Performance Analysis DiffServ based Quality of Service in MPLS Network's

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Abstract—Over the last years, we have seen a rapid deployment of real-time applications on the Internet, there have been also many research works about Quality of Service (QoS). Internet had new trend with an evolution for development of new applications for all customers. These new applications required an increase in bandwidth guaranteed over the networks, with new services that are developed and deployed. The new Enhancement in providing quality of service (QoS) on the Internet is based on the Different Services (DiffServ). DiffServ divides traffic into small classes and allocates network resources on a per-class basis. In this architecture, packets are marked with different DiffServ code points (DSCP) at edge routers, and the priority for packet's is given via the value of this field. In the other hand, MPLS is a fast forwarding mechanism depends on Labels. The main advantage of MPLS is its support for traffic engineering which result in best utilization of network's resources like link capacity. The integration of using MPLS (as a forwarding mechanism) with DiffServ (as a QoS mechanism) offer high Quality of service especially for real time applications (such as VoIP, Video Conference. We simulate and Evaluate in this paper the performance of MPLS-DiffServ network's by means of OPNET simulator. Our results showed Superiority of MPLS-DiffServ over other kinds of networks and then was clear in decreasing End-to-End delay, delay variation, upload response time, queuing delay, and Traffic Dropped, also in increasing the traffic received.

Index Terms—MPLS, DiffServ, QoS, Traffic Engineering, VoIP, Video Conference.

1 Introduction

With the new trends of multimedia applications in the IP networks, bandwidth became critical issue in the Internet community and service providers alike. Many multimedia applications such as video streaming and VOIP and Video conference caused massive congestion on IP network's. These applications and services not only need bandwidth, but also require a guarantee of quality of service, such as delay, Jitter and packet loss. QoS requirements put new challenges to service providers [1]. QoS does not create capacity, but only supports the priorities of traffic and allocation of resources under the terms of congestion [2]. Standard organizations such as IETF proposed many criteria to support QoS in IP networks. This included MPLS network as well as Different Services, many (RFC's) were published for both services and their integration [3]. When an MPLS network supports DiffServ, traffic flows can receive class-based network treatment that provides bases for QoS guarantees [4]. The objective of this work is to study the affect of the QoS mechanism with DiffServ-MPLS on network parameters such as jitter, delay and throughput. The study showed improvement in the throughput, jitter and delay when using MPLS-DiffServ network as compared to IP only or MPLS only.

2 Related Work's

In [5] QoS analysis in a wired IP network discussed with more realistic enterprise modeling and presents simulation results. Two major queuing disciplines are evaluated i.e. PriorityQueuing and Weighted Fair Queuing. In the end, it is also analyzed how network's database service with applied QoS may be affected in terms of throughput (average rate of data received) for internal network users when the server is also accessed by external user(s) through Virtual Private Network (VPN).

A traffic engineering enhancement to the QoS-OSPF routing protocol is proposed and used as the path selection algorithm in a DiffServ-MPLS network presented in [6]. The proposed scheme, called TE-QOSPF, exploits the use of non-shortest paths to improve load-balancing and avoid network congestion. Simulation results show that the algorithm outperforms the QoS-OSPF scheme in terms of loss ratio, link utilization, and delay.

Based on the simulation results in [7] it can be derived that MPLS provides best solution in implementing the VoIP application compared to conventional IP networks because of the following reasons. Routers in MPLS takes less processing time in forwarding the packets, this is more suitable for the applications like VoIP which posses less tolerant to the network delays. Implementing of MPLS with TE minimizes the congestion in the network.

The affects of First in First Out (FIFO) & Priority Queuing (PQ) on packet delivery for applications such as Video and VoIP discussed in [8]. In this paper, it is investigated how the choice of the queuing discipline can affect the applications and utilization of the network resources in the routers.

In [9] an improvement of MPLS-TE called EMPLS-TE is presented, it is based on a modification of operation of Forwarding Equivalence Class (FEC) in order to provide the quality of service to stream multimedia. EMPLS-TE defines paths for network traffic based on certain quality of service.

[10] Presents a QoS performance study of real-time applications such as voice and video conferencing in terms of Packet Delay Variation (PDV) over DiffServ with or without MPLS TE in IPv4/IPv6 networks using OPNET. The effectiveness of DiffServ and MPLS TE integration in IPv4/IPv6 network is illustrated and analyzed. This paper shows that IPv6 experiences more PDV than their IPv4 counterparts.

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3 MPLS

MPLS (Multi-Protocol Label Switching), as standardized by the Internet Engineering Task Force (IETF) is a layer 3 packet switching technology that transmits traffic effectively and supports QoS on the Internet. MPLS improves the performance of routing in the network layer [11][12]. Fig 1 shows the MPLS header.

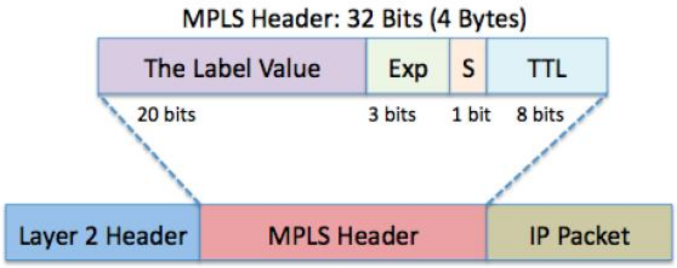

Fig. 1: MPLS Header

MPLS is used in Internet Service Provider (ISP) networks and as a backbone to Internet Protocol (IP) to provide guaranteed efficient bandwidth and Quality of Service (QoS) provisioning in the network [13][14]. MPLS supports multiple Layer 2 protocols such as ATM, Frame Relay and Ethernet. Because of the variety of the underlay network structures, MPLS is able to establish end to- end IP connections with different QoS characteristics associated with the multiple transport media [15]. A label is a small, fixed index, which identifies a Forward Equivalence Class (FEC); a group of IP packets that are forwarded over the same path with the same packet treatments. With MPLS, the packet is faster than with use IP address because MPLS uses labels to quickly check the next hop that leads to the destination without going to the network layer to analyze the packets along the path [9]. Routers along the path do not have to examine the IP header of every passing packet, they only examine the contents of the label. The label inserted between the layer 2(data link layer) and the layer 3(network layer) in the OSI model; therefore it is called layer 2.5 protocol [7],[13].

4 Quality of Service (QoS)

Quality of Service is defined as the set of techniques to control bandwidth, delay, and jitter and packet loss in a network. QoS also provides techniques to observe network traffic [16].The internet and IP protocol were designed to provide best-effort traffic where all packets are treated equally. But as applications load is getting higher and network traffic is becoming highly diverse, just increasing the amount of resources such as available bandwidth to avoid congestion does not provide proper resource utilization and is not sufficient to meet applications requirements. There are many of queuing schemes used to achieve QoS:

- First In First Out (FIFO): does not classify packets. When the arriving rate is greater than the sending rate on the interface, FIFO enqueues and dequeues packets in the order the packets arrive.
- Priority Queuing (PQ): assures that during congestion the highest priority data does not get delayed by lower priority traffic. PQ is designed for environments that focus on mission critical data, excluding or delaying less critical traffic during periods of congestion.
- Weighted Fair Queuing (WFQ): alocates a percentage of the output bandwidth equal to the relative weight of each traffic class during periods of congestion.
- Custom Queuing (CQ): assigns a certain percentage of the bandwidth to each queue to assure predictable throughput for other queues. It is designed for environments that need to guarantee a minimal level of service to all traffic.

To handle this, the use of QoS mechanisms ensures that packets will receive appropriate treatment as they travel through the network. This helps applications and end users to be in line with their expectations and with the commitments contracted by the customer with the network operator. Fig 2 shows The basic QoS Model.

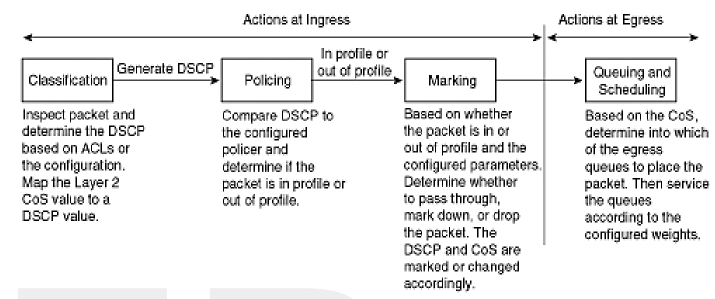

Fig. 2: The basic QoS Model

5 DiffServ

If Differentiated Services[17] had been discussed by IETF and being commented as RFC2475, RFC2597, RFC2598, RFC2474 and RFC3270. DiffServ approaches the problem of QoS by dividing traffic into a small number of classes and allocating network resources on a per-class basis. The class is marked directly on the packet, in the 6-bit DiffServ Code Point (DSCP) field. The DSCP determines the QoS behavior of a packet at a particular node in the network. This is called the per-hop behavior (PHB) and is expressed in terms of the scheduling and drop preference that a packet experiences. From an implementation point of view, the PHB will be translated to the packet queue used for forwarding, the drop probability in case the queue exceeds a certain limit, the resources (buffers and bandwidth) allocated to each queue, and the frequency at which a queue is serviced [18].

The differentiated services architecture is based on a simple model where traffic entering a network is classified and possibly conditioned at the boundaries of the network, and assigned to different behavior aggregates. Each behavior aggregate is identified by a single DS code point. Within the core of the network, packets are forwarded according to the per-hop-behavior (PHB) associated with the DS code point [19]. The IETF defined a set of 14 standard PHB's as it clear in Fig 3:

-Best effort (BE). Traffic receives no special treatment. It used for types of non-interactive traffic.

-Expedited Forwarding (EF). PHB is the key ingredient in

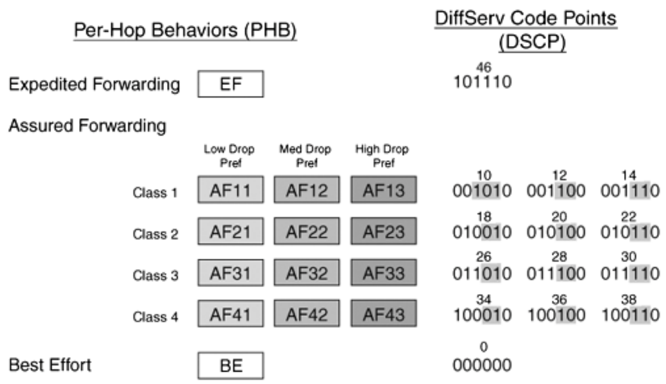

Fig. 3: DiffServ PHB's

DiffServ for providing a low-loss, low-latency, low-jitter, and assured bandwidth service. Real time applications with stringent delay requirement such as VoIP, interactively game are especially suitable to be forwarded using EF.

- Assured forwarding (AF) are defined to provide different forwarding assurances. The AFxy PHB defines four AFx classes; namely, AF1, AF2, AF3, and AF4. Each class is assigned a certain amount of buffer space and interface bandwidth to guarantee certain QoS. Within each class AFx, three drop precedence values are defined. Under congestion, the packets marked with high drop precedence will be dropped first.

6 MPLS INTEGRATED WITH DIFFSERV

MPLS inherently provides powerful traffic engineering capabilities including explicit route LSP's, path preemption, path protection and fast reroute. On the other hand, DiffServ provides QoS by classifying traffic into Behavior Aggregates (BAs) and associating each with a specific PHB which specifies the priority treatment at each node. The combined implementation of MPLS and DiffServ delivers end-to-end services with consistent and predictable quality. Fig 4 shows DSCP allocating in MPLS header.

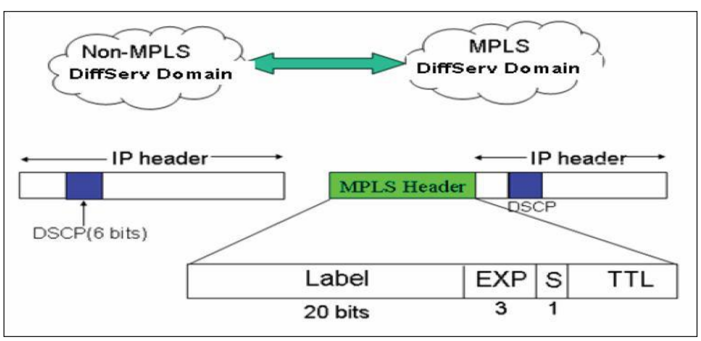

Fig. 4: DSCP allocating in MPLS header

The principle of MPLS is to allot a label to each package when it enters the network. This label is allotted according to the class of relay to which the package belongs. The definition of these classes depends on the operator of the network but it can also take into account the DiffServ class of service. The label thus decides in each router of the next router, the DiffServ behavior and the possible use of the reserved resources. The function of DiffServ is to help to put priorities when the congestion starts. It penalizes certain flows to decrease the time and the loss of others; it is thus a control mechanism of congestion. MPLS allows rerouting the traffic in the event of congestion; it is thus a mechanism of avoidance of congestion [20]. In the event of congestion, DiffServ alone makes it possible to choose which packages will be eliminated in first; MPLS only tiny room the chances of congestion but if it occurs, the packages are thrown randomly. When MPLS and DiffServ are both used, the congestion is less probable and one chooses which packages will be thrown in first if it arrives [21].The first challenge with supporting DiffServ in an MPLS network is that label-switching routers (LSRs) make their forwarding decisions based on the MPLS shim header alone, so the PHB needs to be inferred from it. The IETF solved this problem by assigning the three experimental (EXP) bits in the MPLS header to carry DiffServ information in MPLS as it showed in Fig 5.

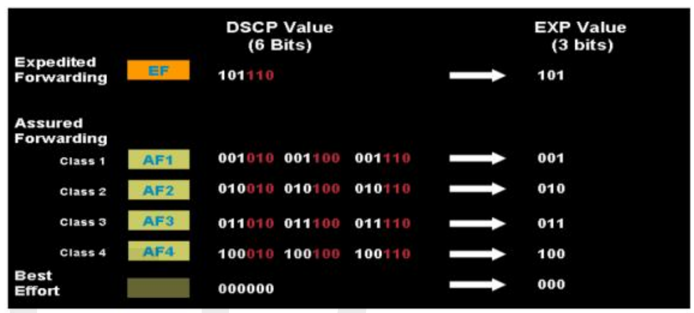

Fig. 5: Mapping 6-bit DSCP field into 3bits experimental (EXP) field in MPLS.

MPLS makes the DiffServ more reliable and faster due to its path-oriented feature. With the MPLS-DiffServ techniques, separate classes of services supported via separate LSPs are routed separately, and all classes of service supported on the same LSP are routed together.

7 SIMULATION RESULT'S AND DISCUSSION:

Simulations in the paper are performed on the Network Simulator, OPNET. We use network topology in Fig6 which simulate the real map of Syria. It is consist of 2 types of traffic. al-Haffa sends FTP traffic to the server located near Damascus "FTP_Server", al_Kirdaha and Jablah sends Video traffic to " al_Kirdaha_Dest" and "Jablah_Dest" sequently also near Damascus. All links between nodes are DS3 (44.736 Mbps). For each scenario the duration of the simulation is 600 seconds.
FTP traffic was set to low load and best effort type of service, where files are 150000 bytes and time between client request is distributed constant with 50 seconds. Low resolution video starting at 10 fps (frames per sec) arrival rate and 128x120 pixels are used and best effort type of service.
In another scenario we used the network topology shown in fig 7. In this scenario we apply MPLS technology and use one static LSP. In the last scenario we used the network topology

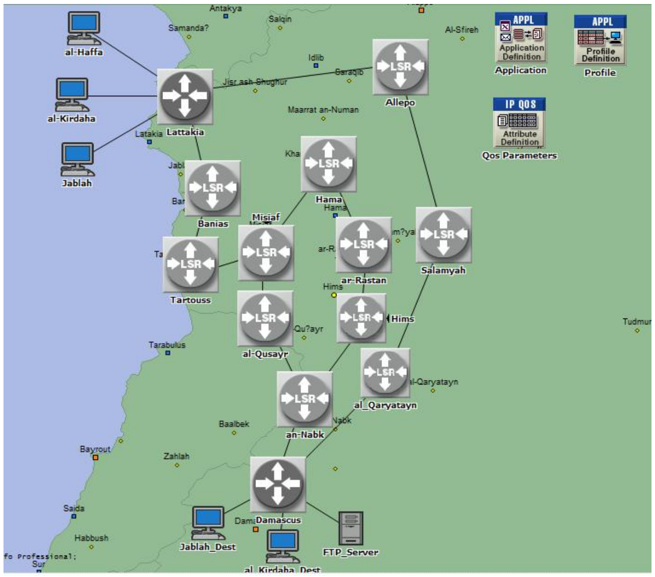

Fig. 6: The network topology used in the simulation

shown in fig8. In this scenario we apply MPLS technology and use two static LSP's (the Red one carry FTP traffic and the blue carry Video traffic) . We made this scenarios also for study the effect of traffic engineering on the whole performance, for MPLS Parameter's we apply two FEC's based on destination port (FTP server and video conferencing sever). We apply also 2 trunks with two deferent traffic class (AF11 for low priority and EF for high priority.

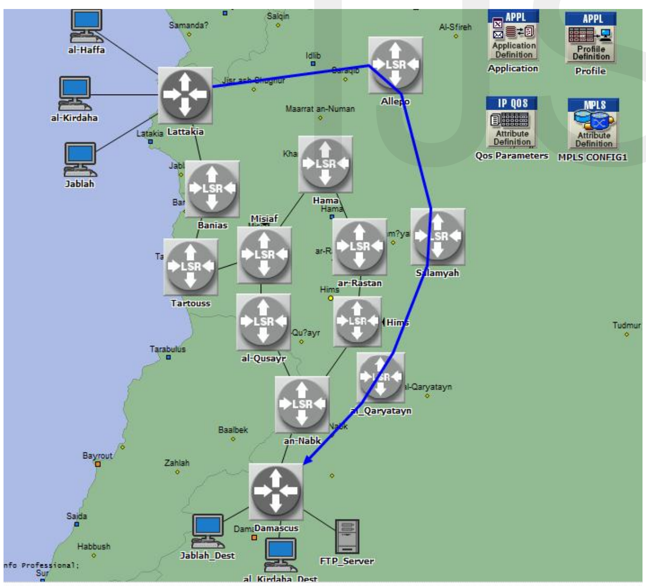

Fig.7: The network topology with MPLS and one LSP

For QoS configuration we used three different schemes: FIFO,WFQ (DSCP based), and PQ (DSCP based).

Performance Metrics:

IP Traffic Dropped: The number of IP datagrams dropped by All nodes in the network across all IP interfaces.

FtpUpload Response Time:Time elapsed between sending a file and receiving the response packet for the FTP application in this node.

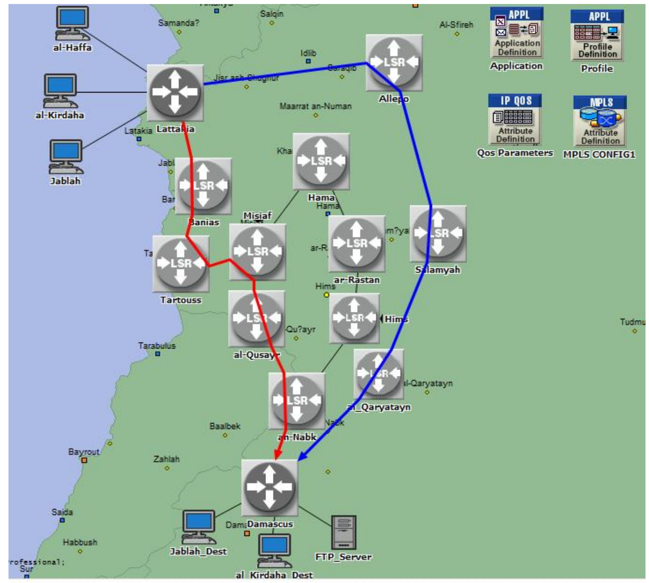

Fig. 8:The network topology with MPLS and two LSP's.

Packet Delay Variation: Variance among end to end delays for video packets.

Packet End-to-End Delay: The time taken to send a video application packet to a destination node application layer. This statistic records data from all the nodes in the network.

Traffic Received: Average bytes per second forwarded to all video conferencing applications by the transport

IP Interface Queuing Delay: This statistic represents instantaneous measurements of packet waiting times in the transmitter channel's queue.

we study three cases according to QoS scheme used:

1-FIFO case:

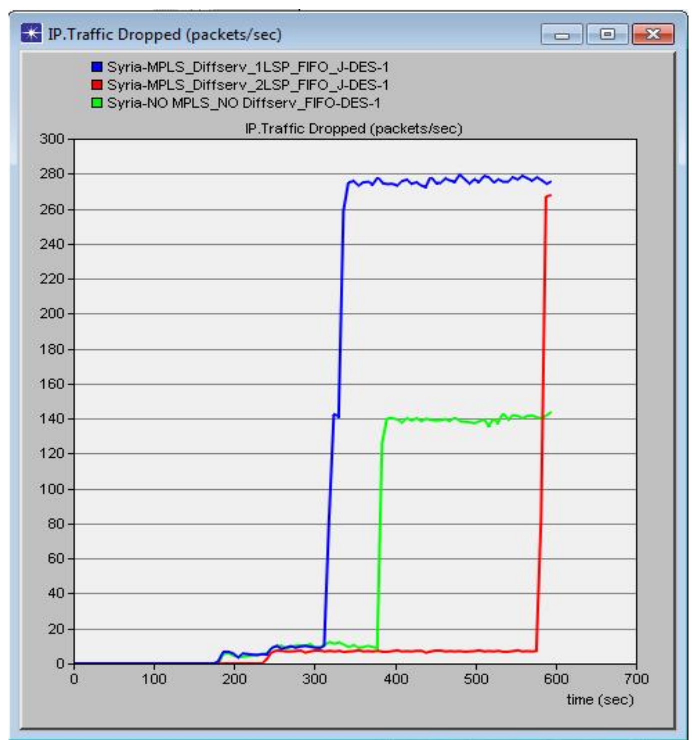

Fig.9 :IP Traffic Dropped (packets-sec) [FIFO]

In FIFO there is no difference when Different services is been or not been. We made this test to see the affect of MPLS and LSP's on network performance .As seen in the Fig.9 we seen that the traffic dropped decrease when we used to LSP's.

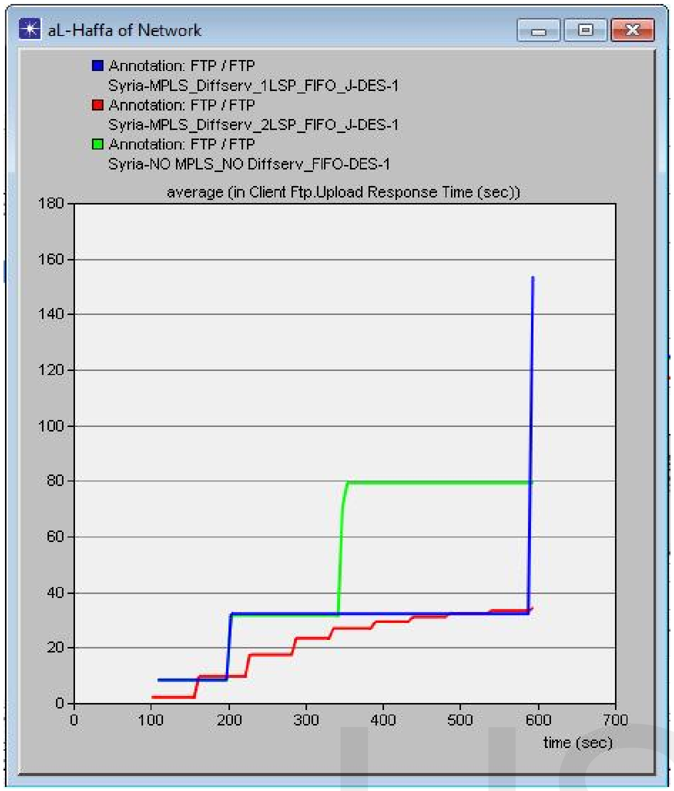

Fig.10: average (Client Ftp.Upload Response Time (sec) [FIFO]

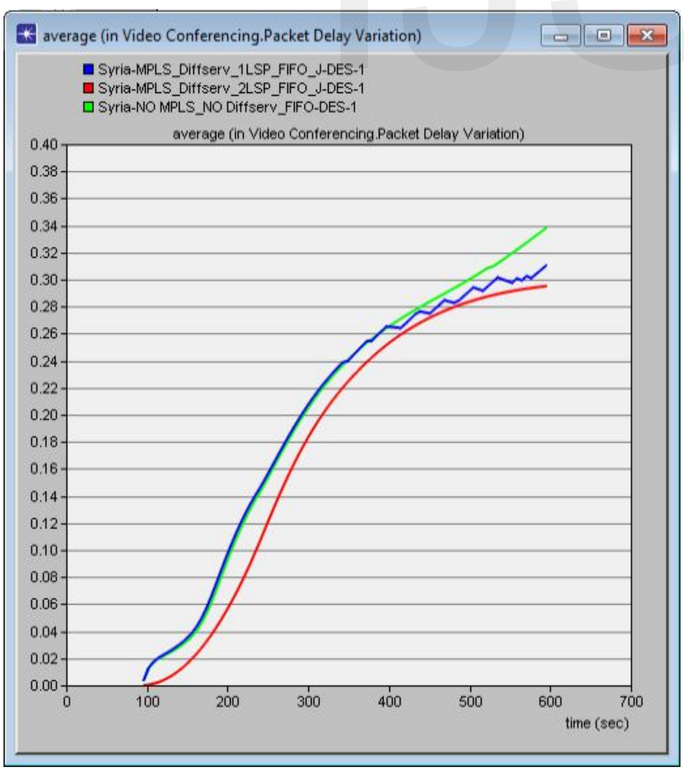

Fig.11: average (Packet Delay Variation) [FIFO]

We saw also in Fig.10 decreasing in Upload Response Time for FTP traffic when we used MPLS with tow LSP's. Using MPLS and more LSP's also decrease the packet delay variation and End-to-End Delay as it shown in Fig11 and Fig 12 sequence.

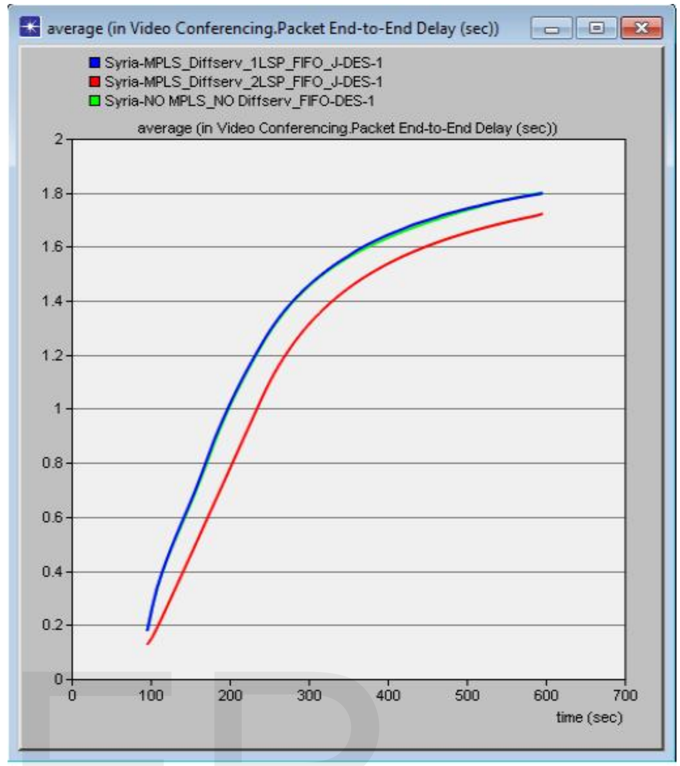

Fig.12: average (Packet End-to-End Delay (sec)) [FIFO]

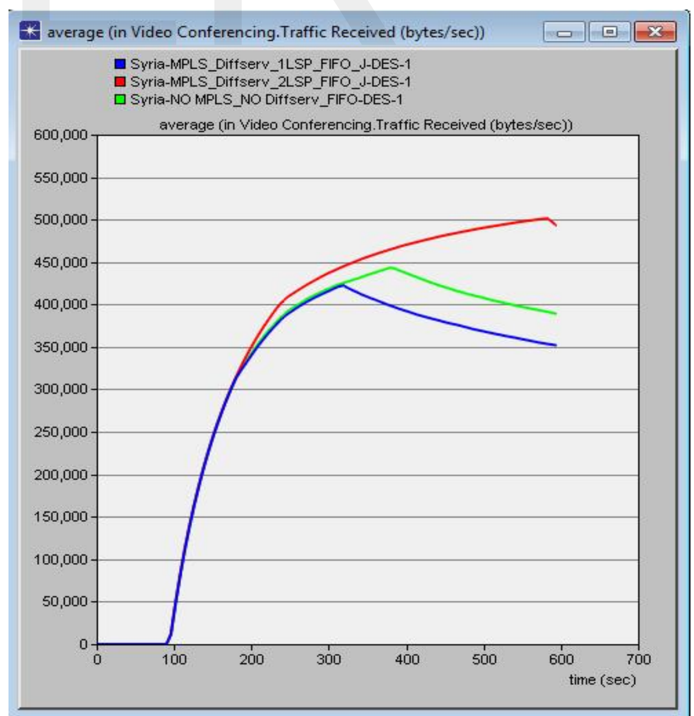

Fig.13 :average (Traffic Received (bytes / sec)) [FIFO]

In Fig13 it is clear the traffic received increased when we used MPLS with two LSP's

2-WFQ Case: In this case there is a clear difference when we used DiffServ. We make three scenarios when we used one

LSP:

1-MPLS_ DiffServ_1LSP_WFQ_J: In this scenario we made the priority for Jableh which send Video traffic to "Jablah_Dest" by assign its traffic to EF. We assign AF11 for the others (aL-Kirdaha and aL-Haffa)

2-MPLS_NO DiffServ_1LSP_WFQ_JK: In this scenario we made the priority for both Jableh and aL -Kirdaha (EF). In other words there is no difference between them.

3- MPLS_NO DiffServ_1LSP_WFQ_JKF: In this scenario we made the priority is the same for all Stations (Jableh, aL-Kirdaha and aL-Haffa) . This is worst traffic because all traffics on the same LSP and have the same priority.

when we used two LSP's there is two scenarios:

1- MPLS_ DiffServ_2LSP_WFQ_J: In this scenario we made the priority for Jableh.

2- MPLS_NO DiffServ_2LSP_WFQ_JK: In this scenario we made the priority is the same for all Stations (Jableh, aL-Kirdaha and aL-Haffa) .

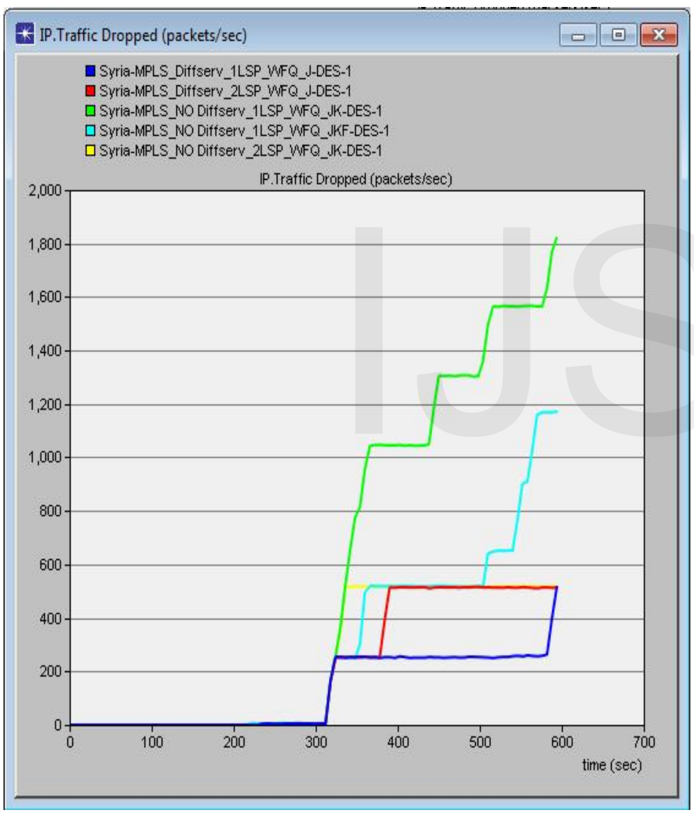

Fig.14 :IP Traffic Dropped (packets-sec) [WFQ]

As it clear in Figures (14,15, 16,17) , using MPLS-DiffServ always give us better result's especially when we use Two LSP's.

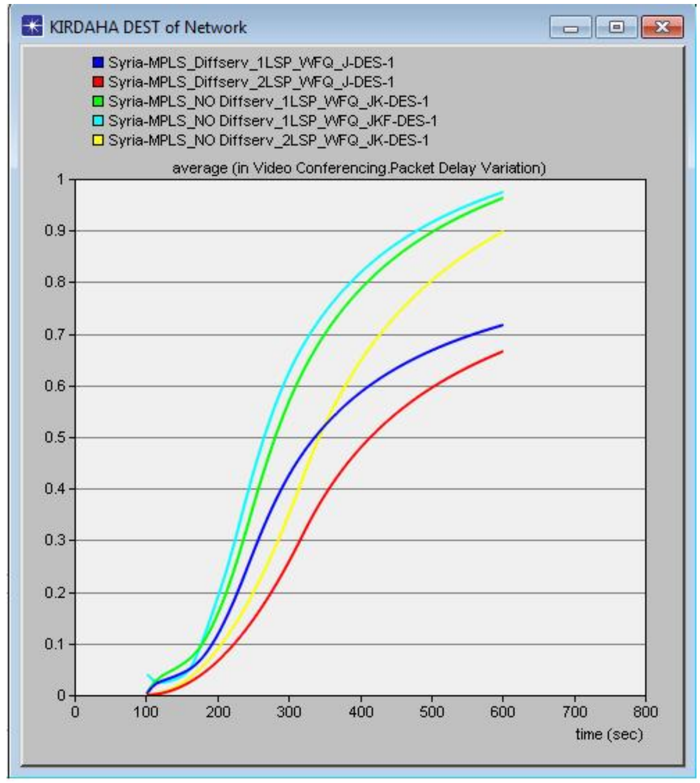

Fig. 15:average (Packet Delay Variation) [WFQ]

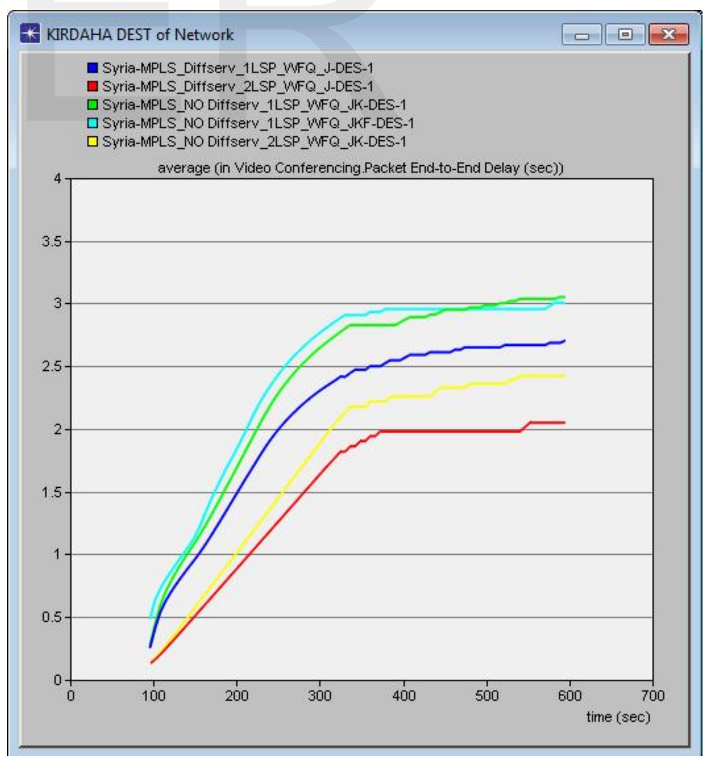

Fig.16: average (Packet End-to-End Delay (sec)) [WFQ]

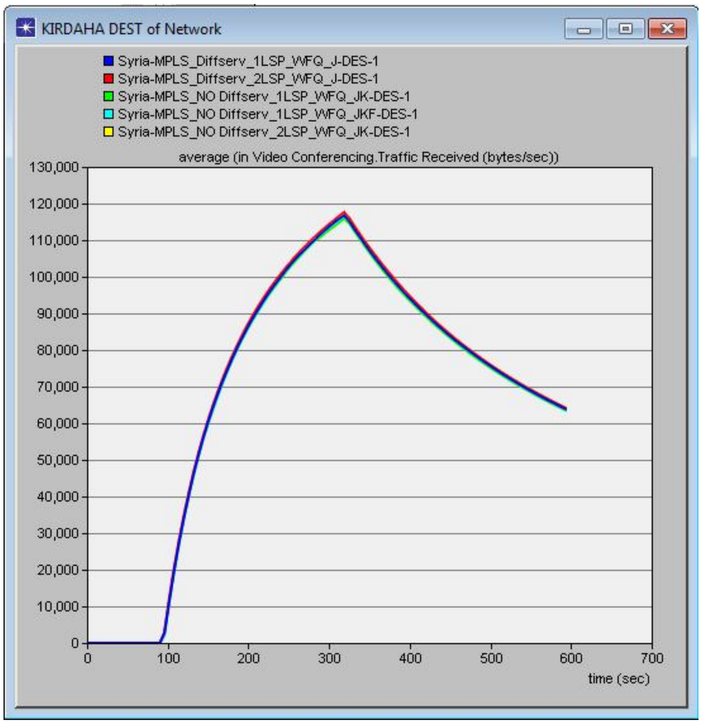

Fig.17 average (Traffic Received (bytes-sec)) [WFQ]

We can observe from Fig 18 that the Queuing Delay in IP Interface(in our case it is IF3) is more less when using DiffServ.

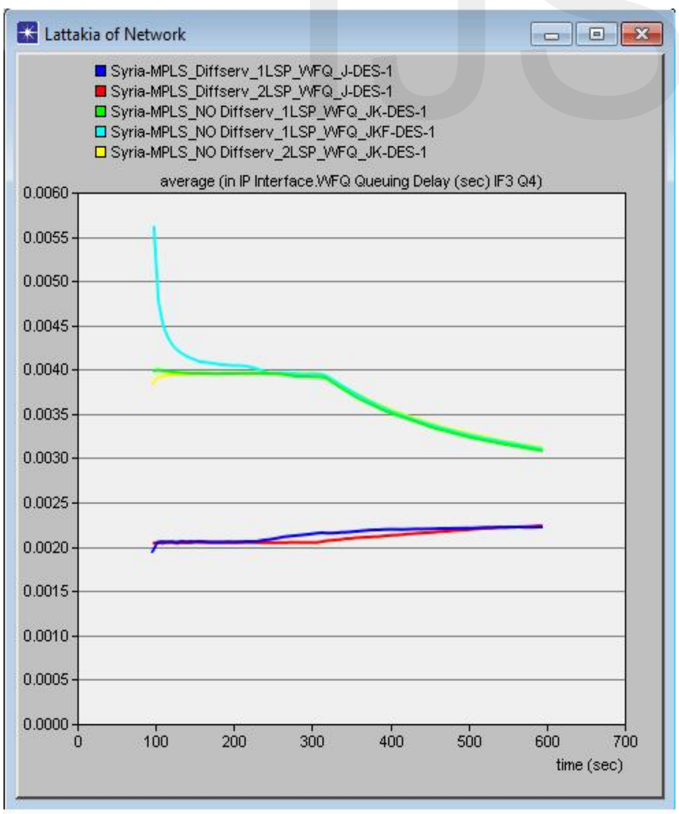

Fig.18: average (WFQ Queuing Delay (sec) IF3 Q4) [WFQ]

3-PQ Case: The scenarios are same as case 2 except that we use PQ scheme as QoS configuration. We can see that the effect of DiffServ is more than the previous two cases.

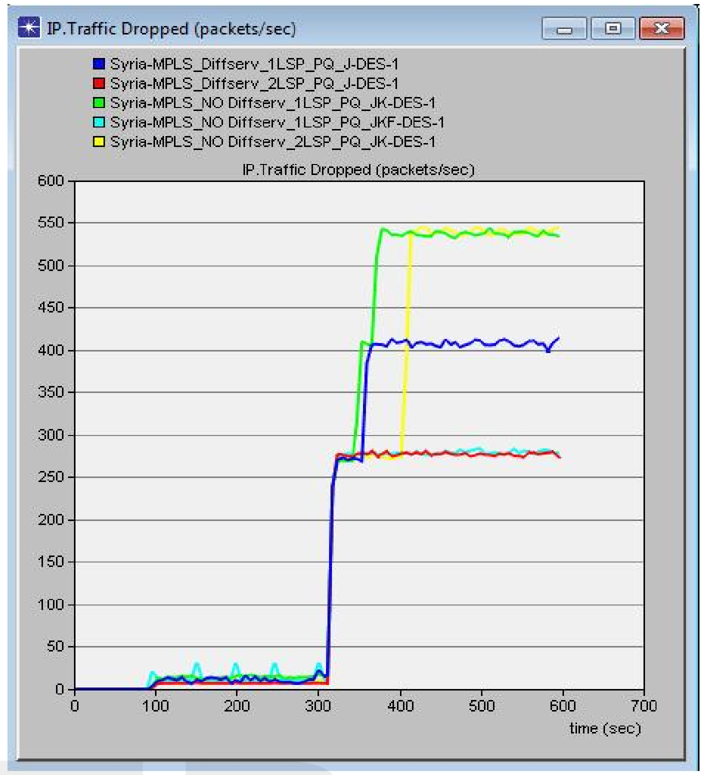

Fig.19 :IP Traffic Dropped (packets-sec) [PQ]

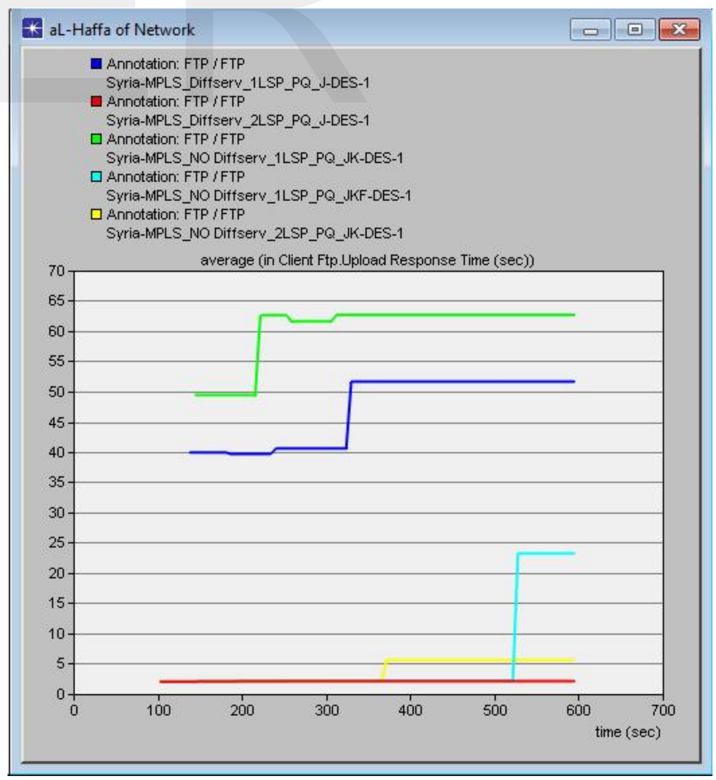

Fig.20 : average (Upload Response Time (sec)) [PQ]

When we have one LSP and put priority to FTP traffic similar as video traffic (EF) we will get less Upload Response Time (in scenario MPLS_NO DiffServ_1LSP_WFQ_JKF) as it

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seen in fig.20.

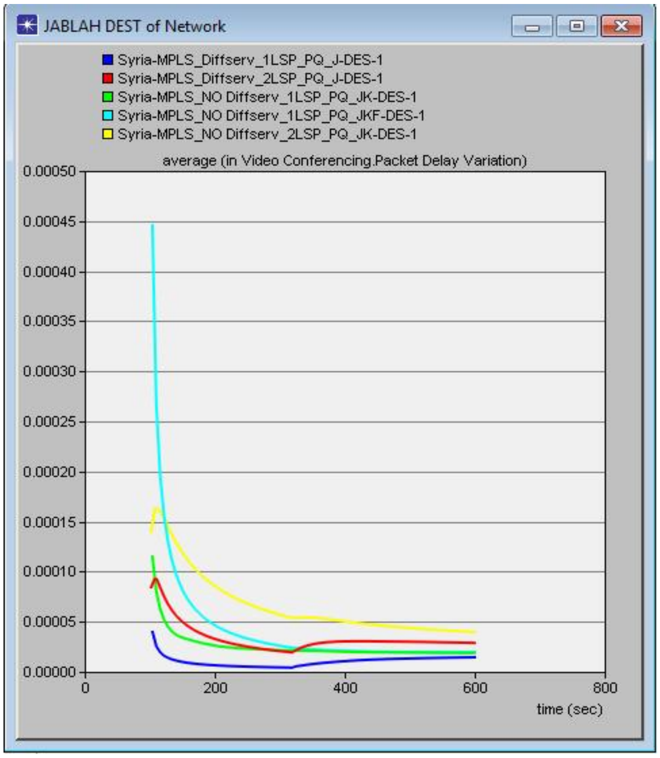

Fig.21: average (Packet Delay Variation) [PQ]

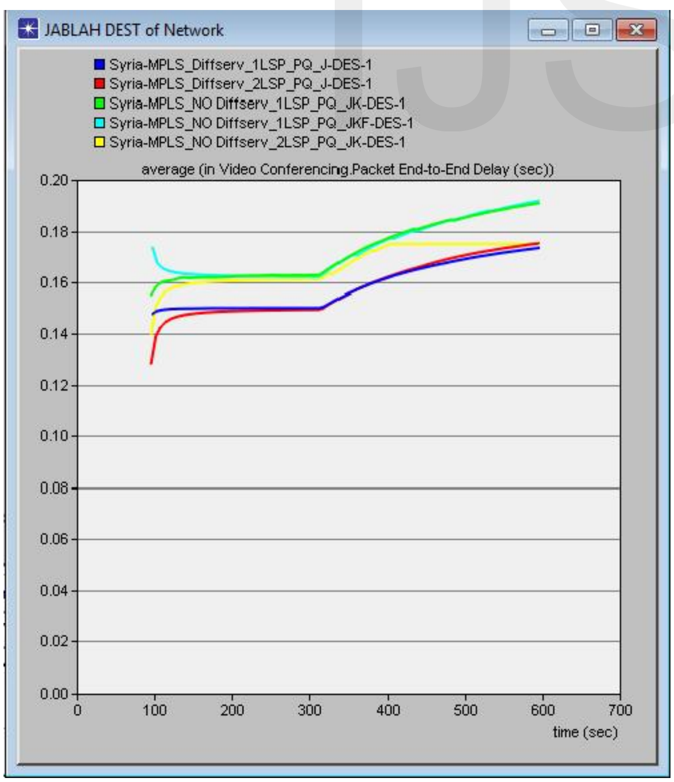

Fig.22: average (Packet End-to-End Delay (sec)) [PQ]

We can conclude from fig.[21,.22] compared to fig [11,12] and fig [15,16] that PQ is the suitable choice for achieve QoS in video traffic because it's law values in delay variation and End-to-End delay.

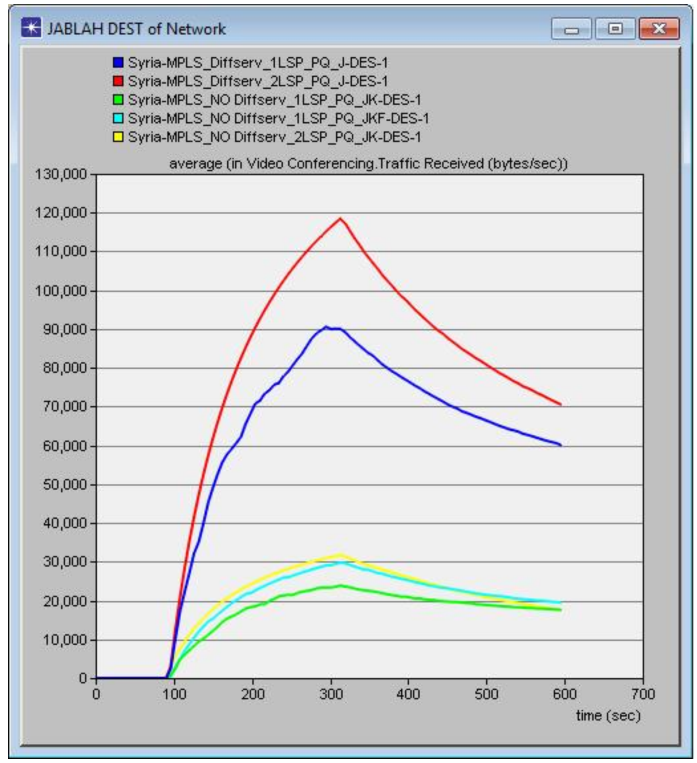

Fig.23 :average (Traffic Received (bytes-sec)) [PQ]

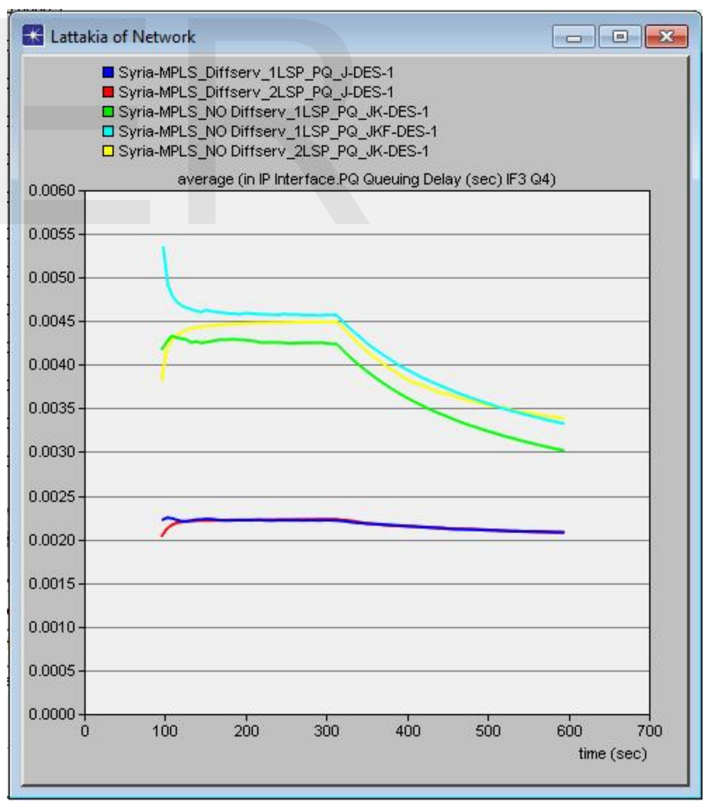

Fig.24 : average (PQ Queuing Delay (sec) IF3 Q4) [PQ]

8 Conclusion

The performance metrics obtained from simulation shows that the combined use of MPLS and DiffServ with Traffic engineering provide less end-to-end delay, delay variation and queuing delay and more received traffic for video traffic compared to traditional IP networks and non-DiffServ networks. Routers in MPLS takes less processing time in forwarding the packets, also Implementing of MPLS with TE minimizes the congestion in the network. DiffServ provide differentiated queue servicing. We apply different QoS schemes and observed that PQ is the suitable choice for video traffic. In our future works we will try to study affect of DiffServ in GMPLS (Generalized MPLS) networks.

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