptable to all the protocols of the Network Layer. It is a new technology aimed at enhances the packet forwarding of the backbone routers in the large networks.

The main concept is to send the packets based on a label, its short length instead of the IP address with variable length.

The Label switching technology was proposed to get better router performance, but this impulse is minimized with advances that offer in router design and accomplishment of line-speed forwarding of IP packets. But later on the main advantage of the MPLS architecture over the old IP forwarding has become clear, the connection-oriented nature of MPLS allows ISPs to implement TE in their networks and get a many goals, including different routing, bandwidth assurance, load balancing, path redundancy, and other services that produce QoS.

IETF develop DiffServ as QoS approach, the major goal of DiffServ is to support a scalable structure for offering a range of services in the Internet with Quality of Service support and without the need to maintain per-flow state in each router.

The combined use of the differentiated services (DiffServ) and multiprotocol label switching (MPLS)-TE technologies is envisioned to provide guaranteed quality of service (QoS).

The main Differentiated Service aware TE requirement is to separate bandwidth reservations for different type of traffic and give different forwarding performance based on the type. This achieve by keeping look of how much bandwidth is available for each type of traffic at any time on every routers in the network.

1.2 Problem statement:

In MPLS traffic engineering, its sets up labels switched-paths (LSPs) along links with available resources, so that bandwidth is always available for this flow and avoiding congestion in scenarios.

This optimization of resources allows LSP's do not follow the shortest path, when the available resources in the shortest path are not enough. But, MPLS TE do not care of QoS, because it operates on the accessible bandwidth at an aggregate level across all classes, so it cannot offer better bandwidth performance on a per class basis.

1.3 proposed solution:

Deployment DiffServ with MPLE-TE makes MPLS -TE aware by QoS, and to be able to separate bandwidth reservations for various classes of traffic and offer different forwarding behaviour depend on the class.

1.4 Aim &Objectives:

The aim of the project is to enhance the QOS by adding DiffServ to MPLS and to evaluate the performance of MPLS TE and MPLS diffserv network for real Time applications (VoIP) and compared the scenario in term of jitter, end-to-end delay and packet delay variation.

The objectives of this project are:

1- To analyze the voice packet when using diffserv with MPLS-TE

2- To decrease the losses and increase bandwidth for received voice signal

3- To assign priority for voice packets.

1.5 Motivation:

By take the benefit of MPLS-TE DiffServ, that support ISPs a set of tools for bandwidth reservations and enhance network performance. Which achieve QoS on a large scale and at minimum cost.

By applying DiffServ can minimize the voice packets delay and probability of packets loss can be improve.

1.6 Methodology:

For simulation, designing a model for the simulation using the simulation tool OPNET ,then justify the research using the simulated data as a measure for analysis.

1.7 Thesis outlines:

This thesis consists of five chapters as follows:

- Chapter two takes literature review that to know the previous study and speak about quality of service and also general overview about MPLS-TE and DiffServ.
- Chapter three speak about methodology, the detail steps of simulation scenario.
- In chapter four takes the simulation and result, and discuss the final result.
- Chapter five provides conclusion and recommendations.

Chapter Two

Literature review and Background

2.1 Introduction:

In this chapter we provide the previous references that were used as a background study for this thesis. In the initial of research using these references to understand the basic concepts of the MPLS and DiffServ technologies. We also were looking for similar work to compare our results with.

2.2 Literature review:

The Differentiated Services [1] is developed to support differing levels of QoS to different traffic flows. It cannot provide per flow bandwidth and delay guarantees. But it makes the stateless network scalable and robust. On the other hand, DiffServ alone is not sufficient to guarantees service level agreement that DiffServ suggests only mechanisms for relative packet forwarding treatment to aggregate flows, traffic management and conditioning. However it does not offer architecture for end-to-end QoS, does not lend itself to handle link failures if there is no traffic engineering. Hence, IETF had implemented MPLS architectures

MPLS traffic engineering uses resources reservation to establish label switched- paths (LSPs) along the links, thus to be sure that bandwidth is always available for a specific flow and minimize congestion. Because LSPs are set up only where resources are available, but, MPLS TE is not care of QoS, because it operates on the available bandwidth at an aggregate level across all classes [2].

In traditional routing, every packet is forwarded between the routers using routing table based on algorithm that has a metric (shortest path based on bandwidth) in every router.

Every packet is forwarded separately in any router. This way is inefficient for real time application [3].

The IETF has introduced many service models to meet the requirement of QoS. The mechanisms and models proposed for enabling QoS. QoS has two main issues that is resource allocation and performance optimization. For resource allocation in the network of internet service provider, Differentiated Service (DiffServ) and Integrated Service (IntServ) are developed by IETF.

IntServ was proposed as new technology for resource allocation to meet the requirements of real-time applications (has strict delay requirements). Typically it has a deadline for data to arrive by. So the packets experience a different delay amount in the way in the network, since of the distortion of timing caused by the delay jitter, the quality of the voice signal would not be good when the receiver just sent the voice to the audio device as the traffic came in. The main function of Integrated Service is to conserve the datagram model of IP-based networks and at the same time support resource reservation for multimedia traffic.

It is depend on using Resource reservation Protocol (RSVP), it can support end-to-end service guarantees in connectionless IP networks.

The major problems in the Integrated Service architecture is large amount of state information when the number of flows increases so it is need a large memory and place processing overhead on the routers and all routers must have RSVP [3].

Base in simulation result in [4] can be verify that MPLS is the best solution in implementing the VoIP application compared to traditional IP networks as IP applications be more and needing bigger bandwidth to forward on Routers, in MPLS takes less processing time in forwarding the traffics, this is more proper for the real time applications like VoIP.

QoS performance evaluation will be conducted by send many video streaming onto DiffSer that combined with MPLS, its verify that it provides guaranteed end-to-end quality of service for multi traffic in IP networks. although, video traffic gave the highest priority in DiffServ and also being routed to other path using MPLS, however in the result show that still some packet drops since video traffic in nature is variable-bit-rate (VBR) and so it will have burst period which may not be able to DiffServ-aware MPLS network[6].

In [7] they designed of a new routing model for DiffServ MPLS networks. The result shows the topology and implementation of a new routing simulator called Extended QoS-based Routing Simulator (EQRS). The aim in the Simulator is to provide new capabilities that enable simulating DiffServ MPLS networks. EQRS allows users to configure parameters of DiffServ MPLS networks, where the dynamics of constraint based routing algorithms as well as traffic engineering mechanisms is tested. The simulation results approve that QoS routing accomplish better network result when well configured also the result shows that QoS routing algorithms enhance the network performance and has better throughput than shortest path algorithm and also EQRS is easy to model, designing and implementation in DiffServ MPLS networks.

Author in [8] it introduces the idea and model of DiffServ and MPLS. DiffServ is scalable for apply in today’s Internet, and MPLS supports fast packet forwarding and the opportunity for traffic engineering. When DiffServ and MPLS are present a very efficient strategy to backbone network providers. The paper attempts to show the idea of DiffServ and MPLS and prove the effectiveness. MPLS-traffic engineering is added a benefit for Diff Serv.

Author in [9] designs MPLS network in simulator which apply Label Distribution Protocol (LDP) and constraint-based LDP (CR-LDP), the main thing in MPLS is label distribution schemes, flow aggregation, ER-LSP, and LSP Tunnel.

The MPLS simulator helps researchers to design and estimate MPLS and related techniques. For example, it can be establish an ER-LSP and LSP Tunnel that can easily applied in the area to support traffic engineering it verified that in this paper.

In[10] author has designed two design for the traditional IP and MPLS network and also MPLS with MPLS-TE to compare the performance of network but have not taken the effect of QoS in MPLS-TE network in to account.

In this research, they were design three model to the networks. They tested with shortest path routing, MPLS- traffic engineering and MPLS traffic engineering with differentiated services to support Quality of Service. They gave a complete conclusion of every of these models and the result.

From the model, author improved that traffic engineering can be applied with MPLS in order to load balance and control the traffic to use the paths efficiently in the network. With this model, they aimed to deliver a more perfect service according to service level agreement to its customer, by lower cost can also deliver services and they improved WFQ gave the best result for voice for both delay and delay variation.

In [11], they are introduced a new scheduler, namely WFQ-P, to sustain DiffServ in a MPLS core router to enhance the networks.

From the theoretical analysis and model result, they verified that the proposed WFQ-P scheduler has many benefits, Its enhance bandwidth using under burst EF traffic by allow some type of traffic to share the same bandwidth and WFQ-P can be easily manage the bandwidth and connection control to assist MPLS traffic engineering.

2.3 Quality of Service (QOS):

QOS is defined as the ability of network elements supporting a certain level of assurance to specific service, lead to enhance the performance and reliable data delivery. Thus, the network must satisfy a set of specific requirements concerning the particular service or data flow it is transporting.

These requirements can be described as short delay or good quality video. However, they are more often measured quantitatively, using numerical values.

We used many types of QoS parameters to compare the performance of the networks, but the main parameters that we are used is end to end delay and delay variation.

Delay, usually is measured as end-to-end delay from source to destination, it is defined as the time passed in milliseconds between the packet being forwarded to the destination. Delay is cause by many reasons, like time of propagation, scheduling and switching decision delays.

Delay Variation, also called Jitter, is the variation in delay between sequences packet. It is also measured in milliseconds and is usually computed by measuring the difference in delay between consecutive packets.

There are three types of QOS models.

- Best effort service model.
- Integrated Service model (IntServ).
- Differentiated Service model (DiffServ)

2.3.1 Best effort model:

In best effort service model there is no guarantee of reliability, throughput, and delay, it uses First in First out (FIFO) as queuing scheduling.

2.3.2 Integrated Service model (IntServ):

Integrated service model is multiple service models which can take variety QOS parameters under consideration. The request message is sent to the network before sending the data. This request is send to the network element for resource reservation done by Resource reservation Protocol (RSVP) [9].

2.3.3 Differential Service model (DiffServ):

DiffServ proposed as best solution to provide QoS, that because implemented IntServ and RSVP was difficult, it was introduced in 1998.The purpose of DiffServ was to meet the performance requirements of the user. Differentiated service mechanisms permit network providers to allocate different levels of service to different users of the Internet. User needs to have a guarantee Service Level Agreement (SLA) with Internet Service Provider (ISP).

It has limited number of service classes indicated by the DS field. Since resources are allocated according to type of class, the amount of state information is proportional to the number of classes rather than the number of flows.

The DiffServ model is based on the 8-bit TOS (Type of Service) field in the IP header. The original TOS definition was not widely implemented, and now the field is split into the 6-bit DiffServ Code Point (DSCP) value and 2-bit unused part figure 2-1 show differentiated service field (DS).

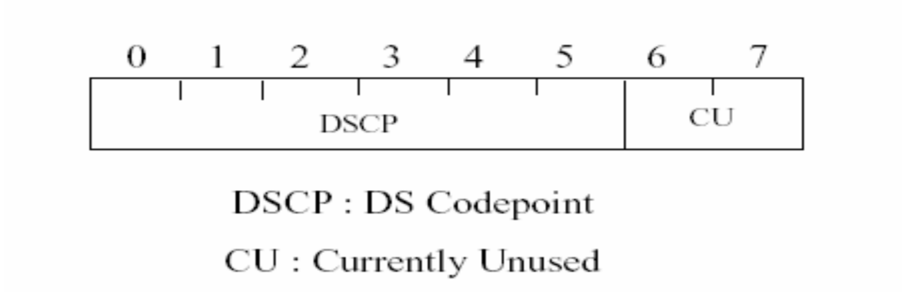

Fig 2.1: Differentiated service (DS) field

In a DiffServ network, the edge routes (boundary routers) have different task than the core routers. DiffServ accomplishes scalability through performing complex QoS functions such as classification, marking, and conditioning operations using the DiffServ Code Point (DSCP) into a limited number of traffic aggregates only at the edge nodes. In the core routers, scheduling and queuing control mechanisms are applied to the traffic classes based on the DS field marking(is the process in which the DSCP value is set accordance with the set of defined rules) all traffic conditioning and dropping at the network layer using IP DiffServ QoS mechanisms.

We can be divided DiffServ domain into two parts traffic classification and Traffic Conditioning.

In traffic classification, the classifier selects packets based on the combination of DSCP value in IP header. We have two types of classifiers first Behavior Aggregate (BA) and the second is Multi-Field (MF). In BA packets select based on DSCP value whereas MF selects packet based on combination field of the IP header (ex source address, destination address, source port, destination port).

In traffic conditioning performs metering, shaping, policing and marking or remarking to ensure the traffic entrance to the DS domain which conforms to the rules specified in the SLA and traffic conditioning agreement. In the edge router traffic conditioning functions are implemented, the four processes are [18]:

- Metering is the process of measuring the temporal properties (rate) of traffic stream selected by a classifier.
- Shaping is the process of delaying packets within a traffic stream to cause it to conform to the SLA.
- Policing is the process of discarding packets within a traffic stream to cause it to conform to the SLA.
- Marking is the process of setting the DSCP value in a packet based on defined rules such as pre-marking, re-marking.

Figure (2.2) discusses function of edge router and core router in DSCP network.

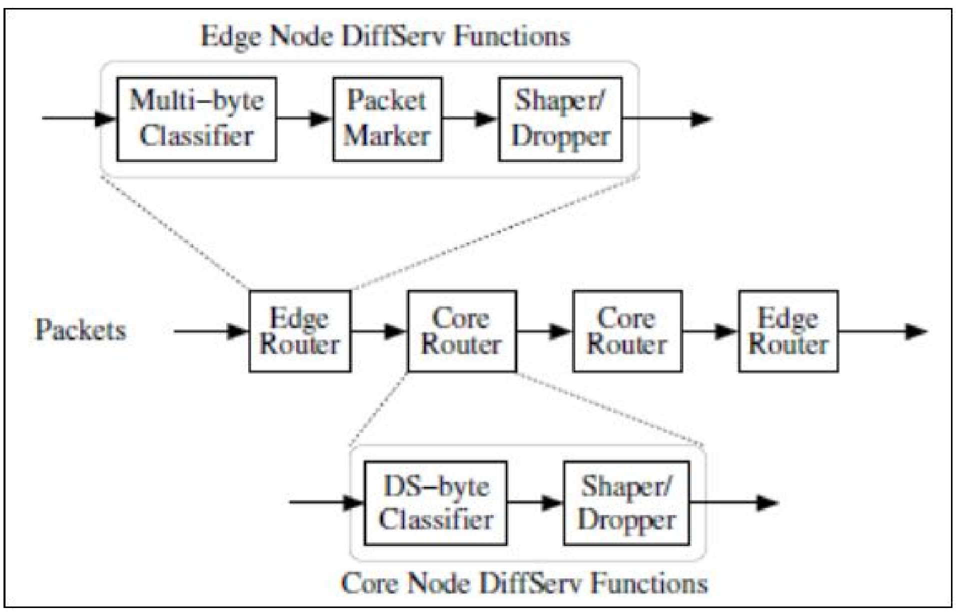

Fig 2.2: DSCP architecture

DiffServ’s edge nodes process and mark the TOS byte in IP packet header by a DSCP, depended on a negotiated agreement. Other routers in the domain that receive the packet are only concerned with the DSCP value to assign a particular treatment to the packet. This particular treatment is called a Per-Hop-Behavior (PHB).

DiffServ has three types of services:

- **Expedited Forwarding (EF):**

EF is a forwarding mechanism with highest priority and is considered best for applications that require first class service, it is used to provide by reliable, low delay and low delay variations to packets[9] .

- **Assured Forwarding (AF):**

AF is a traffic that has higher priority than best effort requirements, but it doesn't provide service guarantees. While DiffServ is adding service differentiation and class-based treatment, it does not consider the route forwarding and as such cannot guarantee bandwidth by itself. But by activating MPLS to work with DiffServ, maximum utilization of bandwidth can be achieved.

- **Best-effort:**

It is the normal service offered by IP networks.

In the classification, the first 6 bits, called the Differentiated Services Code Point (DSCP) and 3 bits is called experimental bits.

Figure 2.3 show the value of DSCP for assured forwarding class, best effort and expedited forwarding and also show the experimental bits (3 bits) in shim header.

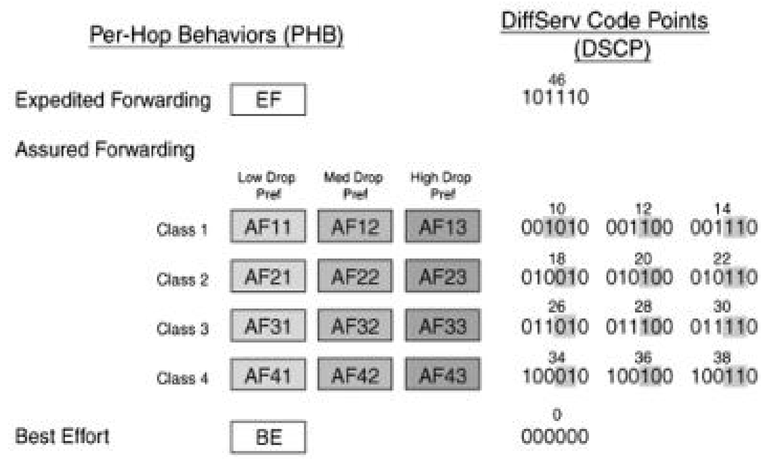

Fig 2.3: Mapping 6-bit DSCP field

2.4 Multiprotocol Label Switching (MPLS):

The IETF developed MPLS as an advanced forwarding technique. MPLS evolved from Cisco's Tag Switching at beginning was proposed to improve router performance, but now it used for many benefits first it has a bits for traffic engineering (TE), and also support QoS technology.

MPLS supports both the switching and routing functions of layer 2 and 3, where the packets are forwarded based on an extra short address called label added in front of the ordinary payload. By this new label can be forwarding the traffic in desired path, and best routing can be established.

MPLS uses the label switching approach to build virtual circuits in IP-based networks. These virtual circuits can follow destination-based IP routing, Packets carry labels to indicate the explicit route they should be taking. Thus, labeled packets follow LSPs. but the explicit routing mechanism in MPLS also allows us to specify hop by hop the entire path of these virtual circuits. Routing protocols such as OSPF (Open Shortest Path First) and BGP (Border Gateway Protocol) establish these explicit routes in advance, and then build tables in each router that define the routes.

The objective of MPLS is to increase the efficiency of data throughput by optimizing packet processing overhead in the IP networks. The edge routers in the network, called the Label Edge Routers (LERs), attach this label to the packet. The core routers in the network, called the Label Switching Routers (LSRs), then route the packet based on the assigned label rather than the original packet header. The label assignments are based on the Forwarding Equivalence Class (FEC) of the packet, where packets belonging to the same FEC are assigned the same label and generally traverse through the same path across the MPLS network. An FEC may consist of packets that have common ingress and egress nodes, or same service class and same ingress/egress nodes, etc. A path traversed by packets in the same FEC is called a Label Switched Path (LSP). The Label Distribution Protocol (LDP) and an extension to the Resource Reservation Protocol (RSVP) are used to establish, maintain (refresh), and tear-down LSPs. MPLS performs a much faster forwarding than IP since the packet headers do not need to be analyzed at every hop in the path. MPLS also provides Traffic Engineering (TE) by allowing traffic to be explicitly routed in the network to achieve efficient load balancing.

The figure below shows the format of this label, also called the MPLS header. It contains a 20*bit* label, a 3*bit* field for experimental use, a 1*bit* stack indicator, an 8*bit* time to live field. Each entry consists of 4 *octets* in a format depicted below [1].

Fig 2.4: General MPLS Header

The Label switching approach was initially conceived in order to improve router performance, but this motivation has diminished with advances in router design and achievement of line-speed forwarding of native IP packets.

A key concept in MPLS is the separation of an IP router's functions into two parts: forwarding and control [5]. The forwarding part is responsible for how data packets are relayed between IP routers, using label swapping. The control part consists of network layer routing protocols to distribute routing information between routers, and label binding procedures for converting this routing information into the forwarding tables needed for label switching

2.4.1 Label:

A label is a short, fixed length, locally significant identifier that is used to identify an FEC. A packet may be assigned to an FEC based on its network layer destination address.

The label also called Shim Header is add in the packets when reaches the LER, its enter between layer 2 and 3 of the OSI model, it also called 2.5 header. This MPLS Shim Header which is structured into four parts has a total length of 32 bits; 20 bits for Label, 3 bits for Experimental (EXP) which is reserved to use in QoS purpose and traffic engineer, 1 bit for Bottom of Stack field (S) is used for determine the end of the Stack. If the Label is at the last one of stack then the value is set to one else is set to zero and 8 bits for Time to Live (TTL) TTL value decreases by one on any hop as it passes during the LSRs. When the stack value reaches to zero the packet is dropped [10] which is shown in Figure3-2.

Fig2.5: MPLS shim header

(a) Label Push (Imposition):

In the edge router this operation is done also called ingress LER , which the router add the label to the packets.

(b) Label Swapping (Switching):

This is done by the LSR during this operation the router forwarding the packets by changing the label to anther label according to class of service and the destination.

(c) Label PoP (Disposition):

This operation is done by the edge router it called egress LER, which remove the label and finally forwarding the packets with IP address out of MPLS network.

2.4.2 Label Edge Router:

A Label edge Router (LER) is do layer 2 function (Switch) and also layer three function (routing) that it is able to forwarding MPLS frames to and from an MPLS domain. It also forward the IP to MPLS FEC binding including the aggregation of incoming flows. It also communicates with interior MPLS LSRs to exchange label bindings. The edge LER called an ingress or egress LSR's, because it is located at the edge of an MPLS cloud (network).

2.4.3Label Switching Router:

LSRs receive an incoming labeled packet, perform an operation on it, switch the packet, and send the packet on new label.

2.4.4 Label Distribution Protocol (LDP):

The main idea in MPLS is that to Label Switching Routers (LSRs) must agree on the labels used to forward packet between the routers so we need protocol to do this function. The label distribution protocol is achieved by employing a set of signaling procedures.

The LDP is a protocol proposed for distributing labels. It is depend on a many messages done by LSR, which LSRs are establish *Label Switched Paths* (LSPs) throughout a network by mapping network layer routing information directly to data-link layer switched paths. LDP associates with FEC in every LSP it establish. The FEC and LSP are associated to specify which packets are mapped to that LSP.

It introduced four types of messages:

1-Discovery messages run over UDP and use send hello messages to learn about other LSRs to which LDP has connect directly. It then establishes a TCP connection and an eventual LDP session with its peers.

2- Adjacent messages send TCP to start session initialization, using the initialization message at the start of LDP session negotiation. This information includes the label allocation mode, keep in mind the value of timer, and which label range was used between the two LSRs.

3-Label advertisement messages to support label-binding advertisements using label mapping messages that advertise the bindings between FECs and labels. To reverse the binding process it used Label withdrawal messages. Label release messages are used by LSRs that have received label- mapping information and want to release the label because they don't need it.

4- Notification messages support advisory information and signal error information between direct connect LSRs that have a LDP session established between them [5].

2.4.5 Label Switch Path:

A Label Switch Path (LSP) is an ingress LSR to egress LSR switched path set up by MPLS nodes to forward the MPLS encapsulated packets of a particular FEC using the label swapping forwarding mechanism, that path has the best route. The best route here means that the path has available bandwidth, low delay, less congestion and low latency [5].

2.4.6 Label Forwarding Information Base (LFIB):

It is used by the core routers in the MPLS domain, the router will compare the label on the incoming packet with the label it has in its information based lookup table. If the routers find a match, they will forward that packet based on that match else the packet will be dropped [3].

2.4.7Forwarding Equivalence Classes:

A FEC is a group of packets that are treated similarly by a router, for example forwarded the packet at the same interface with the same next hop and label, and assigned the same class of service. When a packet enters the MPLS domain at the edge router (ingress node), it is mapped into an FEC. The mapping can be achieved according to a number of factors, for example, the address prefix, source and destination address together, or ingress interface. At the current moment there are three defined FEC elements, an address prefix, router ID and the source and destination port and IP addresses. A set of IP packets that are forwarded over the same path and treated in the same ways and can be send by a single label to LSR is shown in Figure (2-6) [3].

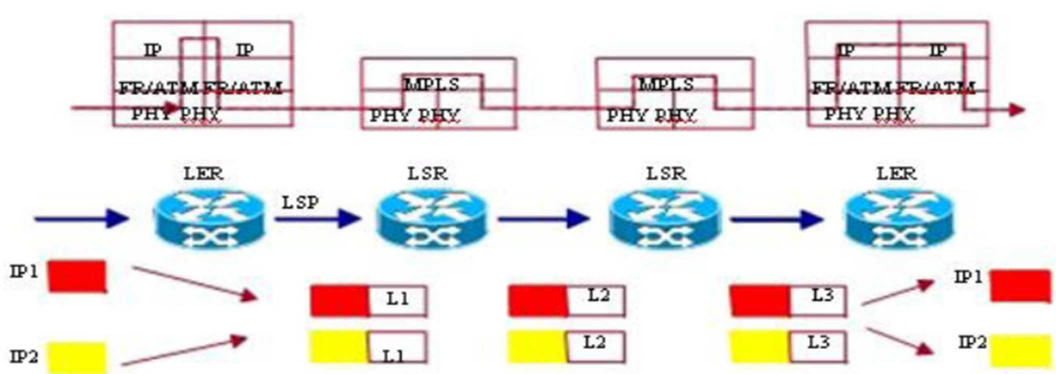

Fig 2.6: Forwarding Equivalence Classes [17]

2.4.8 Forwarding traffic in MPLS domain:

In the MPLS domain, When packet enters the network labels are assigned in their headers by Ingress router and then the packets are mapped on to the LSP using Forwarding Equivalence class (FEC).All the packets which match the same FEC, are forwarded on the same LSP. The FEC is setup according to set of features as destination IP, class of services and other thing. The core LSRs send the packets depended on label information but not like traditional network based on the IP address. When the router receives the packet it checks label information base (LIB) instead of routing table and determines the next hop in MPLS domain.

Finally the Egress router removes the label from the packet header and forwards the packet to the next hop according to IP address and from here the traditional IP forwarding of packets continues.

Every MPLS node has two tables to forwarding the packets Label information base (LIB) and Label Forwarding Information Base (is used by the core routers in the MPLS domain. The router will compare the label on the incoming packet with the label it has in its information based lookup table. If the routers find a match, they will forward that packet based on that match if there is no match the packet will be dropped).

The figure below (2.7) shows the forwarding of packets from ingress to egress router.

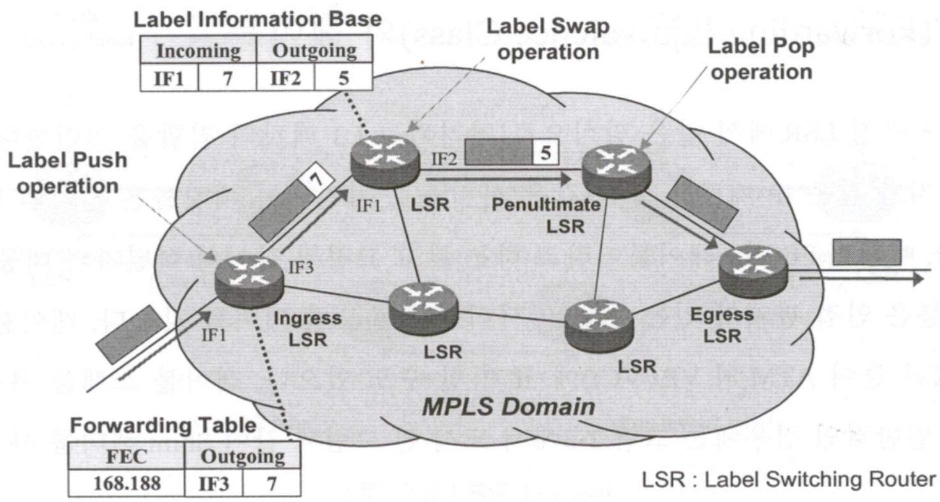

Fig *2.7*: MPLS Label switching network [18]

2.4.9 Signaling Protocols in MPLS Network:

When IP were forwarded packets it looking into its destination address at any router in the path. The packets were sent depended on the shortest path metric, which is the cost calculated using the time it takes to reach the next hop. When the packets in the network increases, the link that has shortest path (low cost) become congested while the links with higher cost paths are underutilized this lead to uneven loads in the links available, in expense of traffic resources. The MPLS addresses these problems with the use of constraint based routing (CBR) [15]. The use of the measuring tools and the accountability of all available multiple paths and its parameters (bandwidth, policy and topology) by CBR makes it easier for implementation of Traffic Engineering. Signaling protocols are used to establish the paths for the traffic to follow these paths are known as Label Switched Path (LSP). There are many protocols which can be used for choosing the paths but in this research we are defined only on the signaling protocols that support Traffic Engineering, which are discussed below:

2.4.9.1 Constraint Based Label Distribution Protocol (CR-LDP):

It is the addition of the signaling protocol LDP. LDP is a control-driven LSP (known as hop by hop LSP or constraint-based LSP), the next hop here is determined either by looking up into the forwarding table of the LSR or control policy used [9]. The control policy may be implemented by some application or the operators.

CR-LDP is extended from LDP with the additional support to explicitly route the information about the traffic parameters for the reservation of the resources along the LSPs. CR-LDP and LDP are both hard state protocol as it sends the signaling messages only once without refreshing. It uses UDP for the peer discovery and TCP for rest of the process like session, advertisement and label request messages [15]. DiffServ as well as the operator configurable QoS are supported by CR-LDP.

2.4.9.2 Resource Reservation Protocol (RSVP):

RSVP uses to set up direct routes to CR-LSPs. It use a protocol called UDP for resource reservation and label distribution. RSVP supports in Integrated Service (IntServ) model of QoS. The Traffic Engineering extended version of RSVP known as RSVP-TE supports loop detection, per iodization, reordering of path and strict and loose CR-LSPs.

The path message is sent by the source to the destination to reserve the path state in every router in path. When the message arrives to the destination, the destination reply by the Reserve message (Resv) which reserves the resources as map by the destination in the routers and maintains the QOS parameters. Path and Resv message are refreshed periodically in

RSVP which leads to the scalability problem in case of large traffic flow [15].

2.5 Traffic Engineering (TE):

TE is the process of increases the performance of network by using available resources in network efficiently. By using all advantage of all the possible offered by the available resources and avoiding unused network utilization. TE is required in the ISP network mainly because all routing protocol (Interior Gateway Protocols) are used the shortest paths to forward traffic.

The main advantage of TE, is ability to forward the traffic in less congested physical path than the shortest path that selected by the IGP across the service provider’s network. TE is a powerful tool that can be used by ISPs to balance the load on the links, routers, and switches in the network so that none of these components is over-utilized or under-utilized.

TE has greatly optimization resource utilization and network performance in ISPs networks. The reasons of the optimization is:

- Minimizing congestion and packet losses in the network.
- Improving link utilization.
- Minimizing the end to end delay taken by packets.
- Increasing the number of customers with the current assets.

The combined use of the differentiated services (DiffServ) and multiprotocol label switching (MPLS)-TE technologies to provide guaranteed quality of service (QoS), that by adding DSCP value in MPLS header in EXP bit.

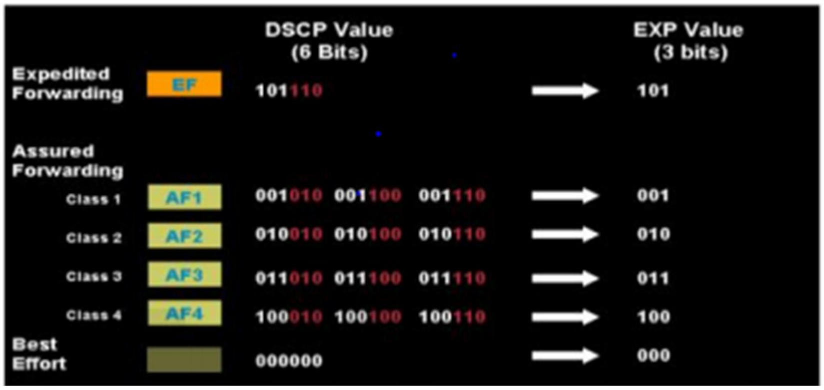

Fig 2.8: Mapping 6-bit DSCP field into 3bits experimental (EXP) for three classes of service [1]

The basic DiffServ aware TE requirement is to separate bandwidth reservations for different types of traffic and give different forwarding behaviour based on the traffic class. This techniques need to keeping track of how much bandwidth is available for every type of traffic at any given time on any routers in the network.

MPLS and TE operate as an aggregate level to all type of service and as a result it cannot depart the bandwidth efficiency on each class basis. The basic DiffServ aware TE requirement is to divide the bandwidth to different classes of traffic and provide different forwarding behaviour depended on the type. This need to keep tracking the amount of bandwidth is available for each type of traffic at any time on all routers in the network.

So the idea of a class type (CT) is proposed [2], the set of traffic trunks passing the link, it is controlled by a special set of bandwidth constraints. CT is used for the purposes of bandwidth allocation in the link, constraint based routing, and access control. A given traffic trunk belongs to the same CT at all links. They are up to eight CTs support by IETF from CT0 to CT7.

DiffServ TE inserts the available bandwidth for every of the eight CTs as a restraint that can be applied to a path.

So CSPF is improved when include CT specific bandwidth in to account when computing a link. For the computation to succeed, the vacant bandwidth per CT at all priority levels has to be known for every link.

One of the most important aspects of the available bandwidth calculation is the allocation of bandwidth among the different CTs. To determine which percentage of the links bandwidth that a CT (or a group of CTs) may use called a bandwidth constraint (BC). There are two bandwidth constrain maximum allocation model (MAM) and Russian Dolls Model (RDM)

In MAM each type is determined the amount of bandwidth and the rest types cannot take advantage of unused bandwidth.

In RDM every type take amount of bandwidth but less priority types can utilize the bandwidth of higher priority classes when that bandwidth is available.

2.6 Queue Scheduling Mechanisms:

Network traffic has different types of traffic and also has different Quality of service requirements according to send a voice, video and data in the same network. Such they forward a multiple traffics, they will need to new scheduling for packet scheduling, bandwidth sharing and admission control [2] to providing a QoS, there must be the mechanisms of buffer management, scheduling mechanisms and way to separate traffics into different service classes.

- Round Robin (RR).
- Priority Queuing (PQ).
- Fair Queuing (FQ).
- Weighted Fair Queuing (WFQ).

2.6.1 Round Robin (RR):

It is a simplest type of algorithm for scheduling process is divided into equal parts, by assigning a time slices. This process is occurs in the circular way. In this scheduling there does not has priority assignment.

2.6.2 Priority Queuing (PQ):

In this scheduling algorithm a variety of queues are produced with their own individual relative priority levels. In PQ when all the queues with higher priority are empty packet scheduling is done from the particular priority queue in First In First Out (FIFO) order [2]. In PQ highest priority traffic will forward with a minimal delay but others with lower priority levels might face the problem of no resource available when those with highest priority was occupied in the queue. So, the major problem of this algorithm is the resource management for traffic with the lower priority.

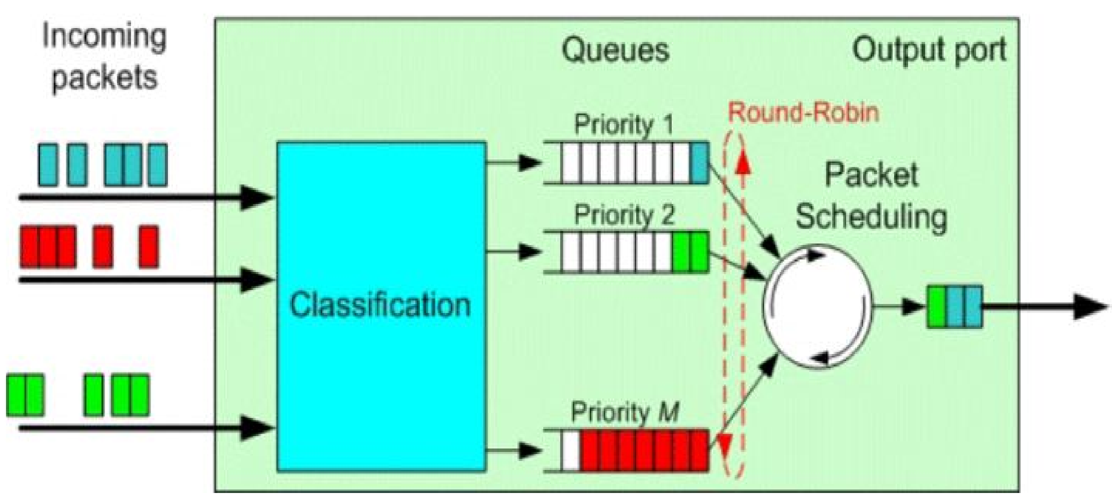

Fig 2.9: Round robin Queuing

2.6.3 Fair Queuing (FQ):

It is also known by per flow queuing. As shown in the figure (2-9) [9] the incoming packets are sorted into M queues. The allocation of output port bandwidth to each queue is in the order of 1/M. The packet sending is done by serving the each queue following the Round Robin algorithm. It has two disadvantages the first it is not able to assign different priority to different queues due to which the one needs more bandwidth is not properly served. The second is comes at the time of processing where the size of the packet is not taken into account while transmitting a packet. The main advantage it is a simple algorithm [9]

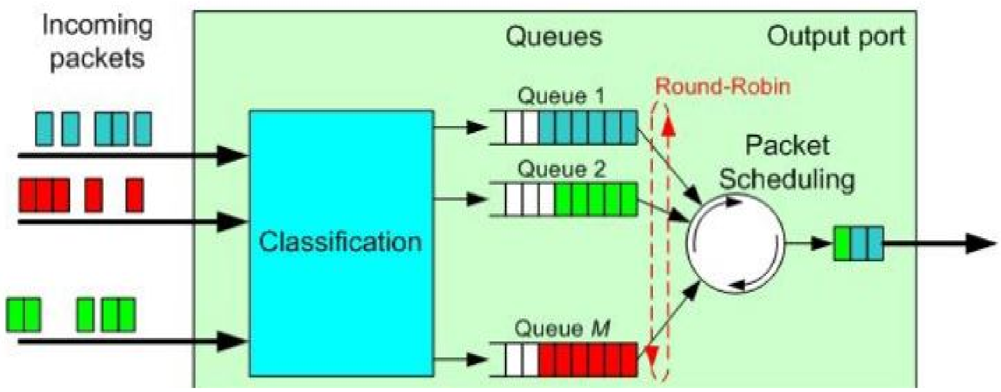

Fig 2.10: Fair Queuing (FQ) [9]

2.6.4 Weighted Fair Queuing (WFQ):

This is WFQ algorithm [9] is specifically designed as solution of the problem existing in the FQ model. In this WFQ model the queuing is done on a flow depend on mechanism in which each flow is assigned to a FIFO queue where these flows are actually the classification of the incoming packets, The bandwidth allocation is carried out fairly among the flows as the WFQ divides the interface bandwidth effectively on the basis of priority.

By establish this mechanism the interactive flows with low volume don't need to wait as they are processed first. While the flows with high volume will get their own queue leading to packets waiting long and finally dropped. Queue sharing is provided between multiple flows in WFQ. Queue sharing is the process in which new flows are assigned to the existing queues if the maximum number of dynamic queue falls behind the active flow in figure (2-10) show the queuing [10].

The bandwidth allocation in WFQ is given by following equation, to EF and BE classes is allocated as:

Where $r = \max(r_{avg}^{EF} + r^{BE}, r_{res}^{EF})$..(1)

r_{avg}^{EF} is the average rate of EF traffic;

$r_{res}^{EF}$is the bandwidth needed to guarantee QoS to EF class under fair queuing concept

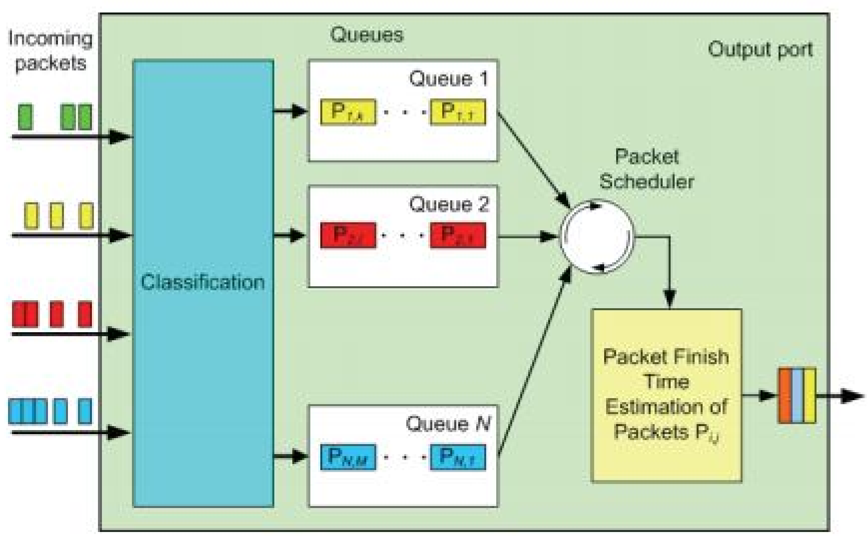

Fig 2.11: weight fair Queuing [9]

Chapter three

Methodology

3.1 Introduction:

In this chapter, MPLS and MPLS-DiffServ networks were designed using a very efficient network simulator called OPNET simulator.

Our aim of research is to show the difference in performance after add DiffServ with MPLS. We will compare different parameters such as end to end delay and delay variation (jitter) for Voice.

3.2 Network design:

OPNET is powerful simulation software in network analysis, which supports various protocols to simulate various networks. It is so easy to execute and accurate results are carrying out the research work.

The modelled network consists in the network topology in figure below, it is the scenario of MPLS with diffentiated service as a QOS.

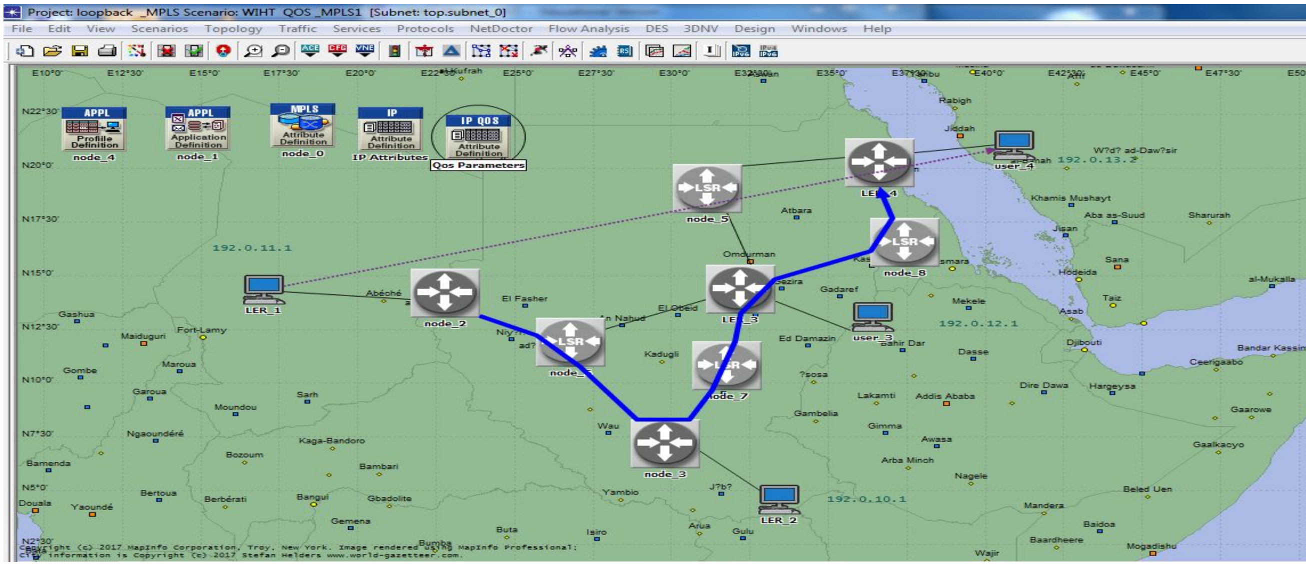

Fig 3.1: Topology of Network

The MPLS core network consists of 4- LSR nodes (Label Switch Routers) within the OPNET Model, and 4 LER-node in Khartoum, bur Sudan, Alfaser, Waw.

The topology show that the core routers are in partial mesh topology that to be able to provide different physical paths to set up the Label Switch Paths.

3.3 Methodology flow chart:

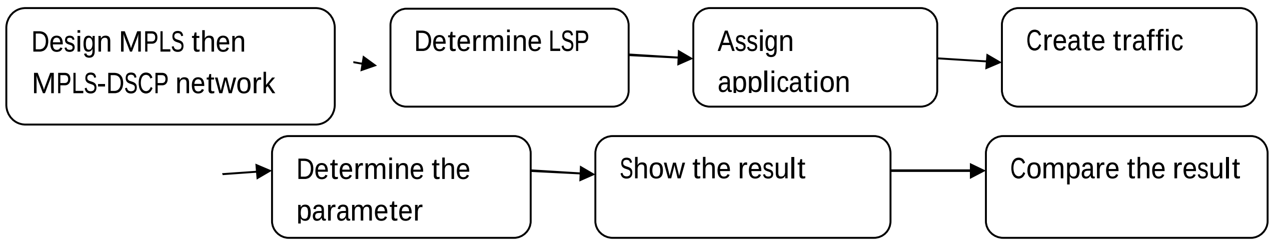

Fig 3.2: Methodology flow chart

Traffic classification can be determined in the traffic source (computers) through the application definition object or in the LER. We have used the application definition method for traffic classification.

When the traffic arrives at the edge router (LER) the traffic will be classified and mapped into the corresponding Queue according to its priority set on the DiffServ code Point (DSCP) according to the TOS field.

3.4 Components must be configure:

To configure the object that are needed in the networks, this objects must be added from the OPNET library to the network's workspace from the Object Palette

(a) Point to point work station

(b) Application Configuration is used to define a set of applications and their general characteristics that will be expressed over the network and Profile Configuration, this component defines the profile of a specific type of application that was previously listed in the Application Configuration.

(c) QOS Parameters is used for QOS definition that will be used over the network resources.

(d) MPLS Configuration is the component that will be used to configure MPLS-TE related items as FEC, LSP, Traffic trunks, Diff-Serv QOS traffics transmitted over the associated traffic trunks that are placed on an LSP.

Client workstation is used as traffic sources generator that is the objects from which we associate the application profile that presents multiple application configuration then configured the type of application that we need.

3.4.1 Application Configuration:

In application configuration determine the voice traffic, figure (3-3) show the step to do this configuration.

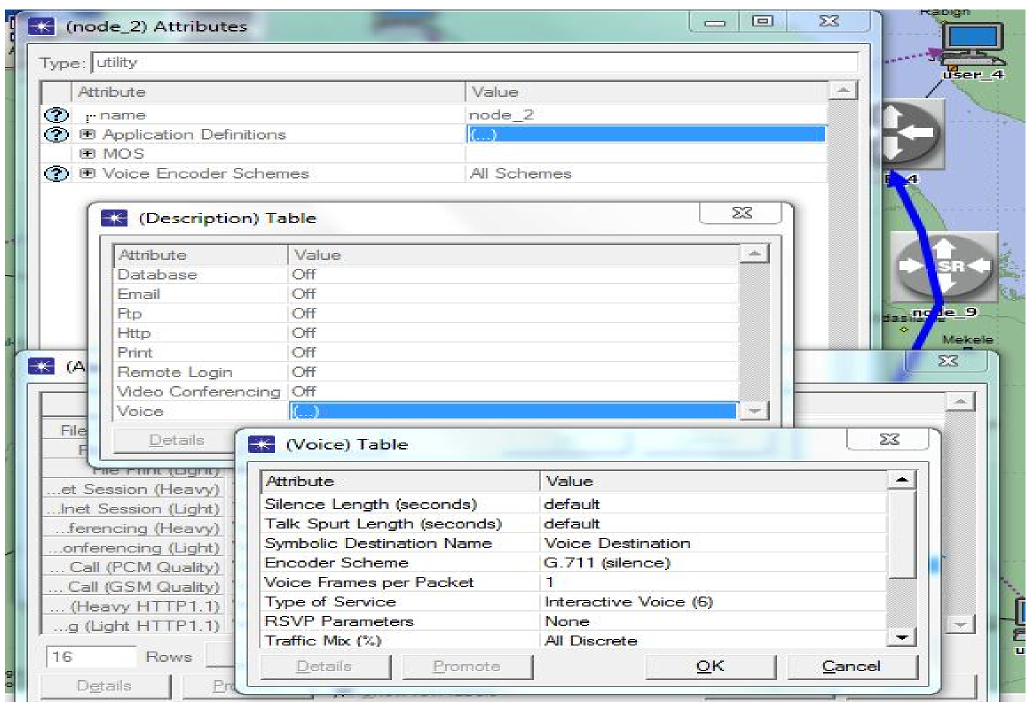

Fig 3.3: Application Configuration attribute

3.4.2 forwarding equivalent class to Label Switching Path:

The traffic needs to be set up with specific Label Switch Path to be send the traffic to the peer LER node where the destination of traffic is existing.

The association of traffic to the LSP is performed by mapping the FEC to the LSP.

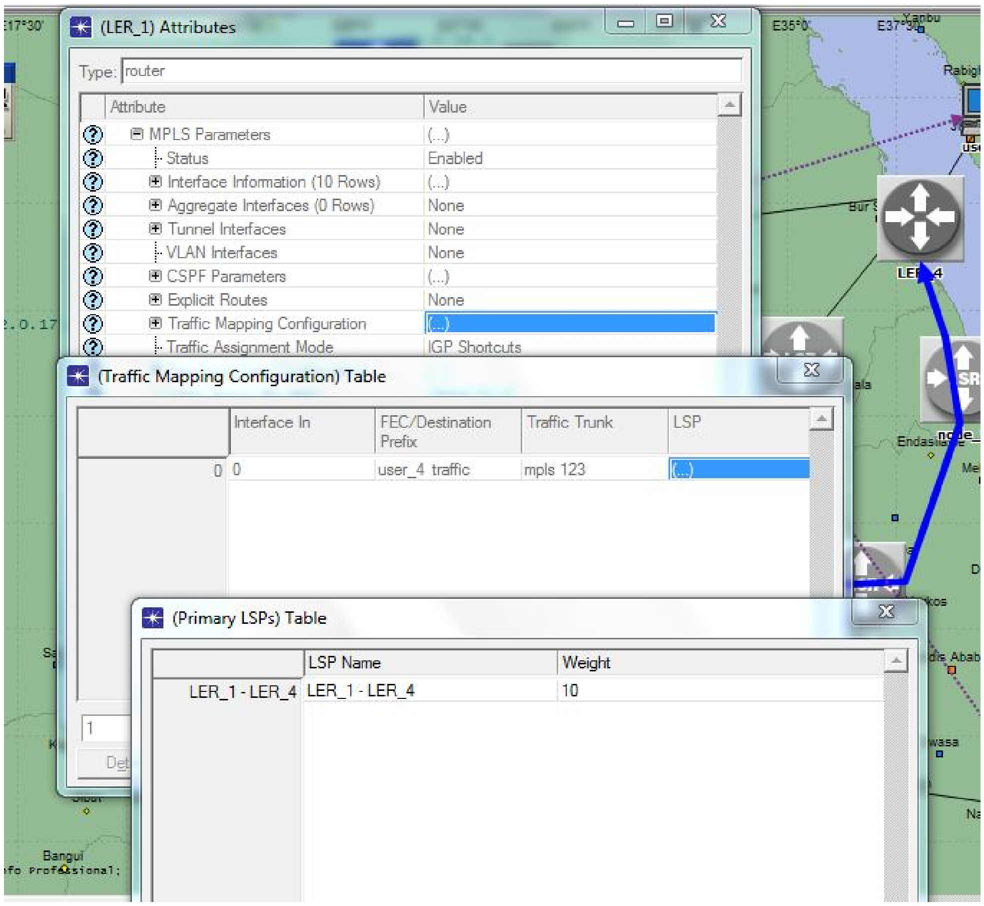

Fig 3.4: Presents the set up of the Forward Equivalent Class to the Label Switching Path

3.4.3 MPLS Configuration:

This object, is known by mpls_config_object, must be added specifically to the tested workspace as part of the MPLS configuration. The element of the MPLS configuration

related to the EXP field is unchanged, because OPNET by default considers as standard mappings. These standard mappings are the Drop Precedence and PHB mappings of the EXP field. Therefore, this model considers that the 3 bits of the EXP field are sufficient to map enough

QOS PHBs in order to determine which is the PHB of the behaviour aggregates (BA) arriving into an edge router LER.

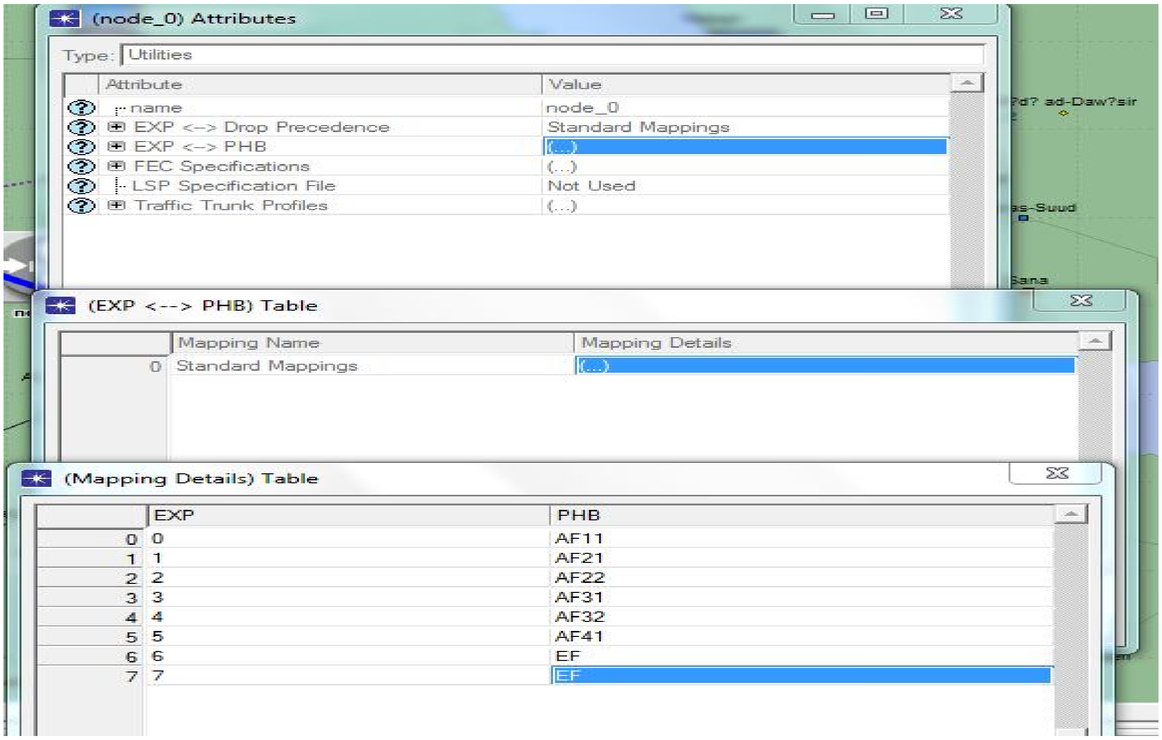

Fig 3.5: The standard mappings of PHB mappings of the EXP field in MPLS Configuration

3.4.4 Experimental to Forward Equivalent Class association*:*

After the Experimental bits are added on the MPLS label in EXP bits, the forwarding decision within MPLS network is depended on the Forwarding Equivalent Classes which separated the packets based on specific one off the following criteria it may be , source address range, destination Address range, type of Service and DiffServ Classification.

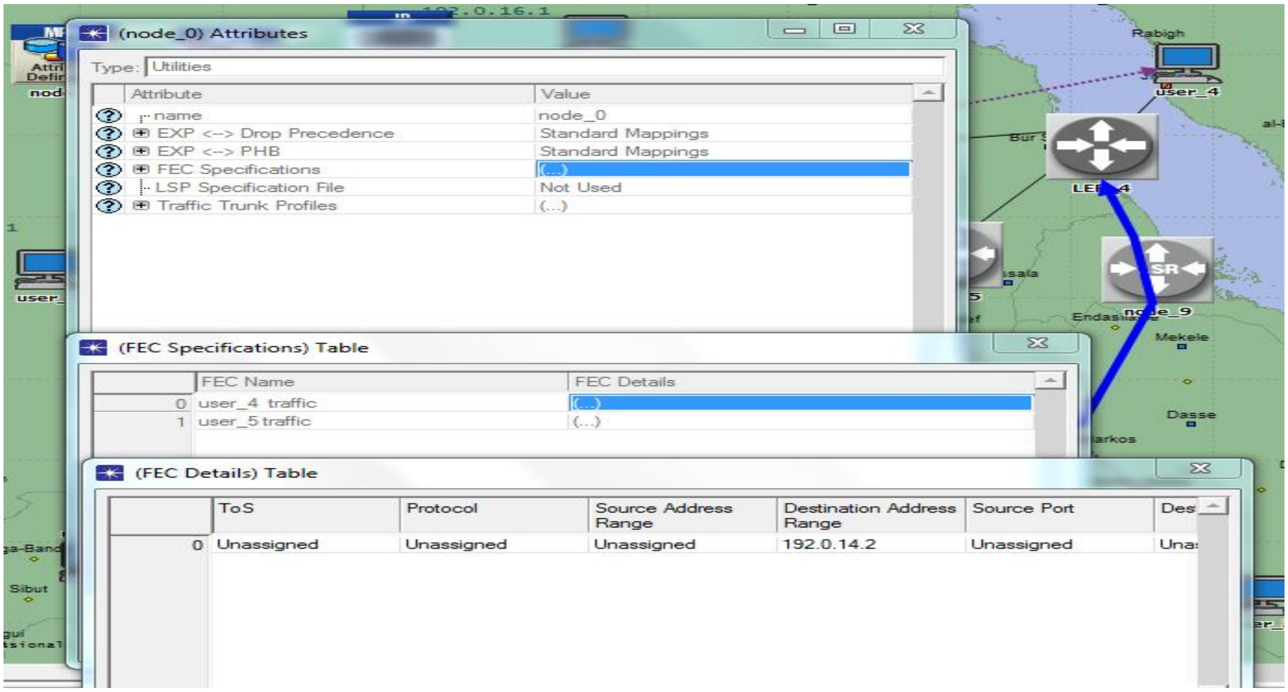

Fig 3.6: MPLS Configuration

3.4.5 QOS Configuration:

At the QOS Parameters object is placed in the tested workspace. All node interfaces have enabled QoS support and have applied a WFQ queuing profile scheme with the characteristics illustrated in Figure. 4-6. According to the theory presented in previous chapters, this WFQ queuing profiles is implemented in this research's case based on the DSCP values.

The QoS Parameters configuration object is added automatically to the workspace of a modelled design by using the following QoS Configuration dialog:

1-Select Protocols _IP _ QoS _ Configure QOS

2- Selected a WFQ from queuing profile scheme.

3- Enable a QOS support with DiffServ IP QoS model. This means the interfaces of the nodes will be made aware of the DSCP. To configure this type of QoS support, the settings applied have to be the same as Figure 4-6.

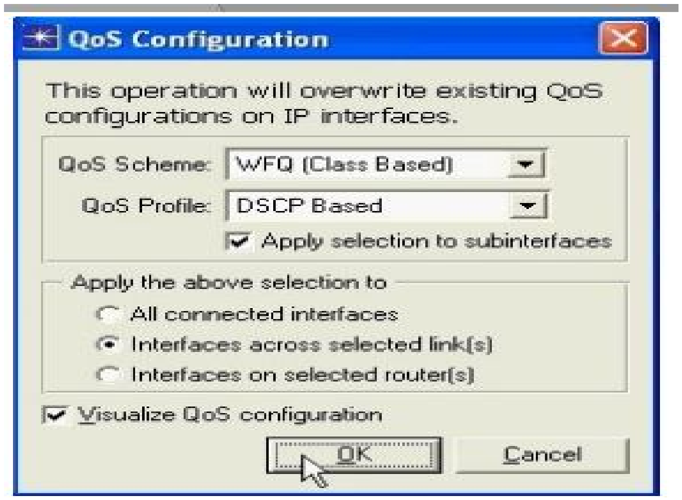

Fig 3.7: QoS Configuration

3.4.6 Create traffic with DSCP:

In this session we create voice traffic from create traffic and then assign priority from DSCP to select expedited forwarding, for voice we set the speech quality as PCM quality speech, the encoder scheme used was G.711 as it is the most efficient encoding scheme for voice application figure (3-8) show the steps.

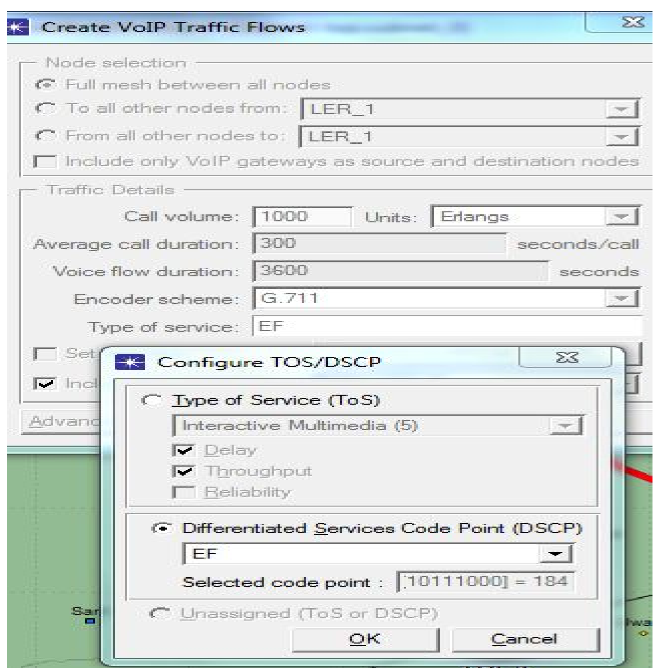

Fig 3.8: Create a traffic with DSCP

Chapter Four

Simulation and Result

4.1 Introduction:

In this chapter we will be compared MPLS model and MPLS-DiffServ models by using voice traffic that being generated from a source node near the LER (Edge router) of an ISP. Our plan is to analysis performance after activating DiffServ on MPLS network. We will assign different parameters such as end to end delay and delay variation for Voice to compare them.

4.2 Result and analysis:

Performance analysis is done in MPLS network considering voice End-to-end delay, jitter, and packet drop were taken as our means for evaluation. The simulation was repeated for three scenario in first scenario MPLS, in second scenario used MPLS- DSCP- WFQ and the third scenario used MPLS- DSCP- FIFO queuing and then running simulation.

For each of these scenarios the simulation was run for a 10 minute to get its steady state. In the simulation the VoIP traffic average call duration 300 second and ends after 3600 seconds. In all the scenarios the VoIP calls are added after each 2 seconds from the start time of simulation to the end of simulation. The simulation result was shown in graphs.

Our scenario is MPLS-TE networks and typical MPLS-DiffServ WFQ and MPLS-DiffServ FIFO network respectively.

The estimation was done by finding the average value and calculating the upper and lower deviation from the average value.

Figure 4.1 shows the jitter value plotted against simulation time for different scenarios mentioned above. Jitter is the undesired variation in packet delay .so it's always desirable to have low jitter as it may cause the packets to be discarded at the receiving end.

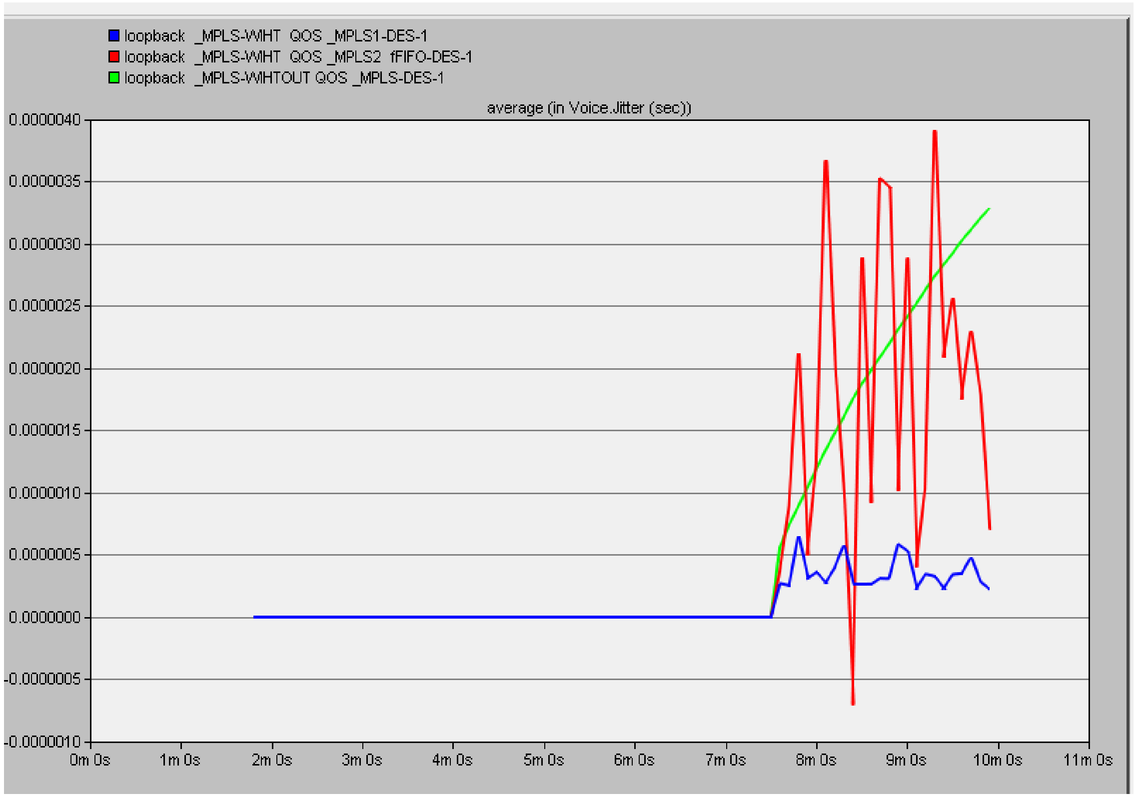

Fig 4.1: Jitter in the scenarios

Figure 4.2 shows end to end delay graph, one can see that WFQ is showing good performance even when compared with FIFO and without QOS in terms of end-to-end delay and jitter. Increase the traffic, the delay for MPLS becomes very high. While the MPLS/DiffServ end to end delay remains at a low level.

Figure 4.2 also shows that the QoS implemented in MPLS-TE network is performing better than the MPLS-TE without QOS network.

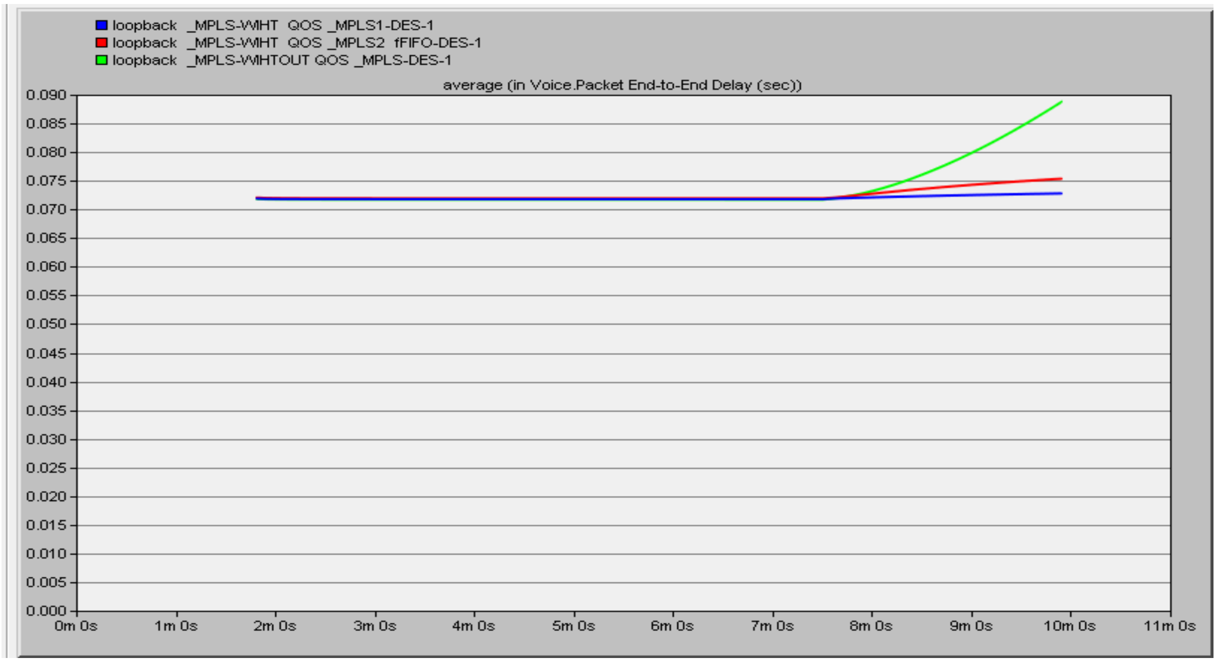

Fig 4.2: End to end delay (sec)

Figure (4.3) evaluates the performance of the variation in delay of packets across the LSP. The performance metric is depended on the difference in delay of selected packets, This difference in delay is called IP Packet Delay Variation (IPDV).

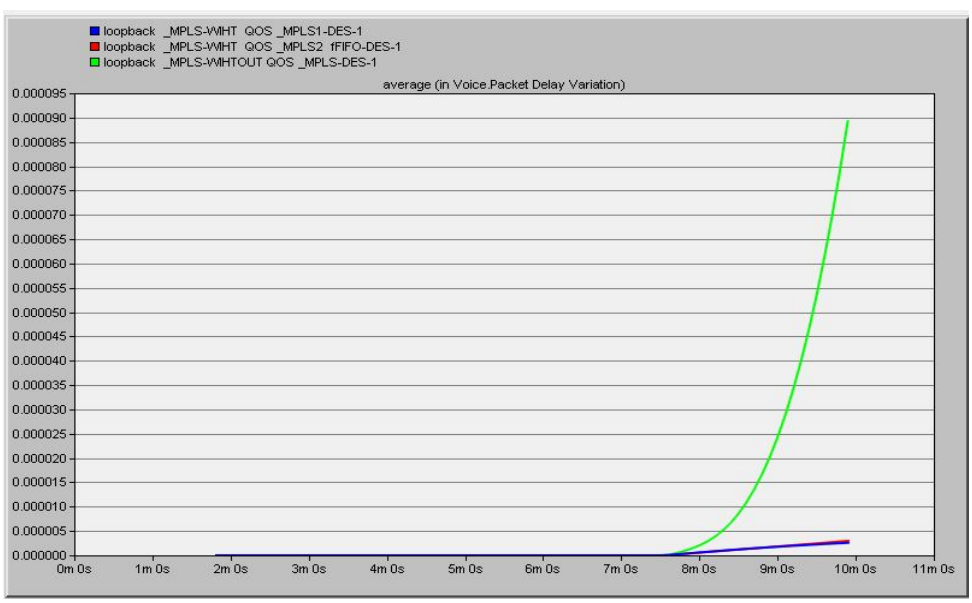

Fig 4.3: Packets delay variation

Figure 4.3 shows the evident of delay variation moved to a very high value for MPLs, while MPLS/DiffServ delay variation stay at a very small value, keeping the QoS performance at the guaranty level.

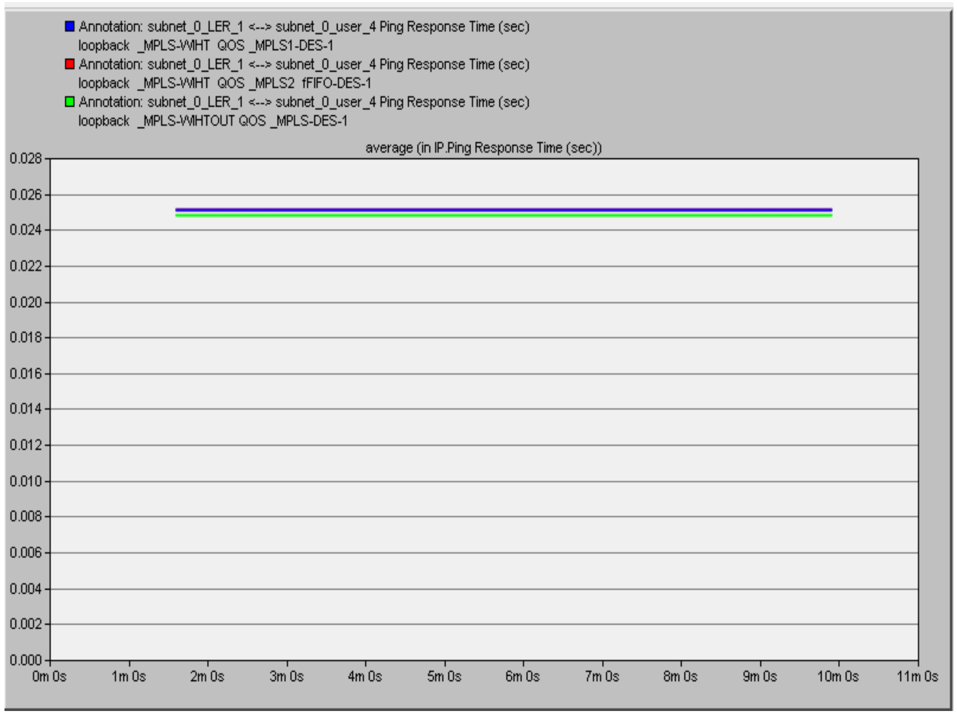

Fig 4.4: Response time of three scenarios

The figure (4.4) show that approximately the same response time

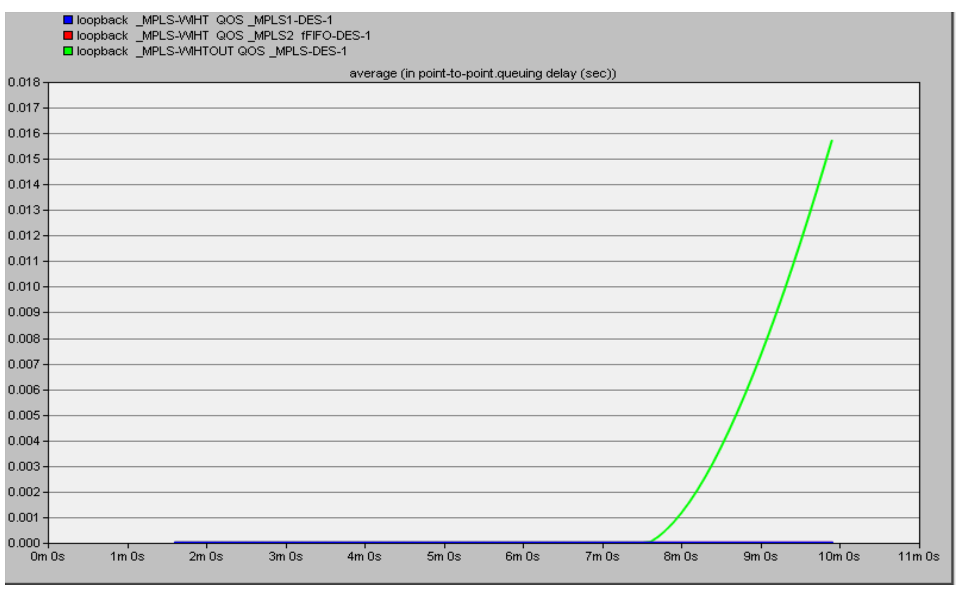

Fig 4.5: Queuing delay

Figure (4.5) is shown that the queuing delay is the same in MPLS with and without QOS and high in MPLS DSCP FIFO.

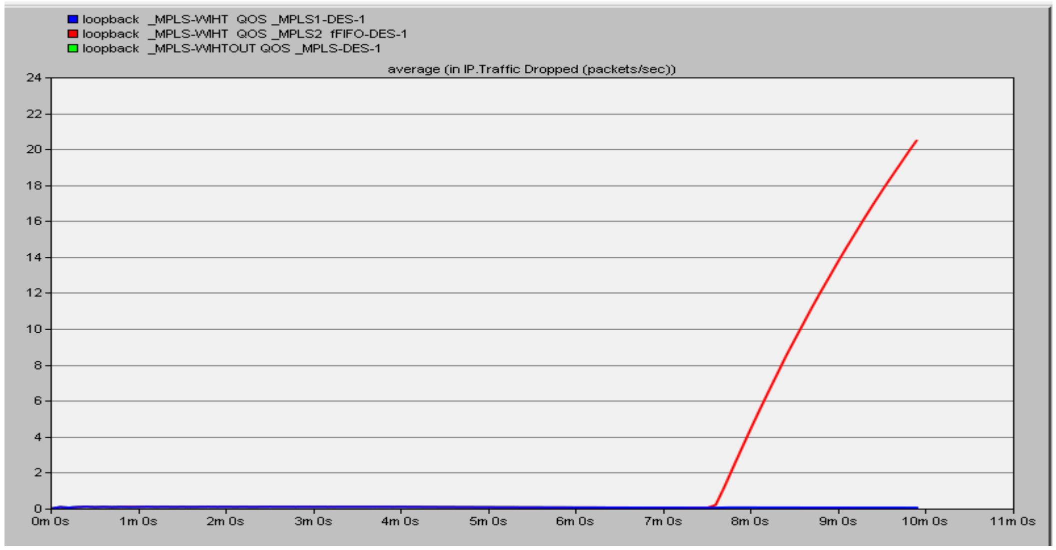

Fig 4.6: IP packet drop in scenarios

Figure (4.6) shows that the probability of packet drop increase in MPLS-TE DiffServ FIFO, and without DiffServ, the MPLS-TE DiffServ WFQ have very low probability of packet drop.

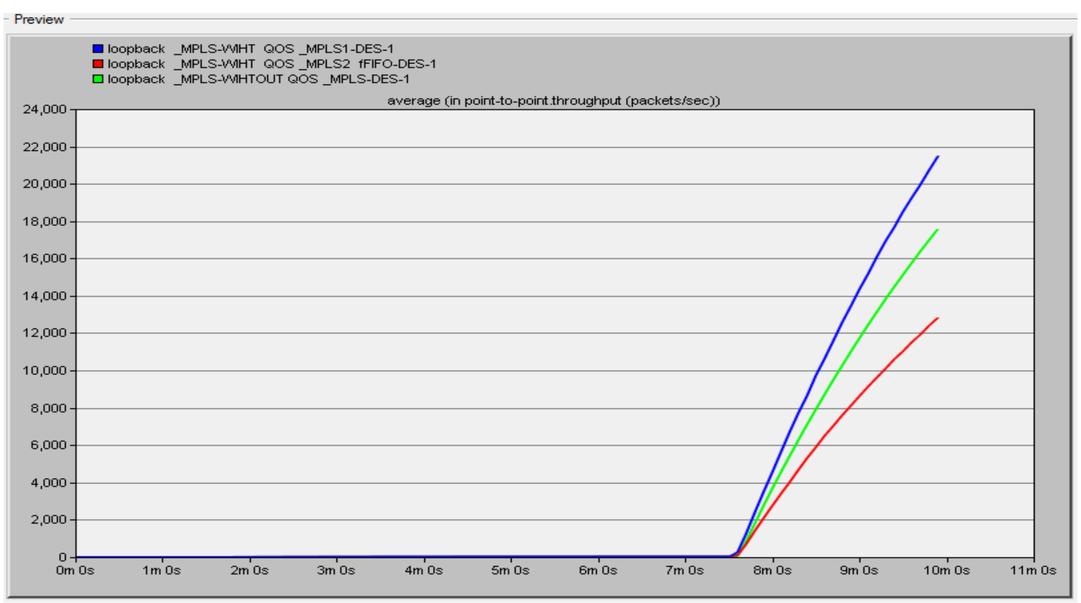

Fig 4.7: Throughput of packets in scenarios by packet/second

Throughput is the amount of traffic that successfully received by the destination node. The throughput is measured by bits per second (bits/sec). If the throughput with a higher value this mean that performance of the network is good.

The figure shows that the throughput of packet is highest in MPLS-TE DiffServ WFQ, then without DiffServ and minimum one in the MPLS-TE DiffServ FIFO have very low probability of packet drop.

Mean opinion score (MOS) is term which is given to the network based in all quality of service parameters ,this also can be said ratio score, in general MOS is limit between 1-5, figure (4.8) is shown the MOS value is 3.6 and this value is the highest value so the MPLS-TE-DiffServ network is more efficiency.

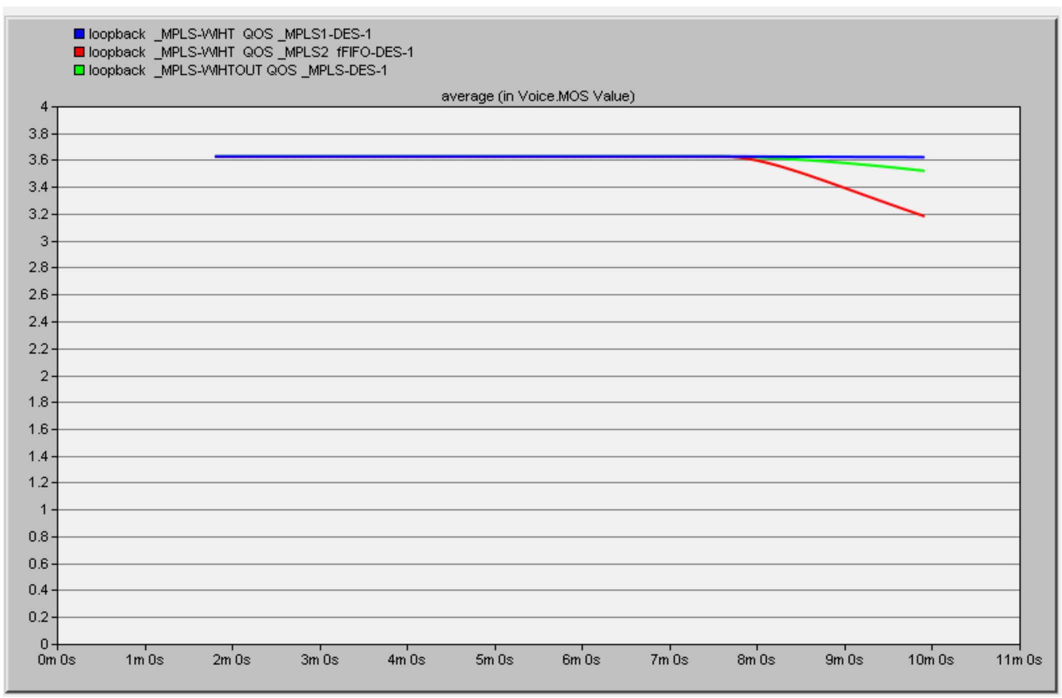

Fig 4.8: Values of mean opinion score

Chapter five

Conclusion and Recommendation

5.1 Conclusion:

MPLS-TE is offer many benefits to service providers, in order to support new various types of applications in the network.

In this thesis the analysis performance of network is seen in the model before and after the DiffServ apply in the MPLS-TE network by using OPNET simulator, then we were analyzed the result.

Different scenarios were used in the process of determining QOS to check if they have any effect in the network performance for voice application. After the analysis of the result from the three scenarios, we conclude that the use QOS in MPLS-TE network performs better than traditional MPLS-TE network for voice packets as it provides lower end to end delay and lower jitter.

In the second side different basic queuing algorithms is used for DiffServ architecture in a process of QOS, implement two queuing FIFO and WFQ, we found that WFQ algorithm performs better than basic FIFO and providing lower jitter, minimum end to end delay, lower packets drop and high throughput.

5.2 Recommendations:

- This research is just takes two type of queuing so I recommend to use the other type of queuing also take just voice over IP as traffic so can use a video traffic because video call also be very important.
- Also I recommended to use MPLS-VPN to show the performance is better than traffic engineer or the not
- To design model using IP version 6 because all network migrate to it.

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